Watersheds

4

"The study of rivers is not a matter of rivers, but of the human heart."
— Tanaka Shozo

All land on earth is a **watershed**. Humans and their activities play an important and essential role in watersheds, yet few people understand them. Still fewer know how a watershed works or can describe the boundaries of the ones in which they live.

A watershed is often called a drainage basin. It is the land area drained by a network of channels, called **tributaries**, that increase in size as the amount of water, sediment, and dissolved materials they must carry increases. Each watershed is an interconnected land-water system that conveys water to its outlet—a larger stream, an inland lake, a wetland, an estuary, or the ocean.

A watershed may be the drainage area surrounding a lake that has no surface outlet, such as Malheur and Harney Lakes in southeast Oregon or a river basin as large as that of the Columbia River. A puddle even has its own watershed.

Within a large watershed tributaries form smaller watersheds called **sub-basins**. Each tributary contributes to overall streamflow for the entire basin. Oregon has 20 major river basins (see Figure 4.)

All watersheds have an aquatic (or water) area, a riparian area, and an upland area. Aquatic areas include standing waters like ponds, lakes, wetlands, bogs and running surface waters such as streams and rivers. The corridor of vegetation next to and influencing the aquatic area is called the **riparian area**.

The point where two watersheds meet is called a **divide**. Connecting the divide with the valley or lowland areas below are the hill slopes or **uplands**. Events in the uplands ultimately

Figure 4. Oregon River Basins

Vocabulary

aquifers	perennial
baseflow	plant associations
climate	radial drainage
dendritic drainage	residual soils
deposition	riparian area
divide	streamflow hydrograph
ephemeral	sub-basins
erosion	sublimation
first-order streams	transported soils
forage	trellis drainage
gradient	tributaries
intermittent	uplands
leaching	water equivalent
parallel drainage	watershed

affect the capture of water on the surface of the land, storage and movement of water below the surface, and release of water to riparian and aquatic areas.

Each stream in a watershed is an ever-changing open-water system. It carves through valleys, collects water and sediments, and conveys the surface runoff generated by rainfall, snowmelt, or groundwater discharge to the estuaries and oceans. The shape and pattern of a stream is a result of the land it is cutting and the sediment it must carry.

Each of us has a "watershed address," which describes our basic relationship with a watershed. One part of our address is our location. We all live in topographic watersheds—areas drained by a common stream. When a raindrop falls on the roof of our house, where is it going? What creeks or rivers will carry it toward the sea?

Some people also live in engineered watersheds, which may not follow topographic lines. When we turn on the faucet in the kitchen sink, what watershed did that water come from? When the water runs down the drain, what watershed is it going to? For example, while rainwater in much of the Portland Metro area flows into the Willamette River, much of Portland's domestic water supply is piped from the nearby Bull Run Watershed, a watershed that flows toward the Columbia River. In this way, one watershed is artificially connected to several other watersheds at once. The watershed of surface flow, the watershed where domestic water originates, and the watershed where wastewater goes are all connected. This means Portland residents live in one watershed and drink water from another, while their wastewater may affect their "home watershed" and others.

Physical features of a watershed

Rain, snow, wind, ice, and temperature variations are all agents of erosion in a watershed. The erosional effects of surface water create stream channels. As streams carve their way through a watershed, they are responsible for most of the "topographic identity" of a watershed.

A watershed is almost like a domicile, a mini-biosphere, with halls of hills and mountains, a floor of river or lake, and a roof of rain clouds. Adapted from *Co-Evolution Quarterly*, Winter 1976/77.

Area

The area of a watershed affects the amount of water that flows from the river or stream that drains it. Generally, with similar climates large watersheds receive more precipitation than small ones. Greater precipitation and runoff may occur on a smaller watershed in a moist climate than on a large watershed in an arid climate.

Shape and slope

Shape and slope of a watershed and its drainage pattern influence surface runoff and seepage in streams draining the watershed. The steeper the slope, the greater the possibility for rapid runoff and erosion. Plant cover is more difficult to establish and infiltration of surface water is reduced on steep slopes.

Orientation

Orientation of a watershed in relation to the direction that storms move across it also affects runoff and peak flows. A rainstorm moving up a watershed from the mouth releases water in such a way that runoff from the lower section has passed its peak before runoff from the higher sections has arrived. A storm starting at the top

and moving down a watershed can reverse the process.

Orientation of a watershed relative to sun position affects temperature, evaporation, and transpiration. Soil moisture is more rapidly lost by evaporation and transpiration on steep slopes facing the sun. Watersheds sloping away from the sun are cooler, and evaporation and transpiration are less. Slopes exposed to the sun usually support different plants than those facing away from the sun. Orientation to prevailing winds has similar effects.

Drainage patterns

Viewed from above, the tributaries of each river system create a distinct pattern. Geology, topography, and climate are responsible for this pattern. Regions with parallel valleys formed by the folding of the earth's surface have a **parallel drainage** pattern. Where the geology is sedimentary rock, fault lines may create a drainage pattern where streams flow parallel to each other and tributaries join at nearly right angles in a **trellis drainage** pattern.

In the Pacific Northwest two of the most common patterns are **radial drainage** and **dendritic** (treelike) **drainage**. When streams drain a central high point, such as a mountain top, they create a pattern similar to the spokes on a wheel radiating out from the central hub. This is radial drainage.

The branching tributaries of a river may also create a pattern similar to the branches of a tree. This is dendritic drainage. Both types may occur within the same watershed. For example, the radial pattern of streams that drain Mount Hood are all within the Columbia Basin, but the drainage pattern of the individual sub-basins formed by these streams have a dendritic pattern.

Figure 5. Stream Orders

Stream orders

In most cases, a watershed system is almost entirely hillsides, called uplands. Only about one percent of a watershed is stream channels. The smallest channels in a watershed have no tributaries and are called **first-order streams**. When two first-order streams join, they form a second-order stream. When two second-order channels join, a third-order stream is formed, and so on (Figure 5). First- and second-order channels are often small, steep, or **intermittent**. Orders six or greater are larger rivers.

Channels change by **erosion** and **deposition**. Natural channels of rivers increase in size downstream as tributaries enter and add to the flow.

Radial Drainage

Dendritic Drainage

Parallel Drainage

Trellis Drainage

A channel is neither straight nor uniform, yet its average size changes in a regular and progressive fashion. In upstream reaches, the channel tends to be steeper. **Gradient** decreases downstream as width and depth increase. The size of sediments tends to decrease, often from boulders in the hilly or mountainous upstream portions, to cobbles or gravels in middle reaches. More sand or silt are found downstream. In some cases, large floods cause new channels to form, leaving once-productive streams dry and barren.

Streamflow types

Besides the ordering system previously described, streams may be classified by how much of the year they have flowing water.

- **Perennial** flow indicates a nearly year-round flow (90 percent or more) in a well-defined channel. Most higher order streams are perennial.
- **Intermittent** flow generally occurs only during the wet season (50 percent of the time or less).
- **Ephemeral** flow generally occurs during and shortly after extreme precipitation or snowmelt conditions. Ephemeral channels are not well defined and are usually headwater or low order (1-2) streams.

Factors affecting watersheds

Climate

Land and water are linked directly by the water cycle. Solar energy drives this and other cycles in the watershed. **Climate**—the type of weather a region has over a long period—is the source of water. Water comes to the watershed in seasonal cycles, principally as rain or snow. In some areas, condensation and fog-drip contribute water. The seasonal pattern of precipitation and temperature variation control streamflow and water production.

