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Curriculum guide to the wetlands of Teton Valley Idaho for grades five through eight

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A CURRICULUM GUIDE TO THE WETLANDS OF TETON VALLEY, IDAHO FOR GRADES FIVE THROUGH EIGHT

by

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ABSTRACT

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Over one half of the wetland acreage originally found in the United States has been lost (Dahl 1990, 6). National policies support the preservation of wetlands because they provide numerous benefits to wildlife, the environment and humans, yet they continue to be drained and filled to accommodate development and cropland expansion. Public education about wetlands is needed to help foster a greater appreciation for them and an understanding of why wetlands need protection.

This paper presents a wetland curriculum guide for Teton Valley, Idaho, an area in eastern Idaho rich in intact wetlands and with high population growth. The guide includes an overview of wetland ecology and conservation and provides activities fifth through eighth grade students can use in the classroom and at wetlands. Once in use, the guide will contribute to the knowledge of wetlands among the residents of Teton Valley and may help generate a force for their preservation.

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CHAPTER I.
INTRODUCTION

Wetlands in the United States are lost at a rate of 117,000 acres per year despite the existence of protective legislation and a federal government goal of no net loss (US Department of Interior n.d., 1). Historically undervalued, wetlands were once thought to be useless lands that harbored insects and pestilence. From 1780 to 1980 over half the wetland acreage in the United States was destroyed, either drained to create agricultural land or filled to facilitate development (Dahl 1990. 6). In the past thirty years, scientists have discovered that wetlands play an integral role in keeping our water clean, our wildlife populations stable and our homes safe from flooding. These and other recent findings have caused federal policy toward wetlands to change dramatically. But public sentiment is slower to shift, development pressure remains high and wetland numbers continue to decline.

The history of wetlands in Teton Valley, Idaho has been a different story. Situated in a high basin at the foot of the Teton mountains, the valley still has a relatively low population density and a large number of intact wetlands. But the once quiet, rural valley is changing and the rapid population growth of the last decade is putting enormous development pressure on the wetlands and riparian areas found there. The residents of the valley and their local government need to actively support the protection of wetlands or they too will be destroyed or degraded like so many wetlands in the United States. There is a growing sense that the future protection of wetlands depends on a public that fully understands the biological and functional importance of wetlands and is willing to act as responsible stewards of these rich, wet environments. There are several strategies used in the effort to preserve wetlands, including policies, incentives, acquisition and education. Education is arguable the foundation through which individuals come to realize why wetlands need protection. Wetland education programs in the public schools hold promise for helping students understand the value of wetlands to wildlife, the environment and humans. They also may contribute to an awareness of the need to protect them.

The goal of this paper is to provide middle school teachers in Teton Valley, Idaho with (1) background information on wetlands science and conservation and (2) activities for the exploration of wetlands by students. The need for a guide to the wetlands of Teton County Idaho was first established during a series of meetings between teachers and naturalists concerning how to use local wetlands and riparian areas as outdoor classrooms. Three landowners with conservation easements and wetlands on their properties wanted them made available for student use. The teachers most interested in utilizing the wetlands with their students taught fifth through eighth grades. The educational value of using the wetlands to demonstrate a variety of ecological concepts and environmental issues was clear to all. Stated teacher needs included general and specific background information on wetlands and a selection of activities covering wetland ecological concepts and issues. A few teachers anticipated having their students act as scientists to explore the little studied wetlands. Finally, there was general interest in involving the students in the monitoring of the physical and biological components of these ecosystems.

This paper begins with a review of the literature relating to the history and goals of environmental education, followed by a review of environmental education wetlands curricula. The main body of the paper, entitled A Curriculum Guide to the Wetlands of Teton Valley, Idaho, follows. It is a document that will be removed from the context of this professional paper and given to teachers in Teton Valley for use with their students. The final section is a discussion and conclusions regarding the implementation of the Guide and perceived outcomes of its application.

CHAPTER II.
LITERATURE REVIEW

Before describing the curriculum materials developed for wetland education, it is important to understand the foundations by which it was developed. Below is a description of the history, successes and goals of environmental education in general, followed by a review of resources and curricula covering wetlands specifically.

Section 1.
Environmental Education: Recent Trends and Future Directions

A. Environmental Education and Its Importance to Society

When students in grades 4-12 were asked in a nation wide survey to rate the critical issues affecting youth today, solving environmental problems was placed second, after AIDS (Roper Starch Worldwide 1994, 33). Public awareness of threats to the environment and support for environmental improvement has reached an all time high (Reilly 1990, 5-6). Though awareness is increasing so are the problems. In 1993, manufacturers in the United States released 2.8 billion tons of toxic chemicals to the environment (US EPA 1995b, 4). Two-fifths of Americans live in areas where air quality is compromised and nearly forty percent of rivers and lakes in our country do not meet minimum standards for either drinking, fishing or swimming (Browner 1995, 6). Clearly the idea that the environment is limitless and resilient, able to absorb the resource demands and waste products of our society without harming human or environmental health, is a concept of the past. Humans have the capacity to cause great harm to the environment; we also have the capacity to learn about the complexities of the natural systems on the earth and be careful, responsible stewards.

The need for an environmentally knowledgeable public has been articulated many times and for a variety of reasons. Federal and state land management agencies have long encouraged environmental education because a knowledgeable public is more supportive of their efforts to manage resources in ways that promote environmental quality (Disinger 1993, 27). As the voting public is called upon more often to contribute to decisions on vital environmental issues, a common language and understanding are imperative to the process. The increasing complexity and urgency of environmental problems necessitates widespread knowledge of environmental concepts and processes as each individual must ". . . work in defense and improvement of the environment on behalf of present and future generations of all living things . . ." (Ramsey, Hungerford and Volk 1992, 35). Each member of our society has a voice in the discussion of how we will manage the resources we share, such as air, water and public lands, as well as in the interplay of development verses protection. Environmental education can be a positive step in the process of becoming knowledgeable and responsible stewards of the earth's resources.

Since the discipline was clearly defined in 1969, it was hoped that environmental education would be the catalyst for creating a population knowledgeable about environmental problems and willing to take action, ever mindful of the delicate balance between quality of life and quality of the environment. An early definition by Stapp et. al. states,

> "*Environmental education* is aimed at producing a citizenry that is *knowledgeable* concerning the bio-physical environment and its associated problems, aware of *how* to help solve these problems, and *motivated* to work toward their solution (1969, 31)."

The Environmental Protection Agency's (EPA) recent environmental education mission statement is, "To advance and support national education efforts to develop an environmentally conscious and responsible public, and to inspire in all individuals a sense of personal responsibility for the care of the environment" (Berger 1995, 6). These two statements, though separated by a quarter century, basically define the same process of educating individuals about the ecological and functional aspects of the environment so they will understand the value of maintaining the environment in a healthful state and demonstrate environmentally responsible behavior.

How successful has environmental education been? Environmental education has played a role in increasing awareness and knowledge of environmental concerns and concepts within our society. It has reached many students, young and old, through programs associated with schools, camps, environmental organizations, museums, parks, youth groups, and governmental agencies. The breadth of such programs is evidence to the number of people that care about the environment and its well-being.

However, awareness of environmental concerns doesn't necessarily lead to knowledge about the environment. Gigliotti asserts, "We seem to have produced a citizenry that is emotionally charged but woefully lacking in basic ecological knowledge"(1990, 9). Research has reported that while awareness of the environment is high, public knowledge of environmental processes and issues is actually quite low in both high school students and adults (Gambro and Switzky 1996, 28, Arcury and Johnson 1987, 36). Environmental education still needs to reach a larger audience to increase environmental literacy rates. Although a growing number of colleges and universities require an environmental science component in their curriculum (Wilke 1995, 20), systematically targeting students in K-12 is imperative to facilitate widespread environmental knowledge.

B. Environmental Education In the K-12 Classroom

There has been much discussion among researchers and teachers concerning what to teach to encourage a greater environmental literacy and promote more responsible behavior. A closer look at the above studies shows that while knowledge levels were relatively low, the real weakness was the students' ability to apply their knowledge to understand the consequences of and potential solutions to environmental problems (Gambro and Switzky 1996, 32). According to research studies, knowledge of environmental concepts is only part of a what students need to develop responsible environmental behavior (Disinger 1993, 37). Cognitive reasoning abilities, including the application of knowledge, problem solving and the evaluation of alternatives, are equally important.

Hungerford, Peyton and Wilke (1980) developed four curriculum goals for environment education programs that encourage the knowledge and skill acquisition necessary for fostering responsible environmental behavior:

1. Ecological Foundations: focuses on the teaching of ecological concepts and processes with the goal of enabling the learner to make decisions on issues based on knowledge.
2. Conceptual awareness: focuses on how human actions impact the environment and create issues that need resolution.
3. Issue investigation and evaluation: focuses on the development of skills and knowledge needed to investigate issues and evaluate solutions.
4. Environmental action skills: focuses on the acquisition of skills necessary to help resolve environmental issues.

The sequence of teaching the four curriculum goals can be adjusted for the age of the students. Elementary students, who tend to be concrete thinkers, can focus on ecological foundations and awareness of human impacts on the environment. Middle school students, who are developing the capability for more advanced thought patterns, can begin to add the skills of investigation and evaluation to their study of ecological concepts and concept awareness. High school students are ready to learn and practice action skills, while continuing to further their understanding of the first three goals (Volk 1995, 60-62).

Another area of discussion is how to incorporate environmental education into the classroom. The two common approaches are to treat it as a single subject (inclusion) or incorporate the components of environmental education into all classes (infusion). In practice most environmental education programs in the United States are based on the infusion of teachings across subject areas, although some environmentally oriented science classes do existence (Disinger 1987, 134).

Proponents of the infusion approach argue that the multidisciplinary nature of environmental education is better served by bringing environmental teachings into a variety of class types including science, mathematics, language arts, social studies and art. Implementing a comprehensive school-wide program can be logistically complicated due to the great amount of coordination and training necessary. A single teacher or group of teachers can use the infusion approach on a smaller scale by initiating a case study of a particular resource or concept, such as a wetland or a unit on energy.

The advantages of the inclusion approach to environmental education are the comparative ease of implementing a program, assuming there is room in the curriculum, and the opportunity for materials to be studied with a logical sequence and a greater scope and depth.

Rather than relying on infusion or inclusion, a mix of strategies throughout the K-12 years appears most appropriate. The elementary grades lend themselves to an infusion approach both because the subject matter is general and a single teacher is available to provide consistency. High school students could benefit from an environmental science class to supply the depth that may be lacking with infusion and have the opportunity to follow an issue from definition to action taking.

Section 2.
Wetlands Education and Monitoring Materials

Wetland education has been viewed as an important component of wetlands preservation since the late seventies. It is hoped that as people become aware of the biological and functional importance of wetlands, they will understand the value of maintaining them in healthy states. A great deal of information exists about wetlands and freshwater environments, with much of it educationally focused. Many conservation organizations, government agencies and schools have developed programs focusing on water and wet landscapes. An overview of literature covering wetland ecology, wetland curriculum guides and monitoring information follows.

A. Wetland Ecology

The scientific study of wetlands began in earnest in the 1960's (Caduto 1990, 203). Today there is a wide variety of resources focusing on water and wet landscapes. The major resource materials include textbooks, field guides, government documents and children's books.

Textbooks There are only a handful of textbooks that focus specifically on wetlands which provide a thorough study of wet ecosystems. These resources are generally geared toward post secondary students, and include the authoritative wetland science book called *Wetlands* (Mitsch and Gosselink 1986). There are also several excellent texts directed toward younger students, such as *Wetlands* by Pamela Hickman (1993), which is full of colorful illustrations and simplified descriptions. Discussion of wetlands can also be found in books covering freshwater environments, including *Pond and Brook* by Michael Caduto (1990), and in most environmental science textbooks. They generally define, discuss the origins, delineate the different wetland types and explain the functional aspects of wetlands. Often included in these tests are an introductory discussion of the properties of water, the water cycle and basic ecological concepts. In addition, most cover the influences of human actions on wetlands and provide some discussion of the management of and future concerns for wet resources. Even though the above mentioned resources focus primarily on "classroom" science, a few provide activity ideas for the exploration of wetland environments (Caduto 1990, Hickman 1993). A historical look at wetlands in the United States can be found in *Discovering the Unknown Landscape: A History of America's Wetlands* (Ann Vileisis 1997).

Field Guides Closely related to wetlands-focused text books are the field guides. They generally introduce similar information as the textbooks but with far more emphasis on the specific species that make up the wetland ecosystems. The Audubon guide to wetlands has hundreds of pages of photographs useful for identifying birds, amphibians, plants, insects and fishes that inhabit wetlands across the nation (Niering 1997). Several publishers of guide books have a series of "beginners" guides appropriate for the child naturalist that, while not focused on wetlands specifically, cover the creatures and plants found in wetlands (Reid 1987, Leahy 1987). These are invaluable for explorations of wetlands, but it is unfortunate they are not regionally focused to simplify the identification process for younger students.

Government Resources Numerous federal and state government agencies have published documents relating to wetlands. The Environmental Protection Agency (EPA) produces an array of materials from technical and policy information to educational resources. Their Wetlands Fact Sheets include an overview of the importance of wetlands, the status of and threats to wetlands and the policies relating to the development and preservation of wetlands (US EPA 1995). Though not in-depth, they provide cross-references to other publications for more information. The EPA is also involved with educational projects, such as *Always a River*, a natural and cultural history curriculum for the Ohio River watershed (US EPA 1991). A Wetlands Information Hotline is where documents can be obtained and questions answered (1-800-832-7828).

The US Fish and Wildlife Service (FWS) provides reports on the status and future of wetlands nationwide (Tiner 1984). They wrote the official definitions of wetlands and are responsible for creating the National Wetlands Inventory, a detailed mapping of wetland locations and types for the whole nation.

Idaho Department of Fish and Game's (IDFG) Nongame and Endangered Wildlife Program has published an excellent series of pamphlets covering wildlife in Idaho. In a simple, easy to read format, they inform the reader about species and ecosystems found in Idaho including migratory and colony nesting birds, threatened and endangered species, amphibians and reptiles, birds of prey and wetlands. They are exceptional resources for the classroom because they provide color photos and are inexpensive to purchase. The IDFG Conservation Data Center, with funding from the EPA, is inventorying the plant and wildlife communities of the wetlands of Idaho and determining their condition and priority for conservation. The publications from this work provide an exceptional, though technical, look at wetlands in the state (Jankovsky-Jones 1996).

Children's Books There are a handful of children's books about wetlands. Several include a description of a child's walk through a wetland, with discussion of the plants, animals, birds and insects encountered (Amsel 1993). The authors generally reveal how special wetland ecosystems are and how important they are to preserve (Cone 1996). Even the youngest child can be exposed to the animal life in wetlands through the board book *Have You Seen My Duckling?* (Tafuri 1984).

B. Wetland Curriculum Guides

A variety of curricula resources covering wetlands and water related environments is available. These guides are generally geared toward primary and secondary students. They are composed of wetlands science information and activities to encourage hands-on learning of ecological concepts and wetlands issues. Most include extensive discussion of human impacts on wetlands and encourage the participation of students in conservation efforts. Some focus on wetlands in general, others describe a region or a specific wetland. They vary in their thoroughness and effectiveness.

There are several excellent resources among the field of wetlands curriculum guides. *WOW!: The Wonders of Wetlands* provides excellent background information, including an interesting section on the history of human use of wetlands (Kesselheim and Slattery 1995). The activities, half of which have an outdoor component, help students explore wetland ecology and issues involving their management and conservation. There are several activities that require the students to apply their knowledge of wetland science by investigating issues relating to specific wetland problems and developing workable solutions. *A World in Our Backyard: A Wetlands Education and Stewardship Program* is an exemplary curriculum guide that focuses on New England (Madison and Paly 1992). The authors clearly present wetland science and conservation information geared toward middle school students, with a discussion of how wetlands fit into the water cycle and watersheds. A large portion of the guide emphasizes how to study and protect local wetlands. *Discover Wetlands* is a curriculum guide put out by the Washington Department of Ecology, that has a broad range of activities (Lippy et al. 1995). *Wading into Wetlands*, a NatureScope publication from the National Wildlife Federation (1997), has activities for primary and secondary students that clearly describe the different types of wetlands. Most of their activities are for classroom use, appropriate for use in city schools but not as useful for areas with accessible wetlands nearby.

Project WET and Aquatic Project WILD are curriculum guides containing activities on water resources, some of which relate to wetland science and issues (Higgins, Kesselheim and Robinson 1996, Project WILD, 1993). They are both associated with the Council for Environmental Education (a nation-wide leader in environment education teacher training programs) and have relatively wide circulation as a result. Unless supplemented with further lessens in wetland science and conservation, it is unlikely the students using their activities would gain a full understanding of the ecological processes and relevant issues concerning wetlands. The background information in these two guides is relatively basic and not extensive, a definite disadvantage to both teacher and student.

C. Monitoring Information

Monitoring wetland and stream parameters over time is a useful tool for evaluating the biological health of water resources and discovering and quantifying changes. It is also an opportunity for students be involved in and contribute to the field of science. Numerous organizations have published information outlining how to monitor various parameters in streams and rivers. Wetlands have received less attention thus far, but many of the stream and river techniques can be applied to in wetland habitats.

An excellent guide to monitoring streams and rivers published by the Adopt-A-Stream Foundation is the *Streamkeeper's Field Guide* (Murdoch and Cheo 1996). It thoroughly covers monitoring procedures for physical characteristics, water quality, macroinvertebrates, fishes, wildlife and plants. Data management is discussed as are steps to solving problems that may be discovered. The guide includes an introduction to watersheds and details how stream, river and wetland health are directly related to the health of the watershed where they occur. Another good resource is the *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools* (Mitchell and Stapp 1996). The guide focuses on nine water quality tests but also includes information on toxics and macroinvertebrate sampling as well as discussion of pollution sources and computer networking of data among schools. The water quality sampling procedures are too complicated for primary students so there are recommendations on how to simplify the sampling to accommodate younger children. Several of the curriculum guides listed above also have monitoring information as part of their explorations of wetlands (Kesselheim and Slattery 1995, Madison and Paly 1992).

CHAPTER III.
A CURRICULUM GUIDE TO THE WETLANDS OF TETON VALLEY, IDAHO FOR GRADES FIVE THROUGH EIGHT

Section 1.
Introduction

A. How to Use This Guide

This guide provides an introduction to wetlands for middle school teachers and students. It includes background information on wetland science and conservation topics as well as activity ideas for classroom and field work. The guide can be used as a resource for (1) a single visit to a wetland, (2) a short unit on wetlands or (3) a long-term in-depth study of wetlands. There is a great deal of flexibility in what can be taught about wetlands, so teachers should feel free to focus on what interests their students and themselves.

The background information can be found in each of the sections of the guide. It is intended to familiarize teachers with the scientific, historic and conservation topics that make up a study of wetlands. Section 2 and 3 give an overview of the structural and functional components of wetlands respectively. Section 4 covers the benefits wetlands provide to humans, wildlife and environmental processes. Section 5 describes the history of human use of wetlands and the dramatic decline in the amount of wetland acreage nationally. Section 6 explains the policies governing wetlands and strategies for their conservation. And Section 7 explains how to initiate wetlands field studies and monitoring programs.

Activities relating to the topics listed above are located at the end of every section and are referenced within the text. Each activity was chosen to be suitable for students in fifth through eighth grades and appropriate for use in Teton Valley, Idaho. Most of the activities in Sections 2-6 are designed for indoor use, while those found in Section 7 are field studies intended for use at a wetland.

The activities are presented in a format that clearly outlines the goals and procedures for each one. The activities are identified by the section in which they are found and an activity number. The educational context of each activity is described under the subject area and skills headings. The environmental education (EE) emphasis is listed based on categories (See Chapter I, Section B) provided by Hungerford, Peyton and Wilke (1980). The objectives and methods for each activity are briefly stated and material lists are provided. There is background information covering the topics found in each activity, as well as references to sections within the text for further information. The procedure for each activity is outlined at length. In most cases, ideas for activity extensions are described and helpful resources listed. No student assessment process is included, based on the assumption that individual teachers know best how to evaluate their students.

The activities are designed to engage the interest of the students by encouraging the exchange of questions concerning the inhabitants, the functions and the issues relating to wetlands. A visit to a wetland early in the unit can encourage students to formulate their own questions about wetlands and help direct the emphasis of the study. The extensive background information can help teachers and students explore more deeply topics that interest them.

B. Why Study Wetlands?

Wetlands have not fared well since the Colonialists settled on the eastern shores of North America. From 1780 to 1980, over half of the wetlands acreage once found in the United States has been destroyed, primarily to make room for agriculture or development (Dahl 1990, 6). In the same time period, Idaho lost approximately 386,000 acres of wetlands, about fifty-six percent of the original acreage (Dahl 1990, 6). In the late seventies, scientists began to discover the biological and functional importance of wetlands to wildlife, humans and the environment. As a result, public perception of the value of wetlands is changing and governmental policy encourages the preservation of wetlands. But pressure to fill, dredge and develop wet areas remains high and wetland habitat continues to be lost at a rate of 117,000 acres per year (US Department of the Interior n.d., 1). Perhaps if more people understood the numerous ways wetlands benefit humans and wildlife, there would be a stronger voice for good stewardship of these unique resources.

Teton Valley, Idaho is an area rich in riparian and spring-fed wetlands. A full nine percent of the county is considered wetlands (US Department of Interior 1995, 6). This is a high number when compared to the national average of five percent and Idaho's average of 0.7 percent (Dahl 1990, 6). There are conservation easements on several properties in the valley which include wetlands, streams or river frontage. The owners of three of these wetland habitats want them made available to local schools for use as outdoor classrooms. Wetland education could be a valuable and timely resource for the area. Teton County is the fastest growing county in Idaho. The population growth has averaged 7% in the past seven years (Cornwall 1998, 1) and development pressures remain high. Though the wetlands with standing water are not attractive to builders, many of the uplands in the valley bottom and much of the biologically rich area adjacent to creeks and the river is being developed. Residents face many challenges as they try to balance rapid growth and economic development with the maintenance of environmental quality and the protection of wetlands.

Foundations in Ecology Wetlands and riparian areas provide a wealth of educational opportunities for students. Wetlands are areas of intense biological activity, similar in species richness to equatorial rain forests and coral reefs, and vital for the survival of many plant, animal, bird and fish species (US EPA 1995, 1). In a surprisingly small area, many ecological concepts can be readily observed and studied, such as adaptations, energy flow and food webs. Wetlands and riparian areas are integral parts of the water cycle and belong within a greater framework called the watershed. Wetlands perform a number of functions that benefit the health of the regional environment, illustrating how each piece of the natural world is part of the greater whole.

None of the three outdoor classroom sites in Teton Valley have been exhaustively studied by professional ecologists. There is great opportunity for the students to research the physical, biological and chemical components of the sites and make significant contributions to the body of knowledge about wetlands in the region.

Multidisciplinary The study of wetlands can encompass far more than just science. History can be addressed by looking at how humans have used wetlands and rivers through time, worldwide, nationally and in Teton Valley. A survey of regulations concerning water resources can help illuminate the workings of government. Social studies projects can highlight how attitudes about and knowledge of wetlands have affected government policy in the United States. Watershed and wetland mapping projects can contribute to geography and art skills (See **Mapping a Wetland**, Section 7, Activity 4), while a variety of writing projects can satisfy language arts requirements (See **A Wet Newspaper**, Section 6, Activity 1 and **A Field Guide to Wetlands of Teton Valley**, Section 7, Activity 1).

Cognitive Reasoning Abilities The study of wetlands can help students comprehend how human actions impact the environment. Students learn how to investigate different issues concerning wetlands and evaluate options for resolving problems. Through role playing activities, such as mock city council meetings, students can become aware of the various attitudes concerning wetlands management and preservation and learn how to weigh the benefits wetlands provide for us in their natural verses developed states. Understanding issues concerning local wetlands can facilitate better comprehension of environmental issues at the national and worldwide levels.

Section 2.
The Meeting of Water and Land: An Introduction to Wetland Structure

A. What are Wetlands?

Commonly called marshes, estuaries, swamps, bogs and fens, wetlands are often described as the transition zone between dry land and deep water. The US Fish and Wildlife Service (FWS) defines wetlands as "lands where saturation with water or periodic flooding during the growing season determines the nature of soil development and the types of plants and animals living there" (US Department of Interior 1993, 1). Wetlands can be found in low lying areas along streams and rivers, in depressions in grasslands, forests and meadows and along the shallow reaches of lakes, ponds, and coastal waters. Wetlands range in size from marshes that can easily fit in a backyard to bogs that stretch for mile after mile.

B. Three Characteristics of Wetlands

Wetlands have three defining characteristics: (1) wetland soils, (2) wetland plants and (3) a wet hydrology.

1. Wetland Soils

Wetland soils, referred to as hydric soils, are saturated with water for at least a portion of each year. They have lower oxygen levels than drier soils because their pore spaces are filled with water and oxygen diffuses in water four times more slowly then in air (Niering 1997, 26). The soil conditions in wetlands greatly influence the types of plants that can live there.

Wetland soils can either be organic or mineral in composition. (See **Soil Surveys,** Section 7, Activity 5). Organic soils have a high percentage of partially decayed organic matter in them. The low oxygen levels found in wetlands inhibit the action of decomposers and leads to less efficient breakdown of plant parts that fall into the water (Caduto 1990, 186). The buildup of organic matter results in a soil that is dark brown or black and is capable of holding a great deal of water. Peat is a good example of soil with high organic matter.

Mineral soils found in wetlands have proportionately less organic matter and more sand, clay and silt. Two chemical processes occur in water saturated mineral soils that create soil conditions that are specific to wetlands. Gleying produces a gray-green soil color and occurs when iron is reduced due to low oxygen levels instead of the usual rusty color when it is oxidized in the presence of oxygen (Mitsch and Gosselink 1986, 99). Mottles in the red to orange range occur in mineral soils that are alternately saturated and dried. These colored blotches result from the oxidation and reduction of different minerals found in the soil (Madison and Paly 1992, 5). Color charts are available that help determine which soil colors indicate hydric soils. Mineral soils are generally found in riparian forests and some marshes (Mitsch and Gosselink 1986, 91).

