A World in Our Backyard

A Wetlands Education and Stewardship Program

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Port Royal, SC 29935-2304
800.368.3382/843.986.9034
843.986.9093 FAX
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Acknowledgements

Written by: Stafford Madison, with Melissa Paly
Graphic Design: Sarah Meltzer
Illustration: Rebecca Leonard
Contributors: Shirley Griffin, Bev Maffei, Cindy Thomashow
Field Testing: Antioch New England Graduate School Wetlands Education Project

The people who helped shape this project in its early stages are: David Lyons, Jeremy Pirtle, Gus Gomes, Cathy Manwaring, Libby Hurland, Brian Lynn, Leslie Beaulieu, Barbara Waters, Randy Sorenson and Joan Hyde.

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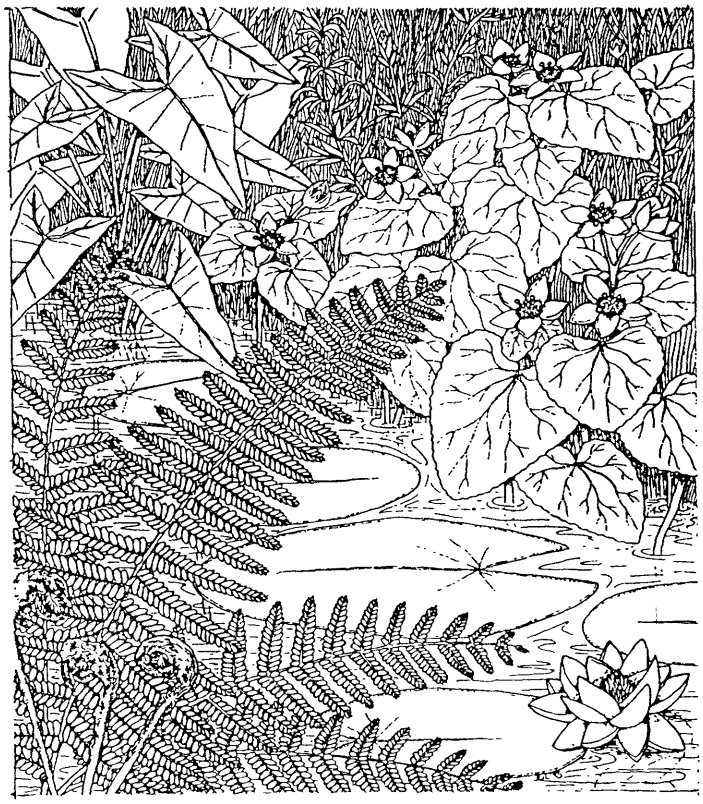

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Wetlands Education & Stewardship: An Introduction

This guide and accompanying videocassette is a resource of information about wetlands in New England for educators. It suggests ways of studying wetland characteristics, why wetlands are important, and how students and teachers can help to protect a local wetland resource. This guide is unique in that it encourages students to go beyond learning about wetlands by "adopting" one: to have them become familiar with a local wetland and advocate its protection through stewardship activities.

This guide aims to help students get to know the complexities of wetlands, discover wildlife, enjoy the experience of being outdoors, and learn how necessary wetlands are to the health of our environment.

Why Study Wetlands?

Awareness of Wetland Functions

Most people don't understand the intimate connection we have with the ecological systems that support our daily lives. When students learn how intimately they are connected to their environment, their perceptions of the world and the use of its resources will change. Wetlands are especially vulnerable to destruction. The value of wetlands has been traditionally underrated: nearly half of the original 215 million acres of wetlands in the United States have been degraded or destroyed. Wetlands continue to be sacrificed for the development of housing areas, recreational sites, airports, etc. People fill them in and pollute them, often unaware of their important functions.

Wetlands are valuable for many reasons: they provide clean water, sources of food, habitat for wildlife, flood protection and recreational opportunities. The importance of wetlands to our everyday lives make them a meaningful focus of study. Students drink water every day. The quality of their drinking water may be due in part to wetlands adjacent to their water source.

Wetlands are Accessible Study Sites

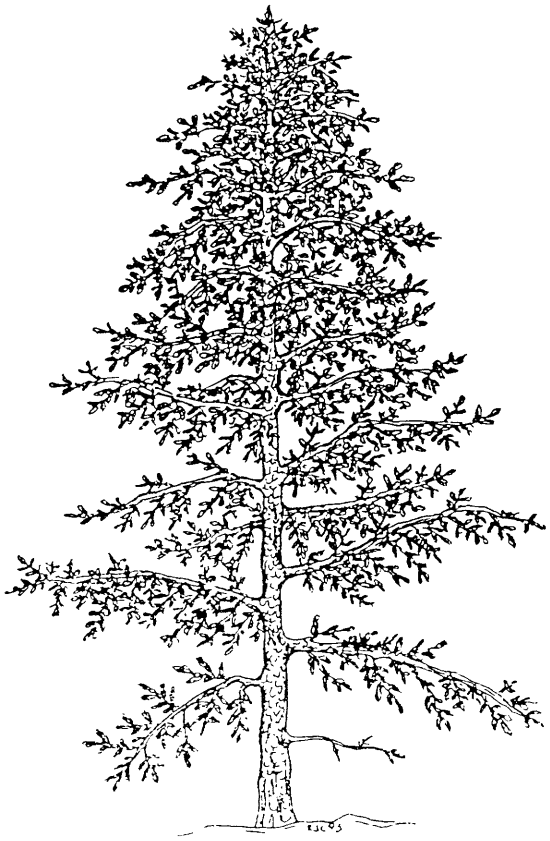
The wetland is an accessible laboratory. Many communities in New England have wetlands nearby, often located near school property. When students make a strong connection to a local natural area, they begin to feel a sense of responsibility and commitment to its well-being. Getting out and exploring a wetland can also be a lot of fun!

Wetlands Provide Opportunities for Stewardship

An integral part of the wetland "adoption" process is the involvement of students in their protection. Stewardship activities go beyond the awareness of wetlands and the threats to them. This guide suggests ways of putting investigative research to good use. Students are encouraged to conduct an inventory of a local wetland and use their information to help protect it.

A Multi-disciplinary Approach to Education

The study of wetlands can incorporate disciplines other than science, such as math, civics, English, music, art, and history.



black spruce

How to Use This Guide

This guide provides background information for teachers to use in conjunction with a variety of activities that introduce students to wetland science and stewardship. It outlines field trip ideas. It details ways students might participate in protecting wetland areas.

Most of the background information for the teacher is at the beginning of each chapter, not summarized with each activity.

The guide is targeted primarily for middle school teachers, though some sections may be adapted for use in high school, such as the chapter on wetland protection.

This guide is not a prescribed curriculum; it has been designed such that teachers can use whatever information they find useful for their particular teaching situation. The guidebook can be useful even to those teachers who don't want to pursue the "adoption" process. Students don't need to know all the information contained in the guide to study a local wetland. Likewise, teachers don't need a degree in wetland science to effectively lead a class on a wetland field study.

This guide can serve a number of teaching scenarios:

- **A three to five day unit.** A classroom might construct and maintain a wetland terrarium to observe every day. Students can learn to describe wetland characteristics and the importance of wetlands to wildlife and people.
- **A long-term multi-disciplinary study.** A comprehensive study of wetlands may require a semester or full year. Incorporate subjects other than science into the study, such as social studies, math and English, history and art. Follow a local development project by attending conservation commission meetings and document the local land use decision-making process.
- **An extracurricular nature/environmental club.** A science club, summer camp, or scout troop might study a local wetland and investigate development issues or organize a cleanup project.

Contents of the Guide

Chapters 1,2, & 3: Wetland Science, Types, & Functions

Background wetland science information is broken into three chapters: general wetland characteristics, classification, and functions. Activities in each chapter provide lessons that support the basic concepts. The approach to teaching these concepts will vary depending on age-appropriateness and experience levels.

Chapter 4: Threats to Wetlands

This chapter provides background information and activities to help students make connections between people and wetlands. What are the threats to wetlands? How has land use in the community changed over time, and how does it impact the hydrology, plant and animal communities, and wetland functions? Which land use activities in particular degrade or destroy wetlands?

Chapter 5: Find a Wetland to Study & Adopt

A number of suggestions for locating wetlands in your community are provided in this chapter. Try to find one that students recognize from their daily lives. It can be in someone's backyard, on school property, or on a state park or conservation land. The city planning department, conservation commission, or local nature center may know of a wetland in danger of development. Learning to use topographic maps is an exercise that helps students find their "environmental address," as well as locate large wetland areas in the community.

Chapter 6: A Wetland Field Study

Chapter 6 outlines a course of field investigation – water quality sampling; wetland soils, vegetation, and wildlife; documenting adjacent land use activities; mapping the wetland; and depicting the site through illustrations, prose, and photography. Sample data sheets are provided to help students record information about what they see and hear, from soils to salamanders.

Chapter 7: Protect Your Wetlands

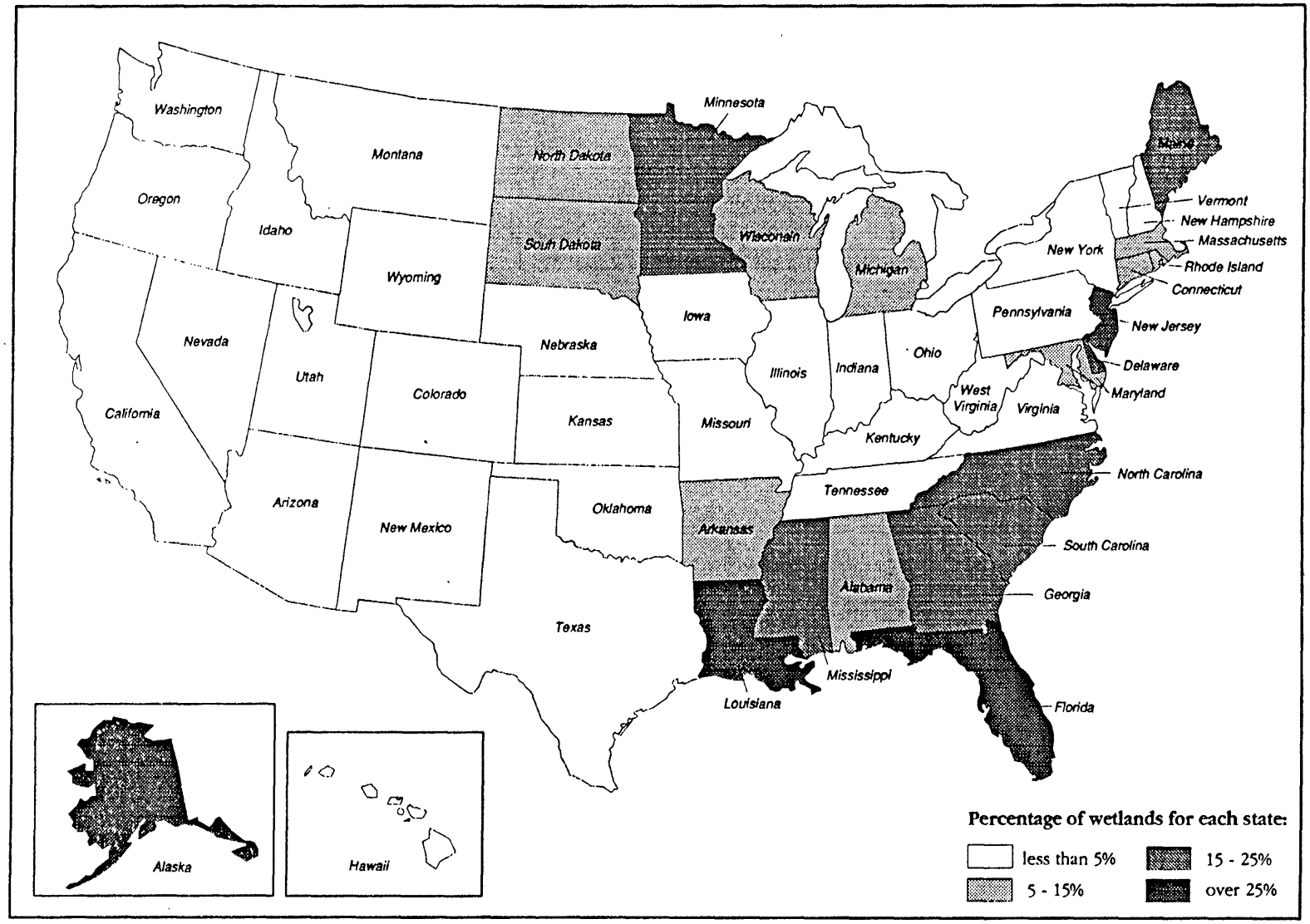
Chapter 7 provides background information on how wetland regulatory programs operate on the federal, state, and local level in New England. The focus of this chapter is to encourage students to become stewards of a local wetland. Providing students with environmental protection tools allows them to actively protect an area and gives them a sense that they can make a difference.

Chapter 8: How to Adopt a Wetland

EPA hopes to motivate students to become concerned enough about a local wetland that they progress from study to protection. If your class ends up using this guide to take any kind of action in the community, whether it's writing an article in the local paper, presenting a field guide to a local watershed organization, or doing a cleanup, EPA will send you a certificate for your involvement and include your school on a wetlands advocate mailing list. Refer to this chapter for more information on how to qualify for an *Adopt-A-Wetland Certificate.*

So get out, get muddy, and get involved in wetlands protection through EPA's *Adopt-A-Wetland Program,* ***A World in Our Backyard***.

Relative Abundance of Wetlands in the United States



Chapter I Wetland Science

The Extent of the Resource:

Wetland Statistics

- *Through the mid-1970's, 99 million acres of wetlands (an area the size of California) existed in the lower 48 states. The states with the most wetland acreage are Florida and Louisiana.*
- *200 million acres are estimated to exist in Alaska, covering slightly more than half the state.*
- *Wetlands occupy 5% of the total land area of the continental U.S.*
- *Inland wetlands account for 95% of the total wetland acreage, coastal wetlands 5%.*
- *75-80% of wetlands in the continental U.S. are privately owned. The remaining 20-25% are owned by federal and state governments.*

What Are Wetlands?

Wetlands are just that – wet lands. Commonly referred to as swamps, bogs, fens, and marshes, wetlands are often transitional areas located between dry lands and deeper aquatic systems, like rivers and lakes. Wetlands can be shallow water habitats, where the soil is covered by water (usually less than 2 meters), or saturated areas, where the soil is wet at or near the surface but not necessarily covered by water. Whether a shallow water habitat or saturated area, wetlands must exhibit these hydrologic characteristics for at least a part of the year.

Some wetlands develop in low-lying areas in the landscape where water drains and collects. Others border salt or fresh bodies of water such as oceans, rivers or ponds while still others are isolated in forests and urban areas. As transitional zones between upland and aquatic systems, wetlands often support both terrestrial and aquatic species, contributing to the diversity of plants and animals they support.

Wetlands also vary considerably in their appearance and size. Regional and local differences in vegetation, hydrology, water chemistry, soils, topography, and climate contribute to the variety of wetland types found around the world. Some wetlands are inundated with water year round while others are only seasonally flooded, and the depth and duration of flooding can vary widely. Others are only saturated at or near the surface of the soil. Wetlands may occupy just a few hundred square feet or cover thousands of acres.

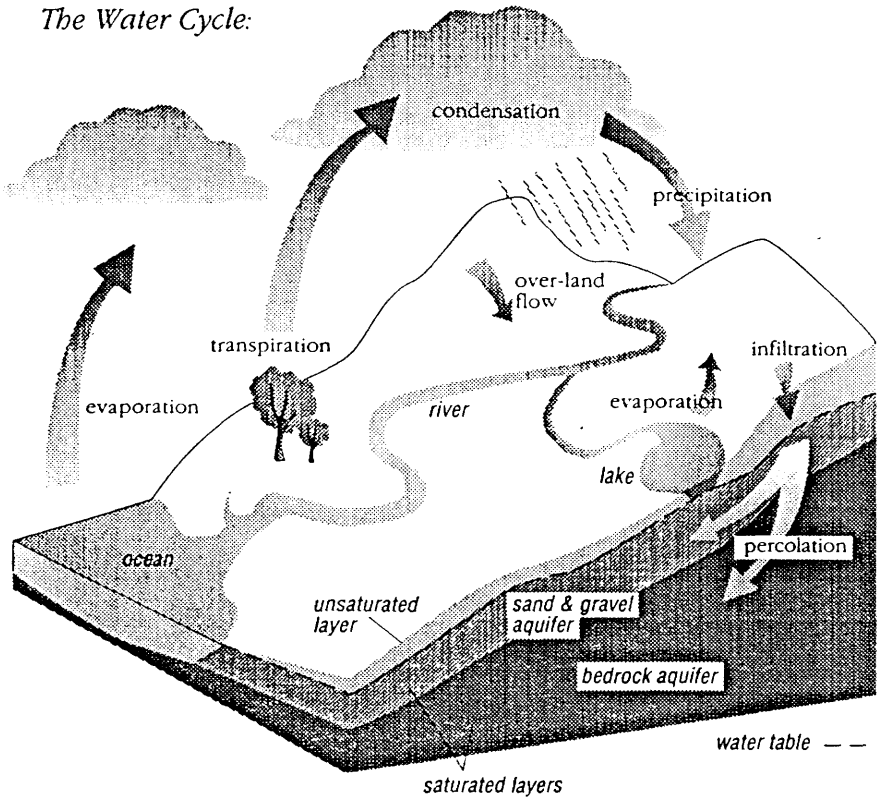
The Water Cycle: The Connection Between Wetlands & Watersheds

The circulation and distribution of water, *hydrology*, is the driving force behind the formation of wetlands. The *hydrologic cycle* or *water cycle* is the continuous circulation of water from the atmosphere to the earth and back. The amount of circulating water remains about the same but can follow many different pathways to and from the earth.

Precipitation (rain) falls to the ground and, due to gravity, tends to keep moving towards the lowest point in the landscape. Water may *infiltrate* (penetrate) the soil surface, *percolate* through the soil and eventually become part of either an underground water system (*aquifer)* or a surface water system (e.g., river). As the sun heats the earth's surface, water molecules *evaporate* from the land and sea as water vapor and return to the upper atmosphere. Plants also give off water through *transpiration*, a loss of water vapor from the leaf surface. As water molecules rise and come into contact

with cooler air, *condensation* occurs (gaseous water turns to liquid water). The cycle repeats as water once again falls to the earth's surface in the form of precipitation (7/8 of which falls directly into the ocean).

The Water Cycle:



The Watershed

A *watershed* is a geologically-determined land area within which water flows from the highest elevations to the lowest, contributing to a particular stream, river, or lake. A watershed can be likened to a bathtub – all the rain that falls on the inner edge of the rim or within the tub will go down the drain, and water falling on the outer edge or on the other side of the tub falls to the floor (or in the case of watersheds, to the adjacent watershed).

Watersheds come in all shapes and sizes, depending upon scale. Just as the bathtub is the watershed for a drain, the land area that contributes to the Connecticut River would be considered a *regional* watershed. The land that contributes to streams which feed into it would be considered *sub-regional* or *local* watersheds.

Similar to a sponge, wetlands help to regulate the amount of water moving through a watershed by retaining water during wet periods and, sometimes, slowly releasing water during dry spells. Wetlands, whether isolated or part of an expansive system, are hydrologically important resources within the watershed.

Getting Your Students Involved:

To understand wetlands, your students need to know where the water in wetlands comes from and why it's important. Increasing their understanding of the many reasons water is important to people and wildlife will heighten their appreciation of a resource which is often taken for granted.

Begin by having students record how they use water in their daily lives. Have each student keep a journal of how they use water during one day's time. Record their responses on the blackboard. Talk about where the water originated – a well, the city reservoir, a town reservoir, a river, rainwater, etc. and where it goes – to septic systems and wastewater treatment plants. Trace the water's path of origin as well as its final destination for each use listed on the blackboard. Emphasize the importance of water and how our uses impact its quality and quantity.

An important concept for students to know is that water is always moving from high to low due to gravity and that any piece of land belongs to a very small watershed which is part of a larger watershed, which is part of a still larger watershed, and so forth. Have students experiment with the movement of water through different gradients by constructing terrariums using potting soil, peat, rocks, sand, and clay. Have each group of students build the most absorbent, the most erosive, and the fastest draining gradients through which water might travel (See Activity 1, *Building a Watershed Model*).

WETLAND CHARACTERISTICS

Despite their diversity, all wetlands have three common characteristics: *hydrology*, unique *hydric* soils, and *hydrophytic* vegetation.

Hydrology

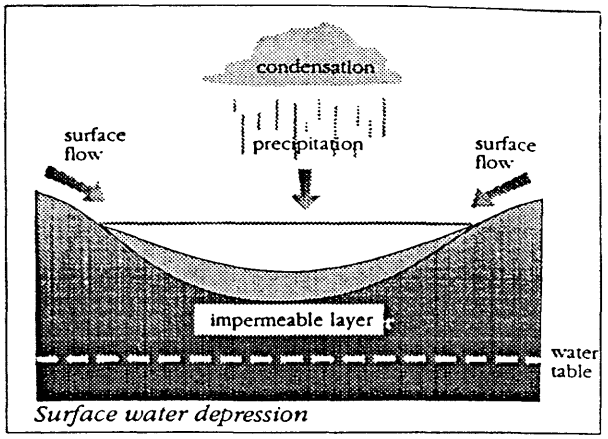
Hydrology, the circulation and distribution of water, is the driving force behind the formation of wetlands. Hydrology, particularly in conjunction with landscape position, determines a wetland's water depth, flow patterns, and the duration and frequency of flooding or saturation. Topography, proximity to other bodies of water, and depth to the water table are all factors that influence wetland hydrology.

The amount of water present and the frequency and duration of flooding or saturation can vary considerably from one wetland type to another. Some wetlands are seasonally wet because water is present only during spring runoff. Other wetlands remain wet year round because they are located where groundwater is at or near the soil surface during most of the year or because they are adjacent to large bodies of water. This variability in hydrology accounts in part for the different types of wetland that develop – from forested wetlands that appear dry in the summer to inland marshes permanently inundated with water. Water can enter a wetland through a number of *hydrologic pathways*, including:

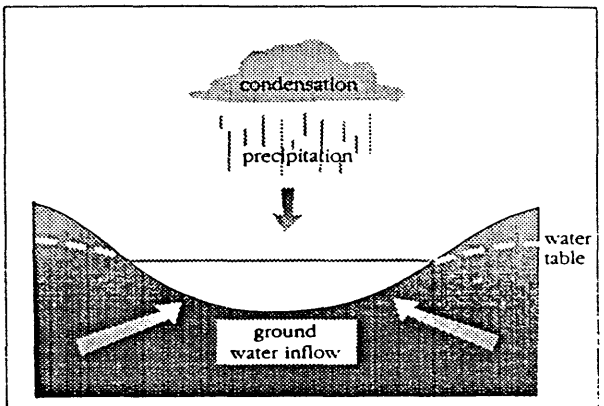
- direct precipitation;
- surface water runoff from brooks, streams, and rivers;
- underground water sources such as groundwater or springs. In low-lying areas, groundwater may lie just below the soil surface (*high water table*), keeping soils saturated from below. Springs or *seeps* are places where the water table intersects with the land surface.
- Flood waters from upstream and adjacent surface water bodies such as rivers, ponds, and lakes; and
- tidal flow and storm surges in coastal areas.

The *amount* of water and the *rate* at which it moves through a wetland also influence: 1) the particular habitat conditions (types of soils and vegetation) found there, which in turn determines wildlife diversity; and 2) the cycling and availability of nutrients within the wetland, which determine a wetland's *productivity*. In general, wetlands created by flowing conditions and frequent flooding (e.g., wetlands bordering rivers and tidal marshes) can support more plants and animals than those with stagnant waters (e.g., bogs) because there is a greater exchange of nutrients from surrounding lands.

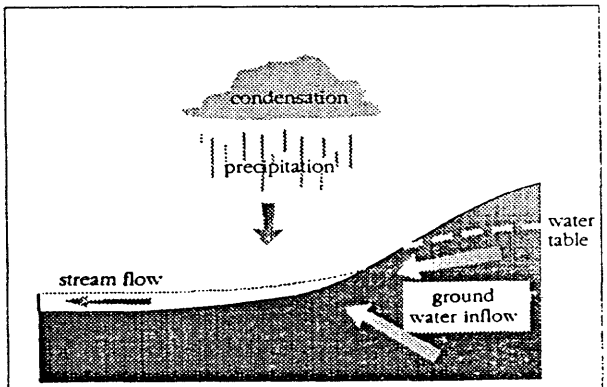
Where does the water in wetlands come from?



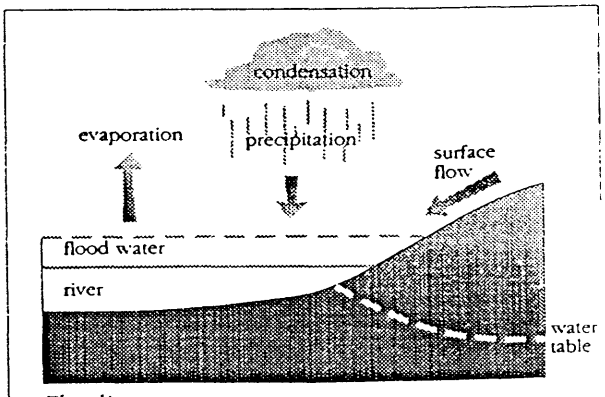
Surface water depression



Ground water depression



Seeps



Flooding

Wetland Soils

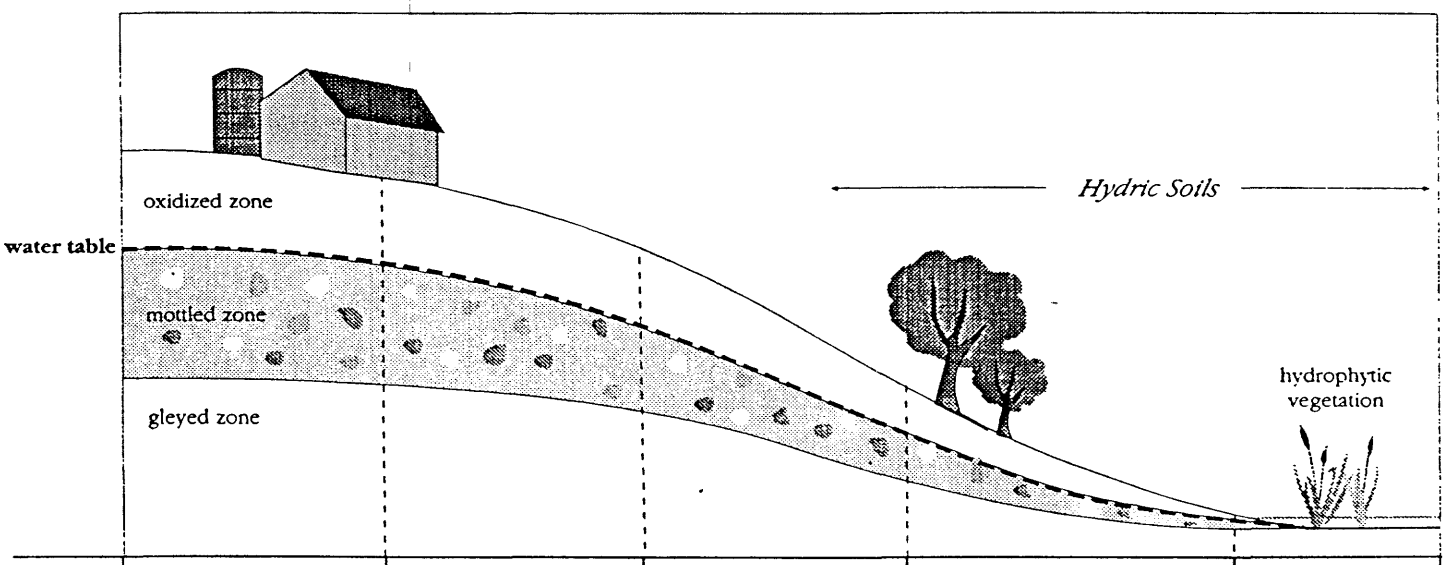
Wetland soils, called *hydric soils*, develop under low oxygen or *anaerobic* conditions created by permanent or periodic inundation or saturation. As water fills the air spaces between soil particles, the rate at which oxygen can diffuse through the soil decreases significantly. This lack of oxygen prevents plants and soil microorganisms from carrying out normal aerobic respiration, a process typical in most terrestrial (upland) areas. Anaerobic conditions usually favor the growth of *hydrophytic* (water loving) *vegetation*, discussed in the following section.