Some precipitation infiltrates the soil and percolates through porous rock into groundwater storage, which recharges areas called **aquifers**. Natural groundwater discharge, called **baseflow**, is the main contributor to streamflow during dry summer and fall months. Without baseflow, many streams would dry up.

Pumping water from an aquifer for industrial, irrigation, or domestic use reduces the aquifer's volume. Unless withdrawals are modified or recharge increased, the aquifer will eventually be depleted. A drained aquifer can collapse from the settling of the overlying lands.

Collapsed underground aquifers no longer have as much capacity to accept and hold water. Recharge is difficult, volume is less, and yields are considerably reduced. Springs once fed from the water table also dry up.

Land and water are linked directly by the water cycle.

Climate affects water loss from a watershed as well as provides water. In hot, dry, or windy weather, evaporation loss from bare soil and from water surfaces is high.

The same climatic influences that increase evaporation also increase transpiration from plants. Transpiration draws on soil moisture from a greater depth than evaporation because plant roots may reach into an available moisture supply. Transpiration is greatest during the growing season and least during cold weather when most plants are relatively dormant.

Wind also causes erosion, controls the accumulation of snow in sheltered places, and may be a significant factor in snowpack melting. Wind erosion can occur wherever wind is strong and

constant, or where soil is unprotected by sufficient plant cover.

Soils and geology

Soil, a thin layer of the earth's crust, could be called the "skin" of a watershed. It is composed of mineral particles of all sizes and varying amounts of organic materials. It is formed from the breakdown of parent rocks into fine mineral particles. This occurs by:

- freezing and thawing in winter,
- heating expansion and cooling contraction in summer,
- wind and water erosion,
- the grinding action of ice, and
- action of lichens and other plants.

Soils are of two types. **Residual** soils are those developed in place from underlying rock formations and surface plant cover. **Transported** soils include those transported by gravity, wind or water.

Climate, particularly precipitation and temperature, strongly affects soil formation. Rainfall causes **leaching**—movement of dissolved particles through soil by water. Temperature affects both mechanical breakdown of rocks and breakdown of organic material. Soil bacteria, insects, and burrowing animals also play a part in the breakdown and mixing of soil components.

Soil often determines which plants grow in a watershed, which in turn establish a protective vegetative cover. Plants also modify and develop soil. Plant roots create soil spaces and extract water and minerals in solution from their roots. Plant litter adds organic matter to soil. It also slows surface runoff and protects the soil surface from rainfall's beating and puddling effects. Soil depths and moisture-holding capacities are usually less on steep slopes, and plant growth rates are often slower.

Forage, timber, and water are all renewable resources. Water is renewed by cycles of climate. Forage and timber are renewed by growth in seasonal cycles. The availability of these watershed resources is dependent upon soil. Soil is, except over long periods, a nonrenewable resource. It may take more than a century to produce a centimeter of soil and thousands of years to produce enough soil to support a high-yield, high-quality forest, range, or agricultural crop. Soil is the basic watershed resource. Careful management and protection is necessary to preserve its function and productivity.

Vegetation

The variety of plant species and their growth and distribution patterns within a watershed are the result of differences in soil type, light, temperature, moisture, nutrient availability, and human activity. For example, temperatures on the north and south slopes of the same hill may vary considerably. Different light intensities may account for the temperature variation on either side of the hill. Temperature differences in turn affect the moisture levels on each of the slopes. Generally south-facing slopes are warmer and drier than north-facing slopes in the northern hemisphere.

The plant species that are present directly affect the ability of a watershed to capture, store, and release water within that particular habitat. Branches of large conifers effectively intercept snow and rain. Some of the moisture in the precipitation will evaporate before it has a chance to reach the ground but the rest is slowed in its descent, lessening the impact to the soil's surface. Sagebrush and other arid land shrubs, on the other hand, are not as effective in slowing snow or rain. Yet in areas with less precipitation, this adaptation provides the greatest opportunity for moisture to infiltrate. Watersheds covered with dense grass cover help the soil capture water much more effectively than watersheds with sparse vegetation.

Plants directly affect the ability of a watershed to capture, store, and release water.

Groups of plants that have evolved together over time are called **plant associations (or communities)**. Plant associations share specific adaptations to certain watershed conditions—climate, soil type, light and temperature requirements, moisture, and nutrient availability as described above. Knowing the basic plant associations found in a particular watershed can tell you a lot about the health of that watershed.

Fish and wildlife

Each watershed has a diverse mix of wildlife species—mammals, birds, reptiles, amphibians, and invertebrates. Plant communities influence which species are found in a particular watershed. Plants, in some form or another, meet the basic habitat needs of food, water, shelter, or space for most all forms of wildlife. And, all wildlife species, large or small, become part of the interrelationships found within a watershed.

Some wildlife never leave their watershed residence while others move among several adjoining watersheds or even migrate hundreds or thousands of miles to live in a completely different watershed during different times of the year. Wildlife populations within a watershed may vary seasonally and annually. Migration, predation, wildlife management (like hunting seasons), or watershed management decisions (development, timber harvest, mining, recreation, agriculture) can all affect wildlife populations.

Wildlife perform a variety of functions within a watershed. Less commonly known but very important contributions include burrowing activities of animals like worms and mice. Their burrows allow moisture to penetrate deep into the soil, aiding the water storage capabilities of the watershed. Small rodents also collect and store nuts and seeds, many of which sprout and grow to provide more food and ground cover. Rodents are also an important part of many watershed food chains. Birds also help transport seeds. Dams built by beavers help increase water storage in the soil and their activities are often responsible for channel changes within a stream system.

Limited exclusively to the aquatic habitats found within a watershed, fish occupy a unique niche. Fish are part of complex aquatic food chains and, along with the aquatic organisms on which they feed, are indicators of water quality.

A number of factors within the watershed control a stream's ability to produce fish food. When producers such as algae and diatoms are plentiful, the aquatic insects that feed upon them also thrive. They in turn are food for other aquatic invertebrates and fish. Overhanging streamside vegetation also contributes insects to the aquatic dinner plate.

Plants, in some form or another, meet the basic habitat needs of food, water, shelter, or space for most all forms of wildlife.

Studies in recent years show considerable evidence that stream systems with migrating populations of salmon and trout are highly dependent on the nutrients provided by the decaying carcasses that remain after spawning.

Fish populations vary with the quantity and the quality of available water within a watershed. Streams that flow cold and clean throughout the year generally provide the conditions that salmon and trout need to be healthy and productive. Human management activities can affect the quantity and quality of water in streams.

Management objectives in a watershed

A key watershed management objective is to maintain effective vegetative cover and soil characteristics that sustain high quality water supplies. Meeting this objective enhances the usefulness and productivity of the land for other purposes. If the soil is protected and maintained in good condition, then other renewable

resources that depend on this most basic form of productivity can be supported.

Timber, forage, minerals, food, and wildlife represent important watershed management considerations. Problems arise when development and use of these resources conflict with the primary objectives of maintaining and protecting high quality water supplies and promoting watershed integrity.

Land ownership is the principal institutional control of a watershed. A private individual or public management agency may be free to apply whatever measures they believe necessary or desirable on their own land. They may regulate access and prevent use and development of associated resources.