The sulfur or rotten egg smell found at some wetlands, especially around salt water, is produced when soil bacteria obtains oxygen from sulfur, a process that releases the smelly hydrogen sulfide (Madison and Paly 1992, 5).

2. ***Wetland Plants***

The presence of wetland plants is one of the more reliable and readily observable indicators of wetlands. (See **Plant Surveys**, Section 7, Activity 2). Wetland plants, often referred to as hydrophytes (water-loving), can be grass-like, forbes, shrubs or trees. All have unique adaptations to survive in soils with low oxygen levels and an often flooded environment. Some plants, referred to as obligate wetland plants, can only live in soil saturated with water. Cattails and pond lilies are common examples found throughout the country. Other plants, called facultative wetland plants, can tolerate occasional flooding such as hawthorn, cottonwoods and many species of willow. Upland plants simply cannot survive in wetland habitats because they have no way of providing oxygen to their roots. Sagebrush and juniper are upland plants found in Teton Valley that need drier sites.

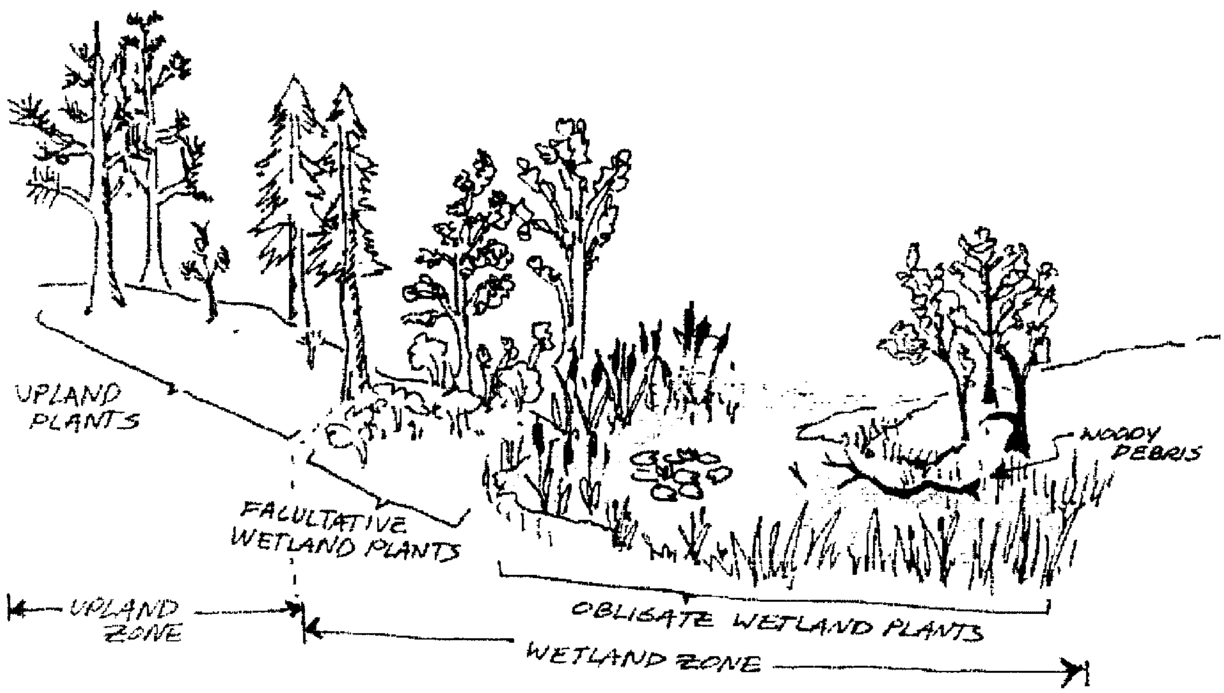


ILLUSTRATION 1. Wetland Cross Section

Plants are either herbaceous or woody in composition (See **Plant Surveys** Section 7, Activity 2). **Herbaceous plants** have soft, leafy tissue that can easily be bent in half. In wetlands, herbaceous plants are further classified by where they grow in the water. **Emergents** are rooted in the saturated soil with stems and leaves that emerge above the water's surface. Grasses, sedges, cattails and reed canary grass are local emergents. **Floating plants** have leaves and flowers that float on the surface of the water, like water lilies, duckweed and water cress. They can be rooted in the soil or be free floating. **Submergents** live underwater, with only their flowers protruding above the surface of the water. Local submergents include pond weed, water buttercup and yellow monkey flower.

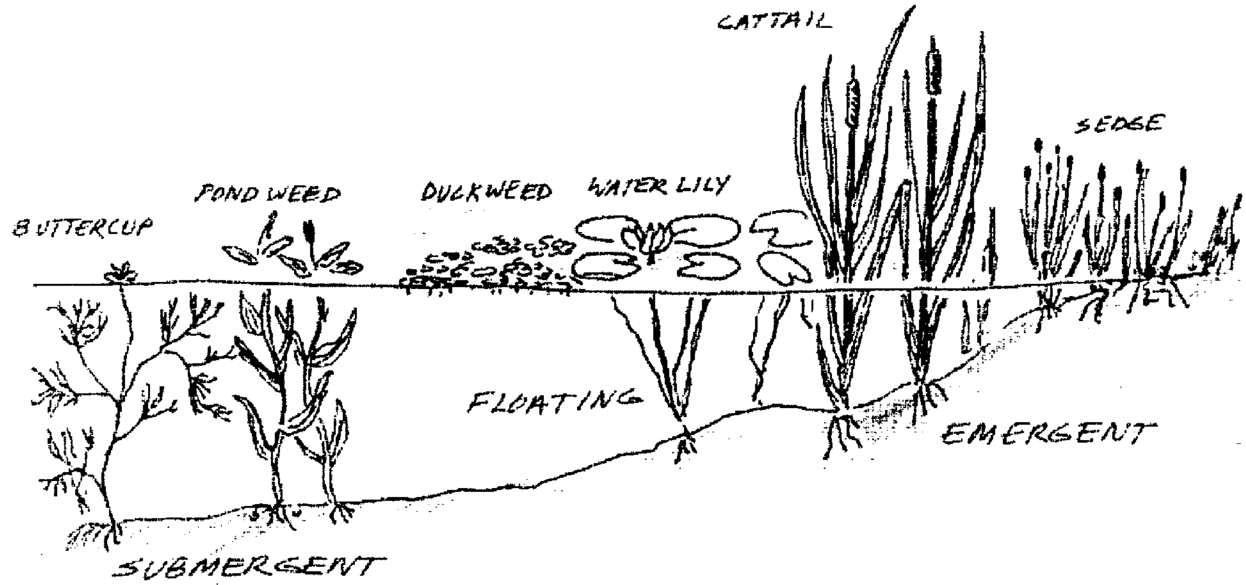


ILLUSTRATION 2. Herbaceous Wetland Plants

Woody plants have hard stems. They are either trees, characterized by a single trunk, or shrubs, with multiple trunks originating near ground level. The tree common to local wetlands is the Cottonwood; shrubs include willows, dogwood and honeysuckle.

3. Hydrology

All wetlands receive a regular source of water. The depth of water that floods the land can just cover the surface or be up to six feet deep, the point at which emergent plants can no longer be supported (Caduto 1990, 187). Sometimes the water is not visible but the soil is saturated just under the surface. Flooding can be permanent, like the wetlands associated with a spring fed pond, or periodic, such as daily inundation's with the tides. It can be based on the seasons, with flooding from spring snow melt, or irregular and occur only with serious floods. The duration of flooding needs to be regular enough to create low oxygen soil conditions and remain long enough to promote the establishment of wetland plants. The source of water in wetlands can be precipitation, springs, ground water, tidal action or floods. (See **Water Surveys,** Section 7, Activity 7).

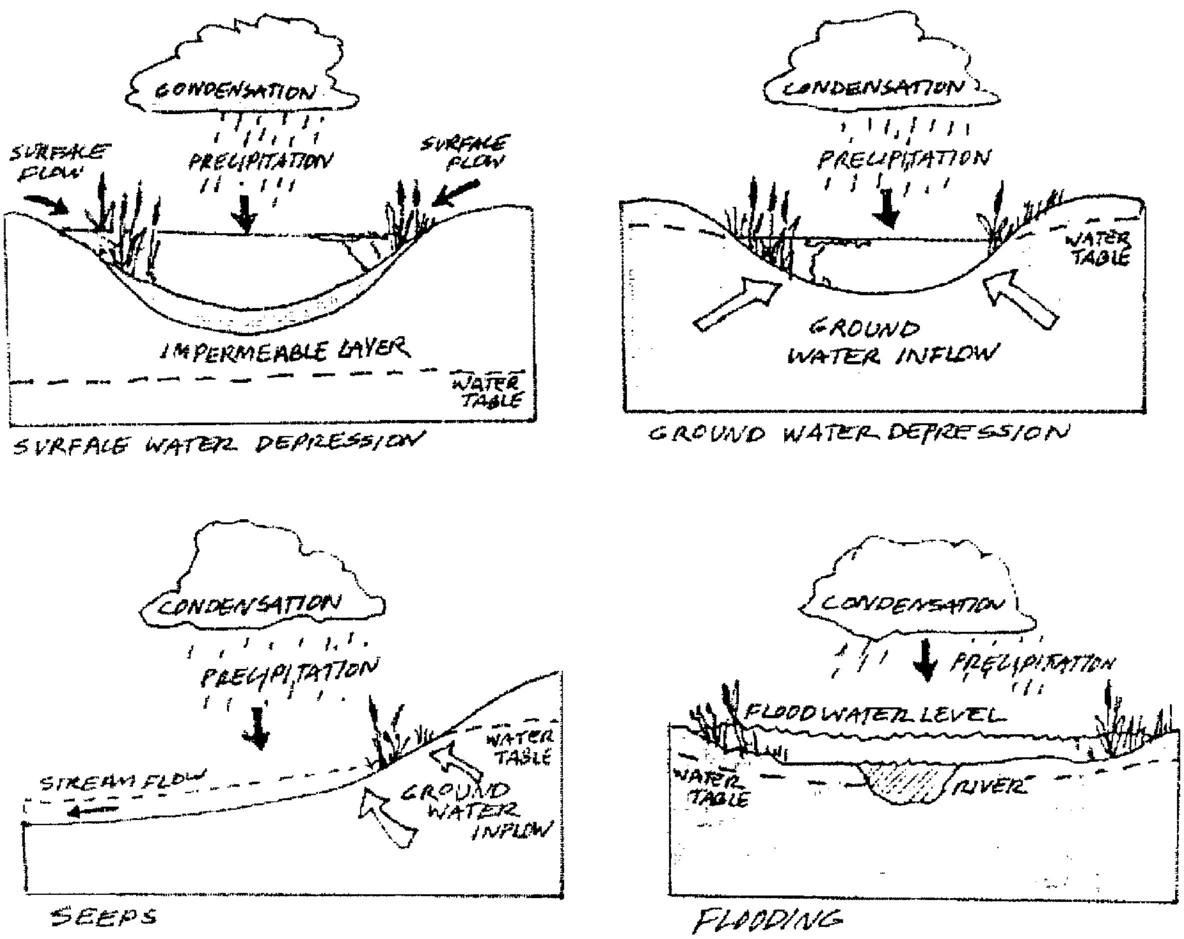


ILLUSTRATION 3. Sources of Water in Wetlands

C. Watersheds

Every person on earth lives in a watershed and those who live in Teton Valley reside in the watershed of the Teton River. A watershed is defined as a geologically contained area where all precipitation flows downhill into a common stream, river or lake. They are separated by divides, which are ridges or other relative high points where raindrops from a single cloud will flow down opposite sides of the hillside. The Teton River watershed contains the valley floor as well as the foothills and mountains surrounding the valley where rain and snow melt flow toward and ultimately into the Teton river. (See **Watershed Model of Teton Valley**, Section 2, Activity 1).

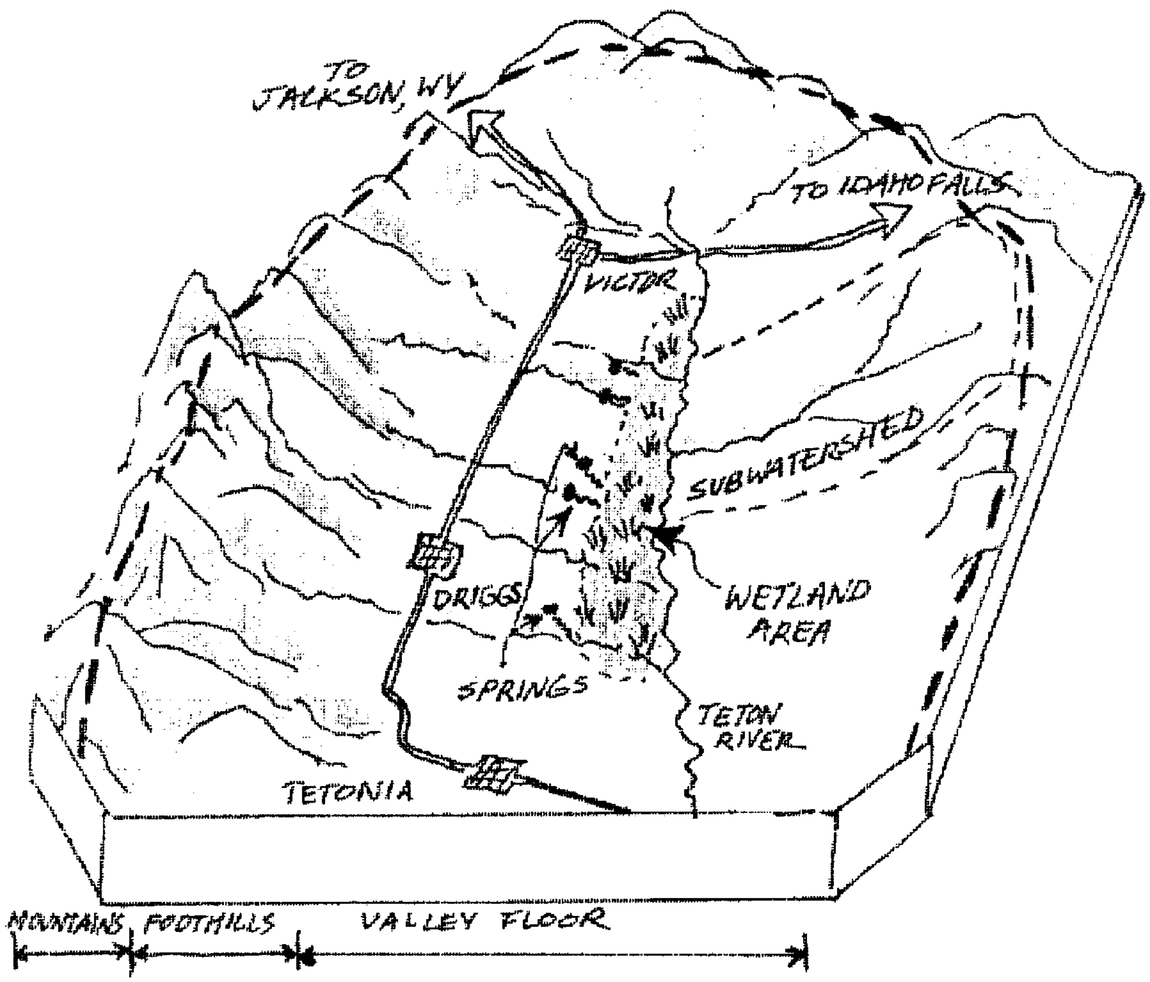


ILLUSTRATION 4. Teton Valley Watershed

The size of watersheds vary greatly. Each of the canyons opening into Teton Valley from the Teton, Palisade and Big Hole mountains create relatively small subwatersheds that drain into the Teton River watershed.

Teton Creek is the largest subwatershed encompassing 33,260 acres, followed closely by Dry Creek at 29,158 and Trail Creek at 28,397 acres (US Department of Agriculture 1992, M-4). The whole Teton River watershed, from the divide in the Tetons to the confluence with the Henry's Fork near Rexburg has an area of 1132 square miles or 724,480 acres (US EPA Website). The water in the river flows north out of the valley and joins the Snake River watershed near Rexburg, ultimately entering the Pacific ocean via the Columbia River regional watershed near Astoria, Oregon. Precipitation falling on the contiguous United States will end up in one of the nine regional watersheds that carry all the surface water of the nation to the oceans (Niering 1997, 126). Several of the regional watersheds are drained by a single river like the Mississippi, the Colorado or the Columbia, while the other watersheds encompass a region that is drained by numerous smaller rivers. (See **Mapping the Watershed**, Section 2, Activity 2).

D. Distribution of Wetlands

Approximately 6% percent of the earth's surface is covered by wetlands, an area slightly smaller than the whole United States (Mitsch and Gosselink 1986, 40). Wetlands exist on every continent and in every environment. The largest concentrations of wetlands are found in the tropical and subtropical regions of the world and in the northern latitudes. Wetlands are common in rainforests and river deltas, along coastal regions and riparian areas. Great expanses of the far north are covered with peatlands. Even the arid regions of the world contain pockets of wetlands. In the United States, the Southeast and Alaska have the largest concentration of wetlands. Nearly 30% of Florida and Louisiana and 45% of Alaska are considered wetlands (Dahl 1990, 6). Other regions with high numbers of wetlands are New England, the Upper Mid-west and the Northern Great Plains (Dahl 1990, 6).

E. Types of Wetlands

Wetlands come in a variety of types, each influenced by their unique hydrology, soil properties, topography, weather conditions and latitude. In the United States, wetlands are referred to by their common names, such as marshes, swamps and prairie potholes, as well as by the classification system used by the US Fish and Wildlife Service. Common names are useful for the layperson and students but tend to be less precise and can include regional variations. The FWS system clearly classifies all water related environments but consists of terminology challenging for students and a myriad of abbreviations. This guide emphasizes common names but will also describe the latter system because of its usefulness in communicating with wetlands scientists and reading government documents and maps.

Wetlands can be broadly divided into coastal and inland wetlands. Coastal wetlands account for about ten percent of the nations wetlands, while inland wetlands make up the remaining ninety percent (Caduto 1990, 185). Vegetation type is important in further classifying wetlands, as wetlands supporting grasses, shrubs, mosses and trees are all considered different.

The FWS classifies all wetlands, as well as standing and flowing waters, into five systems: Marine, Estuarine, Riverine, Lacustrine and Palustrine. Marine refers to all lands flooded with ocean water, like mud flats and the intertidal zone of beaches. Estuarine refers to lands flooded with a mixture of salt and freshwater, like those found in bays and at the deltas of rivers. Riverine refers to wetlands found within the channel of streams and rivers. Lacustrine refers to water in lakes (defined as a body of water at least six feet deep and 20 acres in size) and the wetlands associated with them. Palustrine refers to all other freshwater wetlands including marshes, bogs, swamps, fens, wet meadows, potholes, desert playas and those found around ponds (less than six feet deep and twenty acres in size) and adjacent to streams and rivers. Most wetlands are either estuarine or palustrine.

TABLE 1. Types of Wetlands in North America		
	Common Names	**FWS Terminology**
Coastal	Tidal Flats, Mangrove Swamps, Salt Marshes	Marine Wetlands Estuarine Wetlands
Inland	Marshes (Potholes, Playas, Wet Meadows, Marshes)	Palustrine, Lacustrine and Riverine Emergent Wetlands
	Swamp and Riparian Wetlands	Palustrine, Riverine, and Lacustrine Forested and Scrub-Shrub Wetlands
	Peatlands (Bogs and Fens)	Palustrine and Lacustrine Forested and Scrub shrub Wetlands

Coastal wetlands are found along shorelines of the oceans (marine) or in bays where some freshwater from rivers mixes with the salt water (estuarine). They include tidal marshes and estuaries, generally inhabited by grass-like, herbaceous plants, and swamps of mangrove shrubs. These wetlands are flooded daily by the tides or irregularly by high waves caused by storms. In each, the saline conditions limit the plant and animal species to those able to cope with the high salt levels.

Inland wetlands are even more variable in type. These wetlands are found in areas flooded by fresh water on a regular basis and underlain by poorly drained soils so the water remains at the surface and doesn't readily soak in. They are often found along rivers and streams and in association with springs. Wetlands can form bathtub-like rings around lakes and ponds or exist in a portion of the shallows. Rainwater and snow melt provide the water source for wetlands found in depressions and low areas, such as bogs, potholes and desert playas, and not associated with flowing water as above.

Inland wetlands can generally be broken down into the three following categories: (1) Marshes, where herbaceous plants predominate, (2) Swamps and Riparian Wetlands, where trees and shrubs abound, and (3) Peatlands, where the accumulation of peat is characteristic. Within these categories, there are further classifications necessary to describe the full range of wetland types.

1. Freshwater Marshes

Found in every state, freshwater marshes are the second most common type of wetland. Called Palustrine Emergent Wetlands by the FWS, marshes are characterized by herbaceous plant life and a noisy cacophony of frogs, birds and insects. The plants can be emergent like grasses and cattails, floating like water lilies, submergent like duckweed or some combination of the three. Mixed in with the grasses, sedges and rushes common in marshes are a variety of forbes, which are herbaceous plants that have recognizable leaves and flowers and do not resemble grasses in form. If shrubs or trees are found, they are not dominant species. Marshes can have standing water all year or just during the wet season. Even when there is no water evident, the soil in marshes often remains saturated.

The largest and most famous marsh in the United States is the freshwater portion of the Everglades in Florida. A hundred miles long and fifty miles wide, it includes thousands of acres of saw grass, technically a sedge with sharp "teeth" that grab at the clothing and scratch the skin of intrepid explorers. It is home to alligators, turtles, snakes and many, many species of water-loving birds.

Prairie potholes are marshes found in the Dakotas, Minnesota and the central provinces of Canada. The extensive network of marshes, ponds and small lakes have formed in depressions carved out by glaciers. Though some of the deeper potholes retain water year round, most are filled with water only during the wet season. The potholes are famous as a "duck factory"; fifty percent of North America's waterfowl nest and raise their young in the 300,000 square mile area (Niering 1997, 52). When the number of waterfowl substantially decreased early this century, efforts were made to preserve some of the most productive potholes to help stabilize duck numbers. But to date, over half of the original potholes have been filled or drained, primarily to create more land for agriculture (Williams, Vincentz and Firehock 1996, 22-3)

Playas are temporary lakes that form in closed basins in the arid west and generally support a wetland community. They often contain high concentrations of salts, leached from the soil by the rain and snow melt that are their primary water sources. The water level in playas is directly related to precipitation and can fluctuate substantially during the year. The marshes can support large amounts of emergent vegetation and provide important habitat for waterfowl. Sometimes referred to as alkali marshes, they are common in Idaho, Utah, Oregon, Nevada and California (Niering 1997, 46).

Wet meadows represent the dry end of the marsh spectrum and, at first glance, may look like meadows of grasses and sedges. They quickly reveal their wetland nature by soaking the shoe of the intruder with their saturated soils. Wet meadows are often found in the flood plains along rivers and streams.

2. ***Swamps and Riparian Wetlands***

Swamps and riparian wetlands are characterized by a predominance of woody plants, either trees or shrubs. Together they are the most common type of wetland in the nation. Swamps can be thought of as wetlands in forests or shrublands, generally found in association with lakes and ponds, and less often in isolated low areas. Riparian wetlands occur along river and stream corridors. Flooding in both is generally related to the wet season but some swamps and riparian wetlands have permanent or nearly permanent standing water. They are present throughout the United States, with high concentrations in the South, the Upper Mid-west and

Alaska. The FWS uses the terms wooded wetlands and scrub-shrub wetlands to describe swamps and riparian wetlands dominated by trees and shrubs respectively.

Examples of swamps and forested riparian wetlands are numerous. Big Cypress Swamp in Florida is one of North Americas largest wetlands, encompassing 2,000 square miles (Niering 1991, 105). The Mississippi river has expansive forested riparian wetlands in its lower reaches called bottomland hardwoods, which provide important winter habitat for millions of ducks (Tiner 1984, 48). Most of the original forests along the Mississippi have been clearcut and drained to make room for development and agriculture, primarily soybean production. The cottonwood forests along rivers in the arid west tend to be much narrower than in the southeast but they still contain pockets of riparian wetlands. These wetlands and the adjacent riparian corridors provide very important habitat for wildlife, especially birds.

3. Peatlands

Peatlands, many complete with quivering ground and crooked trees, cover approximately one percent of the earth's surface (Niering 1991, 131). The majority of peatlands worldwide are found in northern latitudes in Europe, Siberia and North America, where they can cover huge expanses. The bulk of North America's peatlands are in Alaska and Canada, but they can be found as far south as Florida. There are concentrations of peatlands around the Great Lakes and in the Northeast. They are found in smaller numbers scattered throughout the Rocky mountains and Pacific Northwest.

Characteristics. The distinguishing characteristic of peatlands is their low rate of decomposition. Peat forms when the rate of accumulation of organic matter (leaves and other dead plant parts) exceeds the rate of decomposition by organisms or, in simpler terms, when more plant material falls into the water than can be broken down by bacteria, fungi and microorganisms, collectively called decomposers. The mass of partially broken down vegetation forms thick mats of peat, primarily made up of fragments of mosses and sedges. Environmental conditions, like low temperatures and an acidic pH, can contribute to a reduced rate of decomposition by limiting the number of decomposers and inhibiting their ability to function. Reduced decomposition leads to lower levels of nutrients available for biological activity, a common occurrence in peatlands.

Relic Species. Peatlands are often cooler environments than the areas surrounding them because they are saturated with water (since water has a high specific heat, it tends to maintain a relatively constant temperature because it takes a lot of energy to further heat or cool it) and the winter ice and frozen soils melt slowly due to the insulating qualities of peat (Niering 1991, 143). As a result they sustain plants that are more boreal in origin, regularly found several hundred miles further to the north in areas with more severe weather. The plants, called relic species, become established when the whole region was experiencing a cooler climate, perhaps as the ice was retreating after the last ice age, and were able to continue to survive because of the cooler conditions in the peatland.