Drainage

The shape of the landscape creates unique drainage conditions which influence the formation and characteristics of soil. Soils can be classified according to the rate at which they drain water. In New England, most wetland soils are classified as either *poorly drained* or *very poorly drained soils*. Water flows so slowly through poorly drained soils that the soil surface is saturated periodically or remains wet for extended periods. Poor drainage in these soils is created by seepage, nearly continuous rainfall, or a combination of the two. In very poorly drained soils, water moves so slowly that it remains at or on the soil surface.

Soil Composition

Based on their composition, hydric soils are classified as either *organic* or *mineral* soils. Organic wetland soils contain lots of



drainage class:	*well-drained soil*	*moderately well-drained soil*	*somewhat poorly drained soil*	*poorly drained soil*	*very poorly drained soil*
soil depth (cm) 0	dark brown	dark brown	very dark brown	black	organic
20	brown	brown	olive brown	mottled	black
40	yellowish brown	yellowish brown greyish brown	mottled	grey	grey
60					
80	olive brown	mottled	grey		
100					
120	mottled	grey			

Soil characteristics change with landscape position from well-drained uplands to very poorly drained wetlands.

partially decayed plant and animal matter that creates a thick black or dark brown layer at the soil surface. Mineral wetland soils contain significantly less organic material and more sand, silt, and clay. They are generally lighter in color than organic soils.

Organic soils. The water-saturated and oxygen-poor conditions in wetlands inhibit the growth of microorganisms that decompose organic materials such as leaves, stems, and roots. Therefore, organic material tends to accumulate over time, forming a dark brown or black layer of *peat* or *muck*. In New England, the organic layer in hydric soils may range from 2 to 30 feet thick or even deeper. Organic soils are further classified according to the amount of plant materials that remain identifiable:

Muck: most of the plant material is decomposed and is no longer identifiable; very few plant fibers can be detected after rubbing between the fingers.

Peat: less than 1/3 of the material is decomposed and most plant fibers are still identifiable after rubbing between the fingers.

The presence of organic matter has a marked effect on both the physical and chemical properties of soils. Organic matter acts like a sponge and absorbs large quantities of water that might otherwise run off the land. On the other hand, when rain strikes bare soil containing little organic matter (like soil from cultivated fields), it breaks the soil down and washes it away readily. Organic soils act like a brake by slowing water down, protecting the mineral soil layer below from the erosive force of rain.

Mineral soils. Mineral soils contain mostly inorganic matter such as sand, silt, and clay with very little decaying organic matter.

Gleying and *mottling* are chemical processes common to water-saturated mineral soils and are therefore useful indicators of wetland soils. *Gleying* occurs when iron deposits in the soil are converted from an oxidized to a reduced state due to extended periods of saturation and low oxygen conditions. This process gives the soil a gray or bluish gray color (iron normally appears red, orange, or yellow in its oxidized state). *Mottles*, orange, yellow, or reddish-brown splotches, appear in mineral soils that are alternately wet and dry. These splotches appear in soils that have been exposed to air during dry periods, resulting in oxidation or rusting of metals such as iron. However, for a number of reasons, not all hydric mineral soils will exhibit gleying and mottling.

Biological Processes in Hydric Soils

Many bacteria living in hydric soils respire anaerobically. They acquire the minimal amounts of oxygen they need by removing it from other compounds, such as sulfur. In this case, sulfate is converted to hydrogen sulfide, creating the "rotten egg" smell characteristic of some wetland soils, particularly those in coastal areas. Anaerobic bacteria also convert the surplus nitrates not used by wetland plants to nitrogen gas, releasing it into the atmosphere.

Getting Your Students Involved:

Get your students to experience the difference between upland and wetland soils first-hand. Have students find an area in their back-yard or neighborhood that they suspect to be a wetland. Have them collect a few samples of earth and describe in their own words how it looks, feels, and smells. They might want to compare soils taken from different locations – in their own yard, a playground, vacant lots, or known wetland sites. (See Activity 2: *Investigating Wetland Soils*.)

Wetland Plants

Wetland plants – herbaceous (non-woody) plants, shrubs, and trees – are commonly referred to as *hydrophytic* (water loving) plants or *hydrophytes*. These plants are specially adapted to withstand the stressful conditions characteristic of wetlands: periodic or permanent inundation or saturation with water, fluctuating water levels, and little available oxygen.

Hydrophytes have adapted to wet, anaerobic conditions in a number of ways:

1) Many have special air spaces called *aerenchyma* in their roots and stems that allow oxygen to diffuse from the aerated portions of the plant to its roots. Some wetland plants are so well adapted that they require no diffusion of oxygen from surrounding soils to their roots.

2) Some plants, especially woody plants, *pump* oxygen from their leaves (a product of photosynthesis) to their roots situated in saturated soils. This process enables the root cells to respire and carry on necessary nutrient exchange reactions with the surrounding soils. This adaptation frequently results in the formation of *oxydized rhizospheres* (rust-colored root channels) in the upper soil layer.

3) Many trees found in wetlands develop shallow root systems, swollen trunks, or roots that grow from the trunk above the soil surface.

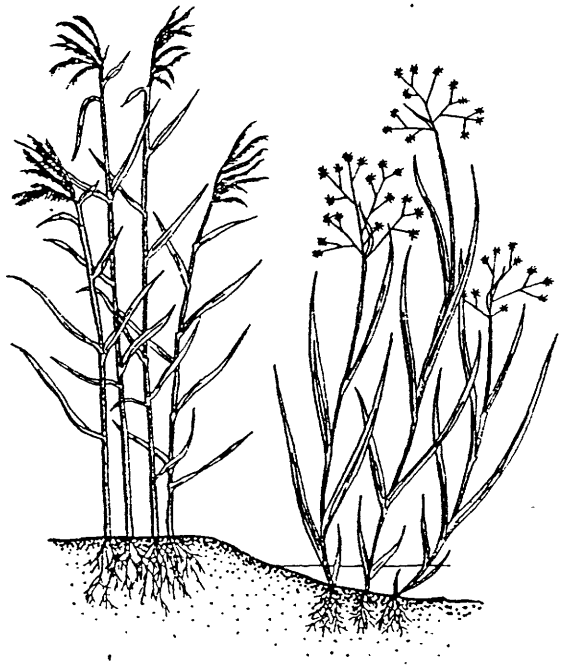
4) Hydrophytes living in saline environments develop structural barriers to prevent or control the entry of salts at the root surface and have organs specialized to excrete salts through glands embedded in the leaf.

Types of Plants

There are many wetland plants and trees that most people are familiar with including cattails, bulrushes, cordgrass, sphagnum moss, sedges, rushes, arrowheads, and willows. A list of wetland plants characteristic of wetland types found in New England appears in Chapter II. The *Wetland Plant Wheel* activity in this chapter will also help students to identify plants in the field.

Herbaceous plants — can be categorized by their location in water:

- *Emergent* plants are rooted in the sediment but have stems, leaves, flowers, and fruits above the water surface. Common types include arrowhead, rushes, and cattail.
- *Floating* plants may be either free-floating or rooted in the soil. They have leaves on the water surface and carry flowers or fruits just above the surface. Common species include the water lily and duckweed.
- *Submergent* plants grow completely beneath the surface, including eelgrass, wild celery, and coontail.



common reed

dark green bulrush

Emergent

Shrubs — are low, woody plants with several permanent stems instead of a single trunk. Shrubs common to New England wetlands include silky dogwood, spice bush, high bush blueberry, and swamp azalea.

Trees — are woody perennial plants with one main stem or trunk that develops many branches, usually high above the ground. Most trees are over 10 feet tall and have a single trunk. Trees found in wetlands include red maple, pin oak, black willow, and Atlantic white cedar.

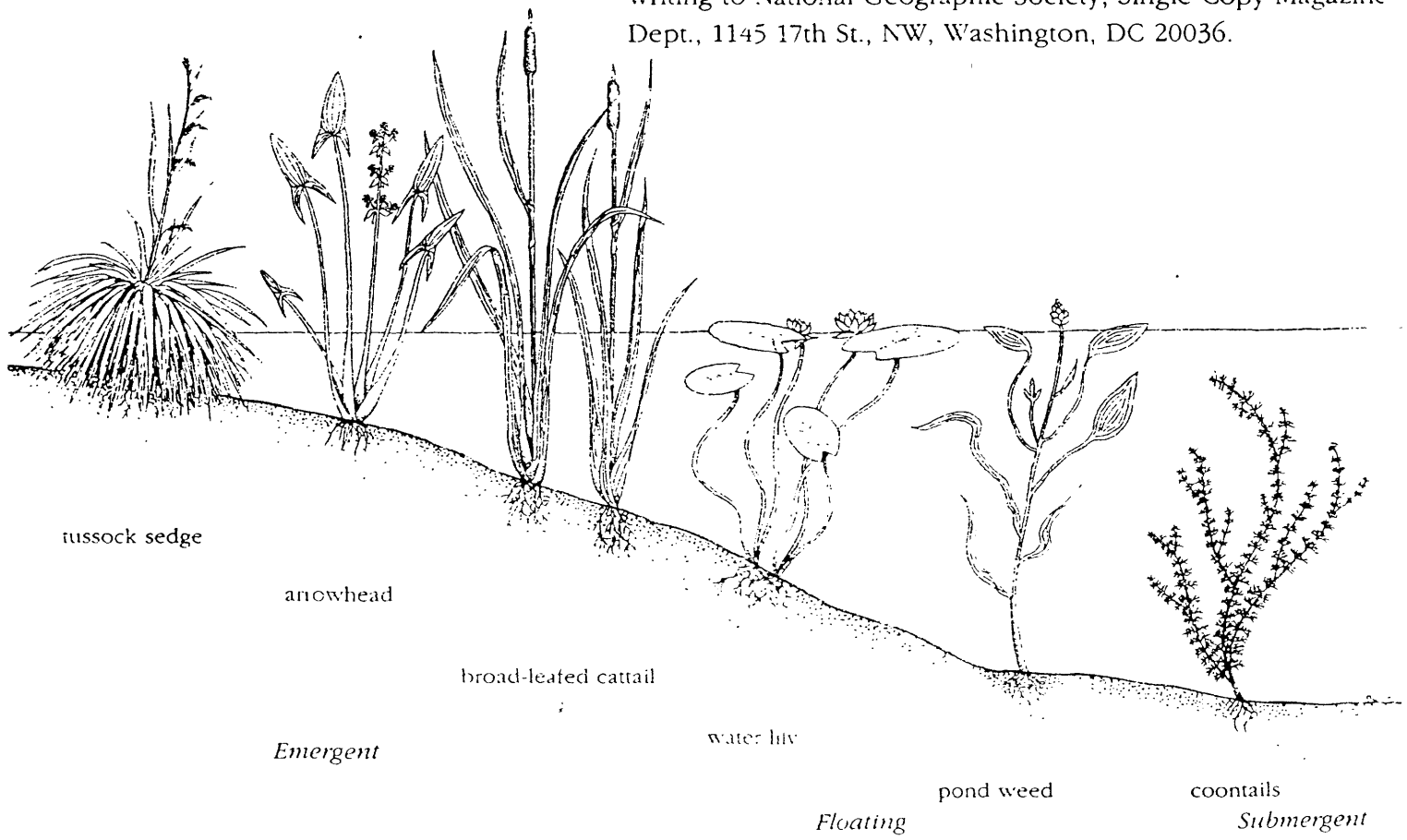
Getting Your Students Involved:

Ask students to describe the different conditions their own bodies can tolerate. Have them describe the adaptations people have made to different climatic conditions. Are they biological or technological adaptations? Students may want to imagine and draw the ways the human body would have to adapt in order to survive in extreme conditions if we didn't have technological solutions.

Activity 3: *Experiments with Wetland Plants,* will help students predict and observe some of the unique characteristics of wetland plants. Activity 4: *Create a Wetland Wheel,* will acquaint students with identifying some of the common wetland plants in New England. This activity is an excellent supplement to a wetland field trip.

For More Information

The cover article in National Geographic Magazine's October, 1992 issue is an excellent source of information on wetlands, with plenty of color photos and helpful graphics. Back issues can be ordered at $2.65/copy by calling 1-800-447-0647 or writing to National Geographic Society, Single Copy Magazine Dept., 1145 17th St., NW, Washington, DC 20036.



Activity 1: Build a Watershed Model

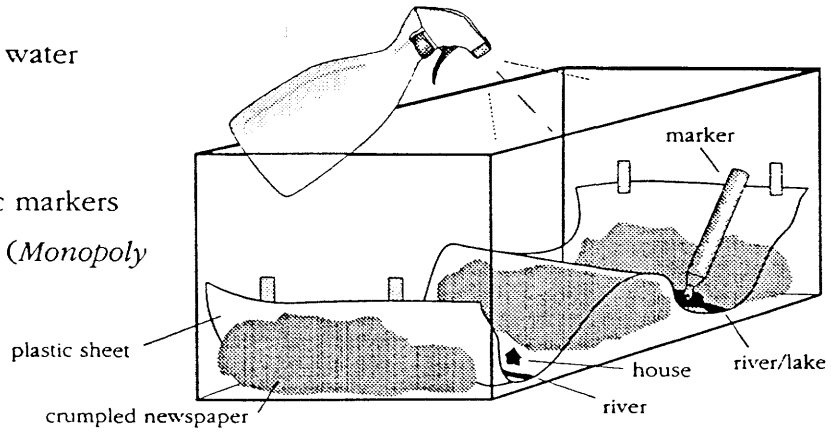
Overview The model built in this activity can be used again and again in other activities to illustrate the functions of wetlands and the effects that changes in land use have on wetland areas (see Chapter IV).

Objective *Activity 1A* will help students understand the concept of a watershed, one of the most fundamental concepts in ecology and environmental studies. If students understand these concepts, they will begin to develop an awareness of their "environmental address" – a sense of their place on the globe and in the natural community. *Activity 1B* introduces students to the concept of wetland functions within a watershed.

Activity 1A

Materials

- Container *
- Spray bottle with water
- Newspaper
- Plastic sheet
- *Waterproof* magic markers
- Miniature houses (*Monopoly* playing pieces)



* Since you will be using this watershed model repeatedly, use the largest container you can find. A 10-gallon aquarium or larger allows students to view the model from all sides. Otherwise, a clear plastic box or wash basin will do.

Procedure

1. If you have more than one container to work with, divide the class into groups to work on the watershed model set-up procedures below. If not, perform this activity as a demonstration.
2. Have the students crumple three sheets of newspaper and place them in the aquarium. Drape the plastic sheet over the paper, fitting it between the three pieces to form two valleys with a ridge in the middle. Tape the plastic to the walls of the aquarium to prevent water from running down the sides. Be sure that water will generally flow towards the valleys and the front side of the aquarium. You now have a model of three hills and two valleys.
3. Ask the students to describe what they think will happen when it "rains." Have them draw a river channel through the valleys on the plastic sheet, placing a few of the houses located alongside the river. Color in a lake where they expect the water to pool.
4. Gently spray some water into one half of the aquarium so that only one of the two watersheds gets wet. Point out how the water runs off the high points and forms a

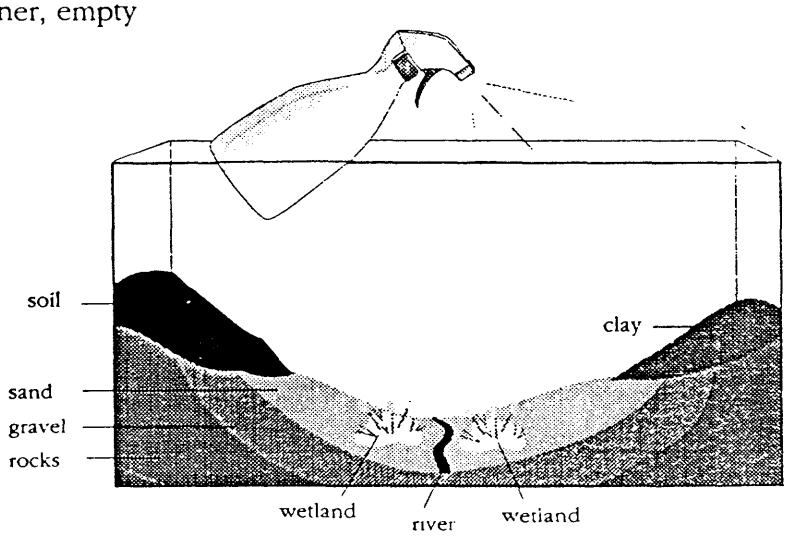
stream in the valley. This is how rain and melted snow run off the land. All of the land that drains into a stream is called a *watershed.* Ask the students to think of a stream in town and talk about where the water comes from that feeds that stream.

5. Now ask the students what will happen when they spray water directly into the middle of the aquarium. Spray water so it hits the ridge between the two valleys. Some water will run into one stream, and some will run into the other. The ridge between these streams is called the *watershed divide* – it's the highest point of land between two bodies of water.
6. Ask the students if they can think of another stream in town and where there is a watershed divide that separates the two systems. Talk about the *Continental Divide* in the Rocky Mountains, where water to the west flows toward the Pacific Ocean,and on the east to the Atlantic Ocean.
7. Call attention to how rapidly the water travels over the plastic surface. Ask the students what the plastic might represent in real life (pavement, roofs, other *impervious surfaces*). To lead into the next watershed model activity, ask the students what other kinds of surfaces exist where land is not paved over (grass, forest, dirt, rock outcrops, marshes, etc). You are now going to build a model of the earth that represents these land covers.

Activity 1B

Materials

- Same aquarium / container, empty
- Spray bottle with water
- A few apple-sized rocks
- Sand, gravel, soil
- Plasticene or clay
- Paper towels or small sponges
- Food coloring
- Wetland plants – cotton swabs (painted brown), pine needles, dried flower heads



Procedure

1. Place the rocks in a heap at both ends of the aquarium. Put gravel around the rocks, and spread them out so that they slope downhill toward the middle of the tank. Place a layer of sand over the gravel, also sloping toward the middle. On one side of the tank, pack soil on top of the sand. On the other side, cover some of the sand with a thin layer of clay or plasticene.

2. Ask the students what will happen when it rains. How will rain affect this landscape differently from the completely impervious landscape? Spray water into the tank, and watch how some of it runs over the surface and some of it sinks in. The water that stays on top is called *surface water*, forming streams, rivers, ponds, lakes, oceans. The water that sinks into the earth (*infiltrates* or *percolates*) is called *groundwater*. As you continue spraying, water will accumulate in the air spaces (*interstices*) between the gravel and sand at bottom of the tank. This body of underground water is called an *aquifer*.

3. Now make a wetland. Review with the students the definition of a wetland and its characterstics: presence of water, special hydric soils, and water-loving *hydrophytic* plants. Take the small sponges, or a tightly rolled paper towel, and place it in the lowest part of your landscape alongside the river. Place the cotton swabs, pine needles, or other "wetland plant" materials in the sponge. Continue spraying water into the tank. Get the soil really wet to create excess water running down toward the wetland. The towel/sponge should absorb the water and become saturated, slowing the flow to the river.

4. Introduce the functions of the wetland: 1) by holding large quantities of water, it kept the river from flooding; 2) it slowed the velocity of water as it approached the river, preventing the sand and soil from eroding; 3) it acted as a filter by trapping soil from running directly into the river.

5. Now take the towel/sponge out and squeeze the water from it. This illustrates how wetlands act like a large sink by storing water during storms and releasing it slowly during dry spells. In this way wetlands help to maintain a more even flow of water in our rivers, streams, ponds, and lakes, which is very important for the plants and animals that live there.

Adapted from *Water Watchers* with permission from the Massachusetts Water Resources Authority.

Extension

1. Initiate a discussion about drinking water in your town. Ask students if they know where the water comes from when they turn on the tap. If you live in a rural or suburban area, chances are at least part your drinking water supply comes from groundwater. If you live in an urban area, you are more likely to get water from surface reservoirs. Call your local Water Department or Board of Health Officer for more information.

2. Manipulate your constructed wetland model to demonstrate how human impacts alter wetlands. See the *Manipulate the Washershed Model* activity in Chapter IV.

Activity 2: Investigate Wetland Soils

Objectives

1) To introduce students to the world of soil, the nexus of living and non-living components of the ecosystem;

2) To visually compare wetland soils to upland soils; and

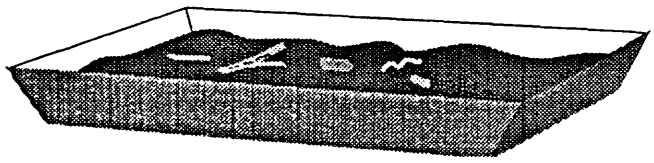
3) To introduce the concept that water affects both the biology and chemistry of soils.

Concepts

Soils are one of the three characteristics that distinguish wetlands from upland areas. Because wetlands are wet some or all of the year, the biological, chemical, and physical character of the soil is altered. The presence of water creates an oxygen deficiency (anoxia) so most oxygen-dependent bacteria and insects can not survive. As a result, decomposition of organic matter, such as fallen leaves and trees, proceeds very slowly and accumulates in the soil. Organic-rich soil is usually very black. Water-saturated conditions may also affect the soil by *reducing* (removing oxygen) the mineral constituents, creating grayish or blue-gray colors.

Materials

- Shovel or trowel
- Bucket or roasting pan
- Soils data sheet from field trip chapter (optional)



Procedure

1. For this activity, the teacher needs to bring both wetland and upland soil samples to the classroom. Alternatively, you could have each student or groups of students bring in their own soil samples. If you're already familiar with a nearby wetland, this should be easy. If you're not, this is your chance to do a little scouting in advance of the class (see Chapter V for suggestions). You can also contact your local conservation commission or planning board to assist you in locating wetlands in your community. Make sure you know who owns the land, and secure permission to use the area.
2. After you've found a suitable location, dig a small pit, remove a block of soil, and place it in a bucket. Do the same in an adjacent upland area. Keep the wetland soil moist otherwise the colors will dull.
3. In the classroom, place the two soil types side by side. Ask students to describe any differences they see (color, smell, texture, roots, insects). The soils data sheet from the field trip section may be used here. Discuss possible explanations for these differences using the background information in this chapter for reference.

Extension & Other Activities

1. Have the students perform a percolation *(perc)* test. Dig identical small soil pits in different locations – sandy soils, wetland soils, upland forest, school playing fields – and fill the pits with water and time how long it takes each pit to drain the water.
2. *Microsmos Curriculum Guide to Exploring Microbial Space,* Dr. Douglas Zook, Boston University School of Education, Kendall/Hunt Publishing, Inc. Dubuque, Iowa. 1992. The *Building A Microbial City* activity in this curriculum explores microbes found in samples of marsh soils.

Activity 3: Experiments with Wetland Plants

Objectives The following activities will give students a better understanding of the special adaptations that allow wetland plants to survive in waterlogged environments.

Background Plants that grow in wetland areas have some special adaptations that allow them to live in conditions that other plants would find too stressful to survive. Wetlands, by definition, are entirely saturated for at least part of the year. During these times, the soil becomes anoxic or depleted of air that most plants need for respiration.

Activity 3A: Drown a Plant

Time required Long term activity, approximately 1-2 weeks.

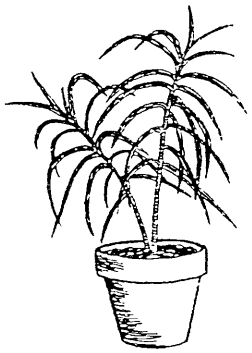
Materials

- Two identical garden variety house plants in transparent plastic containers (e.g., geraniums, coleus, rubber plants, etc.)
- Wetland plants such as pitcher plants & bladderworts*
- Deep dishes or plastic containers
- Many types of plants not available through a local garden center can be mail ordered from the Carolina Biological Supply Company, 1-800-334-5551.

Procedure

1. Place the two garden variety plants near a window that gets some sunlight. Water one plant every few days when it seems dry. Keep the other plant totally saturated with water in the dish below. See how long it takes the saturated plant to wither, rot, and die (approximately 1-2 weeks).

2. Place a wetland plant in a transparent container and keep the soil well saturated. Over time, have students compare the condition of the wetland plant to the saturated house plant.



3. Have the students make predictions about what might happen to the saturated house plant and list their reasons.

4. Review plant biology with the students and have them revisit the predictions they made earlier. Why do plant leaves need sunlight, water, and carbon dioxide? Why do plant roots need oxygen? Why is the saturated plant wilting while the other one is growing just fine?

Wetland Plant Adaptations

- *Special air spaces called aerenchyma in roots and stems allow oxygen to diffuse from the aerated portions of the plant to its roots.*
- *Some plants can "pump" oxygen from their leaves to roots in saturated soils. This allows the root cells to respire and carry on necessary nutrient exchange reactions with the surrounding soils.*
- *Many trees develop shallow root systems, swollen trunks, or roots that grow from the trunk above the soil surface.*
- *Plants in coastal wetlands develop structural barriers to prevent or control the entry of salt in their roots and excrete salt through special glands in their leaves.*

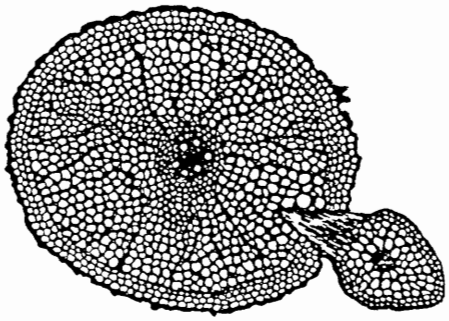
Activity 3B: Under the Microscope

Materials

- Cattail from a nearby wetland
- Stalks of grass from a lawn or open field
- Microscopes or magnifying glasses
- Optional: a few samples of other wetlands plants (burreed, spatterdock, pickerelweed, arrow arrum)

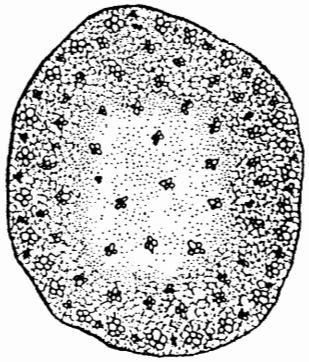
Procedure

1. Explain the structural adaptations of wetland plants to students and have them feel the stems and leaves of the cattail and any other wetland plants you can collect (e.g., burreed, pickerelweed, spatterdock). The low density tissues of these plants feel "spongy" because of their numerous air spaces.
2. Have students cut the stalk of the cattail into several thin cross-sectional pieces. Have them look at the different channels through the microscope or magnifying glass and draw what they see. The center of the stalk is hollow, and the stem itself has small air channels throughout. These are called *aerenchyma,* and they transport air from the stem and roots to the rest of the plant. They also act as structural support that allows such a tall, thin plant to remain upright even in high winds.
3. Now examine and draw the cross-sections of the *nodes* of the upland grass (the nodes of grasses are solid). How do these compare with the cattail? (They lack the hollow spaces – *aerenchyma* – observed in the cattail.) What does this tell you about the cattail's ability to adapt to watery conditions?



aerenchyma

cattail cross-section



upland grass node cross-section

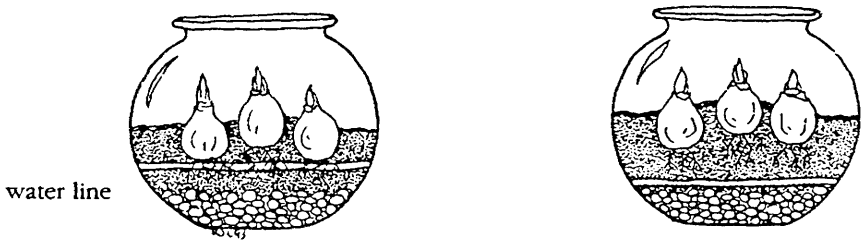
Time Required A few weeks.