All watershed users should know that private actions have public consequences on water quality and quantity.

Many watersheds are in public or state ownership. Unless protected by specific legislation or agreement, most are used and developed to take advantage of all resources available for the general public benefit. It is in these multiple-use watersheds that management may face the most serious conflicts and challenges. Protecting the water resources of some of these watersheds may require limiting and balancing development to provide the greatest possible benefits with the least significant disruption of the water resource.

Legislation and government edicts also provide controls that can aid water resource management. These laws may include:

- land use planning,
- zoning,
- permitted and prohibited land uses or types of development,
- restrictions on water use,
- limitations on water development,
- pollution control, or
- fill and removal restrictions.

All watershed users should know that private actions have public consequences on water quality and quantity.

In Oregon, and the Pacific Northwest, watershed councils are a growing voice in guiding the management of local watersheds. These councils are voluntary local advisory groups formed around interest in a particular watershed. Watershed councils use consensus-based decision making (depending on the support of all council members rather than a majority) to foster coordination and cooperation in managing their local watershed. As advisory groups their determinations do not have the force of law, but inform management agencies about the concerns and wishes of those most closely affected by watershed management decisions. In many cases these councils also plan and implement projects for

Adapted from original artwork by Sandra Noel, *Adopting A Stream A Northwest Handbook*, Adopt-A-Stream Foundation, 1988.

watershed protection, improvement, and education.

Watershed councils also play an important role in the Oregon Plan for Salmon and Watersheds. The Oregon Plan establishes local networks and partnerships between citizen groups, communities, local governments, state agencies and others to allow citizens to be proactive and address watershed problems. Currently the Oregon Plan has two parts. The Oregon Coastal Salmon Restoration Initiative, often called the Oregon Salmon Plan, seeks to develop programs to preserve and restore native coho salmon populations in coastal basins. The Healthy Streams Partnership is the second component. Its purpose is to create networks and partnerships to improve water quality throughout the state to meet the federal Clean Water Act standards.

Summary

Rivers, upland areas, mountaintops, and flood-formed bottomlands with their associated riparian areas are all part of one system. All are integrated with each other. Hillside shape controls the rate of water flow. All living elements in the watershed interact with and modify the energy flow through the system. The unique combination of climatic conditions, soil types, topography, vegetative cover, and drainage system define the specific character of each watershed.

Rivers do not stop at state lines or national boundaries. The effects of natural and human processes in a watershed are focused at its outlet, wherever it may be, even if a watershed crosses another state or country's borders. Each watershed is a part of a larger watershed whose downstream portion is affected by upstream influences.

Everyone depends on the resources watersheds provide. As the human population continues to grow, the demand on those resources intensifies. Human uses of land and water resources affect the ecological dynamics of a functioning watershed system, altering natural habitats as well as the quantity and quality of its water supplies. Some changes are improvements. Others are not. It is up to the public at all local, regional, state, and national levels to meet the challenges of balanced, productive watershed management.

Adapted from W.E. Bullard, "Watershed Management Short Course," Oct. 1975, and used with permission.

Extensions

1. "Where Does Water Run?" *Aquatic Project WILD*, pp. 21. Grades 6-12.
2. "Watershed," *Aquatic Project WILD*, pp. 132. Grades 4-12.
3. "To Dam or Not to Dam," *Aquatic Project WILD*, pp. 170.
4. "Identifying Your Watershed," *Watershed Uplands Scene*, pp. 17-36. Grades 9-12.
5. "Weather and Climate Investigation," *Watershed Uplands Scene*, pp. 89-108. Grades 9-12.
6. "Branching Out," *Project WET*, pp. 129-132. Grades K-2 and 6-8.
7. "A-Maze-ing Water," *Project WET*, pp. 219-222. Grades 3-8.
8. "Color Me a Watershed," *Project WET*, pp. 223-227. Grades 9-12.
9. "Common Water," *Project WET*, pp. 232-237. Grades K-8.
10. "Dilemma Derby," *Project WET*, pp. 377-381. Grades 6-12.
11. "Get the Ground Water Picture," *Project WET*, pp. 136-143. Grades 6-12.
12. "Irrigation Interpretation," *Project WET*, pp. 254-259. Grades K-8.
13. "A Grave Mistake," *Project WET*, pp. 311-315. Grades 6-12.

14. "The Pucker Effect," *Project WET*, pp. 338-343. Grades 6-12.

15. "Surface Water," *The Comprehensive Water Education Book*, pp. 141-143. Grades 4-6.

16. "Floods and Erosion," *The Comprehensive Water Education Book*, pp. 144-145. Grades 3-6.

17. "Lakes," *The Comprehensive Water Education Book*, pp. 146-147. Grades 4-6.

18. "Watersheds," *The Comprehensive Water Education Book*, pp. 151-152. Grades K-6.

19. To make a simple watershed model crumple up a large piece of butcher paper and put it on the floor. Imagine that the paper is the surface of the land, the edges the shoreline, and the floor the sea. Use a permanent marker to trace the ridgelines separating one watershed from another. Then trace the river systems with a various colors of water soluble markers. Spray water on the watershed. Each river system will have its own color, but all colors mix in the estuaries and sea.

20. Since everyone lives in one, a first step in understanding watersheds is to explore your own local watershed by outlining its boundaries. Check with your local library for topographic maps if you cannot determine the boundaries visually.

    a. On a map, trace the lines along the high points that separate your creek or river from the next.

    b. Map the land use in your watershed (e.g., streets, forests, farms, yards, etc.)

    c. List all possible places rain goes in your watershed.

    d. Go outside the school building. What happens to the rain when it falls on the school roof? Does any of it get to a stream or river? How?

    e. Are you ever anywhere that is not in a watershed?

    f. Collect newspaper clippings on watershed management problems in your area.

    g. In small groups have students design their own watershed. Each design should include the location, climate, uses of, abuses to, human impact on, and group perceptions of what a watershed should and should not be. After preparing visuals to depict their watershed, groups present their design to the class. (Contributed by Mary Roberts, 1989)

21. Have students develop an oral history of their watershed. Students should first develop a list of questions they want to research about their watershed, then set up interviews with people in the community. Questions should include past watershed events, both human-caused and natural, how it looked fifty or more years ago, and more. Students can then summarize their research into a written report or verbal presentation or both.

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A sense of place: your ecological address

Activity Education Standards: *Note alignment with Oregon Academic Content Standards beginning on p. 483.*

Objectives

Students will (1) define watershed, (2) determine boundaries of a watershed on a map, (3) draw a map of their own watershed, (4) identify potential effects of human and natural events on a watershed, (5) calculate the number of miles of streams and rivers in their watershed, and (6) identify potential effects of intermittent streams in the watershed.

Method

Students will brainstorm, create, and illustrate a definition of a watershed, outline watershed boundaries on maps, draw a map of their own watershed, and answer questions about watersheds.

For younger students

1. Consult extension activities at the end of each chapter to address the needs of younger students.
2. Read activity background information aloud to younger students or modify for your students' reading level.
3. A three dimensional model, perhaps of modeling clay, may help younger students visualize a watershed. Then, use the Umatilla Drainage Basin and Mid-Coast Drainage Basin maps (or substitute a map of a local watershed) as overheads along with a teacher-led discussion and inquiry to answer all questions.