Bogs and Fens. Peatlands are generally broken down into bogs and fens, each of which are further divided into over a dozen unique types based on plant life, pH, and soil conditions. Fens are more common in Greater Yellowstone Ecosystem but there is a bog in Yellowstone. The discussion below refers to generalities relating to both.

Bogs are defined as peat accumulating wetlands which obtain their water primarily from precipitation. They form in depressions that, in many regions, were scraped out by glaciers. In the northern parts of Alaska and Canada, permanently frozen soil called permafrost define the bottom of bogs. Though there are differences among bogs, most share the following characteristics: low levels of nutrients, the dominance of sphagnum moss and acidic conditions (pH of less than 4.2). There is very little inflow of nutrients to these wetlands because rain and snow, the primary water source for bogs, are not rich in minerals. Since decomposition is slow, the nutrients in dead plant tissue often become stored in the peat and are not recycled in the ecosystem. Sphagnum moss forms vast water saturated mats that fill the shallows and float on the surface of bogs. The mats can eventually extend quite a ways out from shore. The characteristic quivering ground in bogs is created when someone steps on the unstable floating mats, which jiggle as a waterbed does when disturbed. With specific environmental conditions and lots of time, mats of peat can be buried, become compressed and ultimately form coal. Sphagnum moss contributes to the acidic nature of the bog by creating ions to use in exchange for nutrients in the water (Niering 1991, 137).

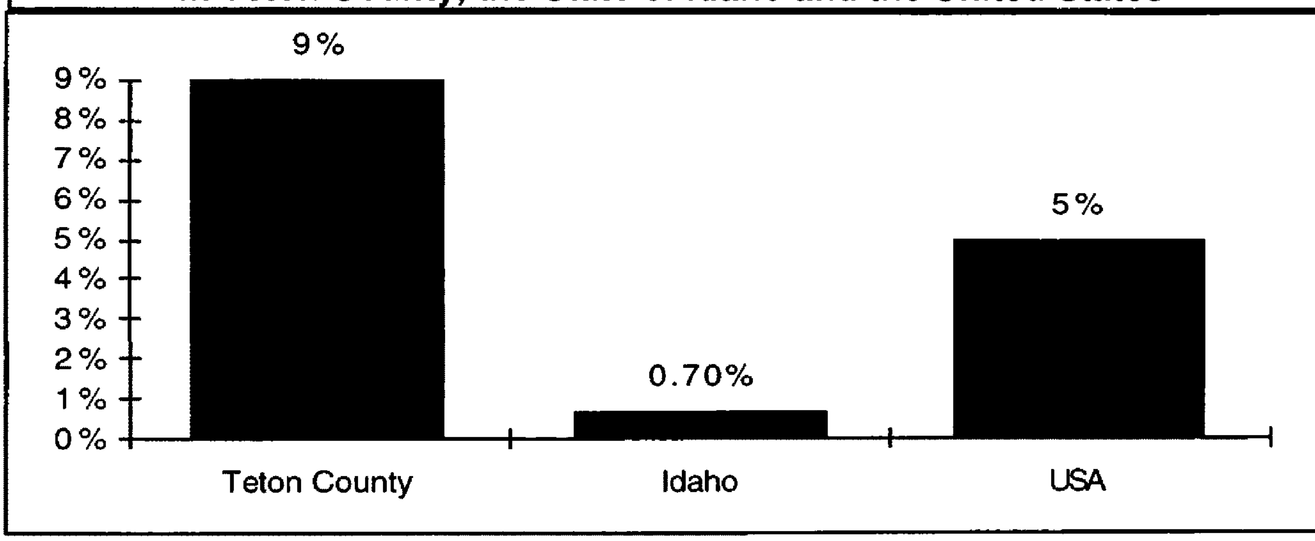
Fens also accumulate peat but are different from bogs in other ways. Fens are fed by surface water or ground water sources. Their nutrient levels are thus higher, the plant composition generally richer and their pH is more neutral. The dominant plant species in fens are sedges, which are triangular stemmed grass-like plants.

Historical Records. Both bogs and fens can provide historical insight into plant and human life. Pollen records, important for determining which plants covered the land at particular times, are preserved in the cumulative layers of peat. For example, the successional pattern of plant growth occurring in New England since the ice retreated over 15,000 years ago has been determined using pollen microfossels found in many layers of peat (Niering 1991, 152). Far more interesting to children, human bodies have been found in bogs in Europe and Florida. Since decomposition is so slow, the corpses are remarkably well preserved. A scruffy beard was evident on the face of the man found in Denmark bog with a noose around his neck, thought to be over 2000 years old (Caduto 1990, 199). Over one hundred bodies were found in a Florida bog in the mid 1980's. Scientists were able to obtain 7000 year old DNA samples from their well preserved brains (Niering 1991, 135).

F. Wetlands in Teton Valley

The wetlands in Teton Valley are relatively plentiful and definitively interesting. There are 26,757 acres of wetlands in Teton County, covering 9% of the land area (US Department of Interior 1993, 6). Teton Valley's wetlands account for 7% of all the wetlands found in Idaho, a state that has lost over 56% on its original wetlands and now averages only 0.7% cover by wetlands (Dahl 1990, 6).

TABLE 2. Amount of Land Area Considered Wetlands
In Teton County, the State of Idaho and the United States



(Based on information from US Department of Interior 1993, 6)

The properties available for use as outdoor classrooms Teton Valley provide living examples of the three major types of inland wetlands: marshes, riparian wetlands and peatlands. Each wetland ecosystem has unique hydrology, soil, functions and vegetation. Even the wildlife species show preferences for specific wetland types.

The most common type of wetland in Teton Valley is the marsh. Found primarily in the bottomlands along the river and its main tributaries, they accounting for about 80% of the total wetlands found in the county (US Department of the Interior 1993, 6). The vegetation in the marshes is emergent and consists primarily of grasses, sedges, rushes and forbes. Some marshes can be readily identified by the presence of cattails, but it is not always easy to determine the difference between marshes, wet meadows and dry grasslands as one gazes across the landscape. Familiarity with wetland plants can help tremendously but most people, even trained scientists, hesitate to definitively call a particular site a wetland without first checking for wetland soil, plants and hydrology. In general, much of the land directly adjacent to the river and creeks that is covered with grass-like plants and is found within the immediate flood plain can be considered a marsh. The further one gets from the river or creek (both linearly and in elevation gain) the more likely a grass-like area is a wet meadow or a grassland.

Teton Valley has riparian wetlands along the river and some of the larger tributaries. Shrub wetlands, a category that also includes the peatlands, account for about 11% of the total wetlands in the county (US Department of Interior 1993, 6). Some of these are considered carrs, a name given to a wetland with a predominance of willows. The willow species found regularly in the carrs of Teton Valley are Geyer's, Bebb and yellow willows (Jankovsky-Jones 1996, 12). Carrs are common throughout Teton Valley and good examples can be found along Trail Creek, just upstream from the Mike Harris Canyon trailhead, and in the lower reaches of Game Creek.

The cottonwood forests that dominate the riparian areas of several of the larger tributaries also contain pockets of wetlands. It is important to emphasize that the terms riparian areas and wetlands are not synonymous. Wetlands are often found in riparian areas but not all of the land in a riparian area is a wetland. Forested wetlands account for only 5 % of the local wetlands (US Department of Interior 1993, 6). This is a small but significant number because of the vital importance these wetlands and the adjacent forested riparian areas have to wildlife. South Leigh, Teton and Darby creeks all have cottonwood forests that stretch across the valley floor.

Though peatlands are not common in the northern Rockies geographical region, Teton Valley has many fens. They are located in the valley bottom east of the river in areas fed by year round springs . Woods Creek Fen is part of a peatland complex that covers 1952 acres of the Valley floor and accounts for about 7 % of all the wetlands in the county (Daniels et al. 1969, 7). Most of the fens in Idaho are found in the Panhandle region. There are a few fens in the Henry's Fork drainage but the plant species found in them is quite different than those found in Teton Valley. A fen located in the National Elk Refuge near Jackson, Wyoming has the greatest similarity to the Teton Valley fens in terms of plant composition (Mike Merigliano pers. comm. 1998).

The fens in Teton Valley have saturated soils or shallow standing water. Creeks, narrow but surprisingly deep, bisect the fens. They contain a mix of emergent vegetation and shrubs. Sedges, rushes, willows and shrubby cinquefoil are the dominant plant species in the fens. Small mounds called hummocks protrude a few feet out of the flooded areas and provide drier spots for low shrubs to grow, including the rare hoary willow. Taller willows take root on pockets of slightly higher ground. Mats of sedge and brown moss peat make up the soil. The fens are also home to eight boreal plant species considered rare in Idaho, but found commonly at higher latitudes. It is assumed that these species have been here since the last ice age.

G. Select Bird and Amphibian Species Found in Teton Valley Wetlands

The wetlands in Teton Valley, like wetlands almost everywhere, are filled with a rich assortment of plants, birds, mammals, amphibians, insects, fishes and micro-organisms. Each species has its own place in the ecosystem, each has an interesting biological history. There are several species that deserve special note here due to their rare status, particular uniqueness or a special way they use the wetland and riparian habitat in Teton Valley. (See **Mammal, Bird and Amphibian Surveys**, Section 7, Activity 3).

Trumpeter Swans

Once thought to be extinct, between 150 to 300 trumpeter swans grace the waters of the Teton River in the winter (Maj and Shea 1995, 17). With a wing span of nearly eight feet (Bobbins, Bruun and Zim 1983, 41) and a weight of thirty-five pounds, they are the heaviest flying bird in the world (Saxton 1995, 3). They can live 20 to 30 years and stay with the same mate for life (Raynes 1988, 4). Swans eat aquatic vegetation, invertebrates and occasionally small fish. An estimated 16,000 trumpeter swans live in North America today, most of them migrating between Alaska and the Pacific coast (US Department of the Interior 1995b, 2).

The Henry's Fork and a few surrounding areas are the winter home to about 2800 trumpeter swans that spend the summer breeding season in Canada, Wyoming, Montana or Idaho (Saxton 1995, 3). The wintering population in the area dropped to about 200 birds in the 1930's due to habitat loss, over hunting and demand for swan skins (Maj and Shea 1993, 14). Swan numbers have rebounded the past half century but memory of most of their historic migration routes to various wintering grounds has been lost. As a result, large numbers of birds descend on eastern Idaho each fall and stay until spring. Crowding at the Henry's Fork has caused some local dispersion, including the population on the Teton River. The high concentration of springs along the river help provide some open water for swans during especially cold weather in the winter making the Teton River desirable habitat for swans.

Though the increase in swan numbers is encouraging for their survival, over-reliance on a few wintering areas puts the birds at risk and can result in die-offs due to harsh weather, starvation and increased risk of disease (Maj and Shea 1993, 15). Transplanting efforts are underway to extend the winter range of the birds further south. The Teton River helps maintain the population of this majestic bird that is considered a sensitive species in Idaho.

Sandhill Cranes

Standing over three feet tall, with a wingspan over six feet, a forehead of bright red, a habit of dancing during courtship and the most prehistoric sounding of all bird calls, the greater sandhill crane is a memorable bird (Robbins, Bruun and Zim 1983, 103). They feed in and around marshes and other wetlands during the summer, eating roots, seeds, berries, mice, small birds and frogs. In the fall and winter they feed in pastures and fields, taking grains, small rodents and insects (Terres 1980, 115). The Rocky Mountain population of the crane is thought to be around 21,000 birds (Drewien and Whitfield 1993, 9). Though not considered rare in the area today, crane numbers plunged to a low of about 250 breeding pairs in the Rocky Mountain region early in the century (Drewien and Whitfield 1993, 9).

Sandhill cranes nest in Teton County in a variety of habitats. The exact number of summer residents is unknown, but it is at least 50 birds. The real importance of the valley for sandhill cranes is as a staging ground for fall migration. Between four and six thousand cranes congregate in harvested or recently planted grain fields west of the river every fall, before they continue their migration further south (Drewien and Whitfield 1993, 11). More cranes gather in Teton Valley than any other fall staging area in the state (Drewien and Whitfield 1993, 11). Occasionally one or two endangered whooping cranes can be seen among the sandhill cranes. These birds are the result of an effort to increase whooping crane numbers by having sandhill cranes at Gray's Lake National Wildlife Refuge hatch and raise whooping crane chicks. No breeding pairs of whooping cranes resulted from the project so it was discontinued.

Great Gray Owls

The great gray owl is North America's largest owl (Ehrlich, Dobkin and Wheye 1988, 294). It averages 22 inches in length, with a wingspan of five feet and has characteristic yellow eyes (Robbins, Bruun and Zim 1983, 176). A handful of pairs nest in the forested areas of Teton Valley each year using abandoned raptor nests (Whitfield and Maj 1993, 40). In the winter several of the cottonwood riparian forests in the valley are home to 30 to 40 great gray owls, the highest congregation of wintering great gray owls in the contiguous states (Michael Whitfield pers. comm. 1998). The great gray owl feeds primarily on voles and gophers and will plunge through the snow to locate rodents that it has detected by sound through the snow. It is considered a sensitive species.

Swainson's Hawk

Swainson's Hawks use Teton Valley for nesting in the summer. They arrive in May after a long migration from their wintering grounds on the grasslands of Argentina. Once the most common hawks in the west, its numbers have declined sharply due to loss of habitat for foraging and nesting and, possibly, the overuse of pesticides on their wintering grounds in Argentina (Whitfield and Maj 1993, 28). Their diet consists of rabbits, lizards, snakes, young birds and amphibians. They are generally found hunting for food over agricultural fields and meadows (Whitfield and Maj 1993, 29), including the wetlands in the valley bottom.

Long-billed Curlew

The largest shorebird in North America, the long-billed curlew nests in the wetlands of Teton Valley after spending the winter on beaches and mudflats as far south as Central America (Ehrlich, Dobkin and Wheye 1988, 124). Their diet consists of insects, crustaceans, worms, amphibians and even the eggs and nestlings of other bird species (Ehrlich, Dobkin and Wheye 1988, 124). Long-billed curlews nest in broad valley bottoms, in or near wetlands. There is concern for the species because their breeding habitat, found throughout the western United States, is declining.

Amphibians and Reptiles

A handful of amphibian and reptile species inhabit Teton Valley. Of the thirty-seven species of amphibians and reptiles found in Idaho (Groves 1994, 2), nine species have been found in the area and two more species of snakes are suspected to live in lower elevations of the valley (Debra Patla pers. comm. 1996). There is great concern for amphibians because their numbers have dropped drastically in many areas of the globe. Western toad numbers were so high in Yellowstone in the 1950's that certain roadways in the park became slippery from their squished bodies (Roberts 1997, 12). Now their population is declining rapidly. Leopard frogs are no longer found in Yellowstone and Grand Teton Parks (Roberts 1997, 12). Habitat destruction has certainly contributed to the decline of amphibians both worldwide and locally, but other factors are suspected also. Increased UV radiation may be harming amphibian eggs, introduction of non-native fish species has played a role in their decline and diseases may be harming their populations (Roberts 1997, 13).

TABLE 3. Teton Valley Amphibians and Reptiles

	Amphibians	
Tiger Salamander	Ambystoma tigrinum	Widespread, wet areas
Western Toad (Boreal)	Bufo boreas	Widespread, wet and dry
Western Chorus Frog	Pseudacris triseriata	Widespread, vociferous
Spotted Frog	Rana pretiosa	Widespread, wet areas
Northern Leopard Frog	Rana pipiens	May be extinct in area
	Reptiles	
Rubber Boa	Charina bottae	Secretive, wet areas
Gopher or Bull Snake	Pituophis catenifer	Rare in area
Western Terrestrial Garter Snake	Thamnophis elegans	Widespread, wet and dry areas
Common Garter Snake	Thamnophis sirtalis	Declining, wet areas
Western Rattlesnake	Crotalus viridis	May be in lower elev.
Racer	Coluber constrictor	May be in lower elev.

(Groves 1994, Koch and Peterson 1995)

Section 2. Activity 1.

Watershed Model of Teton Valley

Adapted from *Discover Wetlands* (Lippy at al. 1995)

Subject Area: Earth Science, Environmental Science

Skills: Observation, conceptualizing

EE Emphasis: Ecological foundations, conceptual awareness

Setting: Indoors

Vocabulary: Watershed, tributaries, non-point source pollution

Objectives Students will understand how water in a watershed moves over, around and through different topographic features such as divides, canyons, lakes, wetlands and rivers.

Methods Creation of a model of the Teton Valley watershed for observation.

Materials

- Piece of plywood (minimum size 8" x 12", as large as 3' x 4')
- Sand, dirt, rocks, newspaper
- Plastic garbage bag
- Spray bottle with water
- Colored fruit drink crystals to represent pollution

Background Information A watershed is not always an easy concept for students to understand. The use of a model with real running water can help students visualize how water moves over the surface of the earth. It should be noted that this model does not include a groundwater component.

Watersheds are discussed in Section 2, C.

Procedure

1. Watershed models can be made using a piece of plywood set on an incline with a combination of sand, soil, rocks, and newspaper placed on it in such a way to mirror the general topography of the area. A plastic bags is placed over the "topographic features" and water is sprayed on the upper end of the plastic to represent rain. The water runs down the plastic in much the same way as water moves across the land. The size of the model depends upon available materials and space. The water from a smaller one can drain into a baking dish, while a towel placed at the bottom of a larger board will collect the excess water.

To create Teton Valley and the surrounding mountains, place crumpled up newspaper on three sides of the board, leaving some gaps to represent the canyons found in the mountain ranges. Fill the middle with a layer of sand and make a linear depression in the sand to represent the river and smaller depressions for the main tributaries.

2. Spray water on the upper end of the model and over the mountains. When the water starts to flow through the model, point out the way it runs down different sides of **divides**, into the **canyons**, along **streambeds**, into the **valley bottom**, where it may enter **wetlands**, before draining into the **river** and out of the valley. The watershed includes all the area that drains into the valley.

3. Discuss where humans live in the watershed and how their actions may effect the water quality in the watershed. Put colored drink crystals in the upper end of the watershed and spray more water onto the plastic. Watch how the pollution is carried throughout the system. Identify sources of pollution in the Teton Valley- oil and gas from vehicles, pesticides and fertilizers, septic system leaks, animal waste, soaps and sediment from disturbed lands. Explain that the quality of water in a stream or river is directly related to what happens on the surrounding land. Whatever is put into the water at the head of a watershed will probably remain in the river on its entire journey to the ocean.

Extensions More detailed watershed models can be made using topographic maps and layers of cardboard, where each layer represents a specific contour interval.

Resources The INEEL has produced a watershed map of the Teton River with shaded relief that clearly shows the mountains, canyons and drainage routes.

Section 2. Activity 2.

Mapping the Watershed

Adapted from *Discover Wetlands* (Lippy at al. 1995)

Subject Area: Geography, History,

Skills: Mapping, investigation

EE Emphasis: Ecological foundations

Setting: Inside

Vocabulary: Topographic map

Objectives Through the creation of a map of the entire watershed, the students will understand how water moves through watersheds and be able to point out wetlands, areas of high value to wildlife and historical sites.

Methods Students use maps of Idaho, Oregon, Washington, and British Columbia to locate major watersheds, wetlands and points of interest in the Columbia River regional watershed.

Materials

- Maps
- Atlases
- Colored Pencils
- Guide books to wildlife viewing sites and historical sites

Background Information The Teton River is part of the Columbia River regional watershed, which includes land in the four northwestern states and British Columbia. Over ten major rivers drain into the Columbia River. As in most areas of the nation, humans have transformed the river corridors and wetlands of the watershed to accommodate settlement, agriculture and industry. There are numerous dams along the rivers.

Procedure

1. Explain that the Teton River watershed is part of the Snake River watershed and the Columbia River regional watershed, one of the nine regional watersheds the drain the waters of the United States.

2. Have each group research a particular river and its watershed, using state maps, the internet, history and wildlife guides and topographic maps. Emphasis can be on rivers that flow through Idaho or on all the major tributaries to the Columbia. Explain map features that may denote wetlands and areas with recreational, wildlife or historical value, such as the symbols for marshes, boat ramps, parks and refuges.

Snake River (ID)	Salmon River (ID)	Clearwater (ID)
Clark Fork (MT, ID)	Owyhee (ID, OR)	Columbia (WA, BC)
Okanogon (WA, BC)	Kootnenay (BC, WA)	Dechutes (OR)
Willamette (OR)		

3. Enlarge a map on the overhead to make large scale maps for the students to work with and a master map of the whole watershed on which all groups will contribute information. Have the students plot wetlands, recreational sites relating to water, historical sites and places with high value to wildlife. When finished with group research, have students report their findings to the class. Each student can make a watershed map of their own as well.

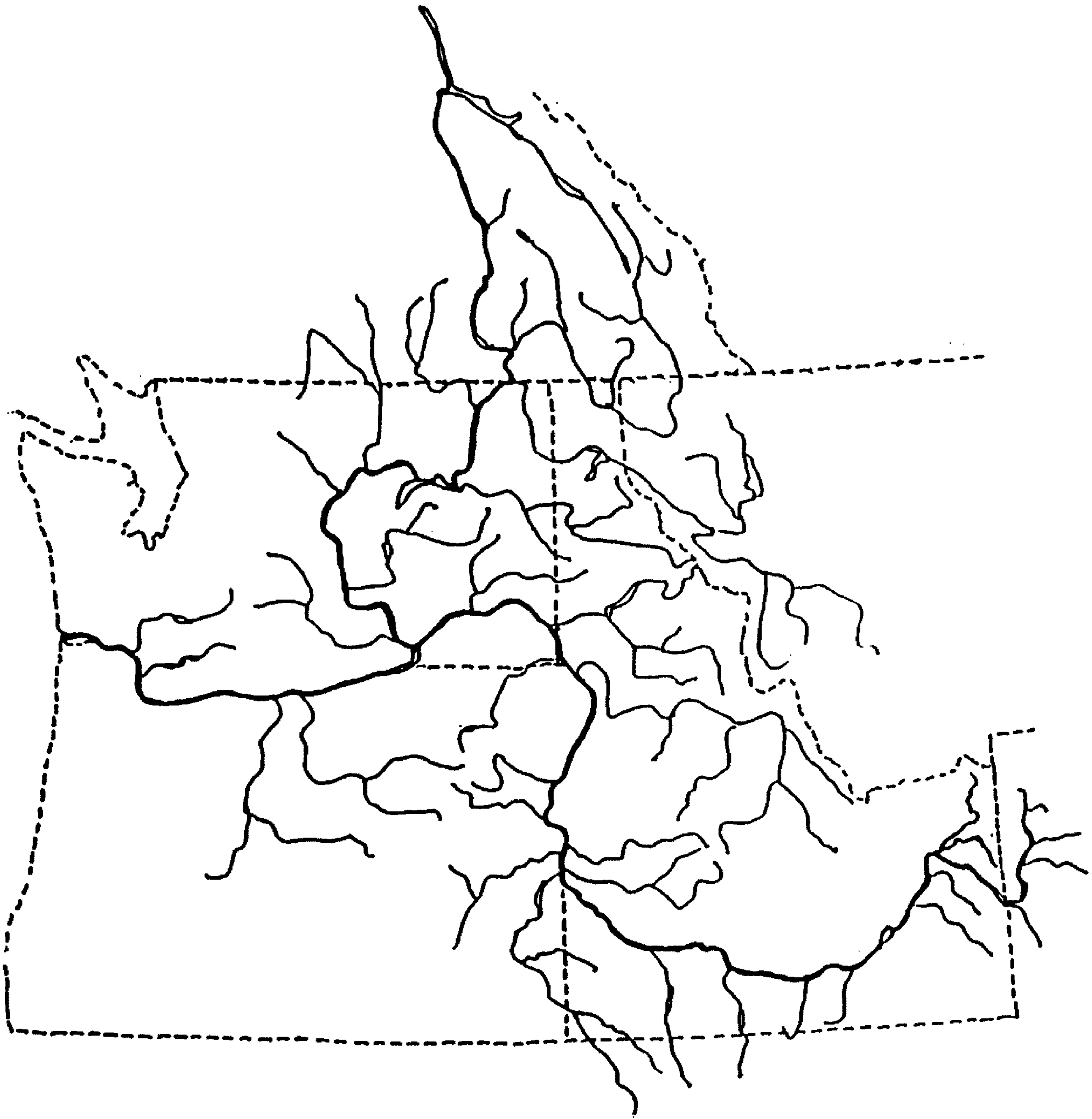
4. Discuss how the watersheds are interconnected by the water flowing from one watershed to the next.

Extensions Measure or find out how many miles water travels between Teton Valley and the Pacific ocean. How many states does the water travel through? How many sections of the journey are through areas with Wild and Scenic River status? How many National Wildlife Refuges does the route pass through? How many feet does the river drop along the way? Hopefully the students will answer 6,200! Where is most of the gradient?

Investigate the rivers that flow out of the Greater Yellowstone Ecosystem to reveal that they flow into three major regional watersheds (1) the Columbia, (2) the Mississippi and (3) the Colorado.

Resources Washington, Oregon, Montana and Idaho Atlas and Gazetteer; US EPA's Surf Your Watershed Website (www.epa.gov/surf).

Columbia River Watershed Worksheet



Section 3.

Wetland Ecology: A Description of the Functional and Changing Components of Wetlands

Wetlands provide habitat for an enormous diversity of organisms ranging in size from one celled zooplankton floating in the water to a thousand pound moose grazing near the shore. Wading birds, shore birds and ducks feed on insects, aquatic plants and fish in the shallows. Birds of prey and diving ducks search the deeper water for fish. Small mammals such as mice and voles eat plants and insects, while others like weasels and mink eat the mice and voles. Muskrat and beaver build lodges in wetlands and eat large amounts of wetlands vegetation. Decomposing organisms consume dead plant and animal tissue and, in the process, make nutrients available to plants. Together these plants and animals are considered a community; in combination with the soil, water and air they are called an ecosystem. The water found in wetlands represents a step in the circulation of water through the hydrologic cycle. Each plant and animal inhabiting wetlands is part of a series of energy transfers encompassing the key elements of the biotic ecology of wetlands- energy flow, food webs, nutrient cycling and productivity. Change in ecosystems results in carrying capacity adjustments and adaptations of plants and animals over time.