Materials

- 6 iris bulbs (available at garden shops)
- Two small glass fish bowls or transparent plastic containers
- Gravel
- Potting soil

Procedure

1. Place about 2–3 inches of gravel in the bottom of the fishbowls for drainage. Fill the bowls with potting soil, and place three bulbs in each so they are about 3/4 covered with the potting soil. Place the bowls by a window with some sunlight. In this experiment, it's important to maintain water levels in the two bowls at different, but consistent, heights. In the *wetland bowl*, keep water about 1/2 inch below the bulb. In the *upland bowl*, keep water so it's just above the gravel.
2. As the bulbs sprout, pay particular attention to the rooting patterns. The *wetland* bulbs should grow a shallow network of fine roots whereas the *upland* bulbs will generate deeper taproots. Why are the bulbs growing differently? Discuss the ability of plants to adapt to different environmental conditions.



wetland bowl upland bowl

Activity 4: Create a Wetland Plant Wheel

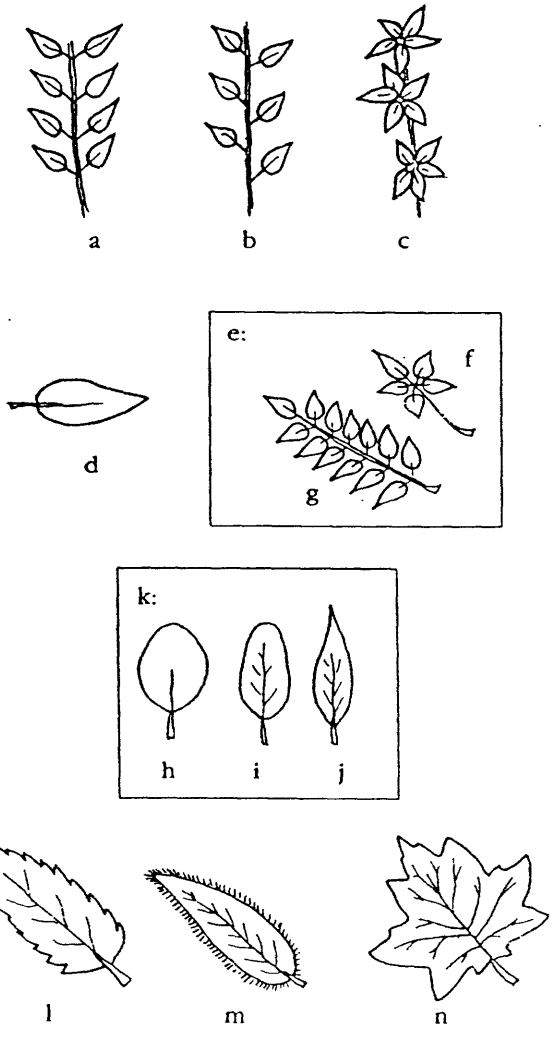
Objective Students will be able to recognize common New England wetland plant species during a visit to a wetland using the wetland plant wheel they construct in class.

Materials

- Construction paper
- Copies of wetland wheels and direction piece
- Scissors, markers
- Paper fasteners

Helpful Facts on Plant Identification

Review this information with the students before constructing the wheel:



- A plant does not always look the same; it may change with the seasons. In winter, most soft plants *die back*, though some leave behind woody stalks, e.g., a cattail. Many trees and shrubs do not have leaves in winter while some do. *Evergreen* plants keep their leaves in winter; *deciduous* plants lose their leaves.
- Many plants do grow flowers though we do not call the plant "a flower." Flowers appear and transform into fruits. Seeds form within the fruits.
- Leaves and twigs are arranged in different patterns on different plants. They may be *opposite* (a), which means that they grow out of the same place on the stem but on opposite sides of the stem.

  Alternate (b) leaves sprout at different places on the stem, alternating from one side of the stem to the other. *Whorled* (c) leaves grow out of the same place on the stem all the way around the stem, like the spokes of a wheel.
- Leaves may be *simple* (d) (one leaf on a stem) or *compound* (e). Compound leaves have several *leaflets* on a stem, arranged in the shape of a hand – *palmate* (f) or like a feather – *pinnate* (g).
- The shape and edges of leaves also are important in identifying plants; leaves may be *round* (h), *oval* (i), *long and/or pointy* (j); edges may be *smooth (entire)* (k), *toothed (jagged edges)* (l), *hairy* (m), *lobed* (n), etc.

Constructing the Wetland Wheel

Use this wheel to help students identify freshwater wetland plants only. Use one of the field guides listed in the *Appendix* for trips to saltwater wetlands.

1. Glue each direction piece to a manila folder or piece of cardboard and cut along the solid outline. Cut out the pie-shaped piece to make a window. Place the pieces back to back, match them up, then glue or staple them together across the top only.
2. Carefully cut out each wheel along the solid outline.
3. Glue the two large wheels together, back to back, so that the centers match.
4. Align the smaller wheels with the larger wheels so that the edge of the smaller wheel lines up with the inside circle (line) on the larger wheel. Match up the two wheels that have numbers 1-16; then poke a small hole through the center of *both wheels at once* with the paper fastener. Now match the smaller wheel numbered 17-32 with the other side of the larger wheel; thread it onto the paper fastener. You should now have a two-sided wheel.
5. Now add the direction piece. Place the two-sided wheels between the two pieces of the direction piece. The top edge of the larger wheel should fit just behind the top edge of the window. Remove the paper fastener. Keeping the direction piece flat, poke holes through the center dots to match the holes in the wheel. Fasten the paper fastener again, and your wetland plant wheel is ready for use!
6. Your students can use the wheel to identify plants on their own at home or during an organized field study (see Chapter VI).

Direction Piece:

Photocopy and cut out **two** direction pieces for each wetland wheel.

Wetland Wheel

Directions:

1. Find a wetland plant to identify.
2. Turn the middle wheel until you find a picture that looks like the plant.
3. Turn the large wheel until you find a description that matches the plant (match the numbers). This will give you the name of the plant!
4. Turn the small wheel until you find the codes that tell you where the plant grows.
5. Hint: Be sure the numbers in the upper right corners of each space in the window are the same.

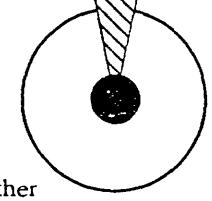
What TYPE of plant is it? ⇨

Description of plant: ⇨

What is its NAME? ⇨

What does it look like? ⇨

Cut out window



Remember to look closely at the leaves and stem arrangement of each plant!

Leaf edges may be:
- entire (smooth)
- toothed (jagged) or wavy

Leaves may be:
- simple (one part)
- compound (many parts – leaflets):
  - pinnate = like a feather
  - palmate = like a hand

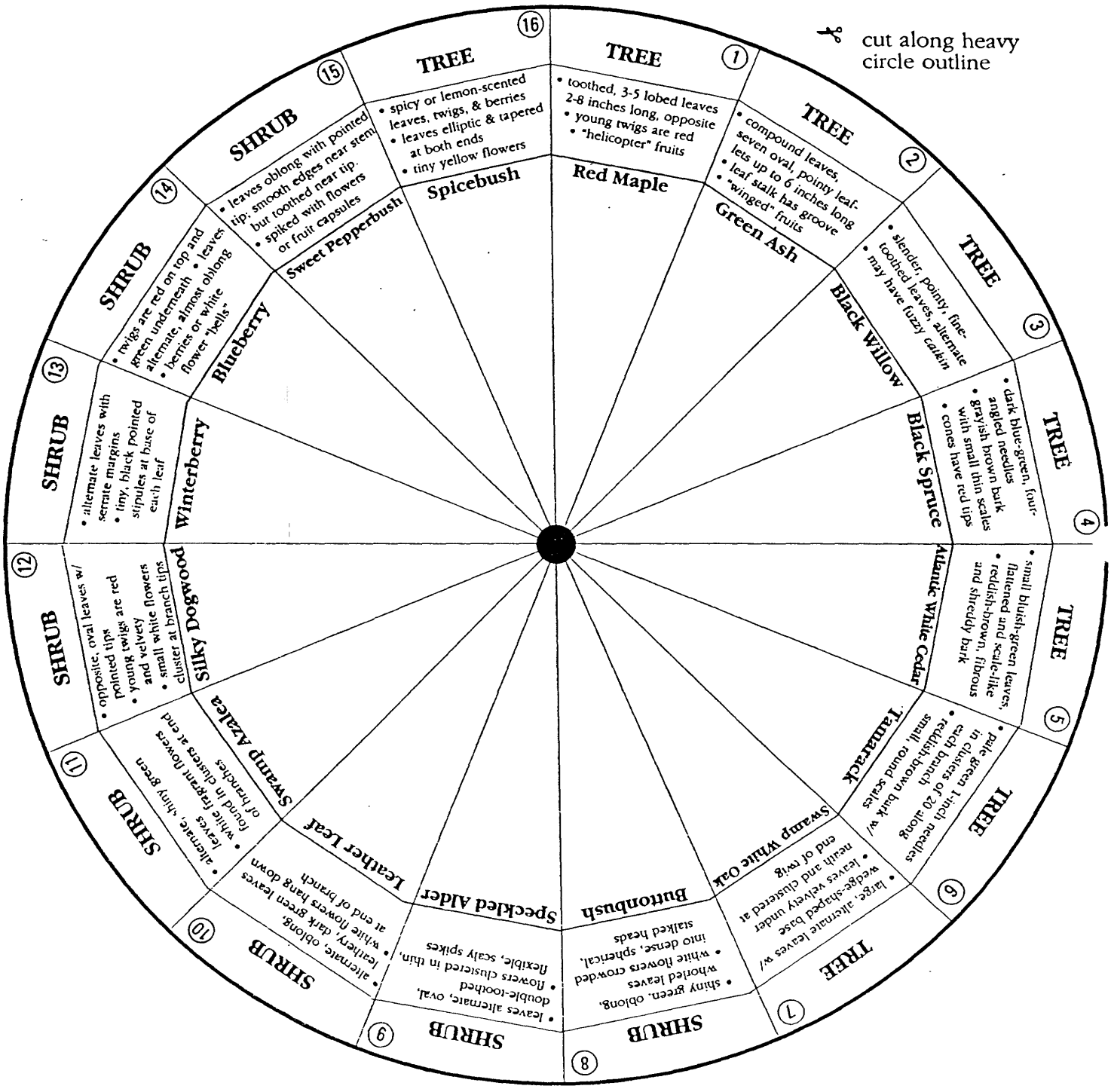
Leaf shape may be:
- round, oval, oblong, egg-shaped, etc.
- lance-shaped (long, pointy) or tapered
- lobed (edges curve inward in places, almost dividing leaf into parts)

Stems and leaves may be arranged so that they are:
- opposite
- alternate
- whorled (like spokes of a wheel)

✂ cut out on outline

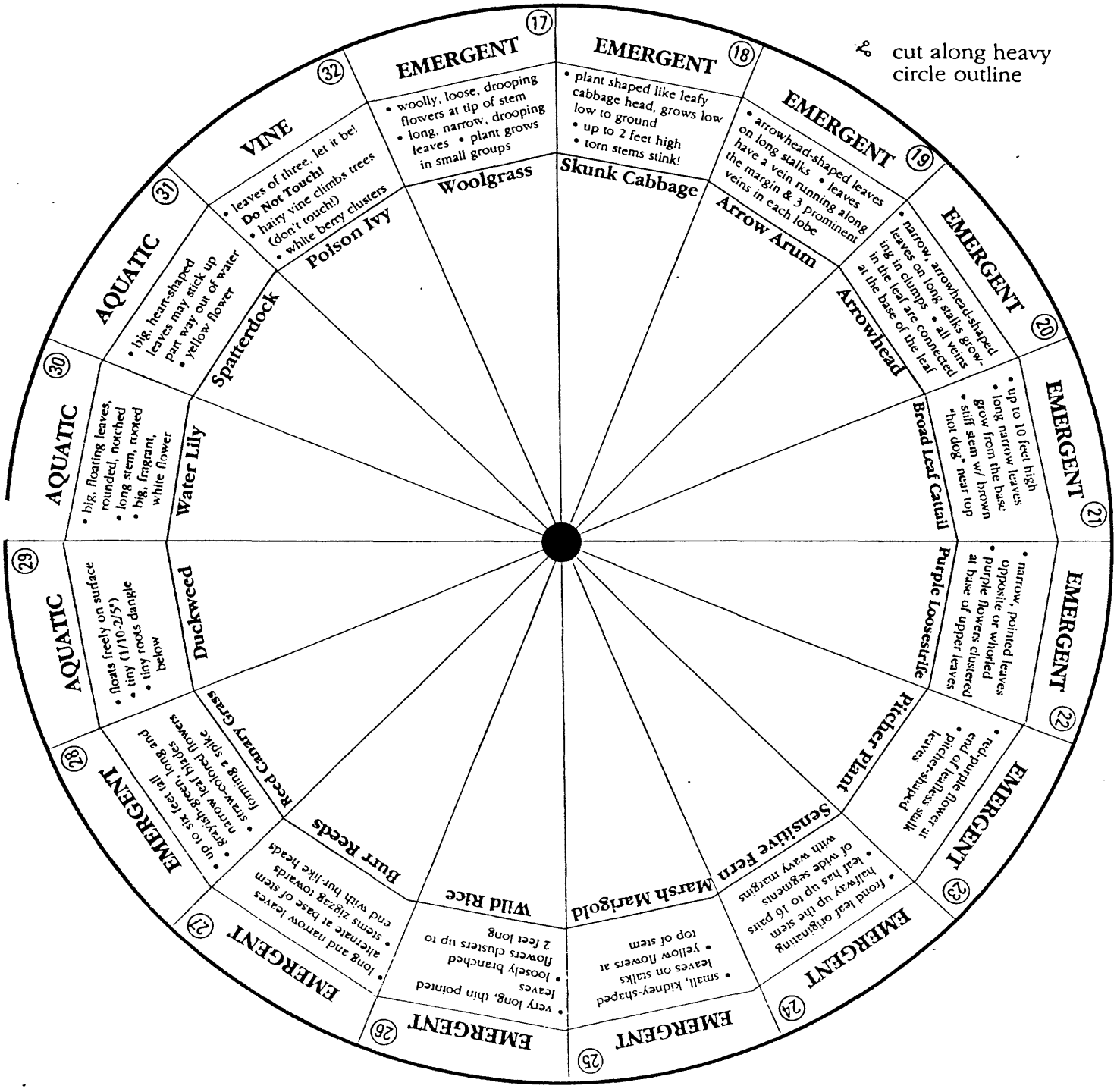
Large Wheel #1:

photocopy and cut out
one for each wetland wheel.



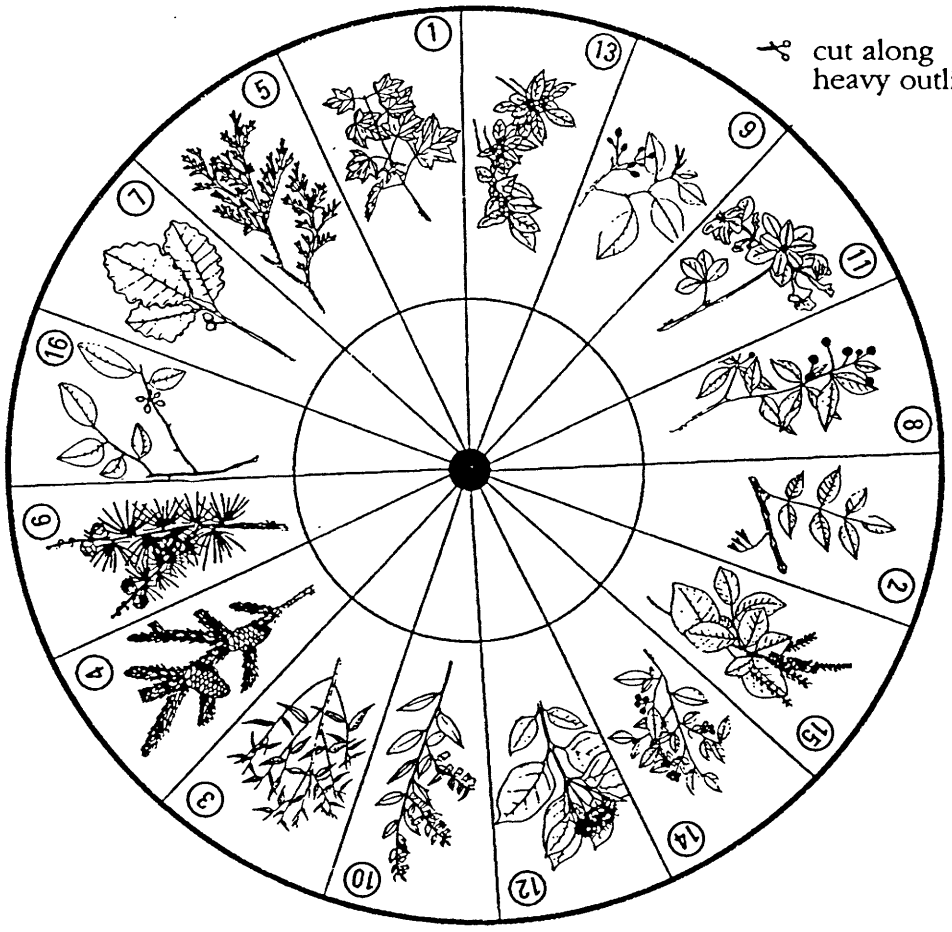
Large Wheel #2:

photocopy and cut out
one for each wetland wheel.



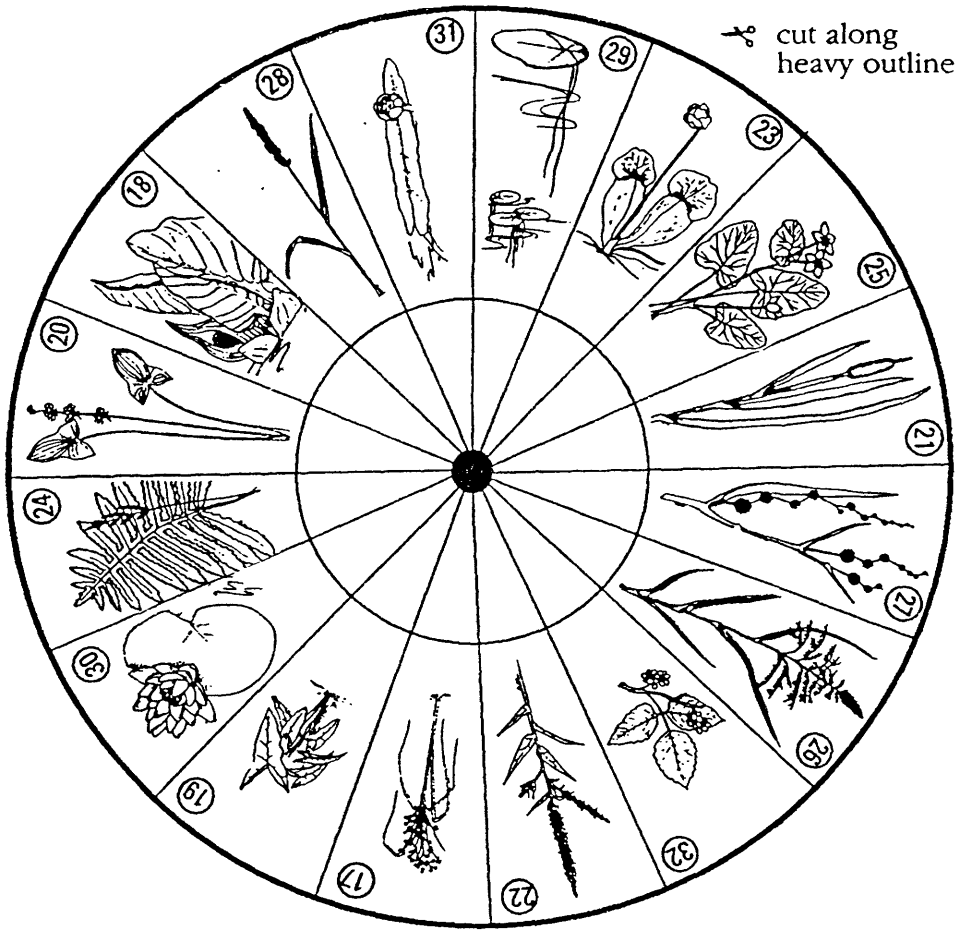
Small Wheel #1:

photocopy and cut out
one for each wetland wheel.



Small Wheel #2:

photocopy and cut out
one for each wetland wheel.



Chapter II Wetland Types

A number of classification systems are currently used to distinguish major wetland types in the U.S. The following broad categories classify wetlands according to their location:

Palustrine: *the majority of vegetated freshwater wetlands, such as forested wetlands, marshes, and swamps.*

Marine: *areas along the coast that include shorelines, shallow water areas, and aquatic beds.*

Estuarine: *wetlands located in sheltered coastal areas where fresh and salt waters mix, such as salt marshes and mangrove swamps.*

Riverine or Riparian: *freshwater wetlands bordering rivers and streams.*

Lacustrine: *wetlands bordering lakes, including the shallow, near-shore areas without plants.*

Wetlands are distributed worldwide and are found in many climates, from the tropics to the tundra. Several types of wetlands are found in the U.S. – *coastal marshes* and a variety of *freshwater* wetland systems (marshes, forested and shrub swamps, bogs, wet meadows, etc.).

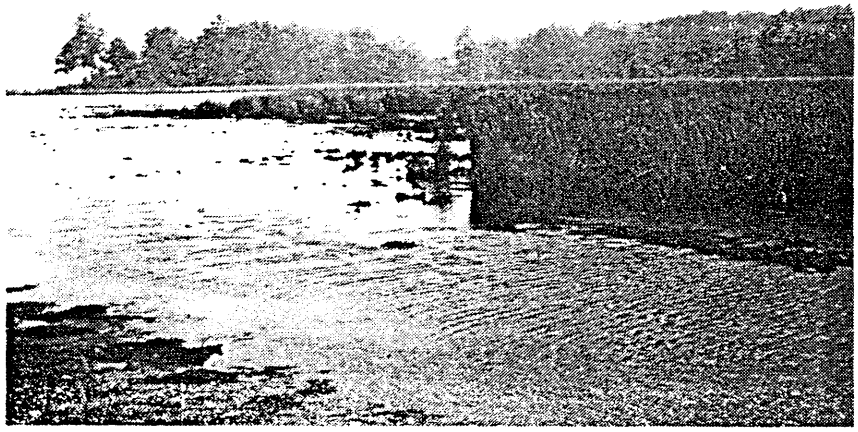
Distinguishing Wetland Types

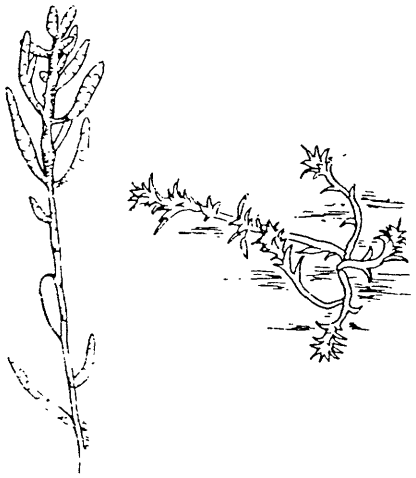
The following categories of wetlands are those common to New England. You can use this section to help you identify the type of wetland you'll be visiting on your field trip. You can also use the illustrations in this chapter to identify plants characteristic of each wetland type.

Forested wetlands are the most common wetland type in New England.

Coastal Wetlands

Coastal wetlands are found along all the U.S. coasts and make up approximately 5% of all wetlands. Since many of the nation's largest cities are located along the coast, these wetlands are especially vulnerable to development pressures.





saltwort/glasswort

Salt Marshes

Salt marshes occur almost continuously along the east coast, in protected areas on the west coast, and in the Gulf of Mexico and Alaska. These areas are periodically flooded by saline or brackish waters due to tidal cycles. Plants and animals inhabiting salt marshes are adapted to the stressful environment of the marshes, including fluctuations in salinity, periodic and variable water inundation due to the tides, and extremes in temperature as tides rise and fall. Salt marshes are dominated by salt-tolerant plants, called *halophytes*, resembling a coastal "sea of grass" that filter and circulate nutrients.

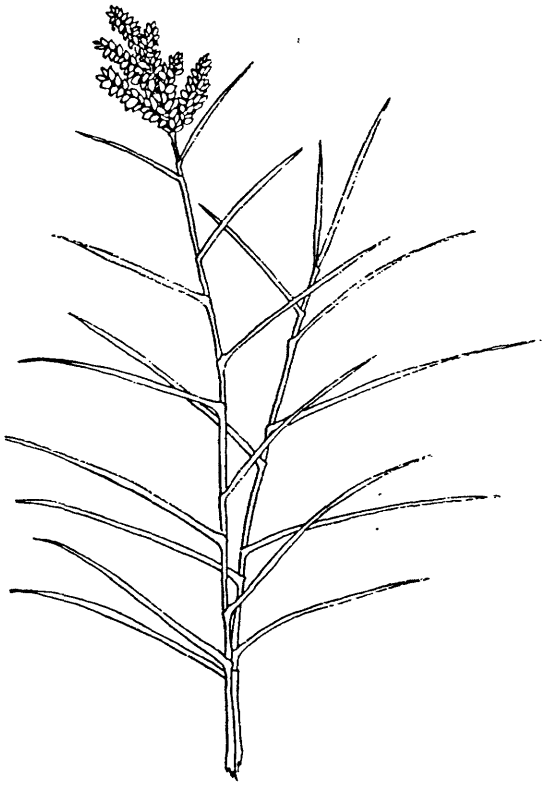
Salt marshes are one of the most productive ecosystems in the world. Tiny pieces of plant and animal matter called *detritus* form the basis of the salt marsh food chain. This material is decomposed by fungi and bacteria which are then consumed by other organisms along the food chain such as plankton, clams, fiddler crabs, snails, insect larvae, and some fish. Almost half of this decomposed organic material remains in the marsh where it accumulates over time to form marsh peat, a mixture of organics, mud, clay, or sand. Salt marshes absorb much of the water from ocean surges during severe storms and this helps to reduce damage from erosion and flooding.