This activity is an adaptation of the original *Stream Scene* activity "Does The Earth Wear A Raincoat" and "Finding Your Ecological Address" from *The Fish Hatchery Next Door* by Bill Hastie, et al., Oregon Department of Fish and Wildlife, 1996. The material was also published in "Ecological Address: At Home In Your Watershed," National Science and Technology Week, 1992-93 Packet, National Science Foundation, Washington, D.C.

Materials

For each pair of students

- copies of student sheets pp. 53-58
- copies of Oregon watershed maps (mid-coast drainage basin and Umatilla drainage basin) or a local watershed drainage basin map (see Chapter 14.4 for source of Oregon drainage basin maps.
- paper for illustrating a watershed "definition" and drawing a watershed "map"
- colored pencils or markers
- string or yarn (about one foot per student)

Notes to the teacher:

To set the stage and work through all the parts of this activity may take two or three class periods. You can also choose the parts that are appropriate for your students or that will fit your classroom schedule.

In the procedures that follow, an "ecological address" includes the name of the watershed in which students live as well as each successively larger stream and watershed—up to and including the major river from which the largest watershed usually takes its name. This system also includes the large lakes or the ocean into which that river feeds. Use the Columbia River basin watershed

Vocabulary

divide
intermittent stream
sub-basin
watershed

as an overhead transparency to demonstrate this concept.

Help students understand their "sense of place." Each of us has a place we want to become part of, care about, and want to protect or enhance. Understanding this concept and the responsibilities that go along with it are part of watershed education. When people have a greater understanding of their watershed, they gain awareness of how their personal actions, local laws and regulations, and everyday practices affect the integrity and stability of their ecological address and the larger biological community.

Depending on age level, students will need varying degrees of background information before proceeding with the "brainstorming and definition of a watershed" part of the activity. The activity's background section is appropriate as is a student reading developed from the chapter content.

A simple demonstration may also help students understand the concept of watershed. Trace the outline of your hand, wrist, and part of your arm on the chalkboard. Color in the space between your fingers and label your arm "Muddy River." Tell the students this outline is a model for a watershed area. Your fingers represent streams that feed into the larger river (your arm). The colored space between your fingers is land, where people live. Let students know that a watershed's name is usually taken from the stream or river that serves as the main collector of all the water in the watershed. Ask students what the watershed you just drew would be called (Muddy River Watershed). Write the name on the board. Create names for the finger tributaries and write those on the board, too. Ask students how large they think watersheds can be, then how small they can be. They should recall this from their background reading. Impress upon the students that large watersheds include many small watersheds.

Use maps that parallel the local watershed situation as closely as possible. Substituting local maps for the mid-coast and Umatilla drainage basin maps where appropriate will help students associate more closely with their own watershed and develop their own "sense of place." Modify the procedures to work with the local map. In urban areas a city map may be needed to determine the exact watershed in which a student's home or school might be found. Depending on the proximity of waterways, the watershed named should reflect that students' ecological addresses can have several components, from the smallest watershed they can observe to a larger watershed of which the smaller one is a part.

It is not necessary for the "map" created in Step 7 to be to scale, but it should represent the watershed(s) in which the students live. Use the Five Rivers water-

Columbia River Basin

Based on: Ed Chaney, *A Question of Balance: Water/Energy—Salmon and Steelhead Production in the Upper Columbia River Basin, Summary Report*, Nov. 1978. NW Resource Information Center, Inc.

shed map as an example. As an alternative or additional activity, have the entire class make a larger map of the watershed on large sheets of paper.

Background

Do you know ...

Water runs downhill. We all know that. The instant that a drop of rain hits the earth, it begins its journey to the ocean. If it falls as snow, it has to wait until it melts! Of course, not all water drops make it to the ocean. Some are taken up by plant roots and are transpired into the air through the plant's leaves. Some evaporate in puddles or other areas that hold water. Some filter down into underground areas, moving slowly downhill. But most water drops end up as runoff, the water that finds its way into creeks, streams, and rivers.

This long or short journey to the ocean takes place within a watershed. If you stand in a streambed and look upstream at all the land the stream drains, you are looking at the stream's **watershed**. Almost all the area of a watershed is land—not water! And, almost everything that drains it happens on that land. In other words, all land on earth is in a watershed.

Every body of water, stream, lake, pond, or river, has a watershed. Even a mud puddle has a watershed! Watersheds can be big or small. A mud puddle has a watershed of only a few square feet, while the Columbia River watershed has 258,000 square miles! The biggest watershed in the country is the Mississippi River, which drains all the land between the Rocky Mountains and the Appalachian Mountains.

A raindrop, no matter where it falls in the Columbia River watershed (unless it evaporates), will end up at the mouth of the Columbia River at Astoria. Most large watersheds are made up of many smaller watersheds called **sub-basins**. For instance, the Columbia watershed includes the Snake, John Day, Deschutes, Umatilla, and Willamette watersheds plus many others.

Watersheds are separated by ridges, called **divides**. The Continental Divide of the Unite States, for example, is in the Rocky Mountains. All the rain and snow falling on the west side of the divide flows into the Pacific Ocean. All the rain and snow falling on the east side of the divide, sooner or later, ends up in the Atlantic Ocean.

Procedure

Now it's your turn . . .

1. What is your home mailing or street address? What are the addresses of several other students in your class? These postal addresses have been devised by society—in other words, they are "social" addresses. Social addresses are important because people need to be located within their community by family, friends, and services such as the mail, police, fire, or ambulance.

2. You have another kind of address, called an "ecological address." Ecological refers to the relationship between an organism and its environment. Just as a postal address tells people one way they are connected to the community, the ecological address tells people how they are connected to the land on which they live. In this activity, your "ecological address" is based on an ecological feature you are just now learning about—a watershed.

3. With your partner, brainstorm words or ideas that make you think of a watershed. Write down your thoughts. Using your ideas as a starting point, create a watershed definition. Write your definition in the space provided for Question 1 on the student worksheet. Now, using a piece of paper and markers, draw and color a picture of the watershed you just defined. When all the groups are finished share your definition and drawing with the rest of the class. Post your drawing on the wall. As a class discuss all of the group's definitions and decide on the definition that best states the meaning of a watershed. You may have to combine several

group's definitions to come up with the best answer.

4. Look at your copy of the Mid-Coast Drainage Basin map. Locate a stream called Five Rivers (Five Rivers runs through the communities of Denzer, Fisher, and Paris). Mark the point where Five Rivers runs into the Alsea River. Where does the Alsea River go? **(Pacific Ocean.)**

5. Locate the Crab Creek watershed by drawing a line around it with a colored pencil or marker. Then, locate the Lobster Creek watershed in the same way with another color. With a third color, draw a line around the entire Five Rivers watershed. Check with your teacher to see if you have correctly identified the watersheds. Answer Questions 2, 3, and 4 on the student worksheet from the mid-coast drainage basin map.

6. Now, look at your copy of the Umatilla drainage basin map. The Umatilla River watershed is in Northeastern Oregon. Locate a stream called Willow Creek (Willow Creek runs through the communities of Heppner, Jordan, and Ione). Locate the Spring Hollow watershed by drawing a line around it with a colored pencil or marker. Then, locate the Rhea Creek watershed in the same way with another color. With a third color, draw a line around as much of the Willow Creek watershed as possible. Answer Questions 5 through 10 on the student worksheet.