A. How Much Water is on Earth?

The movement of water through the water cycle occurs all over the earth. In some places water is plentiful, in others it is scarce. Regional differences in climate and topography are responsible for the uneven distribution of water around the globe, but the amount of water available on earth, often called the water planet, is constant.

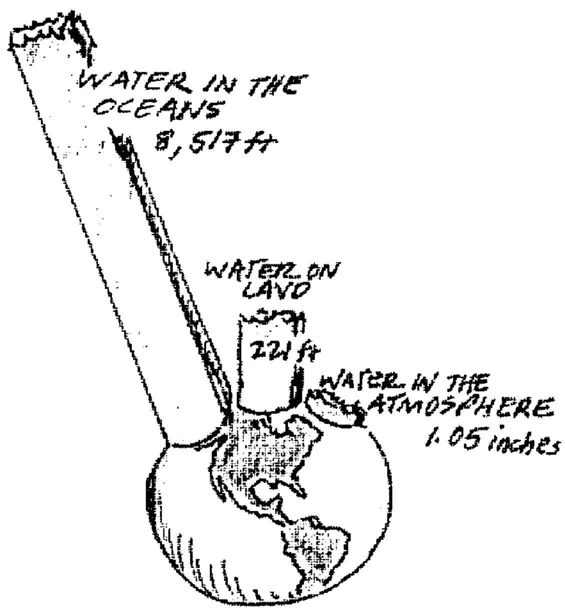


ILLUSTRATION 5. Water in Air, on Land and in the Seas

There are approximately 326 million cubic miles of water moving through the water cycle. At any given moment, about 97% of that total can be found as salt water in oceans and seas, leaving only about 3% as fresh water. The majority of the fresh water is frozen in icecaps and glaciers, a full 79 %. Groundwater accounts for about 20% of fresh water, and surface water features, including lakes, rivers and wetlands, include about 1% (Murdoch and Cheo 1996, 5). The amount of water in the atmosphere is about 0.001 % of the total water supply, a seemingly small amount but enough to cover the surface of the earth with one inch of water if it were to fall all at once as rain (Dennis 1996, 6). As a comparison, assuming the surface of the earth was smooth, the water in the oceans would uniformly cover the sphere to a depth of 8,800 feet (Dennis 1996, 7). (See **Where in the World is Water?** Section 3, Activity 1).

TABLE 4. Where Water is Found on Earth 326 Million Cubic Miles of Water	
Oceans	97.47 %
Atmosphere	0.001 %
Land	2.53 %

Where Water is Found on Land 8.2 Million Cubic Miles of Water	
Glaciers and Ice Caps	79 %
Groundwater	20 %
Surface Water	1 %

Where Water is on the Surface of the Earth 80,000 Cubic Miles of Water	
Lakes	58 %
Soil Moisture	37 %
Rivers	3 %

(Murdoch and Cheo 1996, 5)

B. Wetlands and the Water Cycle

The water that makes wetlands wet is part of a world-wide water circulation system called the water, or hydrologic, cycle. Powered by solar energy, water is continuously moving between the atmosphere, the oceans and the earth. The amount of water in circulation is constant but there are a variety of forms and pathways water can take on its journey through the cycle.

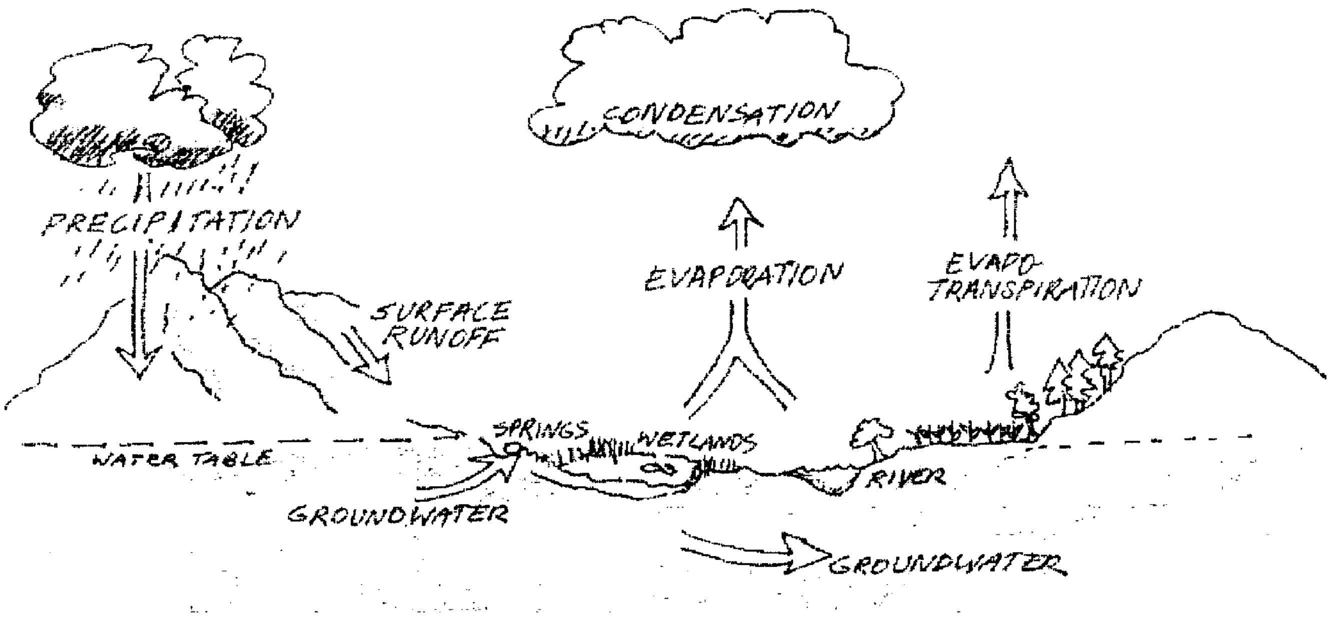


ILLUSTRATION 6. The Water Cycle

Evaporation and Transpiration Liquid water from the surface of the earth becomes vapor in the atmosphere through the processes of evaporation and transpiration. Heat from the sun causes water molecules to evaporate from the land and oceans and enter the atmosphere. Transpiration is the release of water from plants. Each day, about 38 cubic miles of water enter the atmosphere from a combination of evaporation from land and surface waters and transpiration from plants. An additional 210 cubic miles evaporates from the ocean (Dennis 1996, 7).

Condensation and Precipitation Water vapor returns to a liquid or solid form (ice) as it cools in the atmosphere, a process called condensation.

The resulting water droplets or frozen particles form clouds, which then produce precipitation. Water is returned to the surface of the earth in the form of rain or snow, with seven-eighths of the precipitation falling on the oceans (Farthing et. al. 1992, 13). An equal amount of water enters the atmosphere and falls as precipitation each day, about 248 cubic miles of water (Dennis 1996, 7). For illustration purposes, the amount of rain that falls to earth each year would cover the entire earth's surface with water 29 inches deep. Through evaporation and transpiration 17 of those inches would quickly return to the atmosphere and the remaining 12 inches either soaks in or becomes surface water and enters streams and rivers (Dennis 1996, 8).

Surface Water and Groundwater When precipitation reaches the surface of the earth, water can take a variety of paths. Some water is intercepted by vegetation and evaporated relatively quickly. Water that reaches the ground, in the form of rain or melting snow, either soaks in or runs over the surface. Water that soaks into the soil can be absorbed by plant roots or continue to percolate through the pores in the soil until it reaches an underground water system, like an aquifer. It is stored there until it reemerges to the surface via seeps or springs to join a stream, lake or other surface water feature (Madison and Paly 1992, 1). Water that runs over the surface moves in a downward direction, due to the force of gravity, and ultimately joins creeks, ponds and other surface water features on a journey down river to the ocean. The cycle is repeated as water on the surface and in the oceans is evaporated and returned to the atmosphere.

Water moves at different rates through different environments. If one were to track a water molecule through the water cycle, great variation would be noted in the amount of time it spends in different phases and locations. Groundwater moves very slowly and may not become surface water again for anywhere between ten and ten thousand years (Dennis 1996, 7-8). Streams and rivers move water rapidly over the surface. Wetlands slow water down because they act like big sponges, absorbing water and releasing it over time.

TABLE 5. A Molecule of Water in the Hydrologic Cycle Average Length of Stay in Specific Locations	
Vapor in Atmosphere	9 days
River with a speed of 3' per second	2 weeks
With First Foot of Soil	2 weeks to 1 year
Large Lake	10 years
Shallow Groundwater	10 to 100's of years
Deep Groundwater	1000 plus years
Shallow Ocean	120 years
Deep Ocean	3000 years
Antarctic Ice Cap	10,000 years

(Dennis 1996, 7-8)

C. The Water Cycle and Teton Valley

What do winter blizzards, raging creeks, bubbling springs and hot, dry summer days have in common? They all represent a piece of the water cycle in Teton Valley. (See **Components of the Water Cycle in Teton**

Valley, Section 3, Activity 2). The floor of the valley receives about 16 inches of precipitation each year, over half of that total falling as snow during the winter months (US Department of Agriculture 1992, 10-11). Since the water content of the snow in the area is low, it takes an average of 10 inches of snow to equal 1 inch of precipitation (McClung and Schaerer 1993, 18). The mountains around the valley receive substantially more precipitation, especially the Tetons where 25 to 50 inches of precipitation at elevations between 7000 and 10,000 feet is common (US Department of Agriculture 1992, 10). As much as 600 inches of snow has fallen in the Teton Range in a single winter.

Water comes charging out of the mountains in late spring and early summer as the snow in the high country melts. Rain and melting snow either soak into the ground, are evaporated or funneled into one of the creeks, referred to as tributaries, that feed into the Teton River. Evaporation rates are relatively high in the summer due to low humidity and warm temperatures.

Most of the ten general soil types found in the valley are considered well drained, meaning that water can pass through them relatively easily and quickly. The exception is found in the bottomlands along and to the east of the river where a combination of poorly drained soil, a high water table and many springs create an extensive wet and semi-wet complex of wetlands.

The depth of groundwater varies across the valley. It is close to the surface, and sometimes at the surface, in the bottomlands along the center of the valley. By comparison wells dug for domestic water on the east side of the valley are generally a hundred feet deep and on the west side they are in the one to two hundred foot range, though it should be noted that these numbers represent ground water that is considered a safe drinking water source and not necessarily the first groundwater hit by the drillers (Dennis Dunn pers. comm. 1998). Though not definitively studied, it is assumed that the aquifer, an area saturated with groundwater, can be found under the whole valley floor. The valley has an unusually high number of springs that return groundwater to the surface, into creeks and the river. The springs contribute a continuous but unmeasured amount of water and are important in maintaining stream flow in the dry season and when irrigation withdrawals are high.

Snow melt and rain cause seasonal surges in the creek levels, with flow from the Tetons peaking in June and the Big Holes a week or two earlier. The flow of the Teton river, the main avenue for water leaving the Valley, is the lowest in January and February and the highest in June.

D. Energy Flow

Energy is required to power every ecosystem. The energy flow in wetlands, as in all ecosystems, begins with plants. They are the only life form able to create chemical energy. In a process called photosynthesis plants use water, carbon dioxide and solar energy to create sugar (oxygen is a bi-product of the process). All other organisms, except for some bacteria, use the chemical energy produced by plants to survive (Caduto 1990, 26).

Terrestrial plants and aquatic plants, including algae, are called primary producers because they create chemical energy. Animals or insects that eat plants are considered primary consumers. Secondary consumers are animals or insects that eat primary consumers. Plant eaters are called herbivores, flesh eaters are called carnivores and those that eat plants, flesh and/or dead plants and animals are called omnivores. Each time energy is passed from one organism to another (via meal time) it is estimated that only ten percent of the original energy is transferred. The rest has already been used for growth, activity, heat production and respiration in the previous organism (Caduto 1990, 26). This concept, often referred to as the Rule of Tens, explains why there are, pound for pound, more producers, fewer primary consumers and far fewer secondary consumers.

E. Food Webs

Plants form the basis of food webs in wetlands and their chemical energy can be made available through two distinct pathways: the grazing and detrital food chains. A portion of the green plants in a wetland will be eaten by grazers, such as dabbling ducks, muskrats, and deer. The rest will die, fall into the water and be broken down by bacteria, fungi and other microorganisms. The result is detritus, a term for partially decomposed nutrient-rich organic matter, which makes up the base of the larger food web in wetlands and provides a valuable food source for the small insects, bivalves, and microorganisms that are low on the food chain (Horwitz 1978, 19).

Food chains are a useful tool in illustrating who eats what. For example, a simple food chain found in wetlands includes a green plant eaten by a water dwelling insect, which is devoured by a trout, which in turn is eaten by an osprey. The detrital food chain can be described also with only a few more steps. Green plants die, fall into the water, are partially eaten and broken down by decomposers, the resulting detritus in consumed by a water dwelling insect, which is eaten by a trout, which is devoured by an osprey. Unfortunately, food chains overly simplify what actually happens in nature. Food webs are better because they show that plants, insects, and fish can be eaten by a variety of organisms. Food pyramids reveal how the decrease in energy available at each level relates to the number of organisms able to survive as one moves successively away from the producer level.

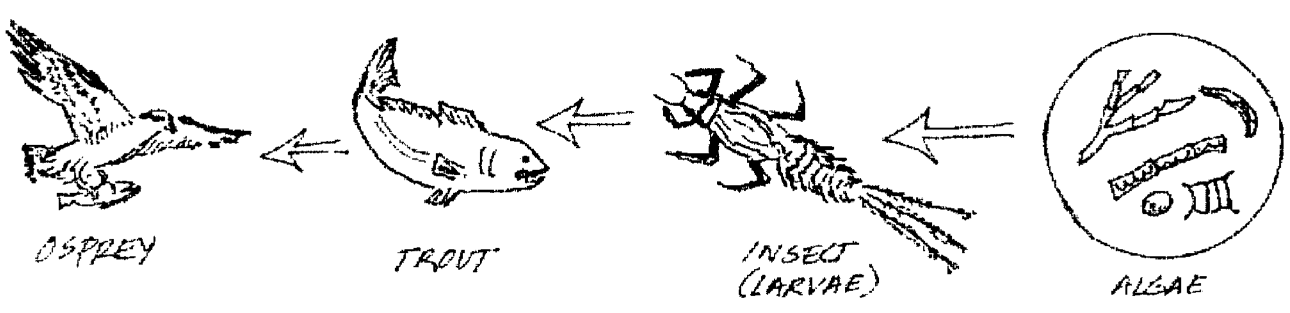


ILLUSTRATION 7. Simple Food Chain

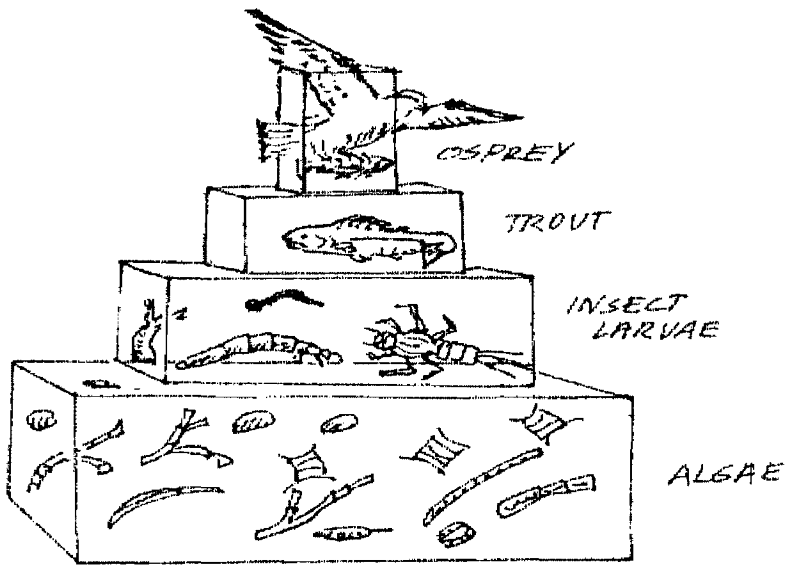


ILLUSTRATION 8. Food Pyramid

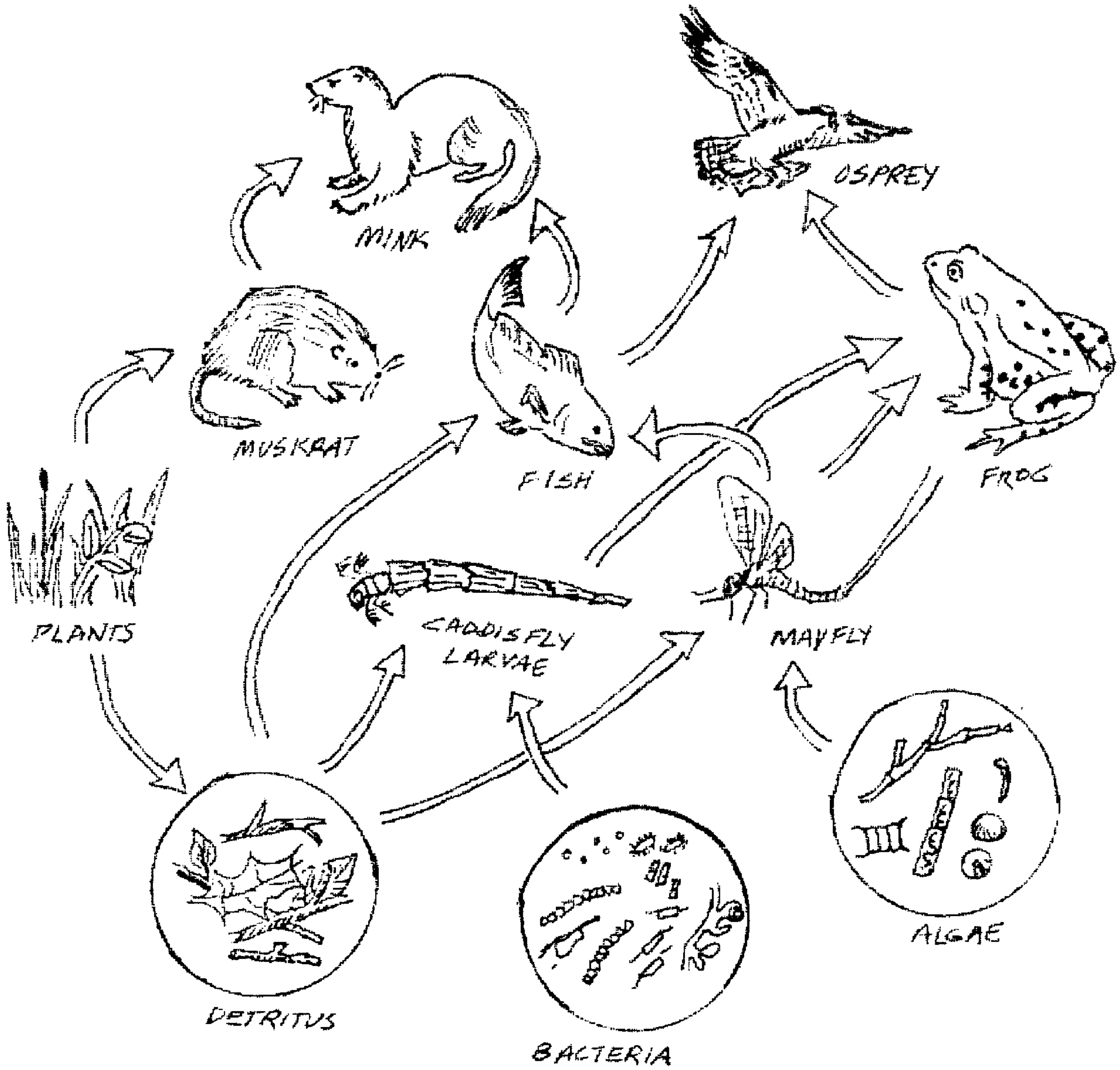


ILLUSTRATION 9. Wetland Food Web

F. Nutrient Cycling

Unlike agricultural fields that need the addition of nutrients in the form of fertilizers to remain highly productive, most naturally functioning ecosystems are able to maintain their productivity by efficiently recycling the nutrients found within their boundaries and using those that are brought in by surface and ground water sources. Decomposers have the critical role of breaking down dead plant and animal matter and making the nutrients incorporated in their tissue available for use by plants again. Water is enriched with minerals from the soil, rocks and organic matter it flows over and through. These nutrients are them incorporated into a wetland ecosystems.

G. Carrying Capacity

An ecosystem can support a finite number of organisms with the energy and nutrients that cycle through its system. This concept, referred to as the carrying capacity, pertains to every species because there is a limited amount of food, shelter and territory available for each. If the carrying capacity is exceeded and too many individuals use a given area, the habitat can be damaged and support fewer organisms. As a result, individual animals and plants may die. For example, muskrat populations tend to peak every six to ten years (Wile 1996, 56). When their numbers are especially high, the marsh vegetation can be severely grazed causing starvation, mass migrations and extensive predation of the weakened animals by mink, hawks and other predators.

H. Productivity

Productivity ranges from very high to very low among the different types of wetlands. Defined as the amount of living matter produced within a specific area, the productivity of marsh ecosystems, the most productive wetland type, are similar to that of tropical rainforests, with approximately 2000 grams of biomass produced per cubic meter per year (Tiner 1984, 20). In comparison, agricultural land produces about 650 grams, temperate conifer forests produce 1300 grams, the open ocean produces 125 grams and desert scrublands produce 70 grams (Davies and Angell 1990, 17). High productivity is dependent on adequate amounts of solar energy for photosynthesis, conservative use of energy by consumers and efficient recycling of nutrients in the ecosystem (Niering 1997, 29).

The high amount of plant material found in wetlands provides the food source to support large numbers of birds, insects, mammals and fishes. Many birds use wetlands and riparian areas to nest and raise their young because there are plentiful food sources and good nesting habitat. It is estimated that 10 to 12 million ducks breed in wetlands in the lower forty-eight states (Horwitz 1978, 21-2). Wetlands, especially estuaries, act as nurseries for seven of the ten most important commercial fish and shellfish (Horwitz 1978, 21).

I. Adaptations

Life in a wetland includes a number of stressful conditions. Residents of wetlands must cope with the rigors of low soil oxygen levels, intense competition and periods of flooding and drought. Many unique adaptations have been made by the plants, animals and insects that inhabit wetlands.

Plants

Since plants normally obtain much of the oxygen they need for nutrient absorption and root growth from the soil, wetland plants have evolved special adaptations to reach oxygen sources. Grasses, sedges and reeds have hollow cells in their stems to transport oxygen from the air to their roots. The leaves of many floating wetland plants have openings, called stomata, on their upper surface to let oxygen flow into the plant. Flooding promotes some woody plants to develop openings in their bark to let oxygen in, while others like willows are stimulated to produce new roots that are filled with air (Niering 1997, 26). Still other plants are able to hang onto the oxygen created during photosynthesis and transport it to their roots (Madison and Paly 1992, 6).

Competition among species in wetlands can be strong. Cattails maintain a monopoly in certain wetland habitats by releasing a chemical that inhibits the establishment of other plant species (Williams, Vincentz and Firehock 1996, 18).

While many wetlands are rich in nutrients, bogs and some fens are not. Several plants in bogs and fens have become carnivorous in their attempts to obtain nitrogen they need for growth (Heidel 1995, 4). Through a combination of sticky hairs, alluring smells, and trap doors, carnivorous plants like sundews, pitcher plants and Venus fly traps catch and then digest insects.

Two carnivorous plants have been found in eastern Idaho and may also be located in Teton Valley. Dramatic as they sound, both are small enough to be easily overlooked. Bladderworts are submergents that have minute sacs that, when triggered to open by contact with a small aquatic insect, inflate and suck it inside. Sundews are terrestrial plants that grow in peatlands that catch insects when they alight on their very sticky leaves.

Once the insects are caught, digestive juices very similar to ours are secreted to obtain the nutrients needed by the plant (Heidel 1995, 6)

Animal, Insect and Bird Adaptations

A large number of animals and birds use wetlands at some point during their life cycle. Most visit during a particular season and use the wetlands as a source of food, a place to rest during migration or a nursery for their young. But a handful live in wet habitats all year long. These permanent residents and seasonal visitors have made physical and behavioral adaptations to overcome the hardships of living in a wet place. For example, amphibians (frog, toads and salamanders) hibernate through the winter in underground burrows, an adaptation to survive freezing temperatures. Some water dwelling insects obtain oxygen from the water, others are able to carry a bubble with them underwater to use as an oxygen source, much like a scuba diver uses a tank (Niering 1997, 27). Beaver and muskrat have webbed feet, warm and waterproof fur and teeth well suited for chewing the sticks and plants that make up their diet. If conditions become too stressful at the wetland many animals, birds and insects can move to a more favorable habitat.

Section 3. Activity 1.

Components of the Watercycle in Teton Valley

Subject Area: Environmental Science

Skills: Mapping, drawing, discussion

EE Emphasis: Ecological foundations, conceptional awareness

Setting: Indoors

Vocabulary: Evaporation, transpiration, groundwater, sediments, nutrients

Objectives Students will understand the different components of the water cycle, how humans use water in Teton Valley and how their actions can contribute to a decline in water quality.

Methods Students will discuss and draw the components of the water cycle specific to Teton Valley, Idaho.

Materials Pens and colored pencils for drawing

Background Information The water cycle is the continuous movement of water between the atmosphere, the oceans and the earth. It is explained in detail in the Section 3. B and C.

Humans use groundwater and surface water for domestic, agricultural and industrial uses. They can adversely affect the quality of water by polluting it with chemicals, pesticides, sediments and nutrients. The water in the Teton River and many of its tributaries has elevated levels of sediments and nutrients, limiting the ability of trout to rear young, increasing the wear on irrigation systems, reducing the populations of water-dwelling invertebrates and increasing the risk of bacterial outbreaks potentially harmful to swimmers and fishermen (US Department of Agriculture 1992, 19). The sedimentation is from a variety of sources including erosion from croplands, timber harvest, roads and trails, livestock overgrazing, landslides and streambanks (US Department of Agriculture 1992, 20). The nutrients are generally from fertilizer enriched runoff from croplands, but leaking septic systems may also play a role (US Department of Agriculture 1992, 19).