Tidal Brackish Marshes

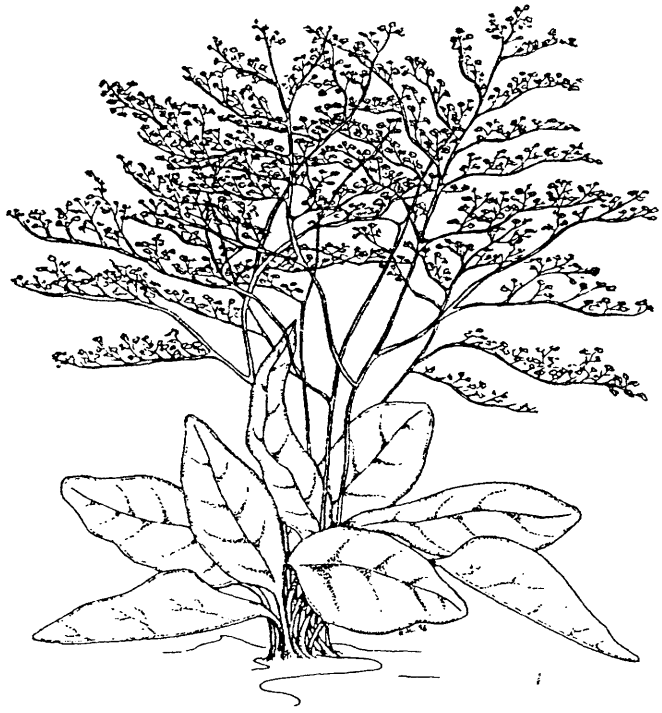
Tidal brackish marshes are transitional areas between salt marshes and tidal freshwater marshes. Because these wetlands are less saline than salt marshes, they allow for a greater diversity of plant and animal species incapable of tolerating the extreme salinity found in salt marshes.

Characteristic Plants for Salt Marshes

Common name	*Scientific name*
Low marsh	
smooth cordgrass	*Spartina alterniflora* (tall form)
High marsh	
smooth cordgrass	*Spartina alterniflora* (short form)
salt marsh hay	*Spartina patens*
spike grass	*Distichlis spicata*
black grass	*Juncus gerardii*
sea lavender	*Limonium nashii*
saltwort or glasswort	*Salicornia europaca*



spike grass



sea lavender

smooth cordgrass

Inland Wetlands

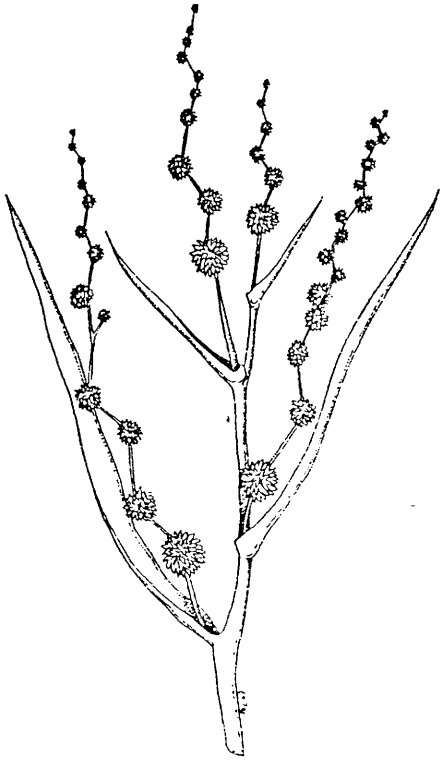
The majority of wetlands in the United States (95%) are inland wetlands. They occur throughout the interior of the country and are commonly found along the banks of rivers and streams, the margins of lakes and ponds, or as isolated depressions surrounded by dry land. The following are freshwater wetland types characteristic of New England.

Freshwater Marshes

Freshwater marshes are dominated by *herbaceous* (non-woody) plants which may emerge above the water, float on the surface, or remain completely submerged. Water levels range from about three feet to six inches or less. Surface water may be entirely absent during late summer or excessively dry periods. Marshes generally have sources of water other than direct precipitation, such as groundwater seeps and streams.

Marshes provide habitat for a variety of species because of their abundant food supply, vegetative cover, and superior nesting habitat. Migratory waterfowl especially use marshes for nesting and wintering areas.

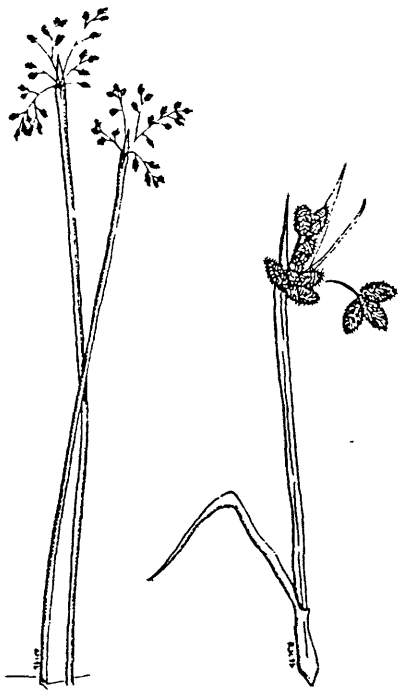
arrow arum



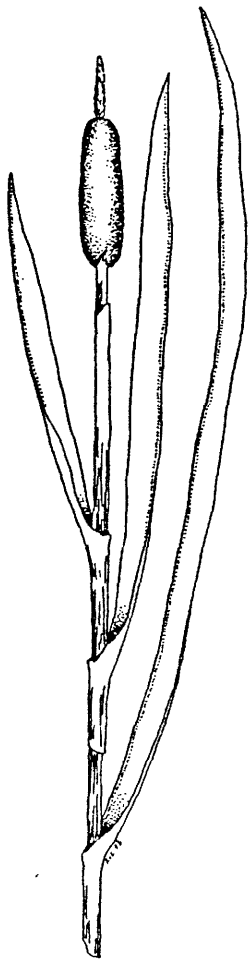
burreeds

Characteristic Plants for Freshwater Marshes

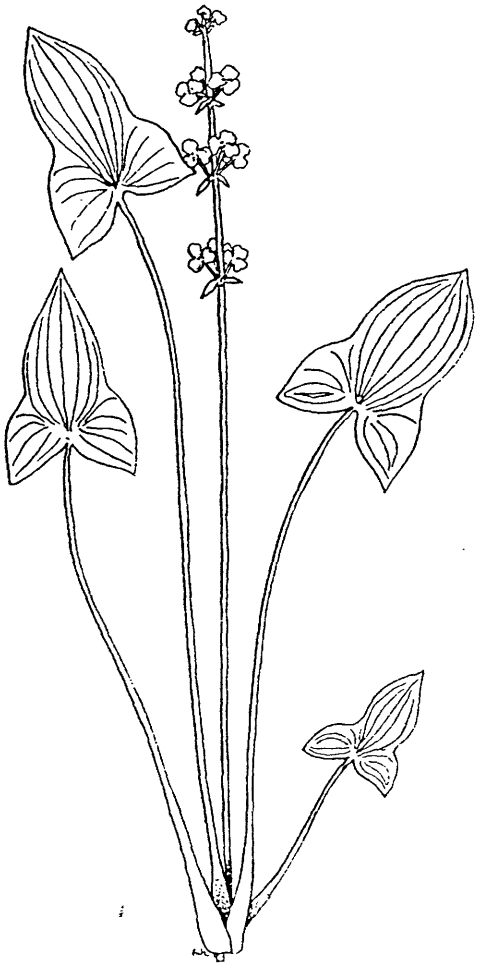
Common name	*Scientific name*
soft-stem bulrush	*Scirpus validus*
sedges	*Carex spp.*
burreeds	*Sparganium eurycarpum*
rushes	*Juncus spp.*
broad-leaved cattail	*Typha latifolia*
narrow-leaved cattail	*Typha angustifolia*
arrow arum	*Peltandra virginica*
arrowheads	*Sagittaroria latifolia*
wild rice	*Zizania aquatica*



soft-stem bulrush



broad-leaved cattail

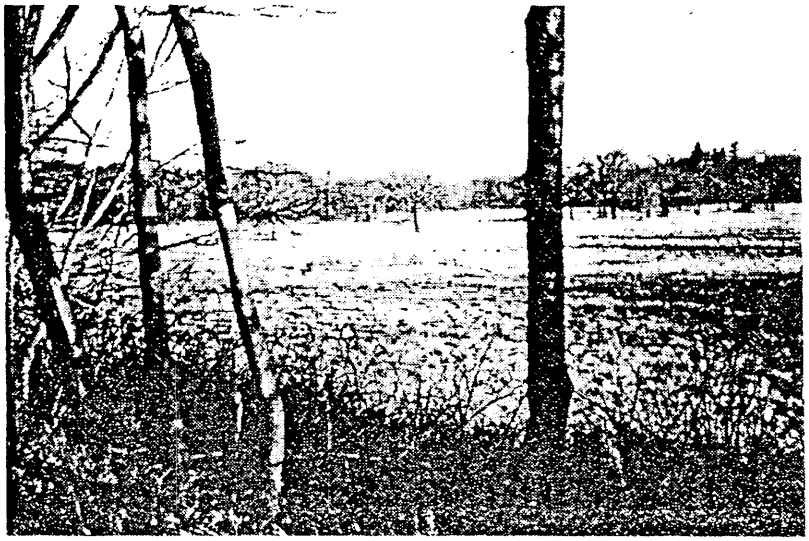


arrowhead

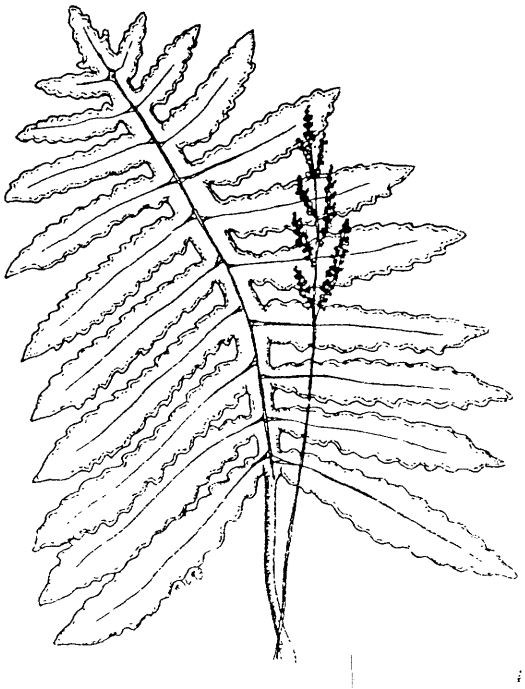
wild rice

Wet Meadows

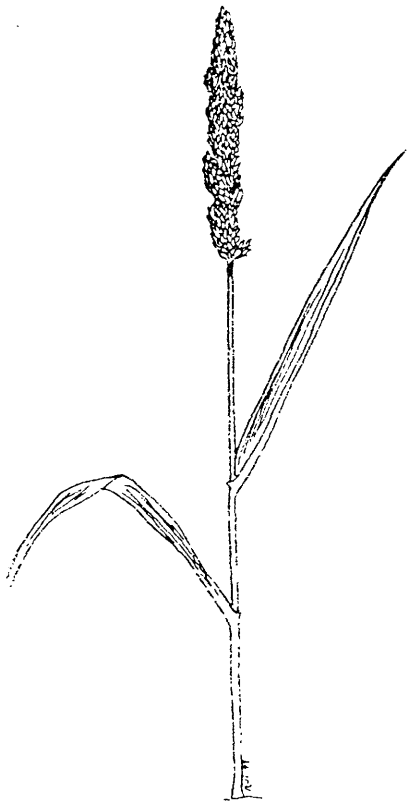
Wet Meadows are a type of marsh dominated by grasses or sedges. Water saturates the soil at a depth of six inches or less but generally is not visible on the surface most of the year.



purple loosestrife



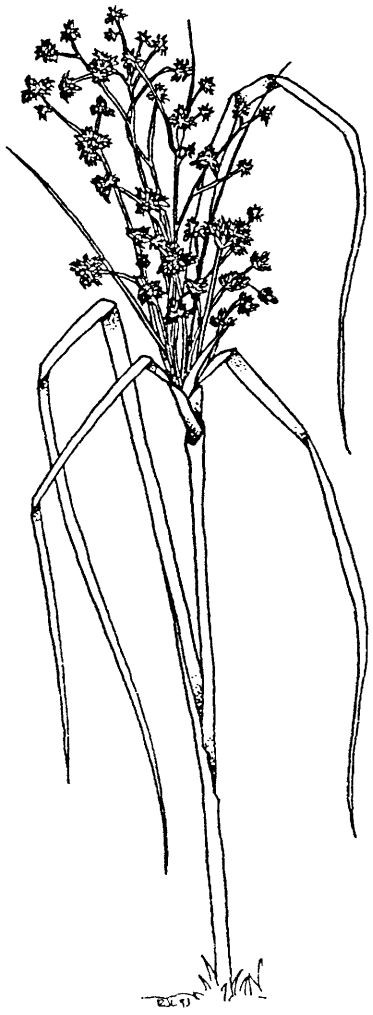
sensitive fern



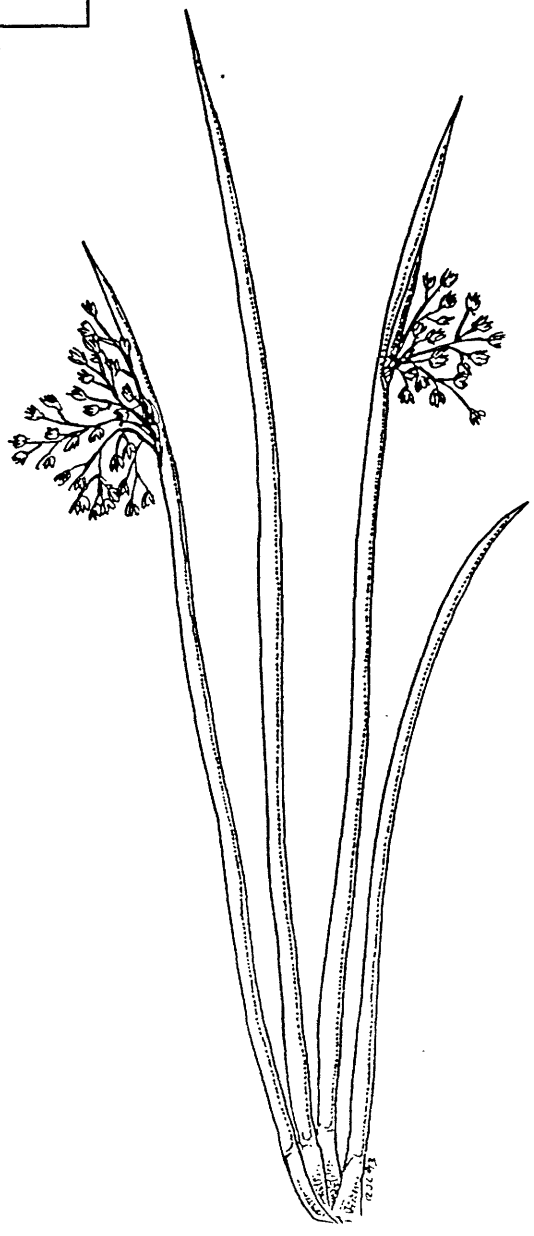
reed-canary grass

Characteristic Plants for Wet Meadows

Common name	*Scientific name*
reed-canary grass	*Phalaris arundinacea*
woolgrass	*Scirpus cyperinus*
purple loosestrife	*Lythrum salicaria*
sensitive fern	*Onoclea sensibilis*
soft rush	*Juncus effusus*



woolgrass



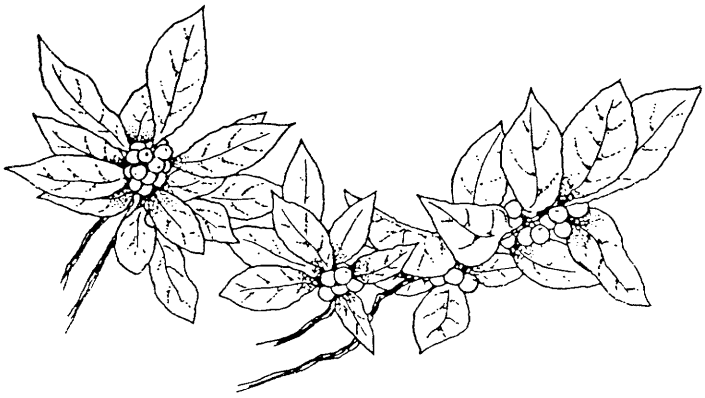
soft rush

Swamps

Swamps are wetlands dominated by woody trees or shrubs, which distinguish them from marshes. Swamps occur in isolated depressions or along borders of lakes, ponds, rivers, and streams. These wetlands are fed water through precipitation, flooded by water bodies such as lakes and streams, groundwater discharge, or a combination of these sources. Swamps may dry out completely during the summer, but all remain waterlogged from winter to spring.

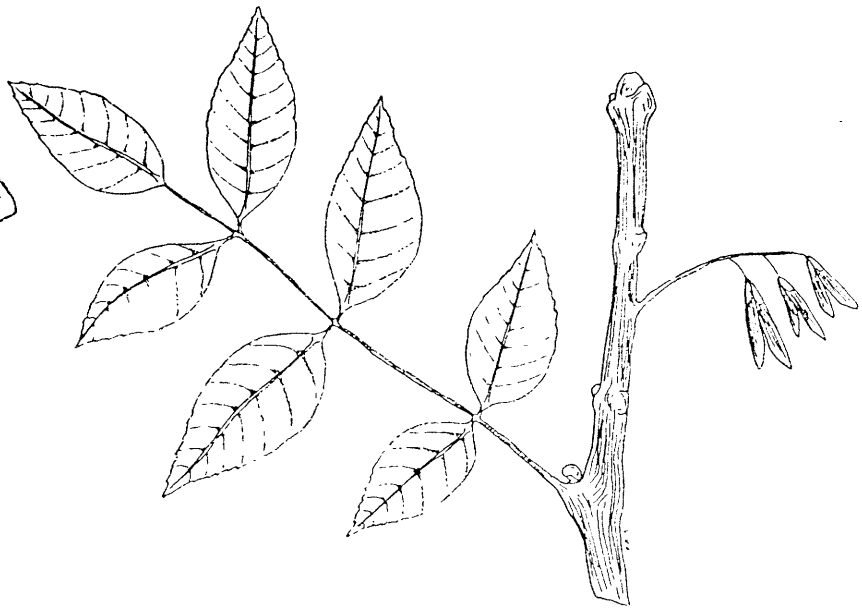
Forested Wetlands

Forested wetlands, the most common wetland type in New England, are dominated by trees usually six meters or taller.



winterberry holly

highbush blueberry

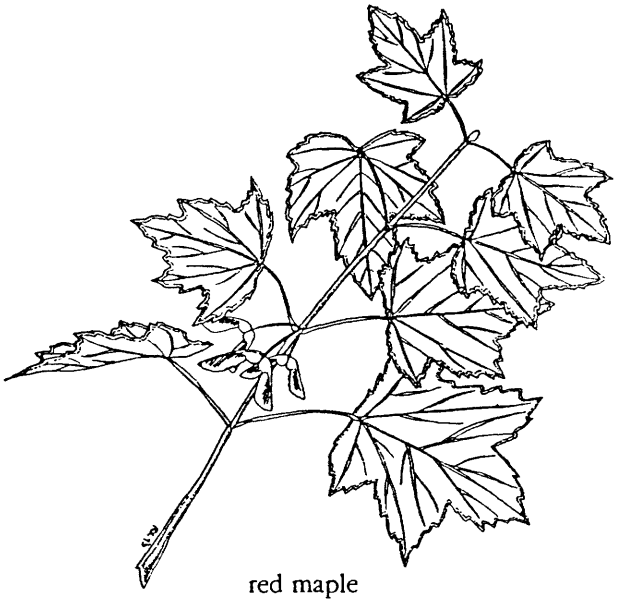


green ash

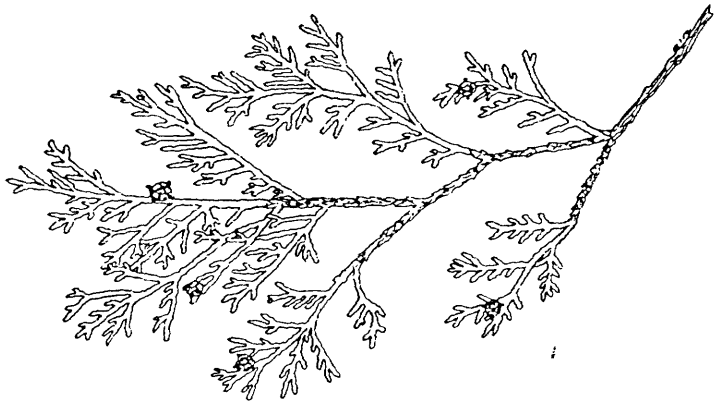
Characteristic Plants for Forested Wetlands

Common name	*Scientific name*
Trees & Saplings	
northern white cedar	*Thuja occidentalis*
red maple	*Acer rubrum*
Atlantic white cedar	*Chamaecyparis thyoides*
black willow	*Salix nigra*
green ash	*Fraxinus pensylvanica*
Shrubs	
highbush blueberry	*Vaccinium corymbosum*
winterberry holly	*Ilex verticillata*
spice bush	*Lindera benzoin*
swamp azalea	*Rhododendron viscosum*
silky dogwood	*Cornus amomum*
Groundcover	
cinnamon fern	*Osmunda cinnamomea*
sensitive fern	*Onoclea sensibilis*
marsh marigold	*Caltha palustris*
royal fern	*Osmunda regalis*
dewberry	*Rubus hispidus*

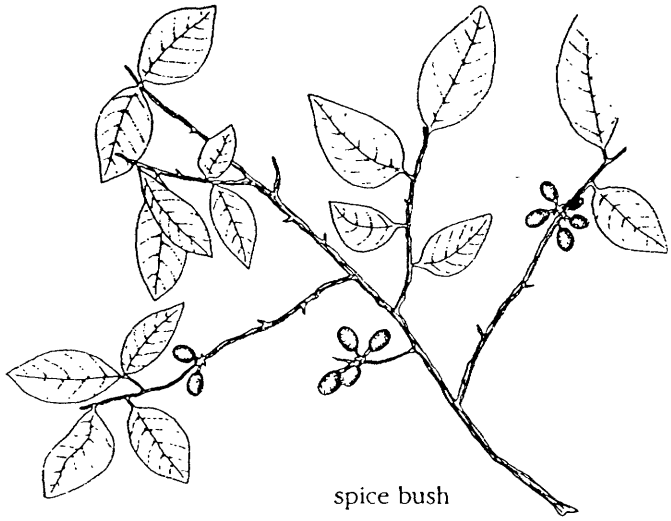
silky dogwood



red maple



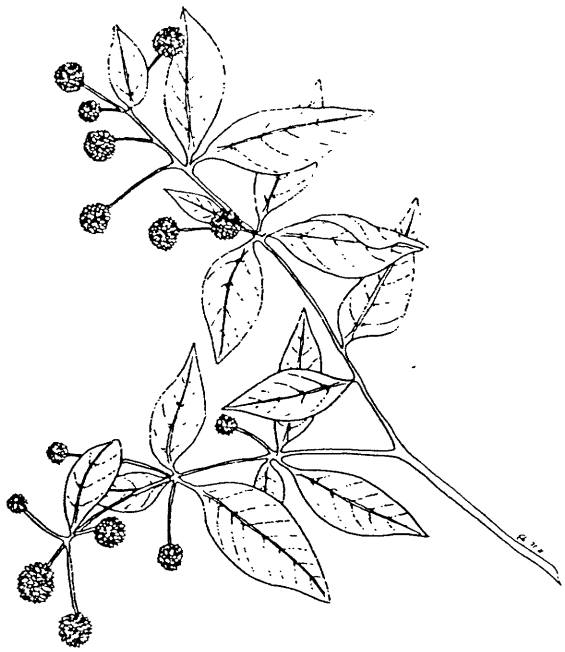
Atlantic white cedar



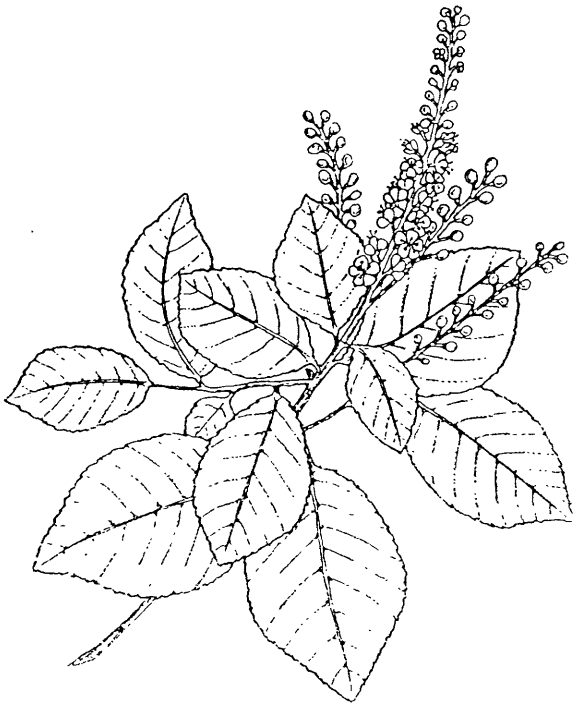
spice bush

Shrub Swamps

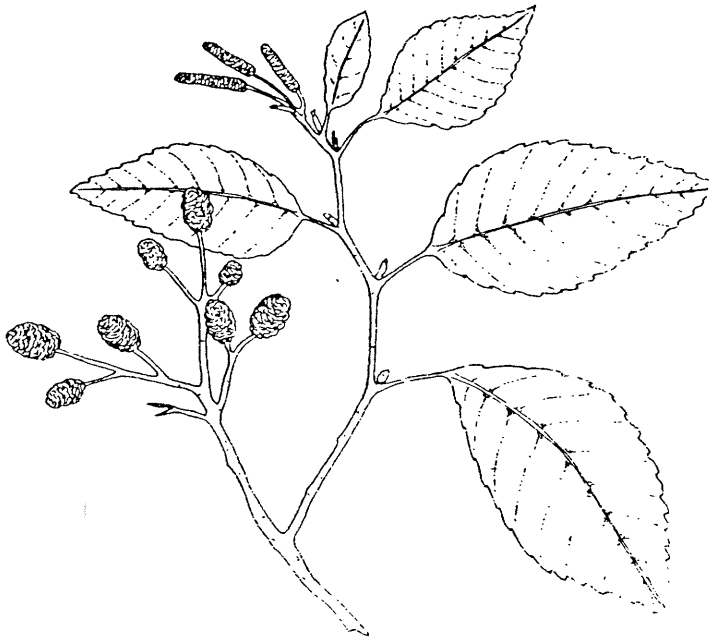
Shrub swamps are dominated by shrubs or young trees less than six meters tall.