7. Using an Oregon state map or local map that shows streams and rivers, name the watershed in which you live. This watershed is your "ecological address." It describes how you are connected to the land and water system that drains it. Share your ecological address while other students follow along on their own map.

8. On the second piece of paper make a "map" of your ecological address. Refer to the Five Rivers or Umatilla drainage basin maps as examples. Label the communities and other important features in your watershed. Share your watershed map with the rest of the class.

9. Brainstorm a list of what you think can happen to water as it moves through a watershed. Use a check to mark the ones caused by human activities. If some items on your list include substances that can get into the water in your watershed, use a marker to trace the path these substances would follow on your watershed map until it empties into larger watershed areas. Repeat this process with another color to mark the effects of non-human influences on watersheds, such as heavy rains, wind, and other natural events. Compare the two lines. Which of the two, human-caused or non-human would have the greatest effect on your watershed? Record your answer has Question 11 on the student worksheet.

10. How many miles of stream and river are in your watershed? Use the "scale of miles" on the published map to determine how many miles are represented by a certain length, usually one or two inches. Use a string to measure that length, then apply the string, following the curves on your map, to measure the distance. Multiply the number of "string lengths" times the map scale to obtain the number of stream miles. Record the number of miles for this step under Question 12 on the worksheet. How many miles of stream were affected by the human-caused events in Step 9? How many miles of stream were affected by non-human events in Step 9? Record your answers on the student worksheet and answer the remaining question.

Columbia River Drainage Basin (a)
Scale 1:4,500,000
Drainage basin boundary
Cascade divide
Western region
Eastern region
Dam
Study area boundary
Elevations in feet
Map compiled from North Pacific U.S. Army Corps of Engineers "Water and Land Resources Map — Columbia River and Tributaries Review Study", NP.12-1, August 1979. Additional compilation from U.S.G.S. 1:2,500,000 map of the United States and Canada Department of Mines and Technical Surveys 1:2,000,000 map of British Columbia.
BRITISH COLUMBIA
ALBERTA
CANADA
UNITED STATES
WASHINGTON
MONTANA
IDAHO
OREGON
WYOMING
CALIFORNIA
NEVADA
UTAH
PACIFIC
OCEAN

MID - COAST
DRAINAGE BASIN
MILES
0 1 2 3 4 5
N
To WALDPORT
ALSEA
RIVER
Canal
Cr
Scott
Williamson
Cr
Yachats
River
Indian
Cr
Crab
Grass
Fisher
Five
Rivers
R
Paris
Panther
Cr
Lobster
Cr
Swamp
Cr
Triangle
Lake
DENZER
Lobster
Five
Rivers
R
ALSEA
RIVER
Mill
Cr
South
Fork
Bummer
Cr

UMATILLA
DRAINAGE BASIN
MILES
1 0 1 2 3 4 5
JUNIPER CANYON
Strawberry
Canyon
IONE
Willow
Jordan
Cr
Rhea
Cr
Sand
Hollow
Butter
Cr
Cloth
Canyon
Willow
HEPPNER
Hinton
Cr
Eightmile
Canyon
Rhea
Cr
Balm
Fork
Willow
Cr
Rhea
Spring
Hollow
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Rhea
Cr
N

Questions

1. Describe a watershed in your own words.

   Answers will vary, but should approximate all the land area that drains into a particular body of water.

2. If you lived two miles south of the town of Fisher, in which watershed (or sheds) would you live?

   You would actually live in the Crab Creek watershed which is part of the larger Five Rivers watershed. Remind students that a large watershed is made up of many smaller watersheds, and that both Crab Creek or Five Rivers would be correct answers to the question.

3. If you lived in Paris, in which watershed would you live?

   Five Rivers

4. Using the mid-coast drainage basin map as a guide, explain in your own words why the following statement is true. "Everyone lives in a watershed."

   All land has waterways running through it that drain into larger waterways. This is also true in urban areas where rainwater feeds into storm drains. The drains then feed into nearby streams or rivers.

5. The watersheds on these two maps are similar in size. Compare the two watersheds. What other similarities and differences did you note when outlining the watershed boundaries?

   Each watershed is composed of several smaller watersheds. The Willow Creek watershed has more sub-basins than Five Rivers. The shape of the watersheds depends on the drainage patterns of the streams. It is much harder to outline the watersheds with intermittent streams than it is to outline streams that have year-round water.

6. In which watershed (or sheds) is the community of Jordan found?

   Jordan is located at the mouth of the Rhea Creek watershed which is part of the Willow Creek watershed.

7. If a stream does not have a name on the map does that mean it is not a watershed? Explain your answer.

   No, stream names are only a convenient way to designate different sub-basins within a watershed. Any land areas through which water drains to a larger body of water is a watershed.

8. An **intermittent stream** is a stream that does not flow year-round. These streams are shown on maps as lines separated by dots. List as many reasons as you can why streams do not flow year-round.

   Lack of rainfall, lack of snowmelt, removal of vegetation that holds back moisture (reducing rapid runoff), the topography (flat or steep), the soil type, etc.

9. How would fish be affected by intermittent flow?

   Fish would be forced downstream to where the stream was flowing or would be stranded in small pools where they would eventually die as the stream dried up.

10. How would wildlife living near the stream be affected by intermittent flow?

    Food, cover and drinking water would be absent from the area, forcing wildlife to go elsewhere.

11. Based on the colored lines on your own watershed map, which of the two, human-caused or non-human influences, would have the greatest effect on your watershed? Why?

    Human-caused effects would have the most influence because they are normally carried further throughout the watershed than natural events. Natural events are usually more localized.

12. How many miles of streams and rivers are found on your watershed map? How many miles of stream were affected by the human-caused events in Step 9? How many miles of stream were affected by non-human events in Step 9?

    Answers will vary.

13. What have you learned about your watershed, an ecological address, and a sense of place in this activity?

    Answers will vary.

Going Further

1. Using a topographic map as a reference, build a model of your local drainage basin. (See "What a Relief" activity in this unit.) Design a way to use this or other models of your local watershed to show someone the key features (rock types, soils, rainfall amounts, slope, and other characteristics) of your watershed.
2. Design an experiment to monitor the daily weather patterns in your watershed for several weeks or even months. Develop graphs, displays, and a presentation to share the results of your investigation.
3. Add five structures or features (dams, irrigation canals, industry, vegetation, etc.—it is even better if these are real) that would affect the flow of water on your watershed map. Develop hypotheses about how each of these structures will affect your watershed. How could you test your hypotheses?
4. Build a list of who and what uses your watershed—from people to fish to wildlife. Research the effects each has on the watershed.

Name

A sense of place: your ecological address

Do you know ...

Water runs downhill. We all know that. The instant that a drop of rain hits the earth, it begins its journey to the ocean. If it falls as snow, it has to wait until it melts! Of course, not all water drops make it to the ocean. Some are taken up by plant roots and are transpired into the air through the plant's leaves. Some evaporate in puddles or other areas that hold water. Some filter down into underground areas, moving slowly downhill. But most water drops end up as runoff, the water that finds its way into creeks, streams, and rivers.

Vocabulary

divide
intermittent stream
sub-basin
watershed

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Columbia River Basin

Based on: Ed Chaney, *A Question of Balance: Water/Energy—Salmon and Steelhead Production in the Upper Columbia River Basin, Summary Report*, Nov. 1978. NW Resource Information Center, Inc.