Procedure

1. Explain the basic elements of the watercycle to the students using a diagram not specific to Teton Valley, such as the one later in this activity.

2. As a class discuss the components of the water cycle in Teton Valley including some of the following:

Major Watercycle Features	Surface and Groundwater Flow
Precipitation	Streams
Evaporation	Water Table
Transpiration	Springs
	Wetlands

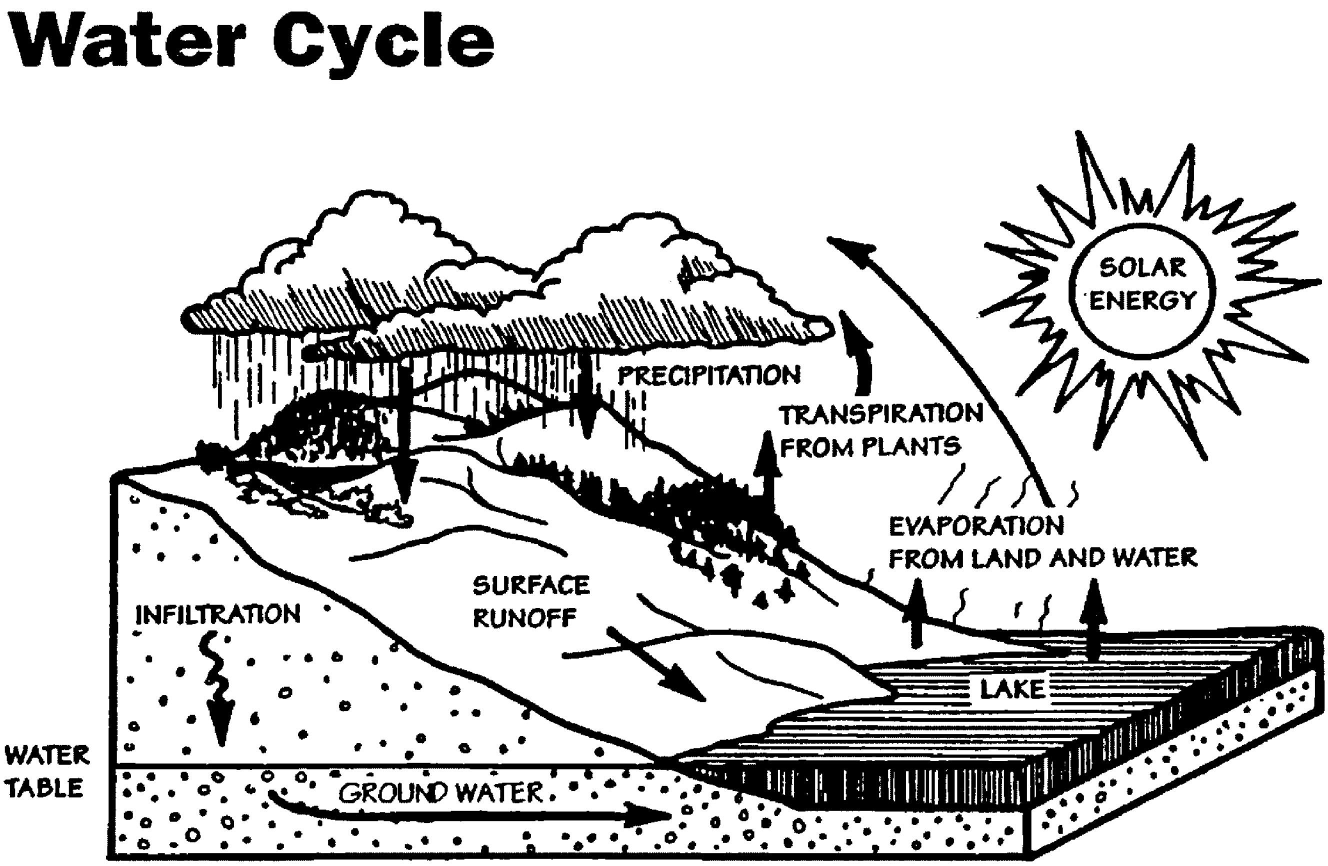
Uses of Water	Potential Threats to Water Quality
Domestic	Pollution- oil, pesticides
Agriculture	Nutrients- septic systems, fertilizers
Wildlife and fish	Sediments- erosion, slides

3. Have the students draw how water moves through the valley, using both cross-section and map views. They can use arrows to represent water flow, symbols to indicate other features such as springs and human uses and color if they choose. Remind them to make a key if they use symbols. There is a worksheet included with this activity that outlines Teton Valley in both cross section and plan views.

Extensions Ask the Natural Resources Conservation Service to make a presentation to your students using their groundwater model.

Water Cycle Illustration

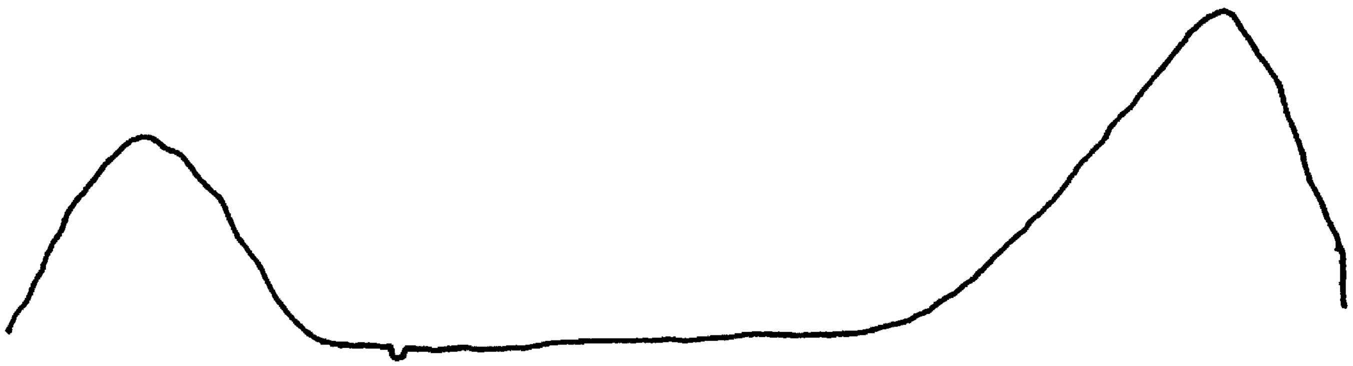
From WOW!: The Wonders of Wetlands (Higgins, Kesselheim and Robinson 1996, 119).



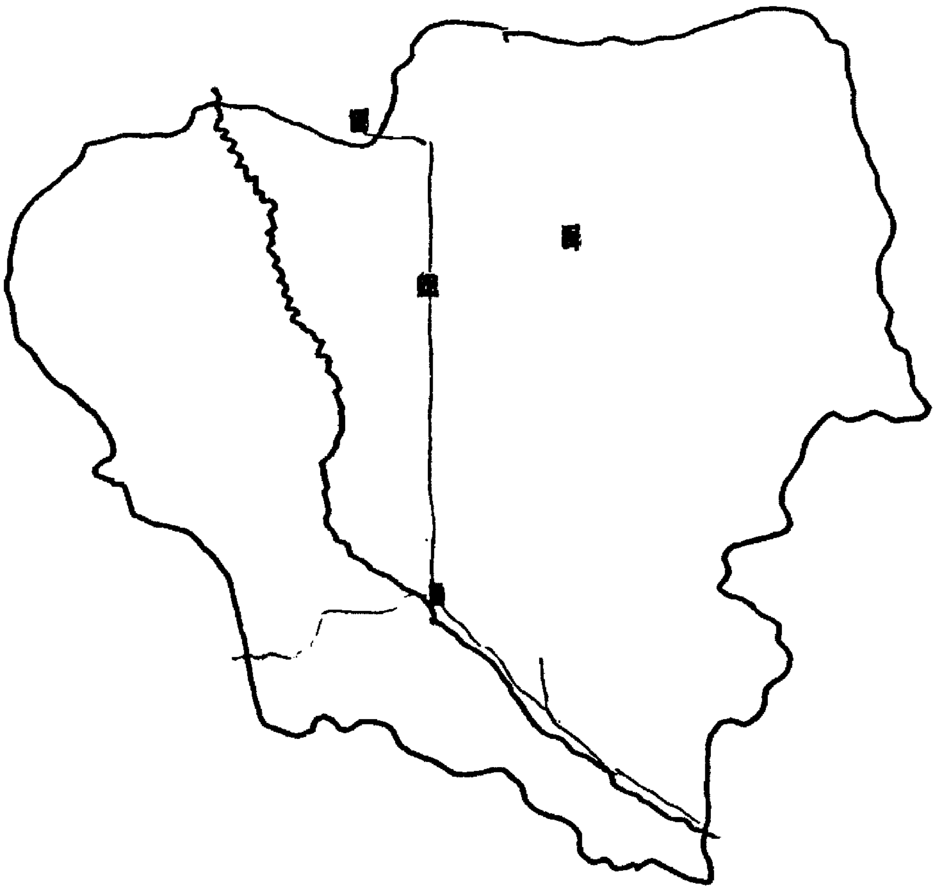
Components of the Water Cycle in Teton Valley

Worksheet

Cross Section



Plan View



Section 3. Activity 2.

Where in the World is Water?

Adapted from *Project WET* and *Always A River* (Higgins et al. 1996, US EPA 1991)

Subject Area: Mathematics, Science

Skills: Calculating, measuring, graphing

EE Emphasis: Ecological Foundations, conceptual awareness

Setting: Indoors

Vocabulary: Salt water, fresh water, surface water, groundwater

Objectives Students will understand how much water is on earth, how it is distributed and the different forms in which it is found. They will become aware of the relatively small about available for human, plant and wildlife use.

Methods

PART I. Using either a liter or a gallon to represent all the water on earth, students calculate the amount of water found as salt water, fresh water, frozen water, groundwater and surface water, then measure the relative quantities to visualize the differences.

PART II. Students make three bar graphs representing the total amount of water on earth, the amount of fresh water and the amount of surface water using percentages given to them.

Materials.

- Gallon jug or liter container filled with water for each group

- Three other smaller containers per group (preferably graduated cylinders with increments but any smaller container will work)
- Teaspoons or milliliter measure (remain consistent with either US or metric system).
- Eyedroppers
- Calculators

Background Information. Photos of the earth from space quickly reveal why the planet is often referred to as the water planet. There are 326 million cubic miles of water moving through the water cycle. The water is distributed between the ocean, the atmosphere and the land masses. Most of the water is salt water and only a small proportion is fresh water. Of the fresh water, nearly eighty percent is frozen in ice caps and glaciers, 20 % is groundwater and the rest is surface water.

At the end of the exercise, the students will conclude that the fresh water supply is very limited. The surface water supply is about 9,454 cubic miles of water, actually a large amount of water. But in many places around the globe fresh clean water is in short supply because precipitation is not evenly distributed and surface water is easily polluted. It is estimated that a third of the surface water is no longer usable as drinking water due to contamination from pollutants (Caduto 1990, vii). Some groundwater supplies have also been contaminated with pesticides and other chemicals. Clean water is becoming a more scarce resource.

Procedure.

PART I.

1. Review with the students that water can be found in three phases: liquid, vapor and solid (ice). It can be salty or fresh. And it can be found on top of or in the ground, as surface water or groundwater respectively.

2. Working as individuals or in groups have the students calculate the volume of water in different locations on earth. Whether you choose to work with a gallon or a liter, it will represent all the water on earth. For calculation purposes, the gallons will be broken into teaspoons and the liter into milliliters. When the teaspoon and milliliter amounts become less than one, conversion to drops helps enlarge the numbers (1 gallon = 768 teaspoons, 1 teaspoon = 60 drops, 1 liter = 100 ml and 1 ml = 12 drops). You might need to review how to multiply percentages and how many significant figures to use. Once they have finished calculating the amount of fresh and salt water, remind them to use only their fresh water totals for the second three calculations.

3. Once calculations are done, have the students transfer the amount of water that represents freshwater (23 teaspoons or 6 ml) from the large container to a smaller container. The water remaining in the large container represents ocean water, so salt may be added for effect. Next the students transfer the water representing

groundwater (4.6 teaspoons or 1.2 ml) into a third container, followed by the few drops representing surface water (14 drops or .36 drop) into a forth container. The water left in the second container represents all the water frozen in glaciers and ice caps.

4. Discuss with the students how the water in the final two containers represents the relative amount of water available for human use. Humans use either surface or groundwater for their domestic needs, in about an even split across the country. Not all surface water is usable become some is polluted. Nor is all groundwater available because of contamination and difficulty of access. Already ground water levels are dropping in many areas because humans use the water faster than it can be replenished. Wildlife and plants must rely on surface water only for their water needs. The importance of judiciously using water and preventing its contamination by pollutants are relevant concluding points.

PART II.

1. Using the information in Table 2, page 31, have the students plot the values for each bar graph. They will need to title the three bar graphs (1) Total Water on Earth, (2) Water on Land Masses and (3) Surface Water and label the vertical axis by tens from 0 - 100%. The labels on the horizontal axis will vary with each graph. Graph (1) Oceans, Atmosphere, Land (2) Glaciers/Ice caps, Groundwater, Surface water (3) Lakes, Soil Moisture, Rivers.

2. Discuss the relative amounts of water and conclude again that humans, plants and wildlife depend on a small proportion of the earth's water. The importance of keeping the water clean and using it responsibly can again be stressed.

Extensions. Students can figure out the amount of water in cubic miles in each location using the totals on the chart and calculating percentages. For example, the total amount of water on land is 326 million cubic miles x 2.53% = 824,780 cubic miles. For the amount frozen in glaciers and ice caps use 824,780 x 79% =651,576 thousand cubic miles.

Relative Amount of Water in Select Locations on Earth		
	Percentages	Amount with Units
Total Water on Earth		
Ocean	97%	
Freshwater	3%	
Atmosphere	0.001%	
Total Freshwater		
Glaciers/Ice caps	79%	
Groundwater	20%	
Surface water	1%	

Section 4.
The Workings of Wetlands: An Overview of Wetland Benefits

Healthy wetland ecosystems provide numerous benefits. They supply habitat for fish and wildlife, recharge the groundwater and remove excess nutrients from the water. Humans value wetlands for the myriad of benefits we obtain from them including improved water quality, reduced impacts of flooding, recreational opportunities and economic benefits from harvesting wetland resources.

A. Water Quality Improvement

Wetlands can improve water quality by absorbing nutrients, removing sediment and filtering pollution from the water. In moderate amounts, nutrients, sediment and pollution can be used by wetland plants or stored in the soils. Wetlands can be easily overwhelmed by these same three additives when they are found in excessive amounts, a threshold that varies with each wetlands. It is best to restore or create wetlands to clean up existing problems, such as toxins in mine waste or excess nutrients in sewage discharge, but not to use them to treat new sources of pollution.

Wetland plants remove nutrients from the water to facilitate their growth. Phosphorus and nitrogen are important nutrients for plant growth. They are found naturally in water but are introduced in greater quantities through a variety of sources including agricultural runoff (fertilizer contains both), sewage treatment plant discharge, leaking septic systems and cattle feed lots. Wetlands can intercept these overly nutrient-rich waters and absorb some of the minerals before they cause harm downstream. The city of Arcata, California has created a series of wetlands to provide secondary filtration for the town's sewage. The treated water reaching the bay via the artificial wetlands is cleaner than it would be with a typical sewage treatment facility (Stewart 1990, 175). The added bonus being ponds and wetlands that attract both wildlife and town residents in need of relaxation.

Excess sediment is a common problem in surface waters all over the country. Caused primarily by erosion, high levels of sediment clog the gills of aquatic fish and insects and smother their eggs. Since water tends to move very slowly through wetlands, sediments and organic matter can settle out of the water and greatly improve the water quality downstream. (See **Wetlands as Sediment Traps**, Section 4, Activity 3).

Wetlands have been shown to reduce levels of pollutants in the water. Several types of wetland plants can help remove pollutants from water and storing it in their tissues. Some pollutants like heavy metals and pesticides can settle out with the sediments in slow moving water (Tiner 1994, 18). Pesticides and other complex chemicals can be made less toxic through the decompositional processes of soil microbes (Williams, Vincent and Firehock 1996, 35). (See **Wetlands Plants and Pollution Absorption**, Section 4, Activity 2).

B. Promotion of Biodiversity

Wetlands are areas of rich biological productivity and as a result provide food, shelter and water for many of species of birds, mammals, amphibians, reptiles and fish. Wetlands rival coral reefs and tropical rain forests in the number of species they support (US EPA 1995, 2). Some wetland species reside permanently in wetlands, others use them only part of the year for breeding, as wintering grounds or as stop-over points during migration. In Idaho, wetlands cover less than one percent of the state yet seventy-five percent of the bird and animal species found in the state use wetlands at least periodically (Stevens 1990, 9). Of particular importance are the riparian areas with trees and shrubs, especially for songbirds (Tiner 1984, 50). While wetlands represent just five percent of the United States land mass, forty-three percent of the threatened and endangered plant and animal species rely on wetlands for at least part of their life cycles (US EPA 1995, 2).

Idaho's rivers and wetlands offer important nesting and winter habitat for several unique or rare species that congregate in the state. The South Fork of the Snake River, from Palisades dam to the confluence of the Henry's Fork, contains Idaho's highest concentration of nesting bald eagles, an endangered species in the lower forty-eight states (Carpenter 1990, 87). The largest nesting concentration of sandhill cranes in the world can be found in Eastern Idaho at Gray's Lake, also home to a few endangered whooping cranes (Carpenter 1990, 89). About 2,800 trumpeter swans spend the winter on the Henry's Fork and Teton Rivers (Maj and Shea 1993, 15) and Teton Valley hosts the largest known wintering population of great gray owls in the nation (Michael Whitfield, pers. comm. 1998).

C. Flood and Erosion Control

When flooding occurs, wetlands located in the floodplain can reduce the flood's impact downstream by providing a temporary storage area for water. Wetland soils act like huge sponges, absorbing flood water and then releasing it slowly. A wetland one acre in size can hold 330,000 gallons of excess water with only a one foot rise in its water level (Niering 1997,35). This storage capability can help lower flood crest levels and reduce the velocity of the water. Many of the damaging floods that occur are caused, in part, by the tremendous loss of wetland storage capacity in the floodplains, primarily because so many wetlands have been converted to agricultural lands or developed (Tiner 1984, 22). (See **Wetlands and Flood Reduction**, Section 4, Activity 1).

Wetland vegetation can help reduce erosion by stabilizing the banks of rivers and coastlines. The foliage and stems of trees, shrubs and grasses help reduce the speed of the water and their roots hold soil particles in place so they are not swept away by waves or rushing water (US EPA 1994, 24). Overgrazing has contributed to substantial erosion in riparian areas and wetlands in the West because vegetation along the shores is destroyed. (See **Wetlands and the Prevention of Erosion**, Section 4, Activity 4).

D. Groundwater Discharge and Recharge

Wetlands can be connected to groundwater resources. Though not well researched in most wetlands, it is known that the surface water in some wetlands moves down through the soil and contributes to ground water reserves, a process called groundwater recharging. As an example, twenty-six percent of wetlands in the lake country of Wisconsin are know to recharge the underlying aquifer (Niering 1997, 31). Springs and seeps, like the ones that feed the fens in Teton Valley, are examples of groundwater discharge sites, where water once stored underground reaches the surface. Since these areas have a consistent supply of water they often support wetlands. The many springs in Teton Valley also help keep water in the tributaries of the river during the late summer months when runoff is low and withdrawals for irrigation are high. The continuous flow of the creeks is very important for the survival of aquatic animals, insects, fish and plants.

E. Recreation

Wetlands offer the public opportunities to go fishing, hiking, bird watching, wildlife viewing, hunting, camping and boating. About 40% of the adult population in the United States like to hunt, fish, birdwatch or photograph wildlife, pursuits they spent approximately $100 billion dollars on in 1996 (US Department of the Interior 1996, e-mail). Idaho is a veritable playground for recreationalists, with vast areas of public land and many rivers and lakes. Wetlands and their associated recreational potential occur all over the state, with concentrations of lakes, forested wetlands and fens in Northern Idaho and riparian wetlands along the major river systems and streams. Marshes and playa lakes can be found in southeast Idaho and spring associated wetlands near the Wyoming border.

F. Economic Benefits

In addition to providing habitat for numerous plant and wildlife species that have commercial importance, the economic value of wetlands includes many of the benefits listed earlier. For example, rather than building an expensive series of dams, the purchase and maintenance of healthy wetland habitat in the Charles River Basin upstream from Boston proved to be the cheapest alternative to reducing flood threats to the metropolitan area (Vileisis 1997, 242-3). In another example, the natural cleansing of water by wetlands helps reduce the cost of expensive filtration processes necessary to sanitize water for public consumption (Ewel 1997, 331-2).

Commercial and recreational fishing was a $40 billion dollar industry in the United States in 1993 and over 70% of this value was from fish that use wetlands directly or indirectly at some point of their lifecycles, mostly for spawning and nurseries for their young (US Department of Interior 1996, E-mail). Sale of the skins of reptiles and the pelts of furbearing animals such as muskrat, nutria, beaver and mink contribute to local economies some area. Over 10 million muskrats are trapped for their pelts each year and the sale of alligator skins from Louisiana alone netted a profit of $16 million in 1992 (Williams, Vincentz and Firehock 1996, 37). Approximately $1.3 billion is spent each year by hunters of waterfowl and other birds dependent on wetlands (US Department of Interior 1996, E-mail). Wetland plants also have economic value. Timber is harvested from swamps, peat is sold to gardeners as a soil enricher and grasses and reeds are used in basketry and chair caning (Madison and Paly 1992, 55). A few plants that grow in wetlands even find their way to our dinner tables, including cranberries and wild rice.

G. World Climate

Wetlands play a role in the exchange of gases in the atmosphere. Plants absorb carbon dioxide and release oxygen during the process of photosynthesis. The oxygen is used to support almost all of the life forms on the planet, including the humans who have burned so many fossil fuels that there is excess carbon dioxide in the atmosphere, a situation that many scientists believe is contributing to global warming. Wetlands, peatlands in particular, act as carbon sinks by storing tremendous amounts of carbon (originally from carbon dioxide used during photosynthesis and stored in the plant's tissues as carbohydrates) in the undecayed plant material that makes up peat. It is estimated that 15 to 20 percent of all terrestrial carbon is stored in peat, twice the amount that is stored in the coniferous forests of the northern latitudes (Breining 1992, 28). Anaerobic bacteria in wetlands, again peatlands in particular, are responsible for producing about forty percent of the world's methane gas (Breining 1992,28). It is still unclear whether methane gas also contributes to global warming or, as recent studies suggest, helps regulate the ozone layer which protects all plant and animal species from ultraviolet radiation (Niering 1997, 35).

H. Education

Wetlands are recognized as excellent learning environments for students of all ages to explore the natural world. Outdoor education centers located at estuaries and other wetlands are common around the country. They provide opportunities for students to learn about the biological components and ecological processes of the wet ecosystems and the issues surrounding wetlands.

Section 4. Activity 1.

Wetlands and Flood Reduction

Adapted from *Discover Wetlands* (Lippy et al. 1995)

Subject Area: Environmental Science, Earth Science

Skills: Measuring, calculating

EE Emphasis: Ecological foundations

Setting: Indoors

Vocabulary: Pore space, organic matter

Objectives Students will understand that wetland soils can hold a lot of water and, as a result, reduce flooding in the watershed where they are found.

Methods Students will measure the absorption capabilities of peat moss, sod, sand and gravel.

Materials

- Scale
- Strainer, bowl and cheese cloth (one setup per group)
- Peat moss
- Potting soil
- Sand
- Gravel

Background Information Wetland soils, characterized by high percentages of organic matter, have the ability to absorb and store large amounts of water. Healthy wetlands can reduce flooding in a watershed by slowing down and storing flood waters. Wetlands then release the water slowly, helping to maintain streamflow and facilitate water recharge into groundwater. Loss of wetlands has contributed to flood damage throughout the world.

Procedure Solicit opinions from students on how wetlands help prevent flooding. Let them know that this activity will help them understand the process. "Mud Measurers" or whatever term the students like, are made with a cheese cloth lined sieve nestled inside a bowl.

1. Divide the class into groups and give a mud measurer set-up to each group. If there are enough measurers and enough time, have each group weigh all four soil types, otherwise each group can measure one or two types and share their results with the rest of the class.

2. With the cheese cloth lining the sieve, partially fill the sieve with one soil material. Place the sieve into the bowl and weigh the whole thing (sieve, cheesecloth, bowl and soil). Record the weight on the worksheet.

3. Pour water over the soil until the bowl is nearly full. Let stand for five minutes, stirring occasionally.

4. Lift the sieve from the bowl. Time how long it takes for the water coming out of the sieve to reach a slow drip. Record the amount of time on the worksheet.

5. Pour the water out of the bowl, put the sieve with wet dirt back into the bowl and weigh the whole mud measurer. Record the weight in the wet weight column.

6. Have the students find out how much water the soil samples absorbed by subtracting the dry weight (A) from the wet weight (B) (B - A = weight of water absorbed). The students can organize and display their data using charts or bar graphs.

7. Discuss or have students think about the following questions:

   a. What soil material absorbed the most water?

   b. Which soil material are similar to those found in wetlands? Peat moss and potting soil both have high organic matter like wetland soils. Peat moss is found in all peatlands. Sand and rocks are found in large quantities in mineral soils in wetlands.

   c. What determines how much water a substance can hold? The amount of air space (pores). Rocks have very few pores and peat moss has very many.

   d. How do wetlands prevent flooding? The pore spaces in wetland soil fill with water, reducing the amount of water that rushes down the creek or river.

e. How do wetlands help maintain streamflows? The water drains slowly out of wetland soils (remember that the peat moss and potting soil held water longer than the sand and rocks), contributing a steady amount of water to streams.

f. What would happen if there where no wetlands in a watershed? The water would drain off all at once and may cause flooding. Streams would go dry unless rains were regular.