buttonbush



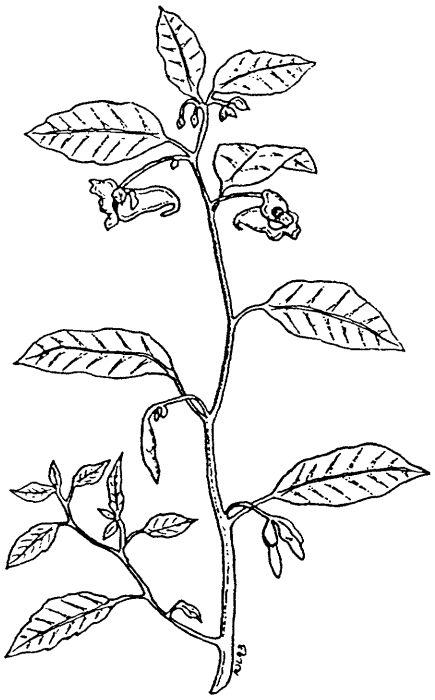
sweet pepperbush



speckled alder

Characteristic Plants for Shrub Swamps

Common name	*Scientific name*
Shrubs	
buttonbush	*Cephalanthus occidentalis*
silky dogwood	*Cornus amomum*
sweet pepperbush	*Clethra alnifolia*
speckled alder	*Alnus rugosa*
swamp rose	*Rosa palustris*
Groundcover	
skunk cabbage	*Symplocarpus foetidus*
marsh marigold	*Caltha palustris*
jewelweed	*Impatiens capensis*
marsh fern	*Thelypteris thelypteroides*
sensitive fern	*Onoclea sensibilis*



jewelweed

skunk cabbage

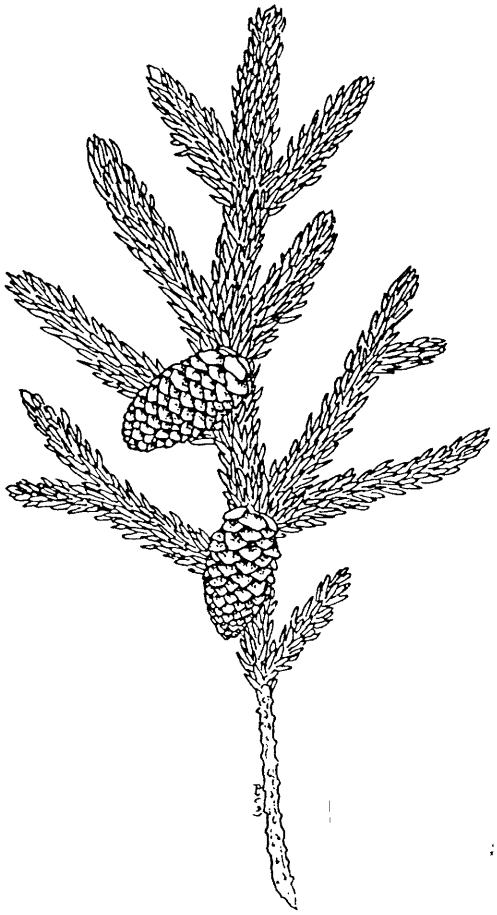
marsh marigold

Bogs and Fens

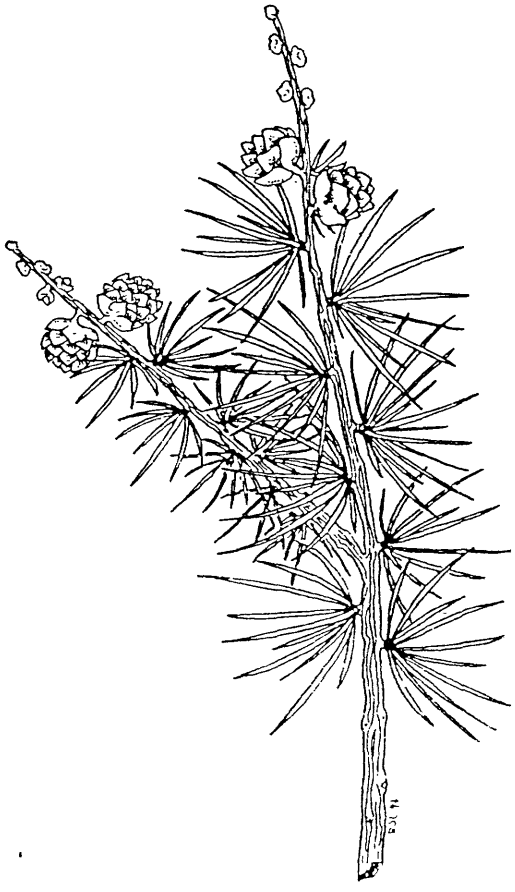
Bogs are peatlands that have no significant inflow or outflow of water and receive water mostly through precipitation. Because the main source of water is from precipitation, as opposed to groundwater, nutrient content is low. In addition, the soil is generally permanently saturated with water. As a result, few bacteria and soil microbes live in bog soils, creating very slow rates of plant decomposition. As plants die, they accumulate on the ground, eventually forming a thick mat of sphagnum moss and peat. Bogs are common in colder northern states such as Maine, Vermont, Wisconsin, Michigan, and Minnesota.

Bogs may eventually fill entirely with peat, giving way to the creation of a spruce or white cedar forest.

Fens are non-acidic peatlands that receive their water primarily from groundwater sources and a little from precipitation. Fens are more nutrient-rich than bogs and support a wider variety of species because of their connection to groundwater.



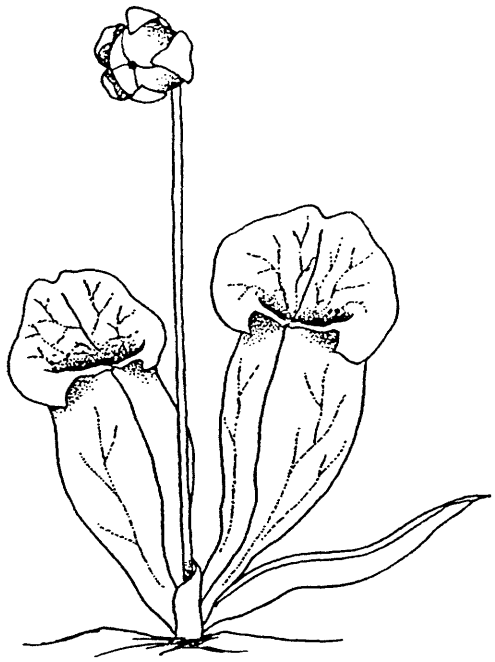
black spruce



tamarack

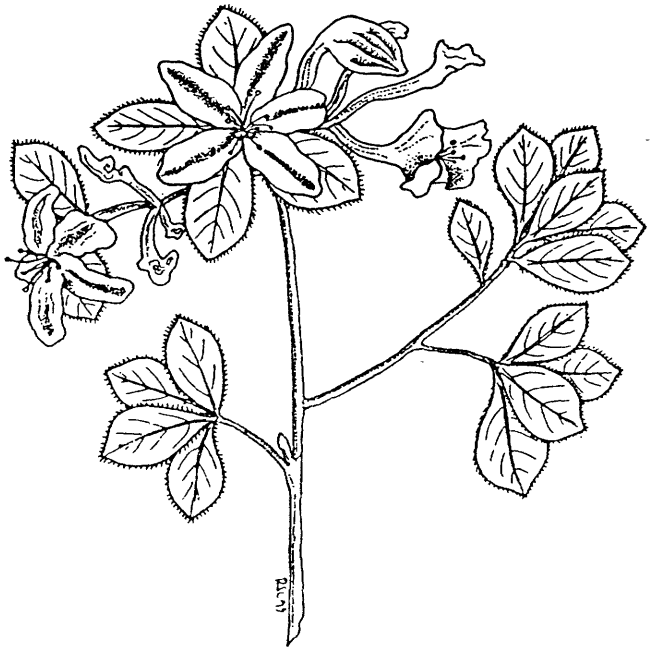
Characteristic Plants for Bogs and Fens

Commonname	*Scientificname*
Trees	
Atlantic white cedar	*Chamaecyparis hyoides*
black spruce	*Picea mariana*
tamarack	*Larix laricina*
Shrubs	
sweet gale	*Myrica gale*
leatherleaf	*Chamaedaphne calyculata*
swamp azalea	*Rhododendron viscosum*
cranberry	*Vaccinium oxycoccos*
bog laurel	*Kalmia palifolia*
Groundcover	
sphagnum moss	*Sphagnum spp.*
pitcher plant	*Sarracenia purpurea*
sundew	*Drosera spp.*
sedges	*Carex spp.*



pitcher plant

leatherleaf



swamp azalea

Vernal Pools

Vernal Pools are temporary pockets of freshwater found in depressions in wooded areas, meadows, and river floodplains throughout the U.S. These typically small and shallow pools are filled by spring rains and snowmelt and usually dry up during the summer months, though some persist year round. Though small and temporary, they provide a habitat essential to many creatures such as fairy shrimp, salamanders, and frogs which require vernal pools to complete at least a portion of their life cycle.

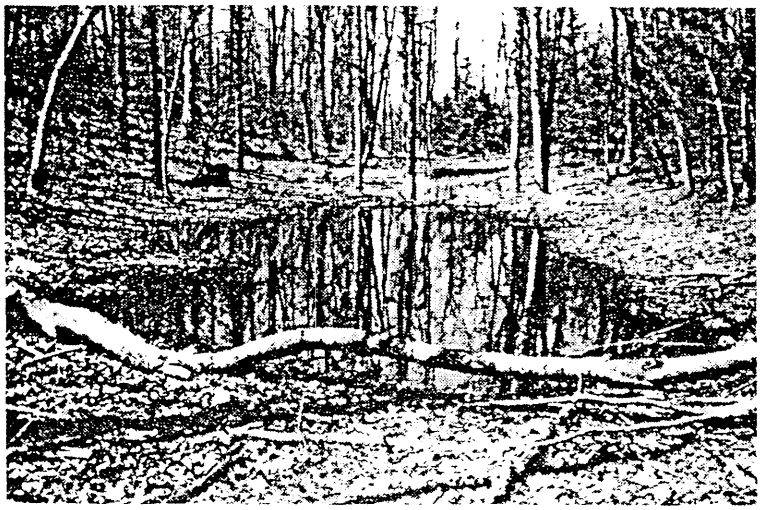


photo by Leo Kenney

Vernal Pool (Autumn)

photo by Leo Kenney

Vernal Pool (Summer)

An excellent reference to use with students is *Spring Pool: A Guide to the Ecology of Temporary Ponds*, published by the New England Aquarium. This glossy, hardcover text (55 pp.) includes several detailed color photos of vernal pools and a field guide to their inhabitants and is available for $15.95 through the New England Aquarium gift shop (617) 973-5266.

Getting Your Students Involved:

Describe wetland types as habitats that support the lives of plants, wildlife, and humans. What kind of food, shelter, and space is afforded by different wetland types? What are the unique characteristics of wetlands as opposed to terrestrial sites?

There are many ways to distinguish wetlands, and although wetland professionals have formal methods for distinguishing them, students can create their own classification systems. One way to enter into teaching about the differences in wetland habitat is to have students create names for wetlands based on their characteristics. You can create cards that have plant types, soil types, and saturation or inundation periods, and wildlife names on them. Mix and group the cards. Have students draw pictures that show how they think this area would look based on the characteristics. Have them come up with a name that metaphorically describes the area.

As you walk out into the 'adopted' wetland, jot down the words being used by your students to describe the wetland. Have them brainstorm additional descriptive words and record them. When you return to the classroom, have the students create a poem, rap song, or picture of the wetland using only these descriptive words. Give the wetland a name that incorporates the most frequently used words.

Using formal classifications, describe the wetland you have visited. See if the class can identify its wetland from your description. Mix it in with the descriptions of other areas. The mystery is to find the one you have visited.

Guide to Wetland Wildlife in New England

Salt and Brackish Marshes

Birds

clapper rails, marsh wren, great egret, marsh hawk, great blue heron

Mammals

raccoon, mink, meadow vole

Reptiles

northern water snake (brackish), diamond-backed terrapin

Amphibians

spring peeper (brackish)

Invertebrates

fiddler crab

Freshwater Marshes

Birds

great blue heron, red-winged blackbird, mallard, Canada goose, marsh wren, wood duck, sora rail, marsh hawk, northern yellowthroat

Mammals

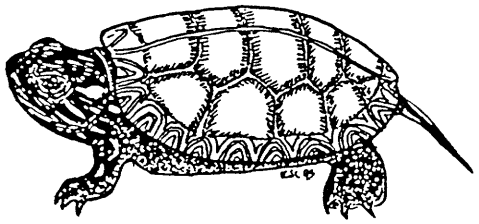
muskrat, raccoon, mink

Reptiles

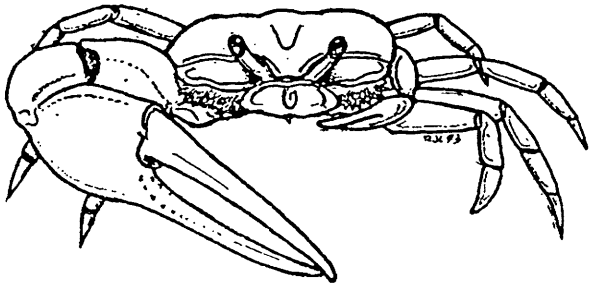
ribbon snake, painted turtle, water snake, snapping turtle, northern water snake

Amphibians

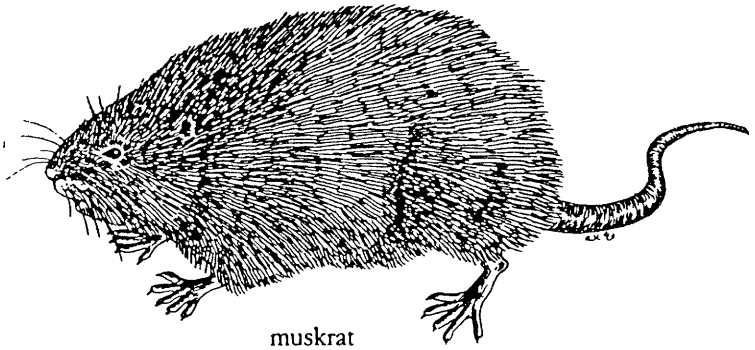
bullfrog, green frog, spring peeper



painted turtle



fiddler crab



muskrat

Wet Meadows

Birds

great blue heron, mallard, sora, song sparrow, swamp sparrow, red-winged blackbird

Mammals

muskrat, eastern cottontail, red fox, whitetail deer, meadow vole

Reptiles

ribbon snake, eastern garter snake, smooth green snake

Amphibians

leopard frog

Forested Wetlands

Birds

wood duck, red-shouldered hawk, tree swallow, barred owl, cedar waxwing, pileated woodpecker

Mammals

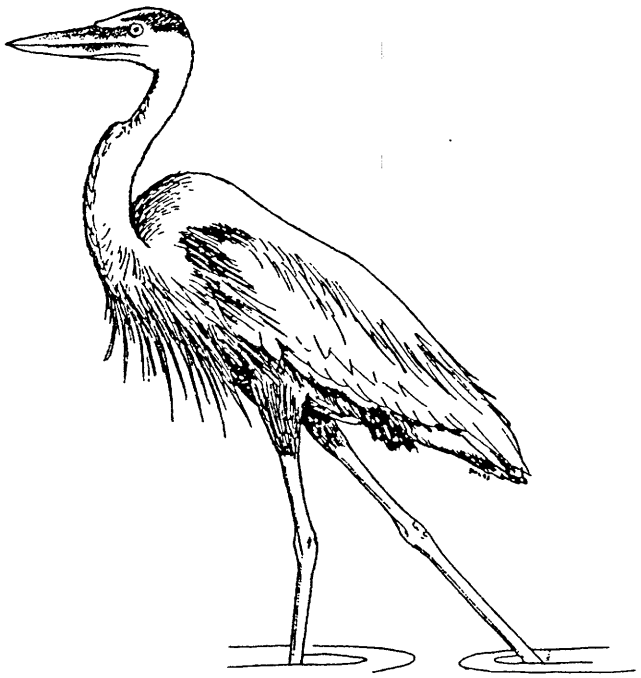
beaver, raccoon, mink, white-tailed deer, snowshoe hare, water shrew

Reptiles

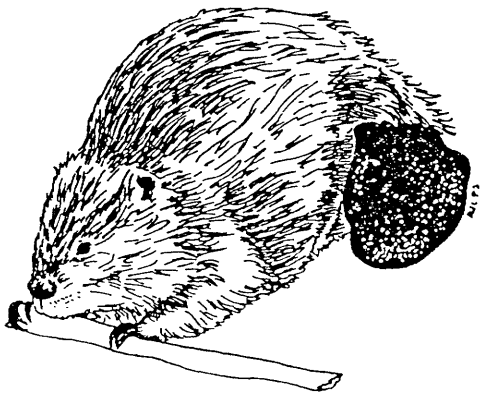
wood turtle, spotted turtle, painted turtle, eastern garter snake

Amphibians

spotted salamander, marble salamander, redback salamander, red-spotted newt, wood frog, leopard frog, pickerel frog



great blue heron



beaver

Shrub Swamps

Birds

cedar waxwing, red-shouldered hawk, swamp sparrow, black-capped chickadee, yellow warbler

Mammals

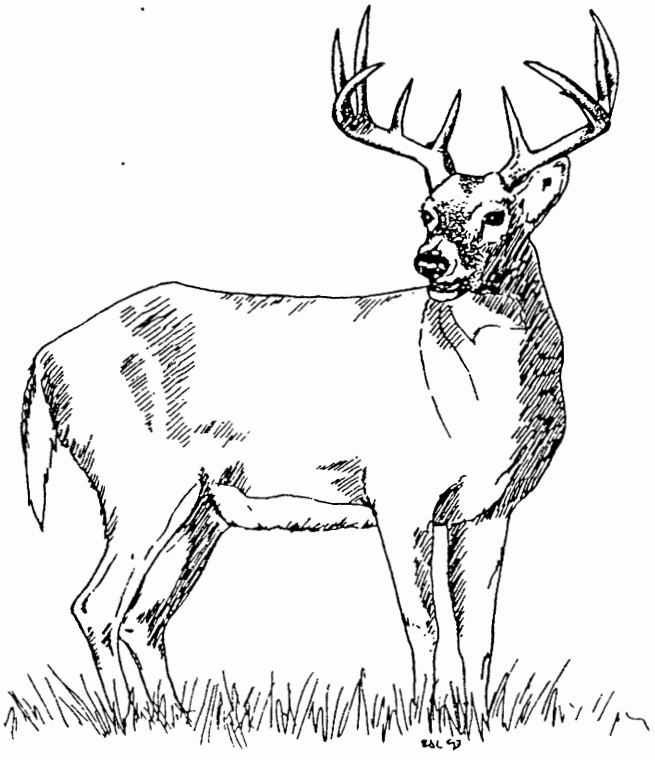
beaver, muskrat, raccoon, river otter, white-tailed deer, opossum

Reptiles

Blanding's turtle, spotted turtle, wood turtle, northern water snake, snapping turtle

Amphibians

gray tree frog, spring peeper



white-tailed deer

Bogs

Birds

yellow-bellied flycatcher, palm warbler

Mammals

water shrew, bog lemming

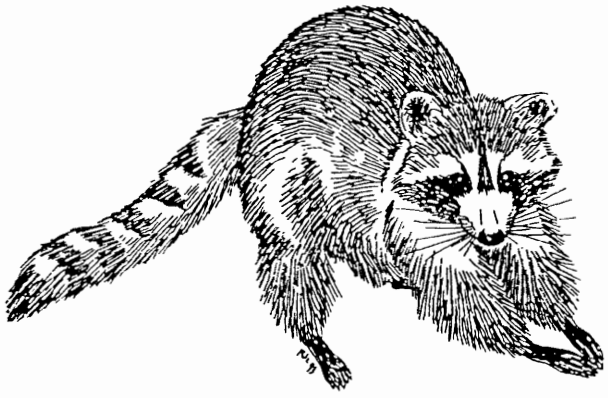
Reptiles

bog turtle

Amphibians

four-toed salamander, gray tree frog

gray tree frog



raccoon

VERNAL POOLS

Birds

great blue heron, ducks, geese, songbirds

Mammals

raccoon, muskrat, shrews, voles, mice

Reptiles

painted turtle, spotted turtle, snapping turtle

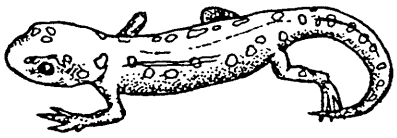
Amphibians

spotted salamander*, Jefferson's salamander*, four-toed salamander, green frog, wood frog*, spring peeper, American toad

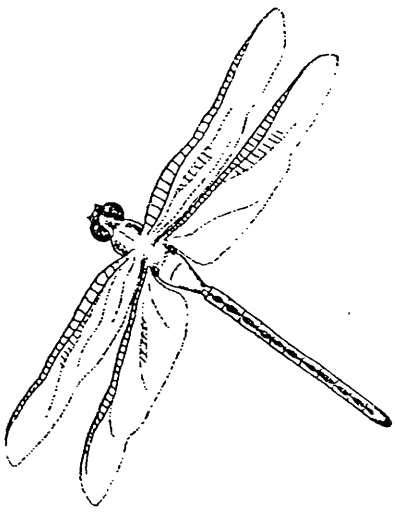
Invertebrates

caddisfly, damselfly, dragonfly, fairy shrimp*, whirligig beetle, water flea

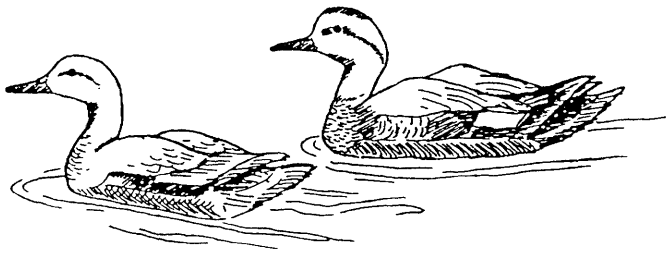
* *Obligate species*



spotted salamander *



dragonfly



ducks

Regional Wetland "Celebrities"

The following are some of the better known wetland systems in the U.S. Many of them are distinguished by the unique regional ecological conditions that created them. Being familiar with wetlands from other parts of the country will give your students exposure to the "bigger picture" of wetlands as a global natural resource. (See Activity 1, *Put It On the Map!*)

Prairie Potholes

— shallow, marsh-like ponds found in parts of Minnesota, the Dakotas and the adjacent Canadian provinces

They are known as the "duck factory" of North America because of the large number of ducks using the area as a stopover during migration from wintering grounds in the south to nesting grounds in the north. At one time the prairie potholes were widespread and abundant. Today they are greatly reduced in distribution and number due to drainage for agriculture.

Prairie Potholes

Pocosins

— evergreen shrub bogs found along the Atlantic Coastal Plain from Virginia to northern Florida

Pocosins are particularly dominant in North Carolina. The word "pocosin" comes from the Algonquin Indian phrase for "swamp on a hill." They are classified as bogs because of their resemblance to the nutrient-poor, acidic wetlands normally found in much colder climates.

Wet Tundra or Muskegs

— vast plateaus of peat found in Alaska and Canada

Mangrove Swamps

— coastal wetlands found in the tropical and subtropical regions of the world

They are common in Hawaii and in southern Florida. These wetlands are dominated by woody plants called mangroves that have multibranched, tangled, thick root systems emerging from the soil. Their extensive root system protects the shoreline from erosion and storm damage. Mangroves are among the few woody plants capable of tolerating the salinity of the

open ocean. They have developed special adaptations that prevent salt from entering the roots and excrete it through the leaves.

Bottomland Hardwoods

Bottomland Hardwood Forests

— forested wetlands located in low-lying areas along river floodplains .

These rapidly disappearing flooded forests are found in southeastern states such as Louisiana.

Okefenokee Swamp

— an Indian word that means "land of the trembling earth" because of its numerous floating islands of vegetation

The Okefenokee, located in southeastern Georgia and northeastern Florida, actually encompasses six different wetland types: pond cypress forest, emergent and aquatic bed prairie, broad-leaved evergreen forest, broad-leaved shrub wetland, mixed cypress forest, and black gum forest.

The Mississippi River Delta

Located at the mouth of the largest river in the U.S., it is one of the richest marsh and swamp wetland systems in the world.

San Francisco Bay

A large portion of the Bay used to be an enormous estuarine salt marsh, but nearly 95% has been lost since the Gold Rush of 1849.

The Great Kankakee Swamp

Before land clearing for agriculture began about 100 years ago, this swamp was one of the largest marsh-swamp complexes in the U.S. interior, located in northwestern Indiana and northeastern Illinois. The Kankakee River which fed this wetland system was channelized in the late 19th century. This process eventually eradicated the great swamp by the late 1930's.

The Florida Everglades

— often referred to as a "river of grass" for the vast expanses of sawgrass that dominate the area

The Everglades also have an abundance of tropical plants including hardwoods, palms, and orchids.

Activity 1: Put It On the Map!

Objective: Students will be able to locate some of the better-known regional wetland types on a U.S. map, learn a few facts about each of them, and distinguish one wetland habitat type from another.