This activity is an adaptation of the original *Stream Scene* activity "Does The Earth Wear A Raincoat" and "Finding Your Ecological Address" from *The Fish Hatchery Next Door* by Bill Hastie, et al., Oregon Department of Fish and Wildlife, 1996. The material was also published in "Ecological Address: At Home In Your Watershed," National Science and Technology Week, 1992-93 Packet, National Science Foundation, Washington, D.C.

Student sheet

Snake, John Day, Deschutes, Umatilla, and Willamette watersheds plus many others.

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Student sheet

Student sheet

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Questions

1. Describe a watershed in your own words.

2. If you lived two miles south of the town of Fisher, in which watershed (or sheds) would you live?

3. If you lived in Paris, in which watershed would you live?

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13. What have you learned about your watershed, an ecological address, and a sense of place in this activity?

1.1 Introduction to Watershed Ecology

A watershed is an area of land that collects, stores, and drains water (both surface and subsurface water), sediment and dissolved materials to a common receiving body or outlet, like lakes and streams. Watersheds are separated by mountain ridge lines. The watershed's natural processes - rainfall runoff, groundwater recharge, sediment transport, plant succession, and many others - provide beneficial services that are crucial to the health of the planet. It is important for people to understand how watersheds work before they make decisions that may affect important watershed characteristics.

From an aerial view, drainage patterns in watersheds resemble a network similar to the branching patterns of a tree. The point where a stream originates is called the headwaters. These small streams are only a few feet wide with a fairly steep gradient, or vertical drop. Water cascades over logs and boulders, forming deep step pools. Downstream, many stream tributaries, similar to twigs and small branches, flow together to form larger streams, like the main branches of the tree. These streams have a wider, deeper channel, with a defined flood plain. Larger streams eventually empty into the mainstem river, comparable to the tree trunk, where the river flows in a wide, meandering fashion, through a flat flood plain and a broad valley. Stream ordering is a way to cassify streams by size. The smallest streams that have year round water and no tributaries (headwaters) are first order streams. When two first order streams come together, they form a second order stream. Further along, a second order stream may join another second order stream to form a third order stream, and so on.

Watersheds vary from the largest river basins to just acres or less in size. For example, large watersheds, like the Columbia River watershed, are made up many smaller watersheds consisting of all the tributaries to the Columbia. To better classify watersheds they are commonly divided into size categories called fields. The largest classification of this kind is termed a 1st field watershed (also called a Region). As part of the ranking system, 1st fields break down into smaller 2nd fields (Sub-Regions) which then can be broken into 3rd fields (Basins) and then 4th fields (Sub-Basins). As a general rule, each 4th field is subdivided into roughly 5 to 15 new units called 5th fields (Watersheds). A typical size for this watershed drainage area is from 40,000 to 250,000 acres. The typical size of a 6th fields unit (Sub-watershed), a subdivision of a watershed, is 10,000 to 40,000 acres.

Stream, Riparian, and Upland Zones

The three major zones in a watershed are Stream, Riparian, and Upland. The three zones are distinct and also interdependent. The Riparian zone is the transition zone between stream and upland.

I------Stream------I I----------Riparian----------I I-----Upland-I

image source: http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/idpmcarwproj16.pdf

Middle Fork Watershed Stewards

The Stream Zone

A stream is more than meets the eye. Its bottom extends down beneath the ground, and its sides stretch out into its floodplains. It is dynamic, constantly changing its course, water levels, and temperatures. It contains a multitude of different habitats for plants and animals. It is a source of food for animals as well as people. It carries glacial silt and sediment down from the mountains, creating rich agricultural lands by depositing them on its floodplain and fertilizing the ocean.

When water rolls down the slopes of a watershed, it carries things with it. Beginning with small matter like tiny bits of leaves and bacteria, as it flows and grows it carries larger and larger matter. By the time the water gets all the way down to the river, it is full of whatever was a part of the land around it. The river can carry sticks, leaves, logs, brush, and even sand, pebbles, rocks, and boulders. Rivers are also closely tied with the atmosphere. Gases from the air, like oxygen, carbon dioxide, and nitrogen dissolve into the water. The colder the water is, or the more it churns as it flows downhill, the more gases there will be in it.

Characteristics of a Healthy Stream

*High water quality (eg. water temp, dissolved oxygen, and pH)
*Connection to a floodplain
*Trees, shrubs and grasses on the floodplain
*A variety of features such as riffles, runs, and pools
*A variety of insects and fish as well as salamanders and frogs
*Minimal algae growth, minimal stream bank erosion, minimal sediments
*Room to adjust to changing landscape or climate conditions
*Room to flood

Stream Habitat

Each stream contains many different habitats and microhabitats, utilized by everything from tiny diatoms to large mammals. A single species may require several different habitats to carry out its life functions, and each habitat is inhabited by its own species that cannot live elsewhere. The casual visitor would not see more than water and rocks, yet the stream is filled with unseen creatures. Some general stream habitat examples are rocks and large woody debris.

Rocks provide several different microhabitats. Animals cling to the side that faces upriver. The side that faces downriver provides a certain degree of shelter from current, while still allowing an animal to hunt for food. The top of a rock, if it is contacting air in some places, will be a good place for animals that can't breathe underwater and need to surface now and then. The underside of a rock makes an effective hiding place for prey.

Large woody debris, such as fallen logs and branches, provide a place for some animals to burrow into and surfaces for others to attach themselves. Streams clogged with natural debris form countless small pools, waterfalls, and other features that provide habitat and hiding places for young fish.They also create areas where small detritus, such as leaf litter, can pile up underwater, providing shelter for many creatures. Other habitats include debris, leaf litter, and algae floating downstream; animals cling to them or burrow into them, as well as eat them.

A cross section of a stream can be divided into four habitat classifications, Surface, Water Column, Benthic Zone, and Hyphoreic Zone. Each section provides unique services and habitats.

Surface: The surface is where the stream breathes, exchanging gases with the atmosphere, including nitrogen, oxygen, carbon dioxide, and carbon monoxide. The surface of a stream is home to algae, frogs, ducks, otters, muskrats, turtles, beavers, skaters, and whirligig beetles. Insects come to the stream's surface to drink or reproduce, or fall in from overhanging branches, and may be caught by fish coming to the surface to grab quick breaths of air or a snack. While they are there, the fish may be preyed upon by eagles and osprey.

Water column: Insects and mammals found in the water-column are often on their way between the surface and the bottom (benthos). Terrestrial bugs and organic material (detritus) microscopic rotifers, protozoa, and bacteria may often be found drifting downstream in the water-column. The stems, leaves, and roots found in the water column are habitats for microscopic organisms and algae (making a fuzzy coating called aufwuchs), snails, flatworms, and insects. Schooling minnows, parr, trout, bass, and sunfish have specialized to stay in the water-column, eating algae, macro-invertebrates, and detritus, or lurking and waiting for a meal to show up on the surface. Kingfishers, otters, muskrats, turtles, and frogs dive from the surface and hunt for food in the water-column.