Absorbency of Different Soil Materials Worksheet				
	Weight Before Soaking (A)	Weight After Soaking (B)	Weight of Water Absorbed B-A	Amount of Time Until Slow Drip
Gravel				
Sand				
Potting Soil				
Peat Moss				

Section 4. Activity 2.

Wetland Plants and Pollution Absorption

Adapted from *Discover Wetlands* (Lippy et al. 1995)

Subject Area: Botany, Environmental Science, Observation

Skills: Observing, predicting

EE Emphasis: Ecological foundations

Setting: Indoors

Objectives Students will learn that some wetland plants can remove pollutants from water and store it in their tissues.

Methods Students create a demonstration that shows how celery stalks can absorb pollution.

Materials

- Jars of water - one for whole class or one per group
- Food coloring
- Two or three celery stalks for each group

Background Information Wetland plants can help remove pollutants from water by storing it in their tissues. Though the water becomes cleaner, the pollution remains in the plants and can be released into the water again when the plant dies. There is a limited amount of pollution wetland plants can absorb before they are damaged or die.

Procedure Set up the procedure on the first day and make observations on the second day. Explain to the students that the food coloring they are going to use represents pollution.

1. Have the student add a few drops of food coloring to the water in their jars. Cut off the bottom two inches of two to three celery stalks and place them in the jar of water.

2. On the second day the celery should be noticeably colored with pollution. If the color is not visible from the outside of the stalk, cut open the celery to see the color in the plant tissue.

3. Discuss the following questions with the students:
a. How did the food coloring get into the plants? Plants "drink" water to keep their cells hydrated and for use in photosynthesis. The "pollution" was absorbed with the water.
b. Why is there still color in the water? Plants can only absorb a limited amount of pollution.
c. What happened to the pollutants? They are stored in the plant tissue until the plant dies, then are released back into the environment.

Section 4. Activity 3.

Wetlands As Sediment Traps

Adapted from *Discover Wetlands* (Lippy et al. 1995)

Subject Area: Environmental Science, Earth Science

Skills: Observing, predicting

EE Emphasis: Ecological foundations, conceptual awareness

Setting: Indoors

Vocabulary: Sediment

Objectives Students will understand that wetlands help filter sediments out of water.

Methods Construction of a model that filters sediment out of dirty water.

Materials

- 9" x 13" pan
- Modeling clay
- Cellulose sponge
- Water
- A few tablespoons of soil, rocks, sand and grass clippings to make water muddy
- Scissors
- Natural material to decorate land and wetland areas

Background Information Wetlands filter sediment out of surface water by (1) slowing down the water to facilitate natural settling and (2) trapping and holding the sediment in vegetation. Water with excess sediment clogs the gills of both fish and aquatic insects, buries their eggs, and starves them of oxygen. Sediment reduces the amount of habitat available to small fish and insects because it fills the spaces between rocks.

Pollutants, such as heavy metals, are often attached to soil particles and can settle out of water in wetlands through the processes listed above. These pollutants are then stored in the wetlands, buried in solid or incorporated into plant parts. They may flush out of the wetlands during high water and become suspended in water again. There are soil microbes that can breakdown some pollutants, but it is unknown how extensively this happens.

Procedure

1. This activity includes the construction of a wetland model that filters sediment out of water. The model can easily be constructed in a baking dish - one end will contain modeling clay, sand or gravel to represent the land, the middle will be a sponge cut to fit across the pan snugly and abutted firmly against the "soil" and the other end is left empty to represent open water and act as a catchment basin for the water that flows through the system. Small twigs, grasses and other plant parts can be put in the land and wetland areas to make them look more realistic.

2. Once the model is complete, pour a half cup of sediment filled water (made by adding one or two tablespoons dirt, sand and grass clippings to clean water) into the upper end of the land mass. The water will run down the land surface, encounter the wetlands (sponge) slow down and drop the large sediments. The sponge will filter out the smaller sediments as the water seeps through it and into the open water area. Not all of the suspended sediment will be filtered out of the water. If the water in the open water section is still quite brown, pull the sponge out so the students can see the sediment that the wetland (sponge) trapped.

3. Discuss the filtration process with the students, including some of the following questions: How well did the sponge filter the water? How would a real wetland be different? How do wildlife and humans benefit from water with less sediment?

Tell the students that sedimentation is the biggest water quality problem in Teton Valley surface water. What contributes to the high rates of sedimentation found in Teton Valley? Erosion from cropland, stream beds, landslides and construction projects. How are humans and wildlife effected? The Teton River no longer has a self-sustaining wild trout population. High sediment levels reduce macroinvertebrate numbers and increase wear on irrigation equipment. See Section 1. Activity 2. for more information on water quality problems in Teton Valley.

Extensions Students could better understand how degradation and destruction of wetlands limits their sediment filtering functions by removing the wetland and pouring the same amount of muddy water on the model. The students could determine a way to compare the amount of sediment remaining in the water with and without the wetland in place.

Section 4. Activity 4.

Wetlands and the Prevention of Erosion

Adapted from Wetlands (Hickman 1993)

Subject Area: Earth Science, Environmental Science

Skills: Observing, comparing

EE Emphasis: Ecological foundations

Setting: Indoors

Vocabulary: Erosion

Objectives Students will understand how plant roots help prevent soil erosion.

Methods Students will compare the soil loss from root systems of two potted plants.

Materials

- Radish seeds
- Four small pots (2-3 inches in diameter)
- Water
- Sunlight

Background Information This very simple demonstration clearly shows how plant roots help reduce erosion. The roots hold soil particles in place so they are not swept away and stabilize the banks of rivers and coastlines. Both the Teton River and its main tributaries have erosion problems in their banks due to reduced streamside vegetation caused by overgrazing, development and agriculture.

Procedure

1. Plant radish seeds two weeks before lesson is planned. Place about twenty seeds in half of the pots and three to four seeds in the other half. The goal is to produce plants with different density of root masses, one with very thick roots that hold the soil tightly in place and the other with sparse roots that do not.

2. Pull the plants out of the pots and pour water over their root masses. The soil in the pot with thick root masses should be held by the roots, while the some of the soil in the pot with sparse roots should wash away.

3. Explain to the students that the same process occurs along river and stream banks and coastal shorelines. Have them discuss the activities that contribute to vegetation loss along streams, rivers and wetlands. The removal of natural vegetation caused by development, agriculture and overgrazing.

Section 5.
Bounty or Barrier? A Description of the Human Use of Wetlands

A. History of Wetland Use

From the earliest records of human life on earth, the use of lands adjacent to rivers, lakes and estuaries has been common. Ancient hunter-gatherers, like humans today, needed fresh water, food and shelter. Lakes, rivers and streams provided water for the early humans and their associated wetlands supplied food and materials for shelter. There are many examples of native peoples using the bounty of wetlands and riparian areas to sustain their lives. Huge piles of shells found at numerous coastal sites suggest the dependence of some Native Americans on shellfish, while others were known to harvest wild rice and cattails from marshes. Waterfowl and fish were used as meat sources and furbearing mammals were trapped for their pelts.

Most archeological sites are found within a quarter mile (0.4 kilometer) of fresh water, and often within 200 meters (Jamie Schoen pers. comm. 1998). Early Americans that inhabited the western coast of Florida around 5000 BC left evidence of their presence by burying their dead in a shallow pond. The pond gradually filled with peat and preserved their remains, even the fish bones, remains of their final meal, in several of their bellies (Coles and Coles 1989, 173). On the opposite coast, fishing artifacts dating back to 1000 BC were found near the mouth of a river with a productive salmon run on the north shore of the Olympic Peninsula in Washington State (Coles and Coles 1989, 62). Native Americans have lived in what is now eastern Idaho for at least twelve thousand years (Walker 1978, 23). The dry conditions and limited resources found in the area supported small groups of hunter-gatherers, one hundred people at most, that moved regularly to exploit food sources and escape extreme weather (Walker 1978, 35). Though their activities were not confined to wetland and riparian areas, they used them for water, shelter and food sources.

Early civilizations based on agriculture began in the fertile basins of the Nile, the Tigris-Euphrates, the Indus and the Yellow rivers around 3000 BC (Barraclough and Stone 1989, 52). The need for irrigation systems to increase agricultural production and trade contributed to the rise of cities, organized governments and even the beginning of written languages (Barraclough and Stone, 52). Only after irrigation canals were put into use could these civilizations move further away from the rivers that so critically supported their crops.

Human settlement patterns based on water resources continue to this day. Over fifty percent of the US population lives within 50 miles of the coasts, a trend that is expected to increase (Barth 1990, 4). A glance at a map also reveals concentrations of towns and cities along the inland waterways and lakes. This development has caused a decline in the number and health of wetlands; the anticipated growth will cause further pressure to drain or fill them.

Native American Use of Teton Valley The use of Teton Valley by Idaho's early inhabitants was probably limited to the late spring, summer and early fall when they would move into the area to harvest plants, hunt and fish. The women dug roots and tubers, collected nuts, seeds and berries and cut alder stems for baskets (Shimkin 1947, 269). Sunflower and balsam root seeds were commonly gathered, as were gooseberries, rose hips, currents and huckleberries (Shimkin 1947, 269 and 272-3). A mixture of sunflower seeds, lambs quarters and service berries was ground into a loaf and eaten like bread (Walker 1978, 91). Cattails were used in their entirety; their roots and pollen were eaten and their stalks were used for baskets and shelters (Stevens 1990, 2). Bird eggs and a variety of insects were also collected and eaten (Walker 1978, 89).

The men would fish and hunt in the valley floor and the mountains. Weirs, nets, spears and dams were used to catch fish, which were preserved for the winter by smoking and drying (Shimkin 1947, 268). Waterfowl were caught and killed with clubs (Walker 1978, 91). Large and small game, including bison, elk, mule deer, antelope, big horn sheep, beaver, rabbit, marmot, ground squirrel and wood rats, were snared or killed with spears and arrows (Shimkin 1947, 265). Their clothing was commonly made from the skins of deer, antelope and big horn sheep, with warmer robes of bison, rabbit, wolf and beaver (Walker 1978, 99). (See **Native American Wetland Stories**, Section 5, Activity 1).

B. Wetland Loss through Time

Settlement around rivers, lakes and coastal areas has resulted in the loss of many wetlands. In ancient times, the building of canals for irrigation and the use of water for growing crops surely destroyed or at least degraded many wetland areas. The mangrove-dwelling native Americans in Florida, possibly descendants of those found in the bog, changed the shorelines of their swamp homes by building seawalls of shells to protect themselves from flooding and provide more dry ground on which to live. In Asia, wetlands have been modified and used for the cultivation of rice for centuries, a practice that has changed the wetland plant and wildlife composition substantially.

The settlement of the United States by Europeans has also contributed to the decline of wetland acreage worldwide. As the towns and cities of colonial New England grew, the filling and dredging of wetlands were natural steps in creating more land for development. Boston and New York are both cities partially built on filled wetlands. Since the functional benefits of wetlands would not be known for many years, there was no incentive for the builders of our nation to preserve the wetland acreage. In fact, the draining and filling of wetlands was considered a good thing because these "worthless" lands produced hordes of pesky insects and harbored disease.

As the nation continued to grow, wetlands were modified to produce more agricultural land and facilitate resource extraction, like the harvest of timber in swamps. George Washington participated in an effort in 1763 to drain the Great Dismal Swamp on the border of Virginia and North Carolina so the area could support farms (Mitsch and Gosselink 1986, 47). The Swamp Land Acts of 1849, 1850 and 1860 dictated the transfer of federally owned swamps and floodplains in fifteen specified states if they would drain the wetlands for agricultural use. About 65 million acres were drained and filled under these Acts (Tiner 1984, 33). About the same, the frontier had already passed the Mississippi River and by 1890 many of the fertile river valleys of the west coast were settled and farmed (Barraclough and Stone 1989, 220). The draining, filling, dredging, damming and plowing under of wetlands stretched from coast to coast. When settler numbers were small and technology basic, these early "public works" caused minimal cumulative harm to the environment. As the population increased and technological advances blossomed, the story quickly changed.

From the turn of the century to the present, wetland losses have continued, increasing in some states, decreasing in others. Of the 221 million acres of wetlands estimated to exist in the continental United States in the late eighteenth century (Dahl 1990,6), only about 101 million acres of wetlands remain, an area about the size of California (US Department of Interior n.d., 1). This represents a loss of about 55% of the nation's original wetlands. Each year an additional 117,000 acres are lost (US Department of Interior n.d., 1), a huge amount but actually a substantial decline compared the average rate of wetland loss between the mid-1970s and mid-1980s of 260,000 acres per year (Dahl 1990,8) and between 1950 and 1970 of 458,000 acres per year (Tiner 1984, 31).

C. Human Impacts on Wetlands

Wetlands continue to be threatened due to increasing demand for land and resources. Most wetland loss through time has resulted from the conversion of wetlands to agricultural lands, but a recent report indicates a decline in percent of losses attributable to agriculture (now about 54%) and an increase in other causes, including urban expansion (Dahl 1990, 2). Conversion of wetlands for agricultural use, housing and industrial development and the construction of water diversions and roads occurs regularly. Resource extraction activities such as timber harvest, mining of minerals, oil and gas wells and the mining of peat further contribute to wetlands loss. Pollution, waste water treatment, overgrazing and the use of groundwater continue to cause degradation and dewatering of many wetlands.

The FWS has identified nine wetlands areas around the nation that are in particular trouble, primarily from pressure from agricultural interests or urban development (Tiner 1985, 35-6). These areas include: 1. Estuaries on all coastlines, 2. Louisiana's coastal marshes, 3. Aquatic wetlands in Chesapeake Bay, 4. Freshwater wetlands in southern Florida, 5. Marshes of the Prairie Pothole region, 6. Wetlands in the Sandhills and Rainwater Basin in Nebraska, 7. Bottomland hardwood forests along the lower Mississippi River, 8. Coastal peatlands in North Carolina and 9. Riparian wetlands in the West (Tiner 1985, 35-6). The concern for Western riparian wetlands relates to the magnitude of their loss and the importance they have to wildlife populations, especially birds. Conversion to croplands, overgrazing and dam building have all taken their toll on western rivers, some of which have lost most of their riparian wetlands (Tiner 1985, 50-1). A report by the FWS concluded that through human actions, riparian ecosystems have been modified more than any other land type in the west (Tiner 1985, 50). The future of these and other wetlands will depend on public sentiment and agency policy toward wetlands.

Section 5. Activity 1.

Native American Wetland Stories

Subject Area:	History, Natural Science
Skills:	Listening, writing, analyzing
EE Emphasis:	Ecological foundations
Setting:	Inside or outside on a nice day
Vocabulary:	Crane, killdeer, swallow, dove, marsh wren and wikiup

Objectives Students will become acquainted with local myth and understand traditional use of myth.

Methods Students will listen to a Shoshone - Bannock story about birds choosing nesting sites then write a wetland myth of their own.

Materials

- Copy of story
- Paper and pencils

Background Information Native American stories are tools for teaching history, morals and social lessons to the children of the tribes. They are generally told in winter when snow is on the ground and the long dark nights provide time for entertainment and stories.

Procedure

1. Explain the use of stories by the Native Americans to the students. This story is from the Shoshone - Bannock tribes, some of whom historically spent summers in Teton Valley collecting plants, hunting and fishing.

2. Have a student or a group of students read the myth out loud. You may want to practice pronouncing the Native American names for birds and define the word wikiup, which is a small temporary shelter woven with sticks.

3. Most of the birds in the story thought they were choosing the best place to nest.

   a. What basic needs do animals and humans have? Water, food and shelter.

   b. Why did the birds make the choices they did about their home sites? Protection from predators and the elements and near a source of food.

   c. Why did they laugh at the marsh wren who chose to live in the wetland? They thought she would drown because there was no dry ground or big trees to nest in.

   d. Which bird made the best choice of nesting sites? Each animal has different needs so their choices were appropriate for the specific bird, but the marsh wren does have easy access to water and rich food sources in the marsh.

Remember that 75% of Idaho wildlife species use wetlands and riparian areas at least part of their lives.

e. What is the lesson hidden in this story? Open for interpretation but could be a lesson in tolerance, for example do not laugh at others' choices because they might be very good from their point of view.

4. Have the students come up with a story based on plants or animals that live in wetland habitats that teaches a lesson in history, science or morals. Some ideas follow in case they have trouble thinking of a topic:

- Why wetland plants keep their "feet" in the water.
- How the beaver got a flat tail.
- Why the cranes congregate in the valley in the fall.
- How or why the frog learned to leap.
- Why the great gray owls meet in Teton Valley for the winter.

Extensions Students can act out their stories for younger children or "publish" a journal of their work.

Resources *Sage Smoke: Tales of the Shoshoni - Bannock Indians* by Eleanor Heady (Cleveland: Modern Curriculum Press, 1991)

Where The Birds Build: A Shoshone-Bannock Story

From *Sage Smoke: Tales of the Shoshoni - Bannock Indians* (Heady 1991)

Long ago when things were not yet settled, the birds held a powwow to decide where each one should live.

After a big supper around the campfire, the tall blue crane, Koontex, who was chief of the birds, said, "Now, we shall divide the land and the rocks and the trees and the streams, so that each bird family has the very best place for its nest."

"Please, O Chief," screamed Kwinaa, the eagle, "let us build at the top of the highest cliff. We have strong wings to fly to such high places, and our children will be safe from prowlers there."

"That is all right with me," sniffed Pantii, the killdeer. "What a bother it would be to fly so high."

"Very well," said the crane. "Kwinaa may build on the cliffs, while you, Pantii, will put your nest on the ground."

"No one has the willow thickets. Let me build my nest there," squawked Kwitawyon, the magpie. "there are plenty of dry sticks for a nest under the willows."

"The willows for the magpies," said Chief Koontex.

"Let us build our nests of mud on the sides of banks and cliffs," chirped Pasokompin, the swallow.

"A good, safe place that will be," agreed the Chief. "your sturdy houses will protect your children from wind, rain, and hunters."

The owl, Pittisi, asked for the tall pine and the dove for a nest on the ground. Koontex, the crane, agreed with all these requests.

But one little bird with a tiny voice like a willow whistle asked to have his home in the marsh among the reeds and cattails.

"You can't build there. You'll drown, shouted the birds. "Oh, no, I won't," chirped Tentsuki, the marsh wren. "Let me tell you how I'll build."

"How? How?" chirped, squeaked, and squawked all the other birds.

"I'll weave the tall slender leaves of the cattails together to make a snug wikiup. Then I'll put in a floor of grass and make my nest on that. My children will rock in the breeze as the reeds blow high above the water."

"But how will you get into your nest?" asked the crane.

"I'll have a hidden entrance," said the wren. "I shall fly under the nest, close to the water, and up through the reeds to the entrance. No one will see my nest because it will look just like the cattails around it."

"How clever," said Koontex. "You may certainly build in the marsh."

Now, since that day, all the birds have built in their chosen places. And Chief Koontex, the crane, followed the wisdom of the wren and chose to make his nest on a platform of reeds in the marsh. He stands on his stilt legs and watches as the other birds come and go. Because he guards everyone, the birds call him Ata, or Uncle.

And the rat's tail dropped off.

Section 6.
Laws and Strategies: An Overview of Wetland Policy and Conservation

A. Policy Overview

The federal government's policies toward wetlands changed dramatically in the mid-1970s. In the prior two hundred years, their policies directly encouraged the draining, channeling and filling of wetlands to accommodate agriculture, development and resource extraction with only a few exceptions. Today the federal government advocates the preservation of wetlands. The policy shift was based on the findings of scientists in the late 1960s and early 1970s regarding the functional and economic values of wetlands, including the role they play in flood protection, water purification, groundwater recharge, erosion control and as habitat for fish and wildlife species. By executive order in 1977, President Carter officially changed the future of wetlands by mandating their preservation by all federal agencies (Horwitz 1978, 52).

For the sake of understanding policy related to wetlands, it is unfortunate there is not one comprehensive law that governs what happens to wetlands and a single agency responsible for overseeing their protection. Instead a handful of federal, state and local regulations exist , with numerous agencies involved with wetland protection.

1. Federal Wetland Protection Programs

Clean Water Act 1972, 1982 - Originally called the Federal Water Pollution Control Act , this statute "seeks to maintain and restore the physical, biological and chemical integrity of our nation's water." Two sections of the act pertain to wetlands:

Section 404 established a permit program to regulate the discharge of dredged or fill materials into the nation's waters, which includes many wetlands. It is administered by the Army Corps of Engineers and the Environmental Protection Agency.

Section 401 requires state certification that any material discharged under a federal permit meets state safe water quality standards.

Food Securities Act 1985 and Farm Bills 1990, 1996 - The Swampbuster provision of these statutes denies federal subsidies to farmers who fill or drain their wetlands to create more agricultural land.

Duck Stamp Act 1934 - One of the first wetland conservation efforts, this act requires the purchase of a duck stamp by all waterfowl hunters and generates revenue to protect wetlands critical for duck reproduction via purchases and leases. To date this program has raised more than $331 million dollars and protected about 3.7 million acres of wetlands (Williams, Vincentz and Firehock 1996, 110) Until the 1970's, the duck stamp was among the few conservation efforts in a time of rapid loss of wetlands.

National Environmental Policy Act 1969 - The Act requires an evaluation of potential environmental impacts on all federally funded development projects, including assessment of wetland impacts if they exist on the site.

Emergency Wetlands Resource Act 1986 - This act directs the FWS to establish a list of high priority federal and state wetlands and provides money for their acquisition.

North American Waterfowl Management Plan 1986 - In this joint agreement between the United States, Canada and Mexico, the maintenance of waterfowl populations are promoted through the restoration and acquisition of important wetlands.

Endangered Species Act 1973 - The act requires that federal agencies protect federally listed endangered and threatened species by preserving their habitats. Since 43% of threatened or endangered species use wetlands for at least part of their lifecycle, this act is important for wetland preservation.

No Net Loss Goal 1989 - President Bush set a goal for the nation to achieve no net loss of wetlands. All agencies involved with wetlands had to emphasize their conservation in programs, policy and activities (US Department of the Interior 1990, 5). In light of continued wetland losses, the Clinton administration is considering a program to categorize wetlands so the most important ones in terms of biology and function are insured protection, while regulations regarding less significant wetlands are reduced (Jankovsky-Jones 1997, 1).

Wetlands Reserve Program 1991, Conservation Reserve Program 1986 and Partners for Wildlife 1992 - These programs provide landowners, in some cases farmers specifically, with incentives to voluntarily protect and restore their wetlands and wildlife habitat through conservation easements, payments and financial assistance with wetland restoration. The Conservation Reserve Program alone has helped establish an amount of wildlife habitat, some of it wetlands, larger that all the federal and state wildlife refuges in the lower 48 states (US Department of Agriculture 1997, 5)

2. *State and Local Wetland Protection Measures*

All of the states along the coastlines and several inland states have regulations regarding wetlands that supplement the federal programs, often with stricter measures. Idaho has not yet adopted any state regulations governing wetlands, though it does support an incentive program for wildlife habitat conservation through the Department of Fish and Game. Local governments can also be involved with wetlands protection through land use regulations.

3. *No Net Loss - Not Yet*

Wetlands continue to be lost at a high rate despite protective policies and increasingly positive public sentiment toward them (US Department of Interior n.d., 1). There are several problem areas that undermine even the best intentions of wetland management. The regulations that protect wetlands are fragmented and complicated. They are found under the jurisdiction of numerous agencies and, in some cases, apply to wetlands incidentally. For example, Section 404 of the Clean Water Act, the primary law offering protection for wetlands, initially covered the discharge of fill or dredged material in navigable waterways only. The regulatory jurisdiction was broadened to cover all waters of the United States in 1975, including many, but not all, wetlands. Section 404 does not regulate all the activities that damage wetlands, including draining or clearing. The permitting process has proven to be inclusive not exclusive. Less than 1 percent of the 48,000 applications for a Section 404 permit in 1994 were denied (US EPA 1995, 5). Lack of funding has lead to poor enforcement of regulations and surveillance of unpermitted activities is almost nonexistent (Kesselheim and Slattery 1995, 45).

Another problem area associated with wetland preservation is the issue of ownership; nearly 75% of the remaining wetlands in the United States are on private land (US EPA 1995, 30). The preservation of wetlands tends to benefit the general public and the environment, while the development of wetlands benefit the landowner, at least economically. While some landowners willingly protect wetlands on their property, not all landowners embrace the opportunity to provide benefits to the masses at the expense of their pocketbooks. The use of voluntary partnerships and incentive programs that promote conservation of wetlands on private lands, like the Conservation and Wetland Reserve Programs, is increasing and has the potential to make significant contributions to wetland preservation, especially those with high value for waterfowl (US Department of the Interior 1994, 23).

Considering the continued loss of wetlands, it is clear regulations in effect today and their enforcement do not provide full protection for wetlands. Over half of the respondents in a 1994 survey felt the need for more wetland protective efforts (US EPA 1995, 5). Policy strengthening, increased incentive programs and more wetland education programs are needed to offer further protection and achieve a no not loss of wetlands.

B. Wetland Protection and Conservation

Wetlands can be protected through a number of strategies: policies that encourage their preservation, land acquisition, incentives for preservation of wetlands on private land, and land use planning. The functions of degraded wetlands can be enhanced, restored and in rare cases created. And education programs that teach the public about the benefits of wetlands help create a force for their preservation.

Policies and Incentives Federal and state policies provide the backbone for wetland conservation. Examples are discussed in prior sections.

Acquisition The purchase of wetlands is a straight forward approach to their preservation. The federal government provides money for the acquisition of wetlands through the Emergency Wetlands Reserve Program. Organizations like The Nature Conservancy and Ducks

Unlimited purchase wetlands as one of their preservation tools. Land trusts and real estate agencies earmark properties with significant wetlands resources to encourage their purchase by buyers interested in conservation.

Incentive Programs and Conservation Easements Landowner incentive programs provide payment for the restoration and preservation of wetland areas and wildlife habitation on private property. Conservation easements are voluntary agreements that limit the uses of a property in exchange for financial benefit to the landowner. They are used by federal and state agencies and land trusts in cooperation with property owners to protect wetlands and wildlife habitat. Several federal incentive programs are listed in the policy section.