Materials:

- U.S. wetlands map handout
- Wetland reference texts (optional)

Part I

Procedure

1. Review the information about different wetland types with students (in this chapter). Generate a discussion with students about what makes one wetland habitat different from another:
   - How are these wetlands distinguished from each other? (characteristic plants and wildlife found there)
   - What environmental factors might cause such differences? (climate, elevation, frequency & amount of water present)
   - What types of wetlands might be found in more than one location in the U.S.? (coastal wetlands, vernal pools, forested wetlands, scrub shrub swamps)
   - Do you know of any distinct types of wetlands that are unique to one region of the country? (see text in Chapter 2)
   - Do you think there are more inland or coastal wetlands in the U.S.? (inland – 95%, coastal – 5%)

2. Hand out copies of the U.S. wetlands map to each student. Have them try to locate the following regional wetland types on their maps:

   Pocosins (North Carolina)

   Bogs & Fens (northeast & north central states and Alaska)

   Prairie Potholes (Minnesota and Dakotas)

   Bottomland Hardwood Forests (southeastern states)

   Wet Tundra (Alaska)

   Tropical Rainforests (Hawaii)

   Mangroves (southern Florida)

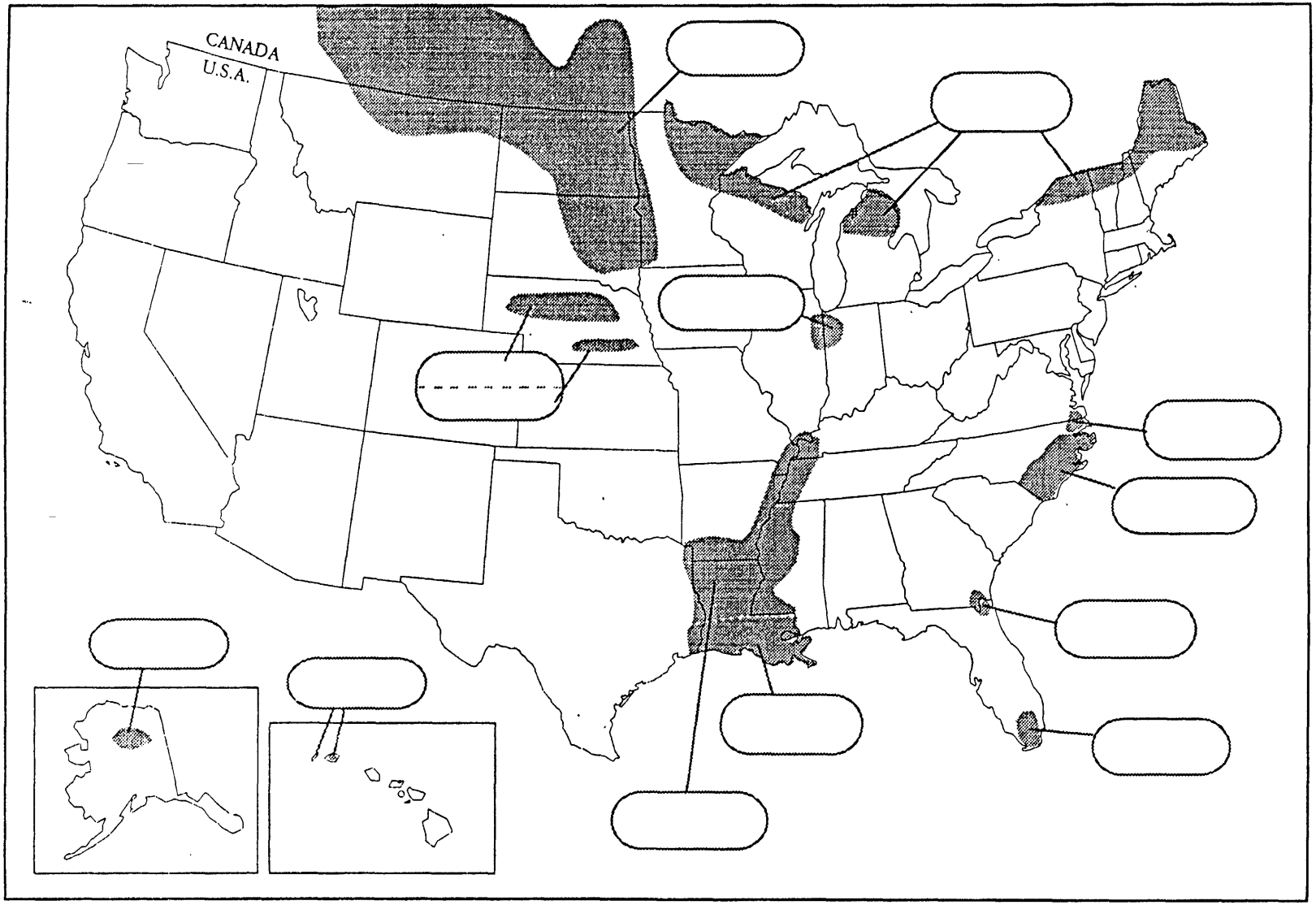
   Great Kankakee Swamp (Indiana & Illinois)

   Mississippi River Delta (Louisiana)

   Great Dismal Swamp (Virginia & North Carolina)

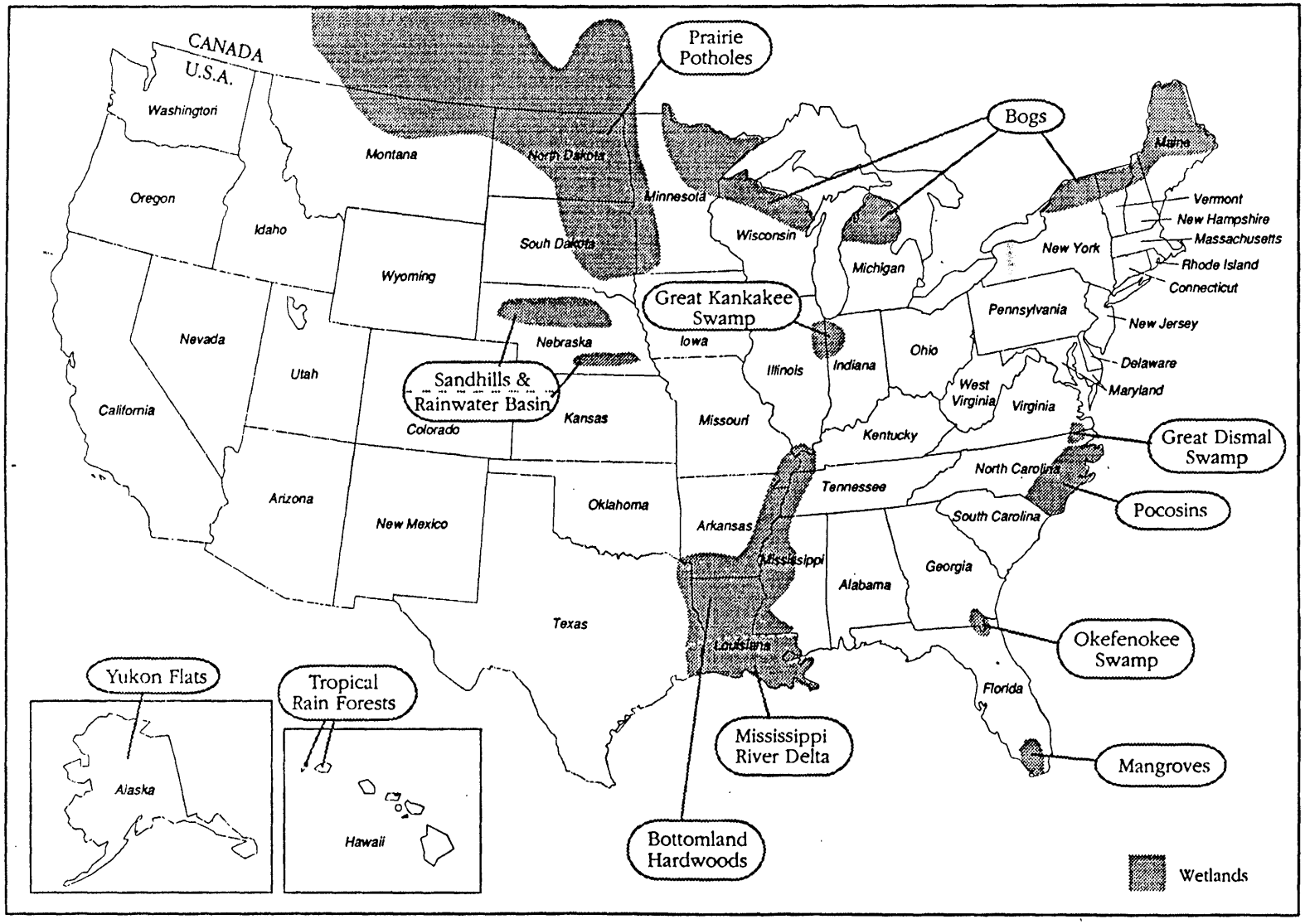
Activity 1: Wetland "Celebrities" of the United States

Student Worksheet



Activity 1: Wetland "Celebrities" of the United States

Teacher's map



Procedure This *Wetlands Jeopardy* activity requires a more in-depth review of the history of well-known wetlands in the U.S.

1. Divide the class into teams. Assign each team to research a different wetland type and develop *Wetland Jeopardy Question & Answer* fact cards similar in format to those already provided below. Use the information provided in this chapter for reference material or consult one of the wetland texts listed in the *Appendix*.
2. After each team has developed a set number of cards, make copies of each *Question & Answer* for each student, including those provided below, to study for a game of *Wetlands Jeopardy* to be held the next day.

Wetlands Jeopardy

Question:	Answer:
A. This area is made up of millions of small depressions left over from the Ice Ages. It extends across 300,000 square miles (780,000 km^2) of plains in several states and provinces. It is one of the most important breeding spots for migratory waterfowl in the world.	(Prairie Potholes region)
B. In 1763, George Washington attempted to drain this wetland, which borders two states. Some of its ancient, bald cypress trees were probably here when European explorers first came to North America.	(Dismal Swamp)
C. The wetlands along the Charles River were filled in during the 1800's and the community known as Back Bay was built. Today Back Bay is part of this major New England city.	(Boston)
D. Part of this famous southern wetland is a national park. It is nicknamed the "river of grass" for the miles and miles of sawgrass that cover it. At the western border of this grassy wetland is a freshwater swamp. And along the southern coastal border, the sawgrass marsh gives way to a mangrove swamp.	(Everglades)
E. These tundra wetlands lie on the Arctic Circle. They are associated with a major river of the same name in the 49th state.	(Yukon Flats)

Question:	Answer:
F. This midwestern state is called the "Land of 10,000 Lakes." The basins of these lakes were gouged out by glaciers during the last Ice Age. Because of the cool northern climate, many of these lakes have gradually filled in with sphagnum mosses, forming these special types of wetlands.	(Minnesota)
G. Parts of this southern wetland contain floating islands of peat which have broken away from underwater peat deposits. The Seminole Indians called this wetland the "Land of the Trembling Earth" because these islands often shake under the weight of people walking on them.	(Okefenokee)
H. This central plains state is the location of the Sand Hills, the Rainwater Basin, and the Platte River floodplain. These important wetland areas provide crucial nesting, breeding, and resting sites for migrating birds such as sandhill cranes and whooping cranes.	(Nebraska)
I. This wetland is in the bayou country of the lower Mississippi. The Cajun people who settled in and around this wetland are famous for their spicy seafood cooking. It is the third largest wetland of its kind in the U.S.	(Atchafalaya)
J. One of the most popular coastal cities in the U.S. was built along wetlands that line this western body of water. Today, over 80% of the original wetlands in the region have been destroyed. But the area still provides important habitat for wildlife.	(San Francisco Bay)
K. This globally rare evergreen wetland type is found in a narrow band along the eastern coastal U.S. ranging from Maine to Mississippi.	(Atlantic White Cedar Swamps)
L. One of the most popular national seashore parks in the East, this Massachusetts coastal treasure includes acres and acres of wetlands.	(Cape Cod National Seashore)

Activity 2: Research Wetland Habitats

Objective Students will develop an understanding of the variety of wetland types found in New England and around the globe by studying their geographical location, physical features and characteristic flora and fauna.

Materials Reference texts *

Wetland Celebrities

Students investigate one or more of the better-known wetlands in the U.S. or other parts of the world.

Wetland Plants & Animals

Students research the plants and animals unique to certain wetland types and report to the class on their findings. Which wetlands have endangered species? What are they? Why are they endangered and what is their status?

Students can present their findings in written or oral reports or by creating mobiles, posters or jigsaw puzzles of their chosen wetland.

Students can also keep a daily journal from the point of view of a wetland creature that is endangered. What is your day-to-day experience living in a wetland? What are your surroundings like? What kind of food do you eat? What kinds of obstacles do you face in staying alive each day – predators, human impacts, weather conditions, etc.?

* A free poster featuring information on wetland wildlife is available through the EPA Region I, Wetland Protection Section, JFK Federal Building, Boston, MA 02203.

Wetlands of Your Family's Country of Origin

Students research the presence and history of wetland types found in their country of origin. Some of the larger wetland systems found in other countries include:

Australia:	*Shark Bay, Kakadu National Park, Coongie Lakes*
China:	*Poyang Lake, Dongting Lake*
Denmark:	*Tollund Bog*
Finland:	*Fens*
Hong Kong:	*Mai Po Marshes*
India:	*Vale of Kashmir, Keoladeo Ghana National Park*
Iraq:	*Tigris-Euphrates*
Japan:	*Kushiro Marsh*
Netherlands:	*Wadden Sea*
New Guinea:	*Sepik & Ramu Floodplains*

New Zealand:	*Farewell Spit, Whangamarino*
South America:	*Pantanal*
Sudan:	*Sudd*
Russia:	*Lake Baykal*
Venezuela:	*Orinoco Delta*
Vietnam:	*Mekong Delta*

The Wetland Alphabet

Have the whole class work on a *wetland picture dictionary.* Ask the students to brainstorm words that begin with each letter of the alphabet and in some way relate to wetlands (e.g., **A**mphibian, **B**ullfrog, **C**attails). Students can illustrate and provide definitions for each term in a compiled scrapbook.

Other Suggested Activities

Have students create a dichotomous key to different wetland habitats. See *Living In Water. Aquatic Science Curriculum for Grades 4-6,* National Aquarium in Baltimore, 1987, pp. 21-29.

References *

A Directory of Asian Wetlands, Derek A. Scott. IUCN, The World Conservation Union, Gland, Switzerland. 1989. 1,181 pp.

Wetlands, Max Finlayson and Michael Moser, editors. Facts on File, Inc. New York, NY 1991. 224 pp.

Wetlands: A Threatened Landscape, Michael Williams. Basil Blackwell, Ltd., Cambridge, MA. 1990. 419 pp.

Wetlands in Danger, Patrick Dugan, editor. Mitchell Beazley, London. 1993. 193 pp.

Chapter III Wetland Functions

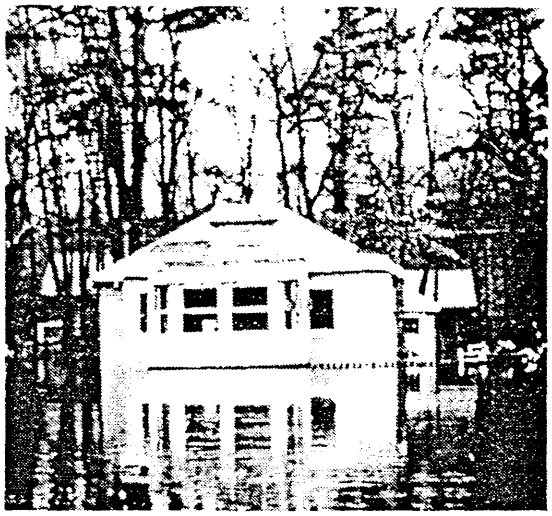
In the 1970's, the Corps of Engineers decided to preserve approximately 8,500 acres of wetlands in the Charles River Basin of Massachusetts instead of building expensive dams or dikes to control flooding. The Corps concluded that wetlands protection was the least costly solution to future flooding problems. The loss of these wetlands would have resulted in an annual cost of $17 million from flooding.

Wetlands have traditionally received "a bad rap" – they've been thought of as wastelands, as buggy, mucky places suitable only for murder mysteries. But as you'll soon discover in this chapter, wetlands perform a number of critical functions. They moderate impacts from flooding, control erosion, purify water, and provide habitat for fish and wildlife. They also provide a unique natural environment for people to enjoy outdoor recreation activities. Refer to the following information on wetlands functions to help you teach these concepts to your students.

Flood & Erosion Control

Flooding

Wetlands located along the shores of oceans, lakes, rivers, and streams protect surrounding properties from flooding by acting as a "sponge," temporarily storing flood water and slowly releasing it back into the system. As storm water enters a wetland from surface runoff or adjacent water bodies, it is slowed down by trees, shrubs, reeds, rushes, and other wetland plants. Slowing the flow of water allows more time for it to percolate through the soil rather than continue downstream. Wetlands with a large surface area also act as a large sink, diffusing large flows over a greater land area and slowing the momentum of rushing water. In this way, wetlands help protect adjacent and downstream property from flood damage. In 1975 alone, property damage from flooding cost the U.S. an estimated $3.4 billion! (See Activity 1: *Flood Storage*)



The floods of 1993: *If wetlands along the Missouri, Iowa, and Mississippi Rivers hadn't been destroyed for agriculture and urban development, some of the floodwater may have had someplace to go other than people's homes.*

Erosion

During a storm, the effects of rushing water can be very destructive. Fast-flowing water can carry a large load of soil particles from the land which are then washed into lakes, rivers, and streams. Excessive sediment in water is considered both a chemical and physical pollutant; it can carry bacteria and toxic particles and can alter the habitat of the receiving water for plants and animals. Wetland vegetation reduces the erosive effect of rushing water by slowing the velocity of floodwaters, binding the soil

The forested wetlands along the Alcovy River in Georgia significantly improve stream water quality affected by wastes discharged upstream. An equivalent amount of pollution removal in a sewage treatment plant would cost $1 million each year.

Innovative sewage treatment facilities utilizing wetland plants for waste processing have been successfully piloted in Harwich, MA and Providence, RI by Ecological Engineering Associates of Marion, MA.

with its roots, and causing suspended soil particles to settle out before they reach open waters. Coastal wetlands also protect shorelines from erosion by dissipating the energy from waves and currents.

Water Purification

Wetlands are particularly good water filters because of their location between land and open water. This allows them to intercept and assimilate many pollutants before they enter rivers, streams, or lakes. Rainwater that runs off buildings and streets in agricultural, residential and industrial areas picks up sediments, nutrients, toxic materials, and other wastes. If that rainwater flows through a wetland before it enters a river or stream, some of these pollutants are filtered by the soil and plants which protect the ecosystems downstream. However, wetlands alone can't solve our pollution problems since every wetland has a limited capacity to absorb nutrients, metals, sediments, etc. Overloading a wetland with pollution reduces its ability to serve this function.

Sediment Trapping

Water flowing into wetlands slows down dramatically as it comes into contact with wetland vegetation. Suspended soil particles or sediments will *settle out* of the water and bind to the stems and roots of plants. The role wetlands play in trapping excess sediments and preventing them from entering river and lake systems is important for a number of reasons:

1) sediments accumulating at the bottom of streams and lakes can smother fish spawning areas and bottom-dwelling aquatic life;
2) wetland filtering reduces siltation of ports, harbors, rivers, and reservoirs, saving a lot of money that would have to be spent on dredging or removing the sediment;
3) sediment particles are often vehicles for transporting pollutants such as nutrients, pesticides, and heavy metals.

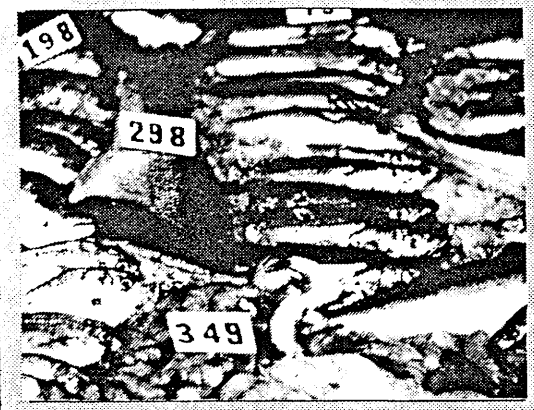
Studies have shown that as much as 80-90% of sediments in the water column may be removed as they move through wetlands! (See Activity 3: *Runoff Race*)

Chemical and Organic Waste Processing

Water flowing through urban areas often contains heavy metals including cadmium, chromium, copper, lead, and nickel. Most of these substances are usually bound to sediments entering the wetland system. Wetland plants can trap heavy metals and pathogens (such as bacteria and viruses) from runoff waters and fix them temporarily in plant tissues. Thick, organic, wetland soils can trap pollutants and keep them out of adjacent water bodies. Accumulation of these pollutants, however, can harm wildlife as they are passed up the food chain.

Certain wetland plants can alter and render harmless viruses, coliform bacteria, and suspended solids after initial sewage treatment, serving as nature's treatment facilities for domestic wastes.

On the Atlantic and Gulf coasts, 66% to 90% of the commercially important fish and shellfish species depend on coastal marshes or estuaries for at least part of their lifecycle.



- *The annual U.S. fish harvest is valued at more than $10 billion. In the Southeast, for example, 96% of the commercial catch are fish and shellfish that depend on estuarine-coastal wetlands.*
- *In 1976, $35.5 million worth of furs from beaver, muskrat and other wildlife were harvested from wetlands nationally.*
- *In Rhode Island, the 1985 commercial harvest of wetland-dependent coastal fishes (e.g., flounder, striped bass, shad, and white perch) had a value of $3.25 million, while the hard-shell clam or quahog harvest alone was valued at more than $14 million.*

Nutrient removal

Elements such as phosphorus and nitrogen are essential ingredients of life for plants and animals, and are therefore considered nutrients; however, too much of a good thing can cause problems. An excess of nutrients carried into surface waters can result in *eutrophication* – an exponential growth or bloom of algae covering the water surface. The rapid growth of algae significantly reduces the amount of oxygen available to other aquatic life, potentially suffocating many of them. Because phosphorus and nitrogen are present in all human wastes, getting the nutrients out of wastewater is a large and expensive challenge.

Wetlands are effective in removing and storing nutrients such as nitrogen and phosphorus from waters flowing through them. Some wetlands are capable of removing 85-90% of phosphorus and nitrogen from runoff water. Microorganisms and wetland plants absorb these nutrients, release some of the nitrogen as gas, and store the remainder in the soil. Algae and some vascular plants can also convert nitrates and phosphates to usable by-products, thereby removing them from the system. Many towns are beginning to experiment with wetlands as effective alternatives to costly sewage treatment plants. (See Activity 2: *Treatment Plants*)

Groundwater Discharge and Recharge

Wetlands with a hydrological connection to groundwater can play a role in maintaining water supplies by:

1) *recharging* groundwater supplies: water stored in wetlands will slowly percolate into the underlying aquifer, and
2) *discharging* groundwater: water flows from the groundwater system to surface water bodies, sometimes maintaining a minimum amount of flow for rivers and streams during dry periods. Not all wetlands perform both of these functions; some wetlands primarily recharge groundwater while others mostly discharge groundwater.

Fish and Wildlife Habitat & Food Webs

Habitat

Though wetlands are most often associated with waterfowl, they provide essential habitat for a wide variety of species – birds, mammals, reptiles, amphibians, fish, and insects – up to 45% of which are rare and endangered. The high rate of wetland loss has contributed to the endangered status of many species. Some species, such as the wood duck and muskrat, spend most of their life within wetlands, while others – striped bass, peregrine falcon and deer – occasionally visit wetlands for food, water, or shelter. Those species that require wetland habitat to complete at least a portion of their life cycle are called *obligate* species.

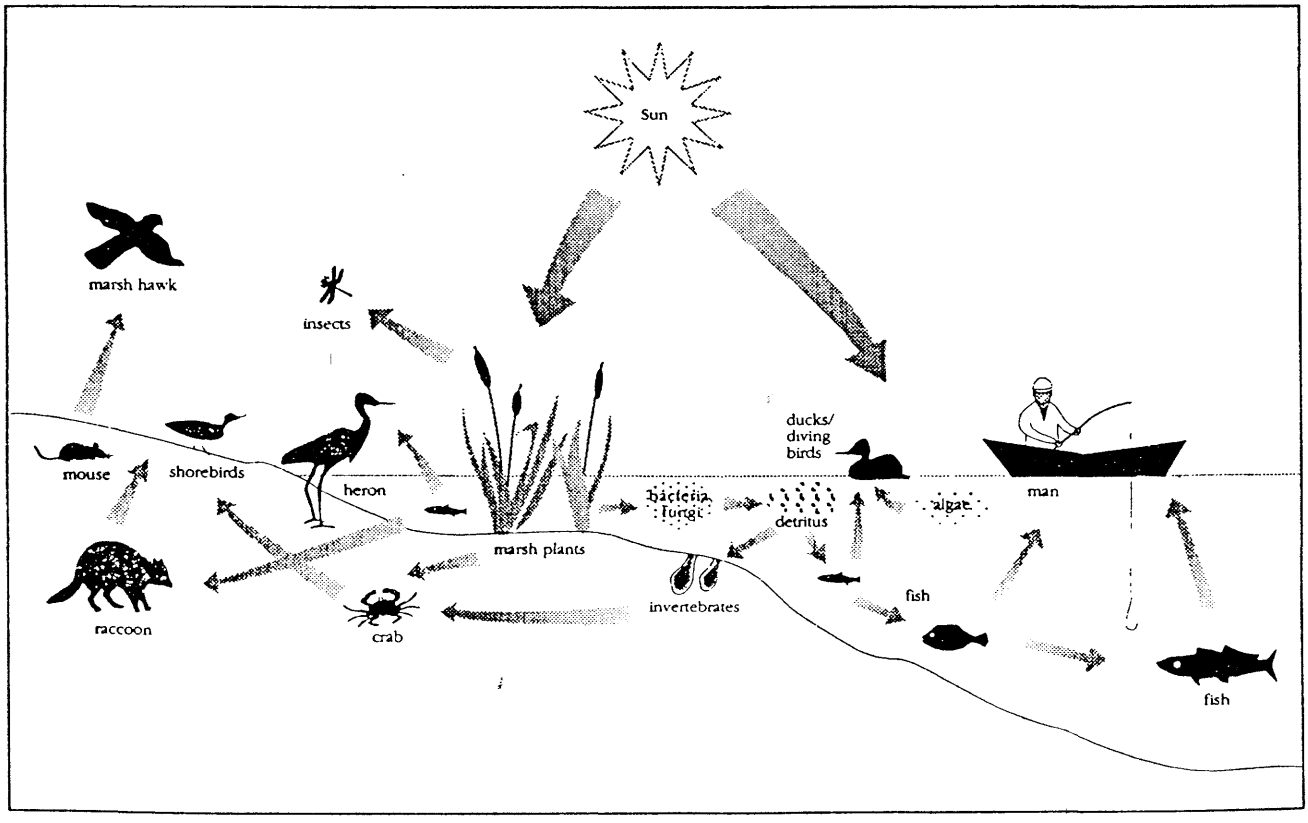
Why are wetlands favored by so many species? They attract wildlife for a number of reasons:

1) their vegetative cover provides shelter from predators;
2) they provide ideal nesting conditions for many waterfowl;
3) they provide migratory birds with a safe "stop over" location to rest during long migrations;
4) they provide essential spawning and nursery habitat for commercially important fish and shellfish;
5) many have an extensive, complex food chain that supports numerous species, including man.

Food Webs

The vast amount of organic matter that accumulates in wetlands is the beginning of food webs for thousands of aquatic plants and animals. Because of their nutrient-rich waters, coastal marshes are among the most productive ecosystems in the world. When salt marsh plants die, their tissues are broken down by bacteria and fungi into *detritus,* nutrient-rich fragments that are flushed out with the tides and made available to fish, shellfish, and invertebrates. These organisms in turn are preyed upon by larger wetland inhabitants – raccoons, otters, herons, and other shorebirds.

Salt Marsh Food Web



WETLANDS SUPERMARKET

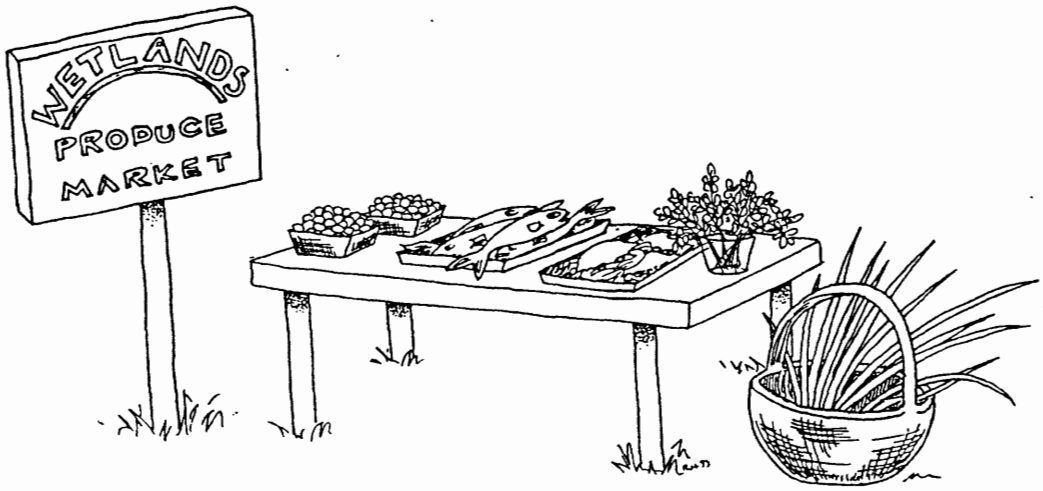
Wetlands are also valuable for the variety of commercial products harvested from them:

Food

- Wild rice, cranberries, blueberries, mint
- Salmon, alewife and other major commercial fish species
- Shrimp, blue crab

Other products

- Marsh grasses for baskets and chair caning
- Peat and sphagnum moss for landscaping
- Reeds for bedding and thatch
- Timber such as northern white cedar, tupelo, and bald cypress
- Beaver, muskrat, nutria, mink, and otter furs



Getting Your Students Involved:

Ask the students to take out their lunches or use the menu from the school cafeteria and trace each item to its original ingredients. Try to locate where each of the ingredients would have originated by geographical location and habitat. Identify the foods that might come from a wetland area. Which would have affected the job of a member of their family?

Finally, have the students create their own wetland food webs in the form of drawings, paintings, or mobiles from the wetland wildlife guide in Chapter II or other reference texts.