Middle Fork Watershed Stewards

Benthic zone: The river bed is called the benthic zone. Many creatures live here on the substrate (mud, sand, rock, and organic debris). Coating the substrate may be found diatoms, aufwuchs, and fungi. Diatoms are responsible for the yellow or brown coloring of rocks, and for the slimy feel of rocks when you first pull them out of a stream. Fungi help break down wood and leaves. Clinging to and eating from all these slimy, edible surfaces are larvae and nymphs of all sorts of insects, water mites, snails, clams, worms, leeches, and flatworms. Also spending their time in the benthic zone and feasting on these many small creatures and algae are crayfish, salamanders, and bottom fish. Large trout and catfish hide in dark places like underwater ledges, log-dams, and pools to hunt their prey. The benthic zone is a popular place for many fish to spawn, too. Salmon and trout create nests out of gravel, sculpins attach eggs to the undersides of rocks, and catfish nest in holes in the banks.

Hyporheic zone: The hyporheic zone is the rock and sand beneath the stream bottom. Many of the organisms that are found on the stream bottom may also be found beneath it. Most of them live within the top 20 inches or so. Here they remain safe from predators. Very small insect larvae and nymphs often begin their lives here, to keep from getting swept away by strong currents. As streams undulate up and down, diving into their hyporheic zones and re-emerging downstream, there is a constant supply of fresh water, oxygen, and food flowing through the hyporheic zone. The hyporheic zone also offers refuge from extreme temperature changes and drought. Female salmon built large nests of gravel and bury their fertilized eggs in the hyporheic zone, keeping them safe from predators and assuring that they will have plenty of oxygen and nutrients. Because the hyphorheic zone is such important habitat, adding extra silt to a gravelly or sandy stream has a significant impact.

Middle Fork Watershed Stewards

You can also look at stream habitats from a birds eye view, called a *longitudinal cross section.* The major habitat classifications are Cascades, Falls, Pools, Runs, and Riffles.

Cascade: When water flows over larger rocks and boulders, it becomes a cascade. Cascades are rough places to live. If you've seen one, you know that water often beats onto rocks so hard that it creates foam and spray. But there is a lot of life in cascades because of the high oxygen levels. To live in cascades, insects stick themselves to rocks. Trout and young salmon travel up and down cascades. A few birds can be found hunting for food in cascades, hopping from one boulder to the next and suddenly diving in, like the American Dipper. Bears and cougars often fish in cascades.

Falls: As harsh as the environment is in a cascade, it is even more brutal in a falls. But like the cascade, the water is highly oxygenated. Diatoms and black fly larvae are able to cling to vertical services quite well. During spawning season, trouts and salmons leap up and over falls to get upstream. Sometimes it takes many tries. And while they're trying, bears, cougars, lynxes, and other fishers catch them.

Pool: Pools provide darkness and slow moving of water. Their oxygen levels are often low. During droughts, pools are sometimes the only parts of a stream that stay wet. When the stream's water suddenly slows down, it drops silt and organic materials. The layer of silt and organic materials at the bottom of a pool is an environment that is friendly to plants and animals which can't tolerate higher water velocities. Aquatic earthworms, salamanders, frogs and snails are often found in pools. Large fish, such as adult trouts, salmons, and catfishes hide from their prey in the dark depths, under pieces of wood and ledges.

Middle Fork Watershed Stewards

Run: Most of the big fish that we associate with streams and rivers can be found in runs, including sturgeons, bass, sunfish, salmon, catfish, and trout. They prey on aquatic invertebrates and smaller fish. Bald eagles usually fish for salmon from runs, and kingfishers dive from trees into runs to catch fish. Raccoons often find crayfish, frogs, and other prey at the edges of runs.

Riffle: Riffles are a rich part of any stream. Because the water is not deep, there is plenty of sunshine, encouraging a rich growth of diatoms on rocks and organic debris. Oxygen levels are high. Large, predatory fishes are too big to travel across them. Current velocities are lower than in cascades and runs. Raccoons, with their nimble feet and "hands," sharp intelligence, and quick eyes, are very good at finding their meals in riffles.

Oregon Chub: A local habitat restoration success

The Oregon Chub has recently been removed from the Endangered Species List, thanks in part to restoration efforts throughout the Middle Fork Willamette Watershed

The Riparian Zone

A riparian zone is the interface between land and stream. It connects the upland zone (the area of the watershed that does not receive regular flooding by a stream) to the aquatic zone (the area of the stream channel covered by water), controlling the flow of water, sediment, nutrients, and organisms between the two. "Riparian" is derived from the Latin word ripa, meaning river bank.

Characteristics of a Healthy Riparian System:

*Vegetation & roots present to protect & stabilize banks
*Sediment filtering
*Water storage and release
*Aquifer recharge
*High water table & increased storage capacity
*High forage production
*Good shade-Cool water
*Diverse fish and wildlife habitat
*Higher late summer stream flows

Riparian vegetation and root systems, combined with the meandering curves of a river, dissipate stream energy and trap sediment. The decreased rate of flow decreases soil erosion and flood damage. When sediment is trapped it decreases the turbidity of the water, replenishes soils, and builds up the stream banks. In the Pacific Northwest, riparian corridors tend to include willows and alder. Both of them like to have wet roots. Alder provides nitrogen fixation, taking nitrogen gas out of the air and make it into biologically useful nitrogen in the soil. This makes the soil near streams and on floodplains more fertile.

The riparian zone acts as a natural sponge, soaking up water as it runs off the land, and slowly releasing that water back into the stream. The riparian zone can improve the water quality of the stream by filtering out nutrients and surface runoff pollution that would otherwise enter the stream. Riparian zones assist in providing the correct stream acidity and assist in recharging aquifers.

Streams flowing through healthy riparian zones are superior habitat for fish because (1) the riparian trees provide shade and buffer temperatures, (2) inputs of woody debris creates fish habitat, (3) inputs of organic matter via leaf fall provides food sources for invertebrates and fish, and (4) invertebrates that fall into the stream from the surrounding riparian vegetation provides food for other organisms.

Healthy riparian zones also provide excellent wildlife habitat, due to the availability of water, high plant productivity (amount of carbon fixed by photosynthesis) and habitat diversity. Riparian zones provide reliable sources of water for wildlife, and the greater productivity allowed by the high moisture content of the soil allows for more potential food for wildlife. In addition, the habitat diversity of riparian vegetation provides many potential niches for wildlife to fill. Riparian zones serve as wildlife corridors that give animals uninterrupted movement along river systems. The riparian zone is also home to many animals that move between land and water, such as insects, amphibians and waterfowl.

Natural Factors that Affect Riparian Zones: Water supply is the major factor that regulates the growth of riparian vegetation. Flood waters transport nutrients, sediment and new seeds from upstream. Floods also strip away larger, established vegetation and allow new seedlings to establish. Soil type in the riparian zone influences the amount of water and nutrients available. Organic-rich soil holds water and provides abundant nutrients to plants, without releasing these nutrients to the water. Gravely soil with little water-holding capacity and few nutrients will have less dense vegetation. Topography, or the shape of the land, affects the location and abundance of plants in the riparian zone. Climate affects the appearances of riparian zones. In the desert, riparian zones are like a green oasis in sparse, dry surroundings. Where precipitation is more abundant, like in the mountains, the upland vegetation, beyond the riparian zone, remains relatively lush.

Riparian Hydrologic Zones: When planning riparian restoration projects, it is important to understand the unique characteristics of the different Riparian Hydrologic Zones. The zones are determined by measuring the elevation above the average water line, as well as looking at where native species are already established at the site. Plants with flexible stems and rhizomatous root systems are usually located from the water line to the top of the bank zone. Larger shrubs are found from the bank zone to the overbank zone and beyond. Tree species are usually found above the overbank zone in the transitional zone and the upland zone.