Land Use Planning Local and state land use regulations can provide protection for wetlands through zoning ordinances, subdivision regulations and sanitary codes (Cohen 1996, 18). Restrictions on development in wetland areas, requirement of buffer zones around wetlands, and regulations controlling the placement of septic systems in wet areas are a few examples of local government options for wetland preservation.

Restoration and Enhancement Restoration involves the restoring of natural functions to wetlands that have been degraded, dewatered or otherwise compromised by human activities. Enhancement projects promote healthy populations of plants and wildlife. They include the planting of vegetation, the re-establishment of the original water flow patterns, the control of weeds and pollution sources and the placement of nest boxes for birds.

Mitigation Mitigation refers to the creation or restoration of wetlands to offset the loss of wetlands to a development project. Success of mitigation projects vary, with most positive outcomes occurring at sites that once supported wetlands.

Education Information is an important tool for wetlands conservation. Attitudes toward wetlands can change slower than policy does, and education efforts help teach the public why wetlands are important and how to protect them. The more knowledgeable individuals are about the values of wetlands and the functions they provide, the more motivated and effective they are at protecting them (US EPA 1993).

Section 6. Activity 1.

A Wet Newspaper

Subject Area: Language Arts, Environmental Science, History, Art

Skills: Writing, drawing, interviewing, computer skills

EE Emphasis: Ecological foundations, conceptual awareness

Setting: Indoors

Vocabulary: Editorials

Objectives Students will refine and synthesize their knowledge of wetlands - including science, functions, values, policy and issues - through the creation of an informative newspaper.

Methods Students will prepare a newspaper focusing on wetlands that may include informative articles, art work, poetry, interviews and editorials.

Materials

- Paper
- Pens and pencils
- Art supplies
- Newspapers for examples
- Computers

Background Information Even in this age of television, radio and internet, newspapers are still a primary source of information. They are an excellent medium for full, in-depth coverage of a topic, such as wetlands. A student produced newspaper can provide excellent opportunities for writing, illustrating and interviewing as well as an understanding of the publishing process.

Procedure A student newspaper can take any number of forms. Explain to the students that they will write, publish and distribute a newspaper about wetlands. They may want to conceptualize and develop the whole project themselves or need help with the focus and initial organization of the paper.

1. Who is the audience? Other students in their school or possibly the community.

2. How do they want to organize the paper?

   a. Different sections like a traditional newspaper.

   - Headline and local news - Swans in Teton Valley, Sediment harming fish habitat, Local wetland preservation leaders.
   - Editorials - The need for preservation of wetlands, Growth requires more land for development.
   - Government - Local projects reduce erosion and create wildlife habitat (Conservation Reserve Program), Overview of policies relating to with wetlands.
   - Arts - Drawings, poetry and fiction about wetlands.
   - Food - Fish population details, recipes.

   b. Different sections for various aspects of wetland science and management. For example:

- Wetland characteristics
- Functions
- Humans and wetlands
- Threats to wetlands.

c. A single topic for a whole newspaper - For example, an issue on wetland wildlife or the functions of wetlands.

3. Once the initial organization is done, have the students become reporters and graphic artists working in specific news departments such as editorials or wetland functions. They may want to choose an editor and department heads to facilitate the production of the paper. Some practice with reporting or interviewing skills may be needed.

4. The use of a computer would allow the students to do their own word processing. Printing of the paper could be done at school or possibly at the local newspaper. Some of the better articles could be printed in the local newspaper.

Extensions The newspaper may turn into a seasonal publication or one that covers special issues.

Resources Look at local newspapers for article and format ideas.

Section 7.
Exploring Wetlands: An Introduction to Field Studies and Monitoring

The most important component of any wetland curriculum is the field study. Not only do the students get to see first hand the processes they have been studying in the classroom but witnessing the wonder of the wet environments often leads to increased interest in and appreciation for wetlands and their inhabitants.

A. Goals

The primary goal of all field studies should be student education. Observing, measuring and assessing the wildlife, plants and water that make up wetlands are excellent ways to support learning. Activities should be designed to challenge the student but not overwhelm them with details. Since three different types of wetlands areas are available to the students, excellent opportunities exist to make comparisons between the plant composition, animal life and soil and water conditions found at each site.

The second goal of field studies is to collect information about wetlands that can be used to evaluate their biological and functional health over time. This process is referred to as monitoring. The study of various parameters can help reveal and quantify changes that may occur at the wetland.

Students can begin to understand how human activities impact water quality.

B. Options for Field Studies

The activities described below are geared toward middle school students and are fairly basic in their approach. They include biological, physical and some chemical components of wetlands. Depending on the goals of the teacher, field studies and monitoring can include one, several or all of the following parameters:

BIOLOGICAL

- Inventories of animal, insect, bird, macroinvertebrates and fish populations
- Study of plant communities

PHYSICAL

- Soil sampling
- Physical characteristics of water
- Evaluation of wetland hydrology
- Survey of physical characteristics of the wetland or waterway.

CHEMICAL

- Chemical testing of water

C. Water Quality Testing

The methods for monitoring the chemical components of water are not covered in full here because they are rather complicated and most require a substantial investment for test kits and lab analysis. There are several excellent guides to the chemical sampling of water which are listed in the resources of Water Surveys, Section 7, Activity 7.

In the past, a handful of schools along the Snake River have sampled water quality parameters and shared their data through computer networking. If the effort were to begin again in earnest, the pooling of data with other schools would give students a chance to understand water quality issues in a much larger section of the watershed and to benefit from interacting with other students doing similar work.

D. Student Safety and Wetland Protection

Before venturing in a wetland, the students should discuss safety considerations and wetland protection measures. Encourage the students to wear footwear and clothing appropriate for the wetland. Knee-high rubber boots are often best, but old tennis shoes or water sandals also work. Long pants and long sleeved shirts can be useful because they provide protection from bushes and insects. A rain jacket, sun hat, sun screen, insect repellent, water and food are important to bring, especially if field work will take more than a few hours.

Though Idaho wetlands are generally benign ecosystems, there are some hazards that students must be cautioned about. Wading in any water body over knee deep or with substantial current should be avoided. Care should be taken along stream banks and on logs because both can be slippery. Students should watch for vegetation with thorns or sharp branches, steep slopes and stinging insects.

Wetlands can be fragile ecosystems, sensitive to damage from human trampling. To protect them, encourage students to stay on trails when possible and avoid breaking branches and harming vegetation. Travel through the wetland quietly to disturb wildlife as little as possible. Avoid bird nesting areas. If rocks and logs are over turned to search for insects, return them to their original positions. Have students observe and identify plants and wildlife without harming them. Carefully plan any collection so the fewest plants or insects are taken. Remind the students to keep track of all their belongings and trash so nothing is left in the wetland.

Section 7. Activity 1.

Field Guide to the Wetlands of Teton County

Subject Area: Earth Science, Botany, Art

Skills: Research, consolidation of information, writing,

drawing, computer skills

EE Emphasis: Ecological foundations

Setting: Outdoors and indoors

Vocabulary: Macroinvertebrates

Objectives Students will communicate their knowledge of wetlands by creating a guide book.

Methods Students write a guide book to wetlands with information on the plant, insect and animal species, soil and hydrology found at the site.

Materials

- Field guides
- Resources on birds, mammals, plants, soils, amphibians, insects and macroinvertebrates
- Paper, pens and pencils
- Art supplies
- Computer

Background Information The following field activities will amass information on the living and non-living components of wetlands.

Much of this information can be consolidated and put into a field guide.

Procedure

1. Let the students know that the information they collect during the field studies of wetlands will be put into a field guide.

2. Determine what information will go into the field guide and who the audience will be. Some ideas follow: plants, animals, amphibians, insects, macroinvertebrates, birds, tracks, scat, historical uses, hydrology, maps and information on types of wetlands.

3. Organize the sections and determine the needs for written text and drawings. Have the students research and write the document.

Extensions The guide could also take the form of plant and animal identification cards with common and scientific names of species, drawings, descriptions, habitats, what an animal eats and who eats it and other interesting facts about the species on each card. They could be taken into the wetland and used on future field trips.

Section 7. Activity 2.

Plant Surveys

Subject Area: Botany, Environmental Science

Skills: Estimating percentages, counting species

EE Emphasis: Ecological foundation

Setting: Outdoors in wetland

Vocabulary: Transect, woody, herbaceous, emergent, floating, submergent, shrubs, forbes, sedges, rushes and grasses

Objectives Students learn about the vegetation found in wetlands.

Methods There are many options for studying wetland vegetation. Rather than presenting a single methodology, several ideas will be discussed.

Materials

- Stakes
- String
- Clipboard or other hard writing surface
- Pencils
- Field guide

Background Information Wetland vegetation is discussed in Section 2, B, E and F. The study of plants can vary in sophistication, from simple identification of groups of plants to more complex identifications of individual species.

Procedure

1. Students can learn to recognize the different groups of wetland plants.
   - Woody and herbaceous
   - Emergent, floating and submergent
   - Shrubs and trees

2. Students can learn to recognize some of the main species in the wetlands- common shrubs, trees, forbes and grass-like plants including sedges, rushes, and grasses. The following rhyme about wetland vegetation may be helpful:

> Sedges have edges, rushes are round,
> Grasses have joints and willows abound.

3. Students can set up vegetation sampling studies to compare plants in different sections of the wetlands or compare vegetation between two or three wetlands.

The use of transects are a straightforward way to sample vegetation in a particular area. An area of study is determined and two stakes are placed in the ground, one at each end of the defined area. In wetlands, plants are found in zones relating to wetness. A cross section of these zones can be studied by placing one stake in or near the water and the other toward a dryer area, such as an upland. A string is used to connect the two stakes. At specified lengths along the string (20' is common) use a hula hoop or some other object that defines a specific area to sample vegetation. By leaving the stakes in the ground, the same area can be surveyed in different seasons or in subsequent years.

Depending upon the skills and interests of the students, the information they collect at each station can be basic or more specific. It may include:

a. The number of individual plants or the percentage of cover for:

- Groups of vegetation- emergent, floating, submergent, shrubs, trees. (Example: 90% emergents, 10% shrubs).
- Or common families, genera or species- grasses, sedges, rushes, specific shrubs, forbes and trees. (Example: 50% sedges, 40% Geyer's willow, 10% forbes).

b. Number of different species- called species richness.

c. The height of the vegetation. Take 4-6 measurements per station and average their heights.

Each student team can have their own transect and collect data at all the stations, or there can be two transects and student groups work at a station or two and share their data.

4. Students can make drawings of common plants.

5. Students can make vegetation maps of part or all of the wetlands that shows where different groups or species of plants are most common. The students can summarize the data in ways that enhance their understanding of the distribution of wetland plants, such as pie charts with percentage cover for different species, genera or families, bar charts with species richness and lists describing species found.

Resources Local naturalists may be able to provide assistance with vegetation sampling.

Section 7. Activity 3.

Mammal, Bird and Amphibian Surveys

Subject Area: Natural Science, Biology

Skills: Observation, documentation, drawing

EE Emphasis: Ecological foundations

Setting: Outdoors

Vocabulary: Scat, amphibians

Objectives Students will learn to find signs of mammals, birds and amphibians even if no animal life is observed.

Methods Through careful observation students will find tracks, scat, nests, egg clusters and hear the sounds created by mammals, birds and amphibians.

Materials

- Guide books covering mammals, birds, amphibians, scat and tracks
- Paper and pens
- Binoculars

Background Information When a group of students descends on a wetland, anything that can move heads for cover. Though highly desirable to see, mammals and amphibians are difficult to sight even under ideal conditions. The signs they leave and the sounds they make will be useful in determining what animals live in the wetlands. It can be useful to introduce to the students the species generally found in wetlands before their visit, though exploration without prior information is also a beneficial approach.

Procedure

1. Discuss with the students different signs mammals, birds and amphibians leave of their presence, including evidence of browsing on shrubs, matted grasses where animals have slept, nests, egg masses and scat. Remind them to use their ears and listen for the songs and calls of birds and frogs.

2. Working in groups, have the students quietly walk to the center of their designated areas and remain still for 5-10 minutes. They can watch the ground for rodent sightings and the sky and bushes for birds. Students can attempt to draw birds to them by making a "pishing" noise (rhymes with dish). Have the students say it a few times, pause, then do it again.

3. After a segment of quiet time, have the students move through their designated areas checking the bushes, ground, sky and water for signs of animals. You may have them place brightly colored flags near a sign so that the class can come back as a group to interpret it.

4. When signs are found or animals sighted, the students can document where they found it, what it looked like, what the animal

was doing and what animal made the sign. They can provide a drawing of the sign or animal.

Extensions

1. Transects can be used for animal sightings in monitoring projects so seasonal and year to year data is taken from the same area.
2. Students can create a list of different species sighted each year and a master list of sightings with all years. The information can be used to estimate population changes over time.
3. Students can attempt to find all the groups of life forms found on earth in the wetland, from simple protozoa to vertebrates. See *Pond Life* for examples of each group (Reid 1987).

Resources Naturalists in Teton Valley can help with the field identification of mammals, birds and amphibians.

Mammal, Bird and Amphibian Surveys			
	Sign of Animal or Sighting Details	Description of Habitat	Drawing
1.			
2.			
3.			
4.			
5.			

Section 7. Activity 4.

Mapping a Wetland

Subject Area: Natural Sciences, Environmental Science, Mathematics

Skills: Drawing, measuring and plotting

EE Emphasis: Ecological foundations

Setting: Outdoors at wetland

Vocabulary: Scale, graph paper

Objectives Students will create a map of the wetland, with information on hydrology, wildlife sighting and plant distribution.

Methods Through measurements and observations, students create a map of the wetland to scale.

Materials

- Tape measure
- Stakes
- Drawing material including graph paper

Background Information The creation of maps help students conceptualize the size and the shape of the wetland. Wildlife sightings and plant types can be located on the maps, as can water features such as streams, ponds and areas with standing water. Maps can vary in their detail and adherence to scale depending upon the interests and abilities of the students. The can include the whole wetland or just a part of it.

Procedure

1. To create a map to scale, distances will need to be measured using a tape measure or by pacing off the area after determining the average length of a person's pace. To simplify matters, the perimeter could be measured and mapped prior to the field study and the students could fill in interior details. For greater accuracy, stakes can be placed around the area to be measured and the distance between the stakes paced off and measured. (Measured pace) x (Number of steps between stakes) = The distance between stakes. If using the pace method, two or three pacers increases the accuracy of the measurements (just average the pacers' totals).

2. A scale will need to be determined. One square on graph paper equals one foot on the ground is the easiest scale to work with but one inch equals ten feet is also very workable. With the above measurements, sketch in streams, areas saturated with water, uplands, regions with thick shrubs or trees, areas with emergent vegetation, places where wildlife was sighted and other interesting observations. The use of symbols can be helpful.

Extensions Determine if there is a correlation between different vegetation types and animal or bird sightings. For example: Are there more Yellow Warblers in the bushes along the creek or river than in areas without surface water? The answer should be yes.

Section 7. Activity 5.

Wetland Soil Survey

Adapted from *Wow: The Wonders of Wetlands* (Kesselheim and Slattery 1995)

Subject Area: Earth Science

Skills: Observation, identification

EE Emphasis: Ecological foundations

Setting: Wetland and Classroom

Vocabulary: Texture, organic matter, Munsell color chart

Objectives Students will understand what makes wetland soils unique and be able to recognize mineral and organic soils.

Methods Using a soil probe or small shovel, students will obtain wetland soil samples from a marsh and peatland.

Materials

- Soil probe or small shovel (trowel OK)
- Yard stick
- Paper and pencils
- Copies of Munsell chart (These can be purchased or created by the students. If student versions are to be made, several 64- color boxes of Crayola® Crayons will be needed)

Background Information Wetland soil information can be found in Section 2. B. There is a substantial difference between the soil in a peatland and a marsh by the river. The former will have high levels of organic matter and latter will have higher concentrations of mineral soil.

Procedure

1. If using the student made soil color charts, take time in class before the wetland visit to color the chart. See end of activity for chart to color from *WOW!: The Wonders of Wetlands* (Kesselheim and Slattery 1996, 237).

2. At the wetlands, either dig a 18" hole with a small shovel or use the soil probe to obtain a sample. The probe is less disruptive to the wetland and will cause less cumulative impact, especially if samples are taken regularly. To minimize damage to the wetland when using a hole dug with a shovel, first cut around all four sides and try to remove the soil block as a unit. When done, replace the soil block and disguise the hole by sprinkling plant material over it.

3. Remove samples of soil at 3", 6", 12" and 18" down from the surface. Let the students feel the soil to detect its texture and moisture level. They can write their observation on the data sheet.

4. Using a color chart, have them determine the color of the soil. Does the color indicate that the soil is a wetland soil?

5. Remember to fill in the hole when you are done.

6. Compare the soil survey from the peatland with that of the marsh. Ask the students to describe the differences between the two soil profiles including color, texture presence of organic matter and wetness. Which has more organic matter? Which has more sand and mineral soil characteristics?

Extensions Take a sample at an upland site to see how it differs.

Resources Employees of the Natural Resources Conservation Service may be able to help with soil surveys.

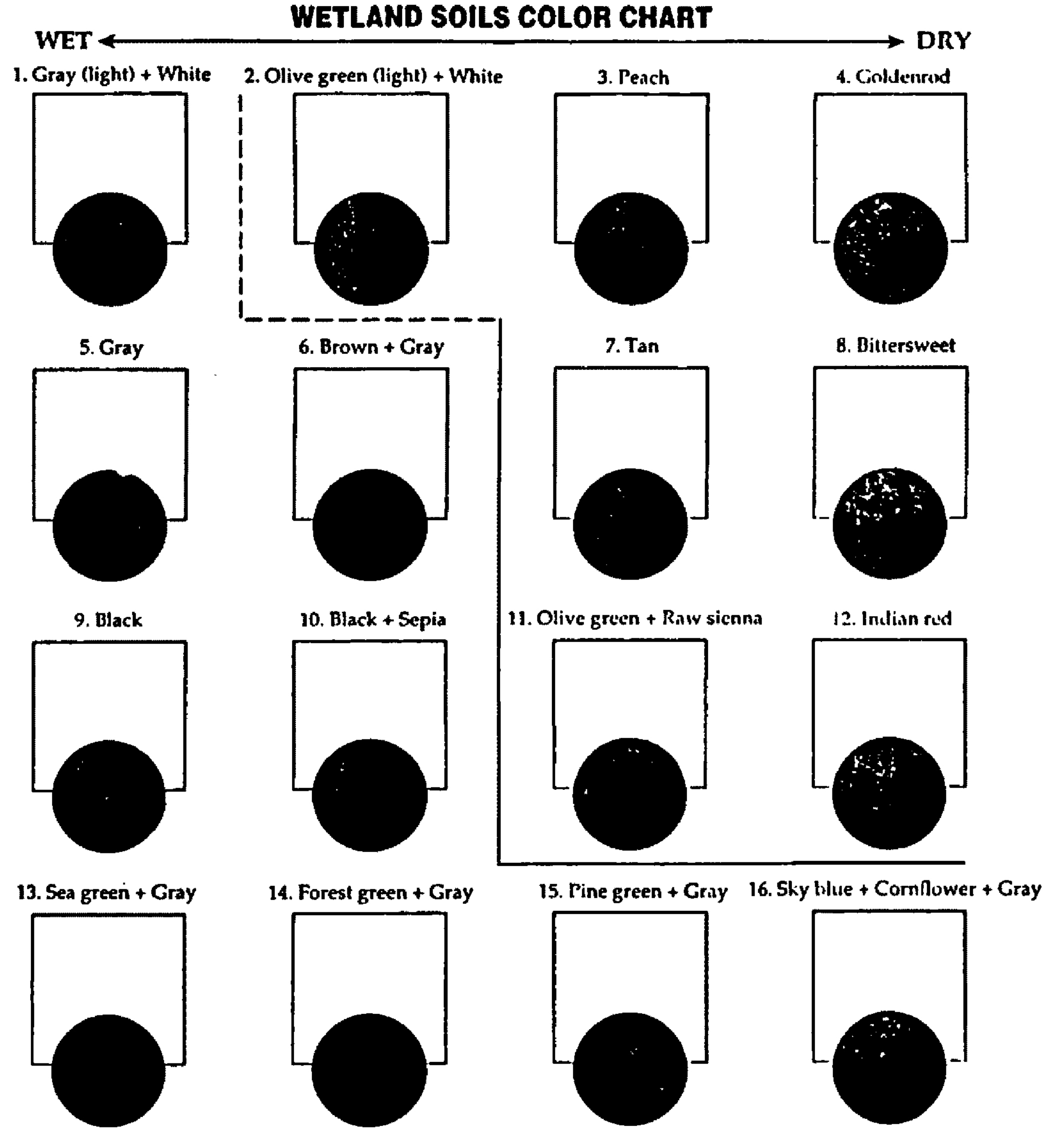
Wetland Soil Chart			
	Texture	**Moisture**	**Color**
3 inches			
6 inches			
12 inches			
18 inches			
	Texture: Gritty (sand), Sticky (clay), Slippery (clay), Plant parts (organic matter)	Moisture: Dry, moist, wet	Color: Use Munsell chart or student colored soil chart.

Use Crayola• Crayons to color in the squares on the chart below. It is very important to use the right colors! Press firmly when coloring, unless the name says "light." Cut out the whole chart and paste it to a piece of posterboard or half of a manila folder. Carefully cut out the black circles, through all thicknesses.

Use this color chart when studying soil in the field. Wetland scientists use similar but much more complicated color charts to identify wetland soils. Hold the chart in one hand; in the other hand hold a sample of soil behind the chart, so that it is visible through one of the holes. Your soil sample may contain bits of rock, organic material, and mineral concentrations. You must key out only the dominant soil color and ignore all other materials. Move the sample around until you find one or two colors that nearly match or approximate the dominant color.

Numbers 1, 5, 6, 9, 10,·13, 14, 15, 16, and sometimes 2 are probably wetland soils; the others are probably not wetland soils. Any soil with a basic (matrix) color that is a shade of dark brown, black, or gray may be a wetland soil. You will probably see other colors and materials within the matrix soil color. These colorful streaks may be the result of certain minerals. They appear as shades of red, orange, and yellow (associated with iron in the soil), or black (associated with manganese, not to be confused with dark organic material). These areas are good indicators of seasonal wetlands and other wetlands that are not always wet. Do not use these color mottles to key out the soil, but recognize that they are an additional indicator of wetland conditions.

WETLAND SOILS COLOR CHART



Section 7. Activity 6.

Wetland Macroinvertebrate Survey

Subject Area: Biology, Environmental Science

Skills: Observation, identification

EE Emphasis: Ecological foundations, conceptual awareness

Setting: Outdoors in wetland or stream

Vocabulary: Macroinvertebrates

Objectives Students will learn to identify major orders of macroinvertebrates and use their data as a tool in evaluation of water quality.

Methods Macroinvertebrates will be collected in wetlands or nearby streams and identified and counted. Simple calculations will be made to assess the biological health of the wetland or stream.

Materials

- D-net
- Ice cube trays
- White plastic dish pans or other light colored plate or pan
- Magnifying glass
- Tweezers and plastic spoons for picking up insects
- Identification materials
- Data sheets

Background Information Macroinvertebrates are aquatic insects found in most healthy streams, lakes and wetland ponds. Many macroinvertebrates represent the larval stage of terrestrial insects, such as dragonflies, mayflies and black flies. The tolerance of macroinvertebrates to polluted water varies, so they are useful indicators of water quality.

Procedure Most sampling procedures for macroinvertebrates are based on streams and rivers and not wetlands. To adapt the procedures to wetlands, sample a variety of water covered habitat types within the wetlands with each survey. Or students can sample a stream that flows through a wetland or one that feeds or drains a wetland.

1. Choose a site in the wetland or stream that is characteristics of the whole area. If the sampling will be a long term study, record or mark the area to be sampled so it is easy to find again.

2. Using a D-frame net, scrape the bottom of the wetland pond or steam bed, around vegetation, beneath undercut banks and in areas with fast and slow current. If there is a moderate flow, it may be useful to have someone stand upstream of the net and shuffle through the cobbles to dislodge more macroinvertebrates.

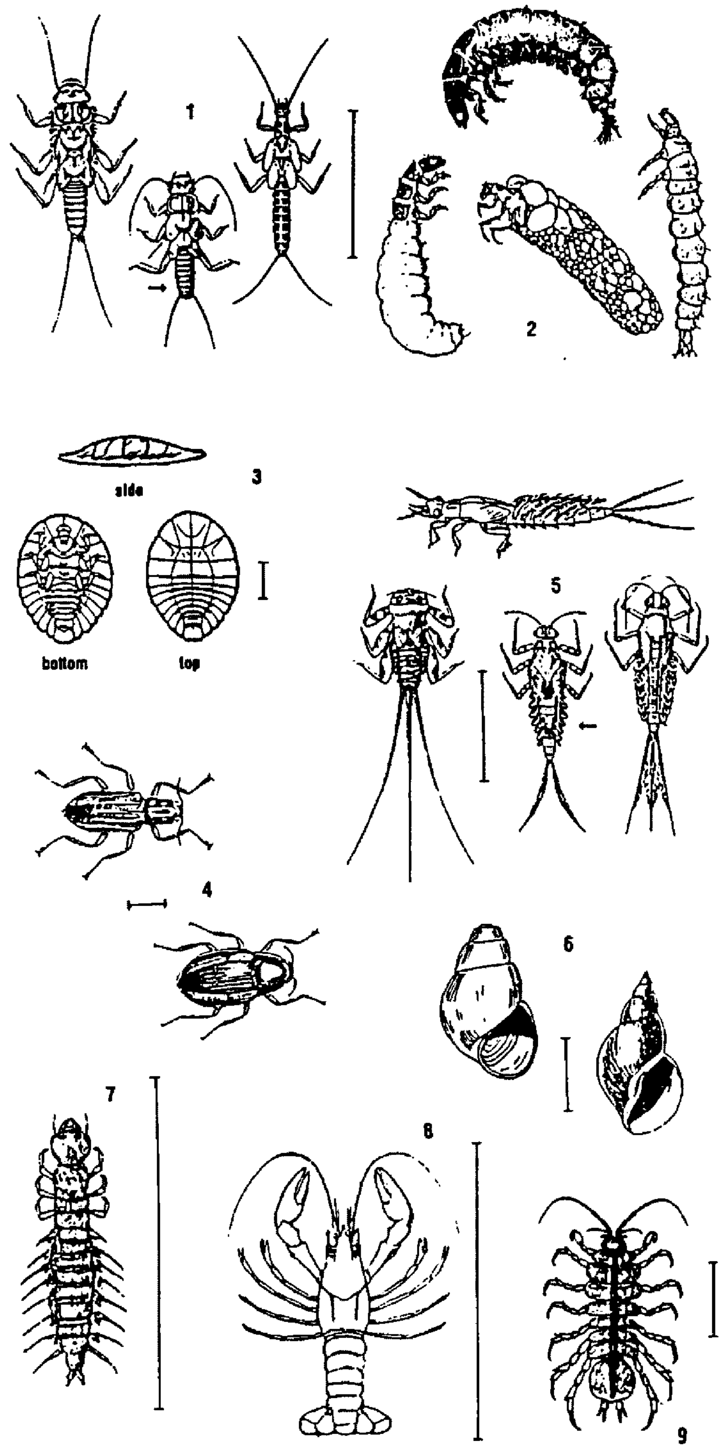
3. Empty the sample into a white (or light colored) plastic dish pan and begin to sort the insects into the ice cube trays according to type.