Recreation & Aesthetics

Even though wetland acreage in the U.S. is diminishing, recreational use remains brisk, particularly for hunting and fishing. In 1980, 5.3 million people spent $638 million on hunting waterfowl and other migratory birds. In 1975, fishing enthusiasts spent $13.1 billion to catch wetland-dependent fish. Hiking, canoeing, and photography are among the many activities that draw people to wetlands. Some of the most-often visited national parks and wildlife refuges in the nation are well-known for their wetlands, including the Florida Everglades, Cape Cod & Assateague Island National Seashores, Chincoteague & Parker River National Wildlife Refuges, and Acadia National Park.

Research & Education

The diversity and natural beauty of wetlands provide a living, hands-on classroom for education and scientific research, as this guidebook demonstrates.

Getting Your Students Involved:

Ask the students to describe their impressions of wetlands and the different ways they are described by our culture. How are bogs, swamps and marshes most often referred to in literature, folk tales, and local mythology? Have students ask their parents how they feel about wetlands. What words do parents use to describe them?

Have the students talk about their outdoor activities. Which of these activities use a wetland area or are affected by a wetland?

Activity 1: Flood Storage

Overview

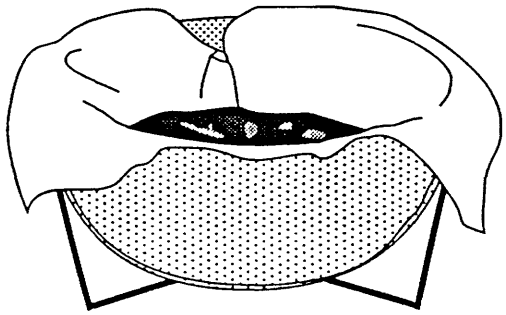
Students will observe how different soil components – peat, sand, gravel, and potting soil – vary in their capacity to absorb and hold water. They will observe how peat, a component of some wetland soils, is exceptional at absorbing large quantities of water.

Background

One important function of wetlands is the capacity to absorb large amounts of water during rainstorms and to release it slowly over time to rivers, lakes, and groundwater. This function prevents extreme flooding during storms and maintains a base level of water flow during dry spells. This water storage capacity is due in part to the presence of organic matter in wetland soils.

Materials

- Peat moss, sand, gravel, potting soil
- Four sieves
- Cheesecloth or coffee filters
- Measuring cups
- Bowls for catching water
- Scales
- Copies of data sheet



Procedure

1. Break the class up into groups with one sieve of material per group. If you have enough materials, give each group four sieves and samples of each soil type.
2. Place cheesecloth or a filter in each sieve and fill them with a different soil type.
3. Have students weigh out the filled sieve *with* the bowl on a scale and record this on the data sheet.
4. Instruct the students to fill the measuring cup with exactly one cup of water.
5. Pour the water into the sieve and let it soak in the bowl for 5 minutes.
6. Remove the sieve and pour the water out of the bowl.
7. Have the students re-weigh the sieve, wet material, and bowl and record the weight on the data sheet.
8. Now have the students calculate the percent of water absorbed by each material by subtracting the dry weight (A) from the wet weight (B) to yield (C).
   C/A x 100 = % water absorbed.
9. Have each group record its results on the blackboard and discuss the findings.

Discussion Questions

1. Which of the materials – peat, soil, sand, or gravel retained the most water? Why?
2. What factors influence a soil's capacity to hold or drain water? (soil texture, its position in the landscape, e.g., on a steep slope – *drains readily* – or low spot that collects water – *drains slowly.*)

3. What determines how much water a substance can hold? (amount of air [pore] space and shape of those pores)
4. What would happen to rainwater if there was nothing in the watershed (such as wetlands) to absorb it? (no buffer areas to absorb floodwaters, wouldn't be able to retain as much water in the watershed) What problems might this cause? (flooding of property during storms, little recharge of groundwater supplies)
5. Have any students had experience with floods – in their own basements or in town?
6. Look through newspapers for articles about flooding. Do the news stories make any connections with the flooding to wetlands loss?

Flood Storage Data Sheet

Material	Dry weight (A)	Wet weight (B)	B – A = C	Percent (%) water absorbed = (C/A) x 100
Peat				
Soil				
Sand				
Gravel				

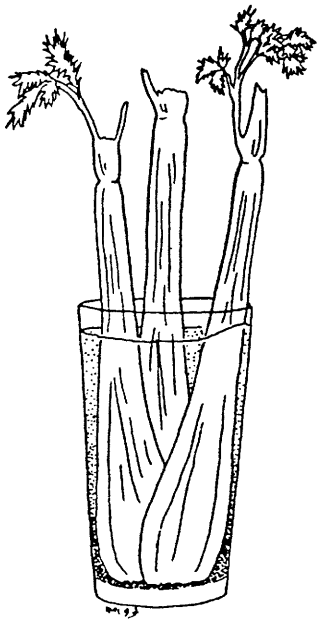
Activity 2: Treatment Plants

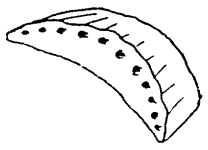
Overview Students will learn how some wetland plants remove excess nutrients and pollutants from water. Students set up the experiment by placing a cut celery stalk in a glass of dyed water and predict what will happen.

Concepts Water carries many substances. Some materials dissolve in water while other materials, such as sediments, are carried in suspension. Some substances carried by water are beneficial for plants and animals. For example, dissolved calcium helps marine organisms build shells, and dissolved fluorine in drinking water helps retard tooth decay. Other substances carried in water may be harmful, including pesticides, heavy metals, oil, and other wastes.

Materials

- A few stalks of celery
- A few beakers of water
- Food coloring





Procedure

Day 1

1. Before setting up the experiment, explain to the students that the food coloring represents pollution by a toxic substance (e.g., a pesticide). Ask the students to imagine water flowing into a wetland with many wetland plants. Explain to them that the celery stalks represent these plants, such as cattails, sedges, grasses, etc. Break up the class into groups (three or four students each) and have them set up the experiment as instructed below.
2. Add several drops of food coloring to the beaker of water.
3. Cut off the bottom quarter of the celery stalks and place them in the colored water overnight.
4. Still working in groups, ask the students to record what they predict might happen to the celery over time.

Day 2

Over time the water will visibly travel (via osmosis) up the stalks, illustrating how plants can absorb pollutants with water they "drink." If the dye is not visible on the outside of the stalk, break it open to see the coloring inside the plant tissue.

Ask the students to revisit their predictions for this experiment. Were their predictions accurate? What have they learned about wetlands and water quality? Use the questions below to generate a discussion.

a. How do wetland plants help to purify water? (Plants take up pollutants from water.)

b. Why is the water remaining in the beaker still polluted? (Plants can only remove so much.)

c. Where does the water go after uptake into the plant? (Water is transpired out through pores – *stomates* – and evaporated.)

d. What happens to the pollutants? (They are stored in the plant tissues and re-released to the environment when the plant dies.)

e. Why can't we dump all our wastewater into wetlands? (Wetlands can only do so much.)

Adapted from *Discover Wetlands*, Washington State Department of Ecology.

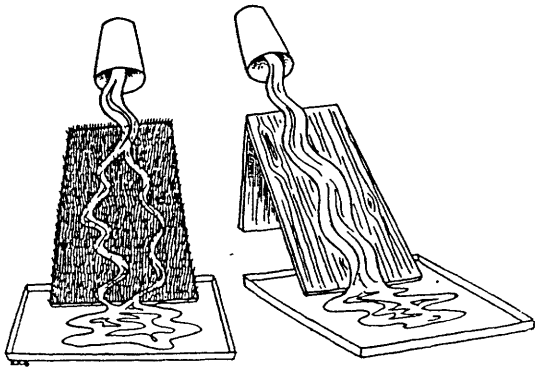
Activity 3: Runoff Race

Overview Two sloped boards are constructed to represent wetlands (one is bare, the other covered with artificial turf). Students will pour jars of sediment-filled water over the boards to observe how wetland plants (the turf) prevents sediments from entering rivers and streams.

Objective To demonstrate how wetland plants prevent sediments from entering large bodies of water (lakes, streams, ponds) and why this water quality function is important.

Materials

- Two jars with equal amounts of water
- Two flat boards of equal width & length
- Half a jar of soil, small rocks, sand and grass clippings
- 1 piece of artificial turf, cut to same size of boards
- Staple gun or tacks
- 2 pans fitted to width of boards (white-colored plastic pans offer the best contrast for observing amount of sediment collected)
- Different textured soil samples (optional, for use in discussion)



Procedure

1. Construct and set up the wooden boards ahead of time. Using a staple gun or tacks, attach the artificial turf to one of the boards. During your demonstration, be sure to support the boards at the same angle (you can also have two students volunteer to hold these for you during the experiment).
2. First lead a discussion with the students about *sedimentation*, asking the following questions:
   - What are some of the non-organic components of soil? (soil particles or *sediments* – from fine silts to coarse sands)
   - How do these materials look and feel different from each other? (They come in various sizes and weight; the silts are much lighter than the heavier sandy particles.)
   - When it rains on *bare* soils – where there are no plants holding soil particles together – what do you think might happen? (Sediments can wash off the land and enter large bodies of water such as lakes, streams, and ponds.)
3. Now ask the students to help you place equal amounts of the potting soil, sand, grass clippings, etc. in the two jars of water. Ask for two volunteers in the class to

shake up the jars until the dirt is mixed well with the water. Set the jars down to allow the sediment to settle.

- What do you observe in the jars? (The heavier soil particles have begun to settle out first.)
- What about the silts? Are they still suspended in the water?

Pretend you're a fish swimming in this water – why would the muddy water be harmful to you? (You couldn't find food, gills would clog with sediments; bottom-dwelling plants and suspended algae would also have a hard time getting enough sunlight to live.)

4. Explain that the *rate* of water flow – how fast it is moving – affects how quickly sediments will *settle out* of the water. (The slower the movement of water, the more sediments will fall out of suspension.) Wetlands are located between land and large bodies of water, and they often help to filter sediments and pollution that might end up in a lake or pond. Sometimes other materials – heavy metal pollutants – can attach themselves to these soil particles and be carried with them.

   How do you think wetlands actually help to clean the water? (Wetland plants help to slow down water as it passes through, allowing larger sediments to settle out. Fine silts collect on the leaves of plants. Plant roots also help to bind the soils in place and prevent erosion in the first place.)

5. Now show students the two boards: one represents a wetland that has been paved over to make a parking lot; the other is a healthy vegetated wetland. The two pans represent a clean lake into which rainwater flows. Ask for volunteers to help demonstrate how wetland plants prevent pollution of other waterbodies. Ask the rest of the class to watch closely and compare what happens with each board.
6. Place some of the potting soil, sand, and grass clippings at the top of each board and have the volunteers pour clean water over the soil and (at the same rate) down the boards.
7. Which one had the faster flowing water and why? (The paved board has no plants to slow down the flowing water) Is there a difference in the amount of sediment that ended up in each pan? In which of these waterbodies would you rather fish or swim? What are some other reasons why clean water is important? (drinking water, home for wildlife)

Adapted from *Discover Wetlands*, Washington State Department of Ecology

Extensions

1. Compare the rate of runoff over paved vs. non-paved areas by having students examine the school parking lot to see how paved surfaces prevent infiltration. Half the class (in smaller groups, preferably) will measure runoff rate in paved areas, the other half in non-paved areas. A small beaker of colored water will be poured on the starting point. A stopwatch is used to determine how long it takes to travel fifteen feet. All the areas used must have approximately the same slope.
2. Have students look for storm drainage gates, waterways, and grass buffer areas to determine how landscape architects do or do not provide for the water collected by the paved areas.

Activity 4: Wetland Metaphors

Overview Introduce common household items – sponge, sieve, coffee filters – as metaphors to the many functions wetlands provide. Working in groups, students will brainstorm which function each object represents.

Objective Students will use metaphors (familiar household objects) to help them understand some of the functions and values of wetlands.

Background Many of the major characteristics of marshes, bogs and swamps can be explored through metaphors. A metaphor is a direct comparison between two things – it gives a vivid image through direct comparison. Two examples: *A tree is a home*, *books are windows of thought.*

For a review of the many functions of wetlands, refer to the background information in this chapter. Use the table below as a guide to metaphors you can use and see if you can come up with some of your own.

Object	Wetland Function
Sponge	Absorbs excess water, e.g., runoff, floodwaters
Bed	Resting place for migrating birds
Whisk	Mixes nutrients
House	Habitat for wildlife
Coffee filter	Purifies water
Sieve	Removes sediments from water
Food	Provides food for wildlife & people

Materials Wetland metaphors:
sieve, whisk, beds (picture), house (picture), food, sponge, coffee filter.

Procedure

1. Prepare a *Mystery Metaphor Container* (pillowcase, bag, box). This should be a container that the students can easily access to pull out at least one object.
2. Show the video *Fabulous Wetlands* to the class **or** lead a general discussion with the students about wetlands. Ask them to close their eyes and imagine a wetland. What does it look like? What plants and animals do they see? Have they ever seen or visited a wetland? Are they familiar with wetlands in their own communities? Try to generate a discussion involving as many students as possible.
3. Now bring out the metaphor container. Discuss the meaning of a metaphor and explain that objects in the container are metaphors for wetland functions.

4. Divide up the class into as many groups as there are objects in the container. Have each group pick an object and discuss the connection between their object and how a wetland functions. If possible, have the groups illustrate this function through drawings.
5. When they are ready, have each group make a brief presentation explaining its wetland metaphor and drawings. Encourage students to build on each other's ideas.
6. Ask students to summarize the major contributions wetlands make to a healthy habitat. Ask them if their own attitudes about wetlands are different as a result of doing this activity. If so, how?

Chapter IV Threats to Wetlands

The Facts on Threats

- *In the 1600's, over 200 million acres of wetlands existed in the lower 48 states. By the mid-1970's, only 99 million acres remained – a loss of approximately 54% of the original acreage.*
- *Wetlands loss from the mid-1950's to the mid-1970's is the result of agricultural conversion (87%)*, urban development (8%), and other development (5%).*
- *Certain states have lost more wetlands than others:*

  California & Iowa *— over 90% of original wetlands.*

  Nebraska *— over 90% of wetlands in the Rainwater Basin. These wetlands are heavily used by migratory birds, and overcrowding results in outbreaks of disease.*

  Mississippi *— 80% of original bottomland hardwood forests.*

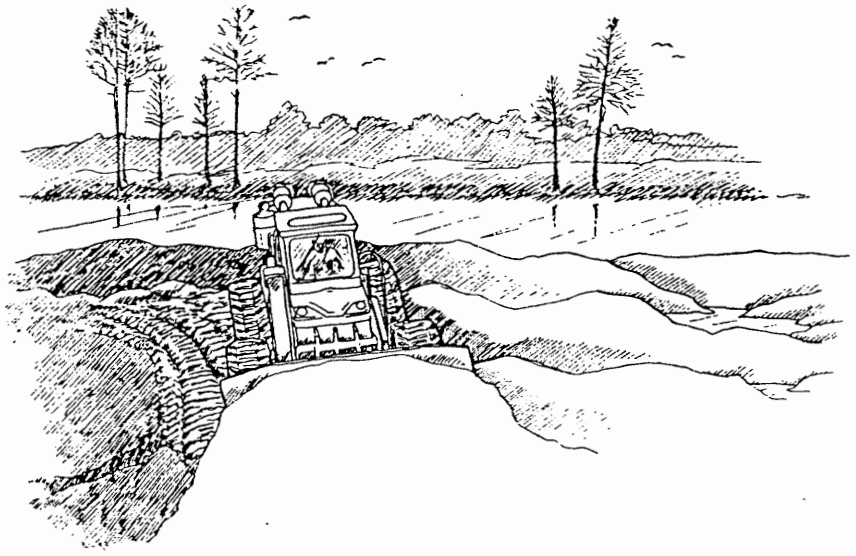
  Louisiana *— loses 30,000 to 40,000 acres of coastal wetlands each year.*

- *Michigan, Minnesota, Louisiana, North Dakota, and Connecticut have lost over half of their original wetlands.*

** This figure may have changed substantially since the mid-1970's.*

A History of Wetland Loss

Until recently, wetlands have been considered mosquito-infested, mucky, dangerous, and unhealthful places – certainly not a place to take your class! Due in part to these misconceptions, over half of the wetlands in the U.S. have been destroyed since the 1700's. They have been drained for agricultural activities, filled for housing developments and industrial complexes, and used as dumping sites for household and hazardous wastes. Despite the fact that scientists have discovered wetlands to be valuable ecosystems, their destruction continues worldwide.



How Are Wetlands Lost?

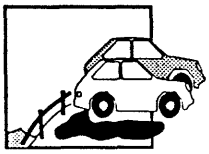
Human Activities

Urban & suburban development — filling and dredging wetlands for houses, commercial buildings, ports, highways, airports, waste disposal sites, and other construction projects. Paving large areas with asphalt and concrete increases the rate and amount of surface runoff which increases the likelihood of flooding. Development can also cause *fragmentation* of large wetland systems. For example, road crossings disrupt the continuity of a system and adversely impact wildlife.

Some Nonpoint Source Pollutants

Bacteria and viruses — found in sewage and septic tank effluents as well as in rainwater runoff from streets and farms.

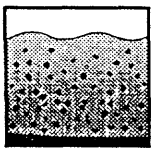
Nutrients — while nutrients like nitrogen and phosphorus are essential ingredients for plants and animals, excessive amounts in water result in accelerated growth of algae. Blooms of algae block out sunlight needed by plants and pollute the water.



Petroleum products — gasoline, oil, and grease are often carried by rain from streets, parking lots, and commercial areas.

Organic chemicals — pesticides and household or industrial cleaners and solvents are carried by rain from farms and commercial areas to water bodies.

Heavy metals — lead, arsenic, mercury, copper, chromium, zinc, and cadmium originate in vehicle exhaust, industrial emissions, incinerators, and landfills. They may be carried by rain water or leached directly into groundwater.



Sediments — The energy of moving water erodes and suspends particles of sand, silt, clay, plant material, and microscopic plankton. This creates a condition called *turbidity.* While turbidity is a natural condition, it can be harmfully accelerated by land use that removes protective vegetative cover and exposes bare soil. Excessive turbidity causes problems for spawning fish and drinking water quality. Turbidity also blocks light penetration thus reducing aquatic plant growth.

Numerous, small impacts to wetlands within a watershed can add up to a significant cumulative loss.

Agricultural activities — ditching, draining, and clearing wetlands for farming.

Pond and lake construction — diking, excavating, and flooding wetlands for water supply, flood protection, recreation, and other purposes.

Mining — for peat, coal, sand, gravel, and other products.

Natural Threats

Erosion, sea level rise, droughts, hurricanes, and overgrazing by wildlife can also impact wetlands.

Wetland Degradation

Pollution from pesticides, heavy metals, sediments, domestic sewage, and fertilizers discharged from a variety of *point sources* (e.g., direct discharges from industrial complexes) or *nonpoint sources* (e.g., runoff carrying road salt from highways) degrade the quality of wetland waters.

There are many ways to remove pollutants from water, but they are generally very complicated and expensive to implement. It is far better to prevent pollutants from getting into water supplies in the first place. Wetlands are effective filters for some, though not all, potential water pollutants.

Consequences of Wetland Loss

Flooding

Billions of local, state, and federal dollars have been spent over the years to dike and dam rivers to prevent them from flooding. Nonetheless, floods continue to seriously damage the property and livelihoods of thousands of Americans, as evidenced by the 1993 flooding of the Midwest. Wetlands are natural flood control systems – they absorb peak flood flows and later release them more slowly, reducing flood damage to property downstream.

Loss of Wildlife Habitat

Up to 45% of rare and endangered species rely to some extent on wetlands to some extent for their survival. As other habitats are lost to development, wetlands even become the last refuge for those animals not usually thought of as wetland-dependent, such as the black bear and Florida panther.

Example: The drainage of 90% of the wetlands in Nebraska's Rainwater Basin for agriculture has concentrated waterfowl in greater densities in the few remaining areas, causing outbreaks of disease. In 1980, 80,000 birds died of avian cholera because of overcrowding in the Basin.

Declining Water Quality

Wetland loss can also result in water quality decline.

Example: Forested wetlands play an important role in reducing excessive nutrients entering the Chesapeake Bay. One wetland was shown to remove approximately 80% of phosphorus and 90% of nitrogen from a tributary entering the Bay. Destruction of these wetlands would increase *eutrophication* (see Chapter III, page 53 for discussion). Atlantic menhaden, the Bay's second most plentiful catch, often suffer mass kills because of a lack of oxygen caused by eutrophication.

Getting Your Students Involved:

How are our lives linked to the health of the environment? What would happen if wetlands disappeared? Record the ways students think their lives might be affected.

Are there any common, everyday activities that you could be doing that impact wetlands, positively or negatively? Get your students engaged in a discussion that might involve the following questions:

- Are there any roads you drive on that cross wetlands?
- What kind of an impact might this have (causes fragmentation, run off of salt, gas, and oil)?
- Are there any shopping areas, airports, or houses in town that are built on, or near, wetlands?
- Are there any state or local parks that you visit that protect wetlands? Do any of the students hunt or fish?

Activity 1: Manipulate the Watershed Model

Overview Students will perform various experiments with the second watershed model constructed in Chapter I to illustrate how human activities can impact wetlands.

Materials

- Constructed watershed model from Chapter I, Activity 1B
- Food dye or colored drink mix
- Clay or plasticene
- Sand and potting soil
- Watering can or plant mister

Procedure

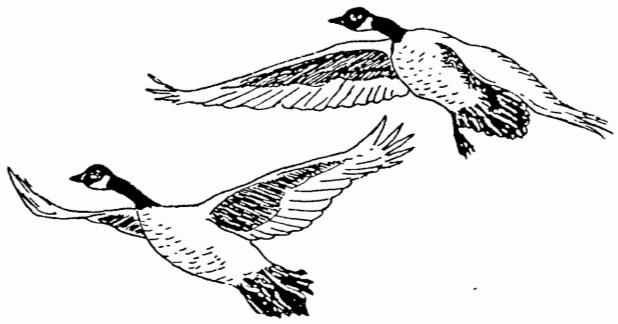
1. Take out the watershed model (Chapter 1, Activity 1B) and review wetland functions (e.g., erosion and flood control) with your students. Have students perform the following experiments with the model to observe how wetlands and other water bodies are impacted by human activities.
2. *Water Quality Protection* — Discuss with students the water quality protection that wetlands provide (Refer also to discussion questions from the Chapter III activities *Treatment Plants & Run Off Race*).
   - Why is clean water important to our everyday lives? (We drink it; use it for recreation – boating, swimming, fishing; it provides a home for many plants, fish, and animals.)
   - What kinds of pollutants contaminate water? (heavy metals, pesticides, bacteria, viruses, fertilizers)
   - What are some of the causes of this pollution? (car emissions, industrial factories, septic tanks, runoff from agricultural fields, etc.)
3. Use food coloring to demonstrate how pollutants on land end up in wetlands and in other waterbodies. Have students remove the wetland from the tank and place a few drops of food dye just below the rock cliffs. Now have them spray the rocks gently with water and watch the color disappear from the surface and end up in the stream. Replace the wetland and repeat this procedure. The dye should appear in the wetland (sponge or towel) instead of the stream.
   - How do wetlands help maintain water quality? (Wetland plants absorb and process nutrients – nitrogen and phosphorus – and store other pollutants in their tissues.)

4. *Reducing Erosion & Sedimentation* — Have students change the types of land cover in the watershed model and see what happens. *Pave* the watershed by placing clay or plasticene over a large portion of it. Sprinkle sand and/or potting soil on top of this surface. Remove the wetland adjacent to the stream. Pour *rain* from the watering can and observe how *quickly* the water runs off the impervious surfaces and what *amount* enters the stream.
   - Did the rapid volume increase of the stream affect the houses along the banks?
   - Did any of the sediment get washed into the stream?
   - Brainstorm a list of effects of turbidity on fish, animals, and plants. (smothers bottom-dwelling aquatic life, inhibits sunlight for plant growth, fills harbor channels, affects drinking water quality)
   - What do you think might happen if the wetland weren't removed from alongside the stream?
5. Talk about places in town that are entirely paved, like a shopping mall parking lot.
   - Where does the water go that falls on these areas? (storm drains)
   - What pollutants might water pick up along the way? (dripping oil, gasoline spills, antifreeze, salt, and sand)
   - Consider what impact these pollutants have on a nearby stream or wetland in light of the previous water quality experiment.

Activity 2: Migration & Habitat Loss

Overview

Students role play migrating water birds traveling between nesting habitats and wintering grounds. They are subject to hazards at either end of the migration path and along the way. In the process, they will experience the environmental and human factors that contribute to habitat loss and degradation.



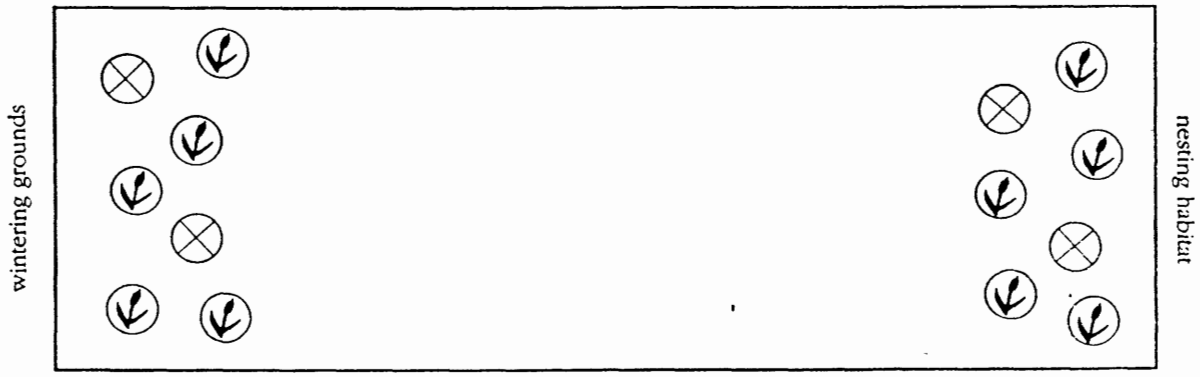
Background

There are many types of migrating birds – ducks, geese, swans, cranes, herons, egrets, gulls, terns, and shorebirds – that require the presence of wetlands in their breeding and wintering grounds. Since these two regions are often thousands of miles apart, they also need to utilize wetlands along their migration route (also called a *flyway*) to provide them with the food and rest necessary to complete their journey.

The primary threat to the survival of migratory water birds is the disappearance and degradation of wetlands. Before regulations, hunters in the 19th century decimated flocks of migrating birds, and wetland habitats were converted to farmland and settlements. Today, agriculture and development continue to reduce the wetlands available as habitat for these migrating birds.

Materials

One plate for each student. The plates should be clearly marked to differentiate top (wetland drawing) from bottom (an 'x').



Procedure

1. Select a large space where students have enough room to run, approximately 50 feet in length. Place the paper plates in two patches on either end of the room or playing field. One of the patches will represent the "wintering grounds," and the other the "nesting habitat." Remember to include enough plates at *each* end of the playing field to accommodate all players.
2. Now tell the students that wetland habitats used by migratory birds are being destroyed for a variety of reasons. Lead a brief discussion in which students are

asked to generate ideas about the probable reasons for 1) habitat loss 2) habitat degradation and 3) wetland conservation.