Toe Zone: The toe zone is the zone that is located below the average water elevation or the baseflow. The baseflow is that level where there is flow all summer long. Generally, this is the zone of highest stresses and the most erosion. It is also described as the scour zone because streamflow velocities are constantly scouring the banks and bed movement is at its highest. This zone is critical to successful treatment of streambank erosion. The toe zone will rarely have much vegetation in it due to frequently flowing water.

Figure1: Riparian Planting Zones can be used to determine where riparian species should be planted in relation to the waterline. This is a general depiction of a riparian zone. Not all streams look like this one. In the real world, some of these zones may be absent. (From Hoag 1999, Hoag and Landis 1999)

Bank Zone: The bank zone is the area between the average water elevation and the bankfull discharge elevation. It is less erosive than the toe zone. It will be exposed to erosive river currents, wind generated waves, wet and dry cycles, and freezing or thawing cycles. The bank zone will generally be vegetated with early seral or colonizing herbaceous species, flexible stemmed willows, and low shrub species. This zone will be inundated far less frequently than the toe zone. Soil moisture levels in this zone will be much lower after spring runoff and fall rains.

Overbank Zone: The overbank zone is located between the bankfull discharge elevation and the overbank elevation. This zone is usually formed from water transported deposits. It is generally flat and often has layered soils. It is sporadically flooded, usually about every 2-5 years. This zone is occasionally exposed to erosive water currents, ice and debris deposition and damage, freeze – thaw cycles and some wind generated wave erosion. Vegetation in the overbank zone should be flood tolerant. Normally, the vegetative composition is about 50% hydrophytic plants (able to grow in saturated soil). Shrubby willows with flexible stems, dogwoods, alder, birch, and others will predominate here.

Transitional Zone: The transitional zone is located between the overbank elevation and the flood prone elevation. The floodplain elevation is flooded about every 50 years. This zone is usually not subjected to erosive water currents except during high water events. For the most part, species in this zone are not extremely flood or inundation tolerant. This is the zone where the larger tree species are typically found.

Upland Zone: The upland zone is found above the flood prone elevation. Erosion in this zone is due to overland water flow, wind erosion, and elimination of vegetative buffers from improper farming practices, over grazing, logging, and development. Vegetation in this zone is predominantly upland species. Drought tolerance is one of the most important factors when determining what species to plant here. (Hoag, et. al., 2001)

Hoag, J. C., F. E. Berg, S. K. Wyman, and R. W. Sampson. 2001. Riparian Planting Zones in the Intermountain West. Riparian/Wetland Project Information Series No. 16. March 2001. USDA-NRCS Aberdeen Plant Materials Center. Aberdeen, Idaho. Accessed at: http://plant-materials.nrcs.usda.gov/pubs/idpmcarwproj16.pdf

The Upland Zone

What do Ponderosa pine, Poison oak, and huckleberries all have in common? They all reside in the upland zone. The upland zone encompasses all the land beyond the stream and riparian zones, and includes a diverse array of habitat types. In the Middle Fork Willamette Watershed, upland habitats include old growth conifer forests, high rocky openings and meadows, oak woodlands, and stands of ponderosa pine, aspen, and Alaska yellow cedar.

Upland habitats are home to countless plant and animal species and can be over-wintering habitat for many reptiles and amphibians who utilize riparian and aquatic habitats in the warmer months. Small natural clearings and rocky openings in upland areas provide unique habitats for uncommon or locally rare plant and animal species. The headwaters of rivers are often found in the Upland Zone.

In the Middle Fork Willamette Watershed, notable upland wildlife species present include: great gray owl, flammulated owl, northern goshawk, harlequin duck, common merganser, black-backed and three-toed woodpeckers, American marten, fisher, Pacific western big-eared bat, red tree vole, peregrine falcon, bald eagle, northern spotted owl, elk, and mountain lion. There are hundreds of plant species, with more than 75 species that are sensitive, threatened or endangered. Threatened and endangered species include northern spotted owl, gray wolf, Bradshaw's lomatium, and Willamette Valley daisy.

Jim's Creek: A Local Upland Restoration Case Study:

The West Cascades foothills once had extensive woodlands and savannas of widely-spaced large Oregon white oak, ponderosa pine and Douglas-fir trees with a grass and wildflower understory. Native Americans are thought to have maintained these habitats through the use of fire, which produced forage for big game, improved traveling conditions, and selected for important subsistence plants such as camas, tarweed, and desert-parsleys. As a result of changes in fire frequency and intensity after European settlement, Douglas-fir now dominates in many of these areas, and many of the open woodlands and savannas converted to forests. Almost 95 percent of open oak and pine habitats have been lost in this ecoregion. Currently, remnant patches of oak-pine woodlands and savannas are found on the margins of the Willamette, Umpqua, and Rogue valleys and some dry, south-facing mid-elevation slopes.

One site with a remnant oak-pine woodland and evidence of Native American use is the area around Jim's Creek, on the Willamette National Forest near Oakridge. The site's important ecological and cultural value has inspired a comprehensive planning effort to restore some of the oak-pine habitat. Once a savanna with large, scattered oak, pine, and Douglas-fir trees, the area is now dominated by a relatively dense Douglas-fir forest. Several of the large ponderosa pines have scars characteristic of bark removal. Native Americans removed the inner bark (cambium) for medicine, so these large trees are considered "medicine trees." However, the large pines are declining in health, and oaks are now restricted to the margins of small, rocky openings.

With no pine or oak regeneration occurring, the site will convert to a Douglas-fir forest if no actions are taken. The large heritage ponderosa pine trees will be lost.

In response, the Willamette National Forest began an extensive outreach effort to the communities of Oakridge and Eugene, including political leaders, Native American leaders, the timber industry, and environmental groups to discuss the issues and ask people how they thought the landscape should be managed. Ecological studies on current and historic vegetation, small mammal populations, and fish populations were initiated to determine restoration opportunities and to guide management in an adaptive management approach. These ecological studies also will provide valuable lessons that could be applied to other sites. The Jim's Creek project is a comprehensive approach to building partnerships and planning science-based restoration that will hopefully restore an important cultural and ecological landscape for future generations to enjoy. (excerpt from MFWWC 10 year action plan)

The Jim's Creek Project started in 2001, and in the end, over 60 stakeholders participated in project planning, with the Middle Fork Willamette Watershed Council acting as the primary facilitator. The project area was thinned of encroaching species such as Douglas Fir. Stand density was reduced from 80 trees per acre to 15 trees per acre. The leave priorities were first for oak and second for ponderosa pine. The timber harvest was completed in 2011. Oak trees have been planted in the project area, but natural oak regeneration has been just as successful. Pine grass has also returned post fire treatments, even in areas that it wasn't anticipated to abundantly respond, such as in an old pine planation that was burned.

Fuel reduction will make the entire area resistant to catastrophic wildfire. Reintroduction of prescribed fire was a major objective of the project. Prescribed fires, similar to the methods used by native americans, were used to improve the composition, structure, condition, and health of stands or to improve wildlife habitat. Recovered elk and game habitat will be maintained through fire intervals. Riparian zones were left untouched based on North West Forest Plan prescripts. A local contractor is currently creating snags for wildlife habitat.