4. Using insect keys and picture resources, identify the macroinvertebrates and count the number of each type. Basic identification material and a useful data form from *Hands On Save Our Streams: The Save Our Streams Teacher's Manual* (Firehock 1995, 157-60) is included with this activity.

5. The students can use their data to get an estimate of water quality by calculating the Water Quality Rating using the Stream Quality Survey sheet that follows. Keep in mind that high altitude streams naturally have fewer numbers of different macroinvertebrate types so a low rating does not necessarily indicate a pollution problem.

Extensions Students can research the different roles macroinvertebrates play in food chains and nutrient cycling in wetlands and streams.

Resources There is a chapter in *Streamkeeper's Field Guide* on macroinvertebrate sampling (Murdoch & Cheo, 1996 118-163). *Pond and Stream Safari: A Guide to the Ecology of Aquatic Invertebrates* provides excellent background information on aquatic insects geared toward students (Edelstein 1996).



Bar lines indicate relative size

Stream Insects & Crustaceans

GROUP ONE TAXA

Pollution sensitive organisms found in good quality water

1 ***Stonefly: Order Plecoptera.*** 1/2" - 1 1/2", 6 legs with hooked tips, antennae, 2 hair-like tails. Smooth (no gills) on lower half of body. (See arrow.)

2 ***Caddisfly: Order Trichoptera.*** Up to 1", 6 hooked legs on upper third of body, 2 hooks at back end. May be in a stick, rock or leaf case with its head sticking out. May have fluffy gill tufts on underside.

3 ***Water Penny: Order Coleoptera.*** 1/4", flat saucer-shaped body with a raised bump on one side and 6 tiny legs and fluffy gills on the other side. Immature beetle.

4 ***Riffle Beetle: Order Coleoptera.*** 1/4", oval body covered with tiny hairs, 6 legs, antennae. Walks slowly underwater. Does not swim on surface.

5 ***Mayfly: Order Ephemeroptera.*** 1/4" - 1" brown, moving, plate-like or feathery gills on sides of lower body (see arrow), 6 large hooked legs, antennae, 2 or 3 long, hair-like tails. Tails may be webbed together.

6 ***Gilled Snail: Class Gastropoda.*** Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

7 ***Dobsonfly (Hellgrammite): Family Corydalidae.*** 3/4" - 4", dark-colored, 6 legs, large pinching jaws, eight pairs feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, 2 tails and 2 pairs of hooks at back end.

GROUP TWO TAXA

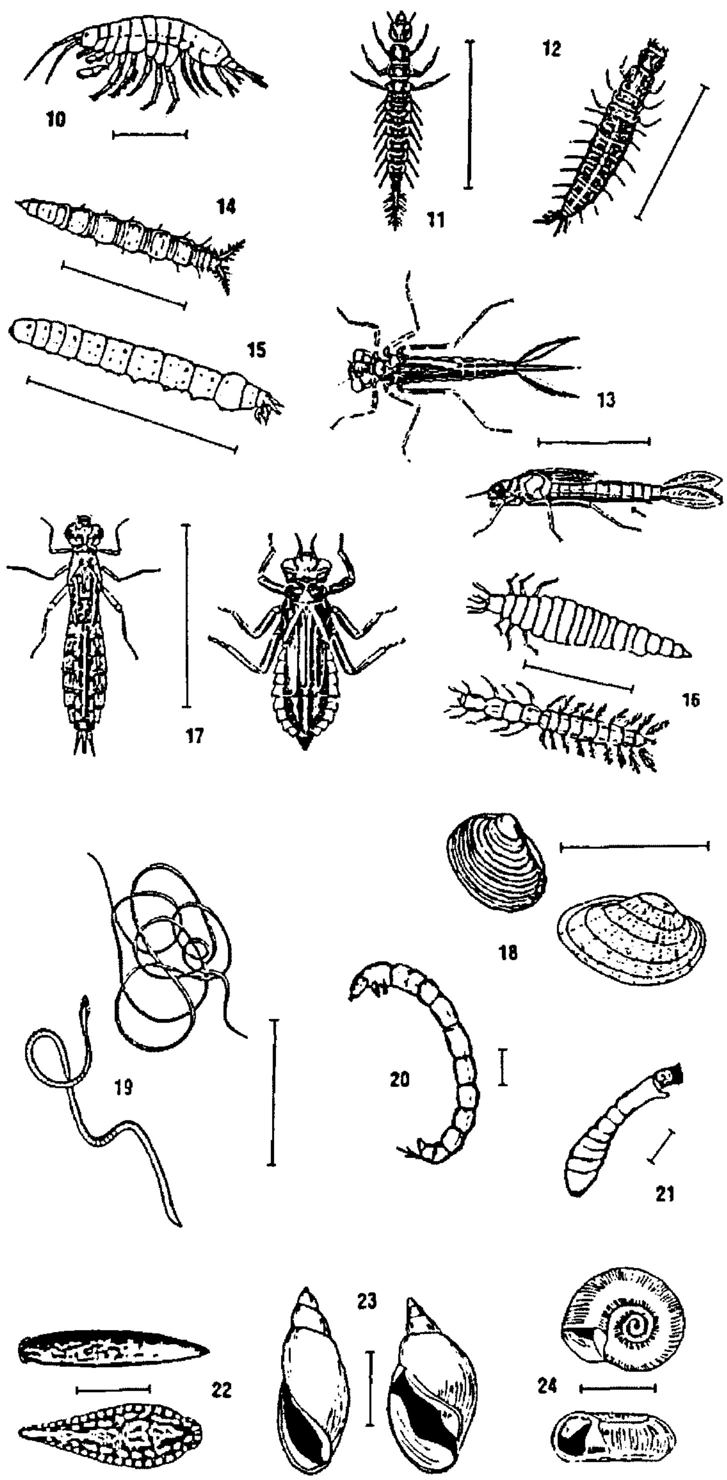
Somewhat pollution tolerant organisms can be in good or fair quality water

8 ***Crayfish: Order Decapoda.*** Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 ***Sowbug: Order Isopoda.*** 1/4" - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

Save Our Streams

Izaak Walton League of America
707 Conservation Lane
Gaithersburg, MD 20878-2983
1(800)BUG-IWLA



Bar lines indicate relative size

GROUP TWO TAXA CONTINUED

10 ***Scud: Order Amphipoda.*** 1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 ***Alderfly Larva: Family Sialidae.*** 1" long. Looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 ***Fishfly Larva: Family Corydalidae.*** Up to 1 1/2" long. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

13 ***Damselfly: Suborder Zygoptera.*** 1/2" - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body (See arrow.)

14 ***Watersnipe Fly Larva: Family Athericidae (Atherix).*** 1/4" - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 ***Crane Fly: Suborder Nematocera.*** 1/3" - 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger-like lobes at back end.

16 ***Beetle Larva: Order Coleoptera.*** 1/4" - 1", light-colored, 6 legs on upper half of body, feelers, antennae

17 ***Dragon Fly: Suborder Anisoptera.*** 1/2" - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 ***Clam: Class Bivalvia.***

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water

19 ***Aquatic Worm: Class Oligochaeta.*** 1/4" - 2", can be very tiny; thin worm-like body

20 ***Midge Fly Larva: Suborder Nematocera.*** Up to 1/4", dark head, worm-like segmented body, 2 tiny legs on each side.

21 ***Blackfly Larva: Family Simulidae.*** Up 1/4", one end of body wider. Black head, suction pad on other end.

22 ***Leech: Order Hirudinea.*** 1/4" - 2", brown, slimy body, ends with suction pads.

23 ***Pouch Snail and Pond Snails: Class Gastropoda.*** No operculum. Breathe air. When opening is facing you, shell usually opens on left

24 ***Other Snails: Class Gastropoda.*** No operculum. Breathe air. Snail shell coils in one plane

Save Our Streams

Stream Quality Survey

October 1994

Name of reviewer: __________
Date reviewed: __________
Data sent to: __________

The purpose of this form is to aid you in gathering and recording important data about the health of your stream. By keeping accurate and consistent records of your observations and data from your macroinvertebrate count, you can document changes in water quality. Refer to the SOS insect card and monitoring instructions to learn how to trap and identify stream macroinvertebrates and how to complete this form.

Stream__________ Station #__________ # of participants __________

County__________ State__________ Group or individual__________

Location __________

Weather conditions (last 72 hours) __________

Date__________ Average stream width__________ ft. Average stream depth __________ ft.

Start Time__________ End Time__________ Flow rate: High__________ Normal__________ Low__________ Negligible __________

If conducting rocky bottom sampling, select a riffle where the water is not running too fast, the water depth is between 3-12 inches, and the bed consists of cobble-sized stones or larger. Monitored riffle area (3' x 3' square) _______ Water depth ______in., in riffle. Water temperature_________ F° ? C° ? Take 3 samples in the same general area. Count each separately and report the highest-scoring sample below. Sample _________ reported of 3.
If conducting muddy bottom sampling, take the required number of scoops from each habitat type: steep banks/vegetated margin (10 scoops), woody debris with organic matter (4 scoops), rock/gravel/sand substrates (3 scoops), and silty bottom with organic matter (3 scoops).

MACROINVERTEBRATE COUNT

Use the stream monitoring instructions to conduct a macroinvertebrate count. Use letter codes (A = 1-9, B = 10-99, C = 100 or more) to record the numbers of organisms found in a 3 foot by 3 foot area. Add up the number of letters in each column and multiply by the indicated index value. The following columns are divided based on the organism's sensitivity to pollution.

SENSITIVE	SOMEWHAT SENSITIVE	TOLERANT
_____ caddisfly larvae	_____ beetle larvae	_____ aquatic worms
_____ hellgrammite	_____ clams	_____ blackfly larvae
_____ mayfly nymphs	_____ crane fly larvae	_____ leeches
_____ gilled snails	_____ crayfish	_____ midge larvae
_____ riffle beetle adult	_____ damselfly nymphs	_____ pouch (and other) snails
_____ stonefly nymphs	_____ dragonfly nymphs	
_____ water penny larvae	_____ scuds	
	_____ sowbugs	
	_____ fishfly larvae	
	_____ alderfly larvae	
	_____ atherix	
_____ # letters times 3 =	_____ # letters times 2 =	_____ # letters times 1 =
_____ index value	_____ index value	_____ index value
Now add together the three index values from each column for your total index value. Total index value = __________		

Compare this total index value to the following ranges of numbers to determine the water quality of your stream. Good water quality is indicated by a variety of different kinds of organisms, with no one kind making up the majority of the sample. Although the A, B, and C ratings do not contribute to the water quality rating, keep track of them to see how your macroinvertebrate populations change over time.

WATER QUALITY RATING

______ Excellent (>22) ______ Good (17-22) ______ Fair (11-16) ______ Poor (<11)

Fish water quality indicators:
☐ scattered individuals
☐ scattered schools
☐ trout (pollution sensitive)
☐ bass (somewhat sensitive)
☐ catfish (pollution tolerant)
☐ carp (pollution tolerant)

Barriers to fish movement:
☐ beaver dams
☐ man-made dams
☐ waterfalls (>1 ft.)
☐ other
☐ none

Stream: ____________________
Station #: ____________________
Date: ____________________

Surface water appearance:
☐ clear
☐ clear, but tea-colored
☐ colored sheen (oily)
☐ foamy
☐ milky
☐ muddy
☐ black
☐ grey
☐ other ________

Stream bed deposit (bottom):
☐ grey
☐ orange/red
☐ yellow
☐ black
☐ brown
☐ silt
☐ sand
☐ other ________

Odor:
☐ rotten eggs
☐ musky
☐ oil
☐ sewage
☐ other ________
☐ none

Stability of stream bed:
Bed sinks beneath your feet in:
☐ no spots
☐ a few spots
☐ many spots

% bank covered by plants, rocks and logs (no exposed soil) is:	**Good** >70%	**Fair** 30%-70%	**Poor** <30%
Stream banks (sides)	____	____	____
Top bank (slope and floodplain)	____	____	____

Algae color:
☐ light green
☐ dark green
☐ brown coated
☐ matted on stream bed
☐ hairy

Algae located:
☐ everywhere
☐ in spots
____ % of bed covered

Stream channel shade:
☐ >80% excellent
☐ 50%-80% high
☐ 20%-49% moderate
☐ <20% almost none

Stream bank composition (=100%):
____ % trees
____ % shrubs
____ % grass
____ % bare soil
____ % rocks
____ % other ________

Stream bank erosion:
☐ >80% severe
☐ 50%-80% high
☐ 20%-49% moderate
☐ <20% slight

Riffle composition (=100%):
____ % silt (mud)
____ % sand (1/16"-1/4"grains)
____ % gravel (1/4"-2" stones)
____ % cobbles (2"-10" stones)
____ % boulders (>10" stones)

MUDDY BOTTOM ONLY: Record the number of scoops taken from each habitat type. Provide any details (mostly sand, little silt, etc.) to best describe the habitat.
☐ Steep bank/vegetated margin ____________
☐ Woody debris with organic matter ____________
☐ Rock/gravel/sand substrates ____________
☐ Silty bottom with organic matter ____________

Land uses in the watershed: Record all land uses observed in the watershed area upstream and surrounding your sampling site. Indicate whether the following land uses have a high (H), moderate (M), slight (S), or none (N) potential to impact the quality of your stream. Refer to the SOS stream survey instructions to determine how to assess H, M, S, or N. If the land use is not present in your watershed, leave the space blank.
☐ Oil & gas drilling
☐ Housing developments
☐ Forest
☐ Logging
☐ Urban uses (parking lots, highways, etc.)
☐ Sanitary landfill
☐ Active construction
☐ Mining (types) ________
☐ Cropland (types) ________
☐ Trash dump
☐ Fields
☐ Livestock pasture
☐ Other ________

Are there any discharging pipes? ☐ no ☐ yes If yes, how many? ________
What types of pipes are they? ☐ runoff (field or stormwater) describe: ____________
☐ sewage treatment ________ ☐ industrial: type of industry ____________

Did you test above and below the pipes to determine any change in water quality? Were changes noticed? NOTE: If you answer *Yes*, you must submit two different survey forms, one for above the pipe and one for below the pipe, to document your claim.

Describe amount of litter in and around the stream as % of ground cover. Also describe the type of litter in and around the stream.

Comments Indicate what you think are the current and potential future threats to your stream's health. Feel free to attach additional pages or photographs to better describe the condition of your stream. ____________

Section 7. Activity 7.

Water Surveys

Subject Area: Earth Science, Environmental Science

Skills: Measuring, identifying, matching

EE Emphasis: Ecological foundations, conceptual awareness

Setting: Outdoors in wetland or stream

Vocabulary: Sediments, pH, dissolved oxygen, nutrients, buffer zone, nitrogen, phosphorus.

Objectives The students will learn to quantify several components of water quality.

Methods Students will sample physical and chemical components of the water in and around wetlands.

Materials The materials vary depending upon which water measurements are chosen. See specific tests for information on each one.

Background Information Depending upon the goals of the teacher and students, the sampling of water can include several types of physical and chemical measurements. If the water sampling activity is intended as an introductory, once per year endeavor, the number of samples and rigorousness of the procedures can be fewer and less particular. They may include measuring temperature, depth, rate of flow and some of the easier chemical measurements, such as dissolved oxygen and pH.

On the other hand, if the sampling is to be regular (once per season or even once per month) and possibly part of a regional student effort to study water quality along the Snake River and its tributaries, the parameters and accuracy of the samples would need to increase.

Since water quality in wetlands and streams is so intimately connected to what occurs on surrounding lands and in the riparian areas, some measure of vegetation health, bank condition and the existence of a buffer zone are important. Simple procedures follow but more detailed information on assessing stream corridor conditions can be found in the *Streamkeeper's Field Guide* (Murdoch and Cheo 1996).

Discussion and sampling information will be given on the following water quality measurements. See the resources at the end of this activity for information on additional tests.

Physical Water Measurements	Chemical Water Measurements	Habitat Assessment
Depth	pH	Vegetation
Temperature	Dissolved Oxygen	Bank stability
Rate of Flow	Sediments	Buffer Zone Size
	Nutrients	

1. Physical Water Measurements

Depth

Regular measurements of the depth of water in wetlands can help the students understand how water levels fluctuate throughout the year. Comparisons between the depth of water in the marshes along the river and the spring-fed fens can illustrate how water conditions vary at different wetlands.

The easiest way to measure water depth is to install a gauge made from a PVC pipe, wooden post or metal stake and check it at specific intervals. Increments of measure (feet and inches or meters) can be painted on the stake in alternating bands of white and red. The stake should be installed in an area that can be accessed (or viewed with binoculars) during both dry and wet seasons.

A chart can be developed for data collection and display of results. A gauge that registers the high water level is useful if the gauge won't be checked very often. An inexpensive one can be made using directions in the *Handbook for Wetlands Conservation and Sustainability* (Williams, Vincentz and Firehock 1996, 72-3).

Temperature

Many aquatic organisms are cold blooded. They cannot regulate their own temperature so their body temperatures are the same as the surrounding water. Each organism has a range of temperatures in which it can survive. For example, many trout and salmon can only live in water fifty-five degrees or below (Murdoch and Cheo 1996, 177). Cold water holds more oxygen than warmer water so if water becomes too warm aquatic organisms can die of oxygen deprivation. Humans contribute to elevated water temperatures in streams and rivers by (1) adding water warmed by power plants, industrial processes and agriculture, (2) removing vegetation that provides shade to the water from streambanks directly or through overuse by grazing animals and (3) the building of dams where water flows from the top of the dam.

A temperature measurement is taken by placing a thermometer with a string attached to it between four to six inches below the surface of the water. After two minutes the reading can be taken, in either Celsius or Fahrenheit. A chart can be developed to track the temperatures and display the data. Temperature differences between the spring water in the fens, the shaded, fast moving tributary water and the wide, slow moving river water will probably be evident.

Flow Rate

Determining the flow rate of water through a wetland, a creek or river is a useful exercise in science and math. The flow rate effects how much sediment the stream can carry (faster water carries more sediment), the amount of oxygen in the water (faster moving water generally has more oxygen because it is better aerated due to rapids) and the amount of erosion the moving water causes (faster water is capable of causing more erosion than slower moving water).

The flow rate of water is a common measurement in stream and river monitoring. If a wetland contains streams like the fens do or is adjacent to a river like the marshes, flow information can also be useful. In fact, little is known about the how much water the springs in the valley contribute to surface water sources so measuring the water flow rate in the fens could provide valuable information.

Flow rates are taken by measuring the speed (velocity) of the water. Use a tape measure to stake off a twenty to fifty foot section of stream that is relatively straight and free of obstacles. Put an orange in the middle of the channel and measure the amount of time it takes to get from the first stake to the second one. Place a person at each stake to call out to the timer when the orange passes their stake. Do this procedure several times and average the results. To calculate the flow rate, divide the distance by the amount of time the orange took to travel the set distance. Rate = Distance ÷ Time. The units can be feet per second or meters per second.

To determine the volume of water moving through a channel at a specific point, the cross sectional area must be determined also. This can be done in a stream three feet or less wide by stretching a tape measure across the creek and measuring the depth at the midpoint, the one quarter and three quarter marks with a dowel or other straight stick (Murdoch and Cheo 1996, 113). Average the depth measurements (add up the three numbers and divide by three) and multiply them by the width of the stream. The answer is the number of cubic feet in the cross sectional area of the streambed. Multiply your answer for the speed of the water (determined above using the orange) with the area of the stream bed to get a cubic feet per second flow rate for the section of stream.

2. Chemical Water Measuring

There are at least four chemical water measurements that are important to document in the wetlands of Teton Valley. They each require a monetary investment, either the purchase of a test kit or fees for lab analysis.

pH

A measurement of pH indicates whether a water source is acidic, neutral, or basic. Neutral pH receives a value of 7 on a 14 point logarithmic scale, so a one number decrease is a ten fold increase in acidity. Acidic substances range from 1-6.9, while basic substances range from 7.1 - 14. Many types of aquatic vegetation are sensitive to pH and even small changes can prove fatal. Most water in streams has a pH between 6 and 7 and the optimal range for most life forms is between pH 6.5 and 8.2 (Murdoch & Cheo 1996, 166-7). Testing can be done using a pH test kit. Directions are included with the kit.

Dissolved Oxygen

Dissolved Oxygen, or DO, is the measure of how much oxygen is dissolved in the water. Oxygen in water comes from the atmosphere and aquatic vegetation. Streams with lots of rapids have higher oxygen than placid streams. Photosynthesis by aquatic plants releases oxygen into the water. Cold water holds more oxygen than warm water. Aquatic organisms need oxygen in the water to survive, though the exact amount varies among species. Water with high oxygen concentrations (greater than 8 mg/liter) are often considered healthier, because the diversity of species they can support is greater (Murdoch and Cheo, 1996 171). DO in Teton Valley may be at levels of concern because the removal of streamside vegetation, higher levels of nutrients in the water and dewatering of streams for irrigation can all contribute to a decrease in DO. DO can be tested using a test kit. Choose a test kit that uses thiosulfate because it is a safer chemical for the user.

Sediments

As mentioned earlier, high sediment levels are a problem in Teton Valley. Sediments suspended in the water can contribute to lower levels of DO and higher temperatures. Sediments can interfere with the breathing and egg viability of aquatic insects and fish and they often carry pollutants (Murdoch and Cheo 182). Erosion is high in the valley and sediments wash into surface water from croplands, natural slides and man made disturbances. Sediments are generally measured with expensive devices (nephelometer or a conductivity meter) but with the use of a good scale and a drying oven, there is a simple method that works well. The procedure is described in the *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools* (Mitchell and Stapp 1997).

Nutrients High nutrient levels, nitrogen and phosphorus in particular, also have been found in Teton Valley. High nutrients can cause algae growth to accelerate. When the large amounts of algae die, oxygen levels can plummet because oxygen is used in the decomposition of plants. Low oxygen levels can cause aquatic animals to die. Sources of excess nutrients can be surface water runoff with fertilizer residue in it from lawns and agricultural fields, sewage treatment plants, poorly working septic systems and pet and livestock waste. Nutrient testing is reliably accomplished in special laboratories, as results from test kits are not accurate.

3. Wetland Habitat Assessment

Some visual measure of the health of the wetlands is important, both for initial evaluation and to quantify changes. Vegetation health, stream bank quality and the existence of a buffer zone between the wetland and land with other uses should be assessed. Signs of human disturbances, including evidence of filling, road building and grazing, should also be noted. The existence of exotic plant species (often called weeds) and the extent of their population should be documented.

The second page of the Save Our Streams Stream Survey Form used previously for macroinvertebrate sampling has a useful check sheet for stream characteristics that can be used to document conditions at a wetland also.

Keeping a photographic record of conditions at the wetlands can be valuable, especially if they are found to be changing . Photos can be taken at the same spot on a regular basis (yearly, seasonally or monthly) to quantify changes.

Extensions A full sampling of chemical water tests could be performed, especially if results could be compared within the whole Snake River region.

Resources *Streamkeeper's Field Guide* (Murdoch and Cheo 1996), *Hands On Save Our Streams* (Firehock 1995) and *Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools* (Mitchell and Stapp 1997).

CHAPTER IV.
DISCUSSION AND CONCLUSIONS

Future of the Guide The guide represents the beginning of an effort to educate students in Teton Valley about wetlands. Once in use, it will be evaluated, edited and enlarged as teachers and students refine their needs for information about wetlands and develop new activity ideas. The guide is strong in wetland science foundations and adequate in its coverage of the role humans have in wetland degradation and loss. In the future, more emphasis will need to be placed on activities that build skills in problem solving and evaluation of potential solutions to wetland issues.

Education and Preservation Wetland education can play an important role in the preservation of wetlands. A public informed about the functional benefits of wetlands is better equipped to understand why wetland preservation is important to wildlife, humans and the environment. Since most remaining wetlands are privately owned and many conservation strategies are voluntary, it is imperative that education about wetlands become more widespread. In an area like Teton Valley, with relatively large numbers of wetlands, a high growth rate and little land use planning, a wetland education program is timely and important. Thoughtfully applied, this guide could prove instrumental in helping protect the wetland resources in the valley.

Education and Stewardship The information and activities in this guide will help students understand the value of wetlands. The field studies in particular will expose the students to the intricacies of life forms and environmental processes in the wetlands. This information about wetlands will effect each student differently. In some students, their new knowledge will motivate them to become better stewards of the wetlands, maybe even taking an active role in land use planning or wetland preservation efforts. In other students the information about wetlands will not inspire them to take action but will provide a foundation of knowledge important for local ballot issues and policy decisions.

Education and the Bigger Picture Finally, education about wetlands in Teton Valley may lead to an increased awareness among the students of environmental issues on a broader scale. According to Lyman O'Neal, an educator in Florida, "If we expect a society to have an interest in the global environmental crisis, we must first motivate them with an experience in their own environment". It is my hope this guide will contribute to a greater appreciation of wetlands and the environment.

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