Some factors to consider:

Factors ***Limiting*** Survival of Migrating Birds:	Factors ***Favoring*** Survival of Migrating Birds:
• wetland drainage	• preservation of wetlands
• drought	• high rainfall
• pollution and contamination of water	• restoration of habitat
• urban expansion	• regulation of hunting
• conversion of wetlands to farm land	• wetlands purchased as conservation land
• illegal hunting	
• lead shot in food supply	
• disease	

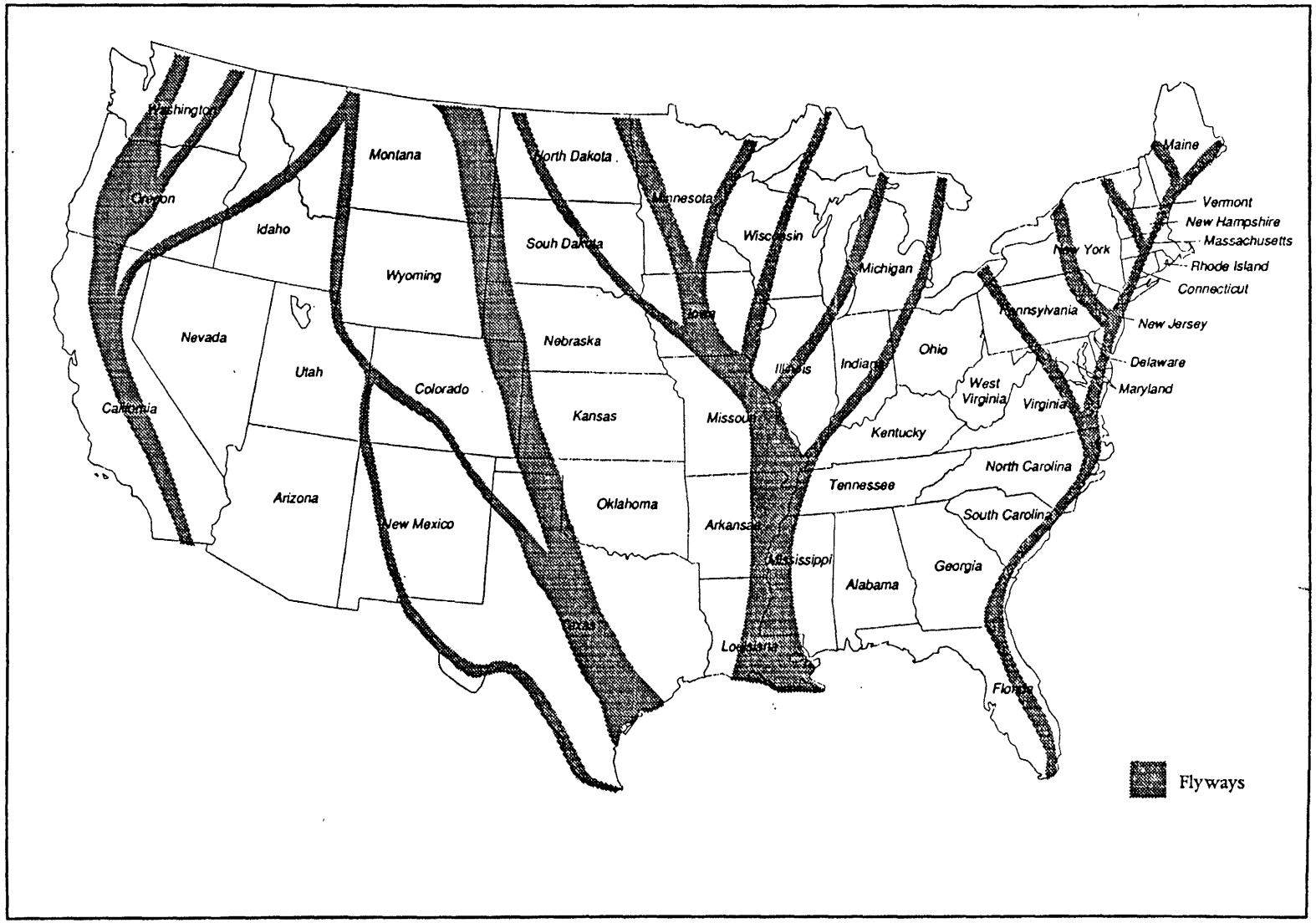
3. Explain to students that they will each represent thousands of water birds migrating back and forth at your signal across the playing field. Tell them that the paper plates represent their wetland habitats, and that each plate can accommodate only two people or *birds* at a time. If they cannot find a plate to "land on", then they have to die because there is not enough suitable habitat available for them to use. These students must move off to the sidelines and watch.
4. Have all the students line up at one end of the playing field, two students for every wetland plate. Tell them that they will be flying to their wintering grounds, and at your signal have them start out at half-speed. Practice this a few times until the students get used to it.
5. Get two or three of the students to role play hunters who will tag only one bird each per migration. Occasionally have the hunters sit out on the sidelines to allow those birds that have "died" to enter back into the game.
6. With each migration cycle, begin to remove and occasionally replace wetlands at each end of the playing field, giving one of the above-listed reasons as you do so. For example, you can explain that an enormous oil spill has resulted in a catastrophic loss of four regional wetlands and remove four of the plates at one end of the field.

Other Activities:

The Migratory Bird Handbook: *Activites & Lessons*, Jamie K. Doyle, Bird Conservation Specialist, Smithsonian Migratory Bird Center, National Zoological Park, Washington, DC 10009. (202) 673-4908.

7. When students have no plates to land on, they must go to the sidelines; they have died from loss of suitable habitat. Explain to these students that they will have a chance to get back in the game when favorable conditions restore more wetland habitat.
8. By the end of the game, there should be fewer wetland plates at each end of the playing field than you started with. Gather the students into a group and discuss the process they just went through. Ask the following:
   - What did they learn about migration?
   - Name some of the factors that benefitted the birds.
   - Name the direct and indirect factors that resulted in habitat loss or degradation.
   - Can they think of any wetlands in their community that might be affected by the above factors?

Flyways of North American Ducks in the United States



Chapter V Find A Wetland to Study & Adopt

In the preceding chapters you've learned about what wetlands are, why they're valuable and what activities are threatening them. Now it's time to turn your attention to the wetlands located within your town, city, or surrounding communities. Your goal may simply be a one-time visit, or you may want to study a particular wetland in depth with long-term protection in mind. In either case, you have to locate them first. The following suggestions should help you in your search:

1) Poll the class to find wetlands they're familiar with, or have teams of students use their knowledge of wetland characteristics to search for possible sites;
2) Rely on the expertise of state and local resources professionals to assist you in your search;
3) Rely on your own powers of observation; or
4) Consult topographic or natural resource maps.

Student-Based Research

Have the students brainstorm wetland areas they already know. This will connect their daily activities to the study. Perhaps they drive by a wetland on their way to school. They may collect bait or other live specimens from a nearby marsh. Maybe they know local tales and legends of an area. Wetlands in urban areas are sometimes crossed by bridges and roadways, or they may be part of a local park.

If students think they know of a possible site, give them a checklist of the wetland hydrology and soil indicators listed below. They can explore their site with these guidelines and bring the results back to class. The whole class might decide on a wetland site by discussing the findings of students or by looking at a map.

Searching For Evidence

Observing the hydrology of wetlands that are **seasonally** saturated or inundated with water may be difficult during the drier periods of the year. If the wetland you visit appears dry, look for the following *hydrologic indicators* to provide evidence for the seasonal presence of water:

- *waterlogged soils:* dig a shallow hole (18 inches) and see if the soil is damp or wet;
- *depressions or low spots* with dark, water-stained leaves;
- *water stains or lines on trees* indicate that water periodically covers the area to at least the depth shown on the objects;
- *thin layers of sediment* deposited by flowing water on leaves or other objects lying on the ground; and
- *water-transported debris* lodged in trees and plants or collected around their bases.

Use this list of indicators to help you distinguish upland and wetland soils:

- *Organic soils:* Look on the soil surface for a thick layer of decomposed organic matter which can be black (muck) to dark brown (peat). Mucks contain plants that have decomposed beyond recognition and peats show very little plant decomposition (many of the plants can be recognized).
- Rub the organic material between your fingers – it should leave a dark stain.
- *Mineral soils:* look for a thick, dark, surface layer; gray subsurface colors; and the presence of reddish-brown, orange, or yellow mottles (iron) near the surface.
- May smell of rotten eggs (hydrogen sulfide) in the wettest soils.
- Beware: if you find soils that appear uniformly tan with a sandy or grainy texture in an area adjacent to your wetland, you may have discovered *fill dirt* that could have been placed there for development purposes.

Contact Local Officials & Others

In some New England states, local conservation commissions are responsible for protecting your community's wetlands. Because these officials are familiar with your town's natural resources, they should be consulted before taking a trip. Commission members can be indispensable sources of local wetlands knowledge – their location, ownership information, development threats, and those best-suited for educational purposes. They may also be interested in the results of any wetland stewardship or study projects the class undertakes.

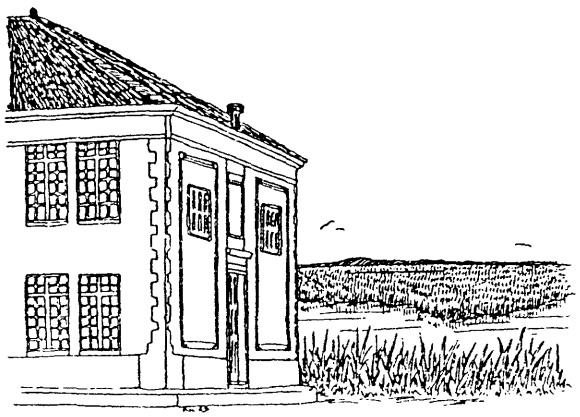
Other organizations can provide you with assistance in locating wetlands. These include state natural resource or fish & game agencies, environmental groups, watershed associations, state university natural resource departments, state cooperative extension services, and hunting clubs. All of these groups are involved to some extent in wetland research, education, natural resource management, or protection. See the *Appendix* for the addresses of the state and federal natural resource agencies.

If your goal is to take your students on a onetime field trip, consider visiting a state park, wildlife refuge, or conservation land that has *boardwalks* weaving through wet areas. Many of these trails give visitors the opportunity to observe a wetland up close without having to wade through water or damp soils. A list of wetland sites to visit throughout New England is found in the *Appendix.*

Look Around You

Rely on your own powers of observation. Keep your eyes open for the presence of water as you travel through town. Where do you remember seeing flooded conditions after a heavy rainstorm? Have you noticed any land that appears soggy or flooded along the side of roads? Are there any wetlands that might border rivers or streams? What about low-lying areas or depressions in the landscape – do these locations appear to collect and hold water for extended periods of time? As you become more aware of what wetlands are, you may find yourself noticing them more often.

Finally, take a good look around your school property. You may have a wetland to study that is adjacent to the school. Many schools have been sited near wetlands, as towns have tended to keep for public purposes otherwise undevelopable land. You may literally find yourself adopting a wetland in your school's backyard!



Use Maps

The world is full of different two-dimensional representations of the earth's surface. The following maps will be useful in trying to locate wetlands:

U.S.G.S. Topographic (Topo) Maps include contours of the land's surface, providing a three-dimensional perspective of t landscape. Topo maps also contain a great deal of other information, such as waterways, transportation features (bridges, roads), and large wetland areas. The typical scale o topo map is 1:24,000. The U.S.G.S. has divided each state int a series of *quadrangles*; you need to find out in what quadrangle your town is located. (Note: Your town may be part of several adjacent quadrangles, in which case you may require a few different topo maps.) You can purchase these maps at many book stores and pharmacies.

State Wetland Maps. Many state natural resource agencies ha wetland maps that are usually more accurate and detailed th topo maps. They may depict wetlands too small to appear o topo map.

Community Base Maps are enlarged maps of towns and citie showing rivers, roads, and zones for commercial, industrial, and residential use. These maps also distinguish public from private lands. Check with your conservation commission, to clerk, or city manager for copies.

National Wetland Inventory (NWI) Maps correspond to U.S.G.S 1:24,000 scale topographic maps. These maps are prepared the U.S. Fish & Wildlife Service. Available through the U.S. Geological Survey by calling 1-800-USA-MAPS or sending yc check to U.S.G.S., EFIC, 507 National Center, Reston, VA 22(They cost $3.50 for paper or $5.25 for mylar.

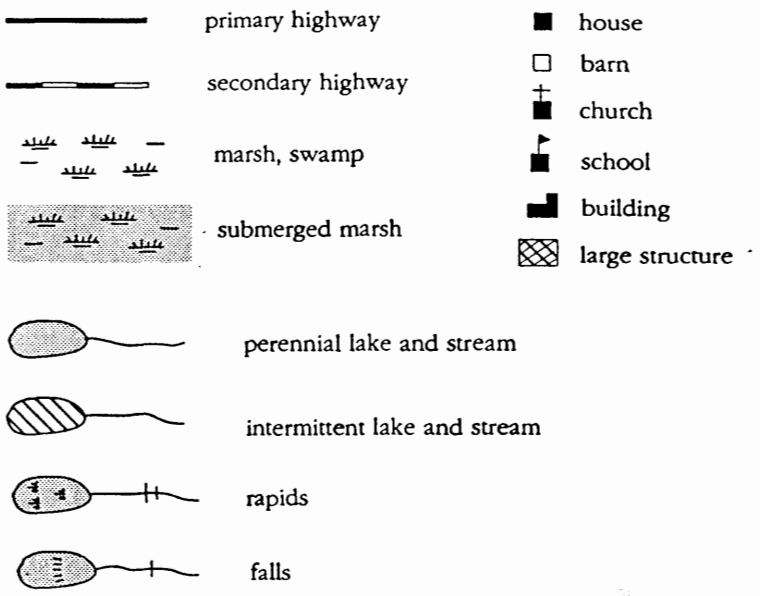
Soil Survey Maps The Soil Conservation Service (SCS) has been surveying the nation's soil types for the past 50 years. Develop on a county-by- county basis, soil surveys contain an enormou amount of detail about the geology, hydrology, and land use characteristics of the area. Use what you've learned about wet soils to locate wetlands on these maps; areas marked as *poorly drained* or *very poorly drained* soils are probably good bets.

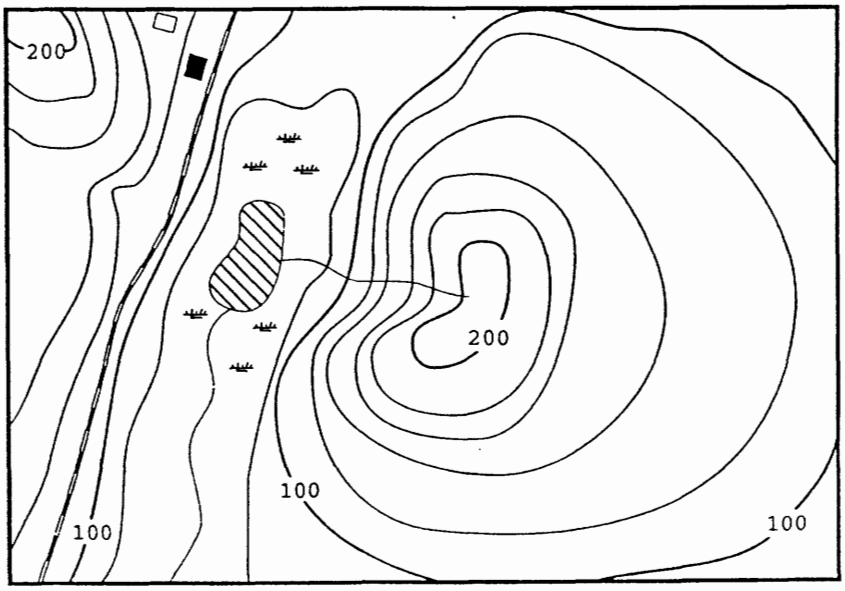
Maps provide many opportunities for learning, whether it's to scope out your community's wetlands or learn about topography in general (See activities 1-4 on mapping.) Examine a topographic or base map of your community to find the larger, more obvious wetland systems. Look for the wetland symbols (≈) close to roadways in order to find wetlands that are most accessible for you and the students. The following *map reading basics* will help you get started:

Scale — Map scale is the size relationship between the features shown on the map and the same features on the earth's surface. This is usually expressed as a ratio (e.g., 1:24,000, where '1' unit on the map equals 24,000 units on the ground in feet, miles, etc.). Maps are available in different scales, which means they show different levels of detail. For instance, a map with a scale of 1:24,000 will show more detail than one with a scale of 1:250,000.

Contours — Some maps may be replete with squiggly concentric lines called contours. Contour lines represent areas of equal elevation in the landscape – ridges, hills, and valleys. As drawn on the map, each contour line represents points of equal elevation; moving from one line to another represents a gain or loss in elevation. Contour lines drawn closely together indicate more rapid elevation change or steepness; lines that are spaced widely apart indicate an area that is gently sloping. Every fifth contour line is darkly marked and labeled with a number representing its elevation above sea level. For example, if the contour interval is 20 feet, every fifth line is 100 feet.

Maps contain many other informative symbols for "reading" the landscape:





* *Also refer to the sample USGS topographic map on page 87.*

Learning to Use Maps

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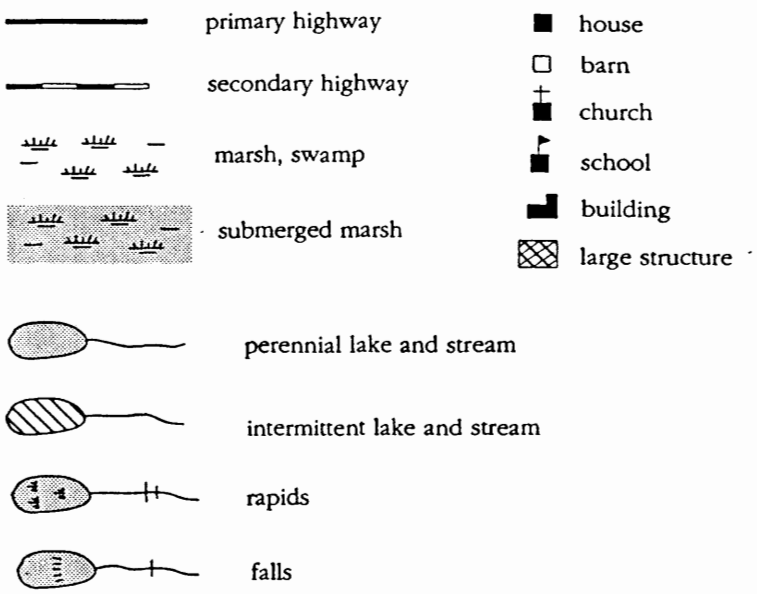
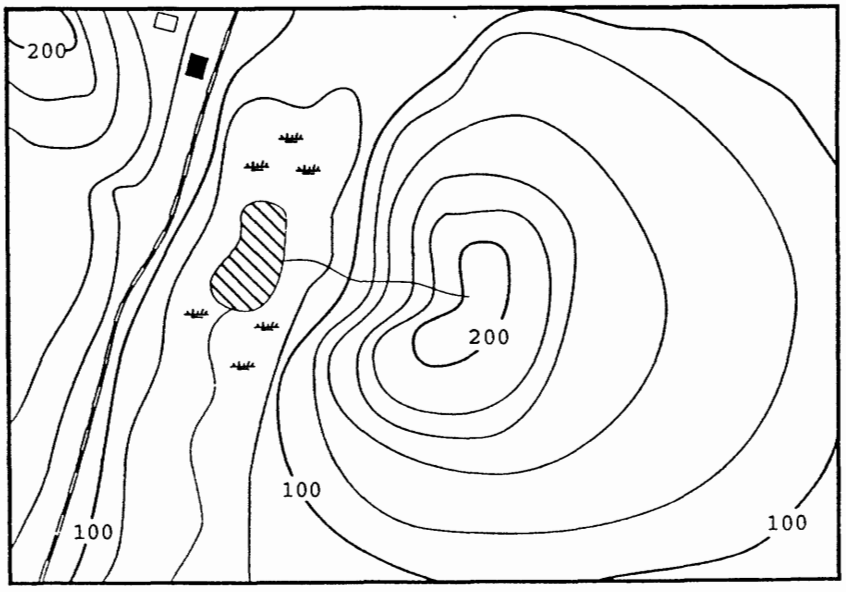




* *Also refer to the sample USGS topographic map on page 87.*

Activity 1: Build a Contour

Overview Students will explore the concept of topographic maps and contours by creating a three-dimensional cardboard model from a topographic map.

Materials Each pair of students should have:

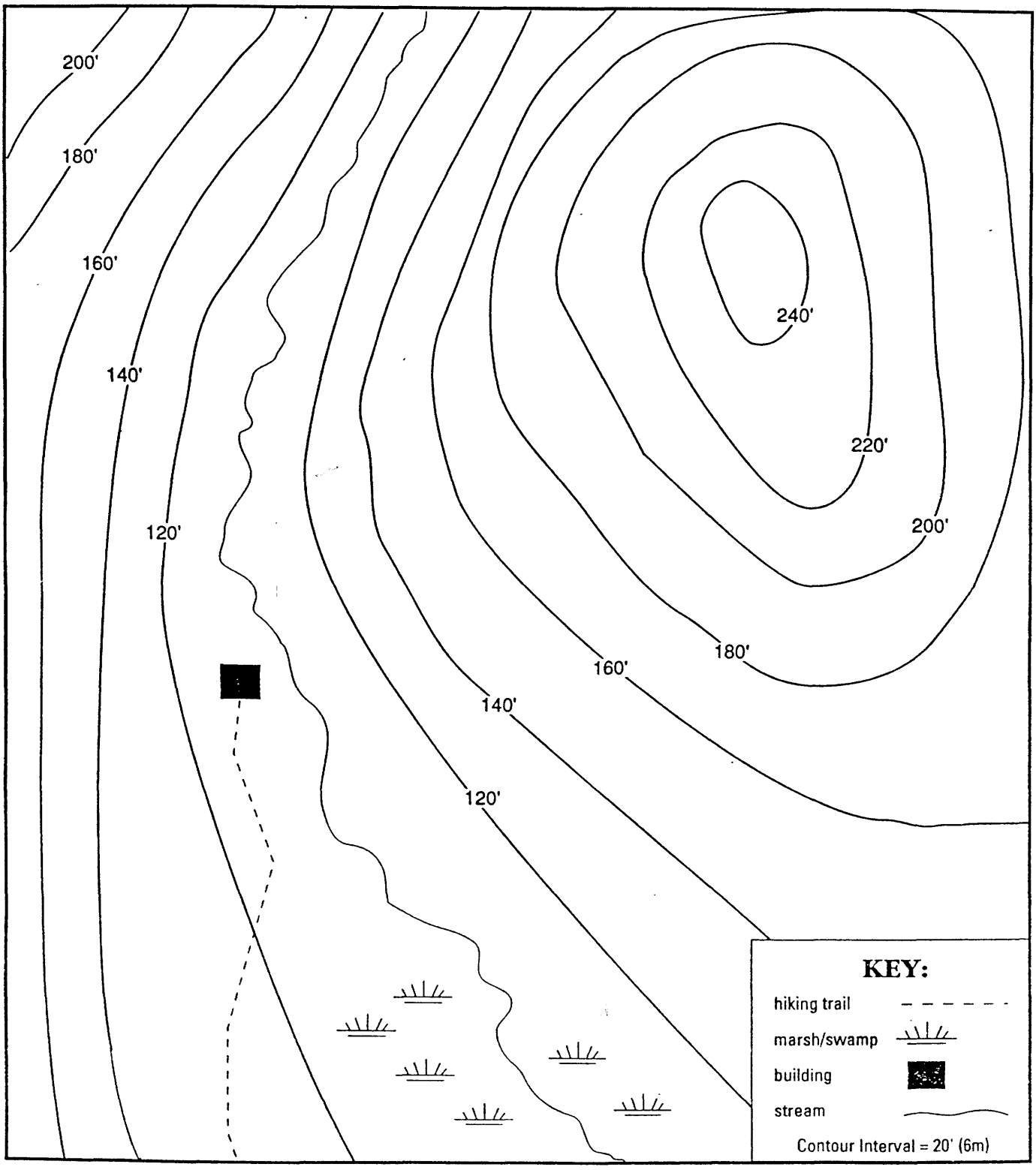
- 2 copies of the topographic map (next page)
- Clay
- Scissors, pencils, markers
- Large pieces of cardboard

Procedure

1. It is best to have students work in pairs so they can discuss their work. Pass out two copies of the map to each team. Discuss the details of the map — what the contour lines represent, location of streams and wetlands, etc. Can students tell from the lines where the ground is gently sloping or where it is steep? (The greater the distance between contour lines, the gentler the slope.)
2. Each pair should have materials ready. Cut one contour map along the 120' contour lines only. There should then be two contour pieces and one stream piece. Save all 3 pieces.
3. Lay one of the large cut pieces on the cardboard, trace it and label it 120'. Reduce the same map piece by cutting along the 140' line. Trace this onto another piece of cardboard and label it 140'. Continue cutting on the contour lines and then tracing and labeling pieces on cardboard. Repeat this procedure with the other large piece of the map. There should be twelve, finished, labeled pieces in all.
4. Using the second copy of the map as a guide, stack the cut pieces in two piles from lowest to highest elevations. As you stack, place three or four small balls of clay between each layer to add height. Lay the stream piece between the stacks.
5. Students should be able to see the *canyon* that the stream runs through. What type of wetland might be found here?

Adapted from *Science is Elementary*, the resource publication of MITS, Inc., the Museum Institute for Teaching Science. Geology, Oct./Nov. 1988.

Activity 1 Topographic Map



Activity 2: Contour Quiz

Objective Students gain experience in interpreting how contour lines on maps represent real-life landscape features by matching sample contours with their corresponding three-dimensional silhouettes.

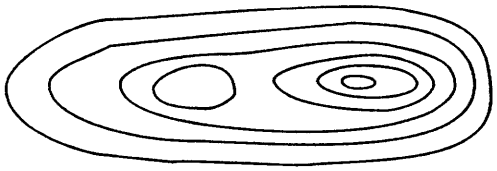
Materials Contour matching quiz worksheet.

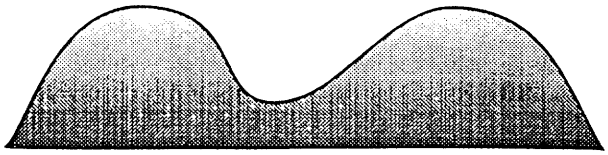
Procedure

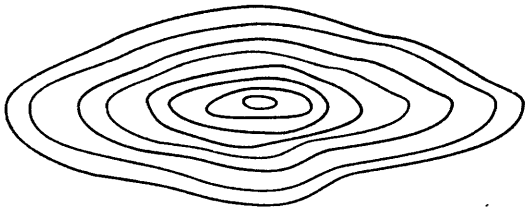
1. Review the concepts of contour lines on maps – how they represent areas of equal elevation in a landscape and where wetlands are most likely found on these maps in relation to them. Moving from one contour line to another represents a gain or loss of elevation.
2. Pass out the contour quiz worksheet and ask students to match the contours with their corresponding hill silhouette. Alternatively, you could provide the students with only the contour configurations, and ask them to draw how they think the corresponding hill silhouette should appear.
3. Break up the students into small groups. Assign each group to work on a different silhouette. Where would they expect to find wetlands on their silhouette (if at all) and why? Remind them that wetlands are often found in low-lying areas in the landscape.
4. Next, place an imaginary drop of water on each group's silhouette and have them determine which direction the water would flow from that point. Where would the raindrop flow and why? The direction of water flow can be determined by examining the contour lines (see illustration on page 86).
5. Ask each group to pick a representative to deliver its conclusions to the rest of the class.

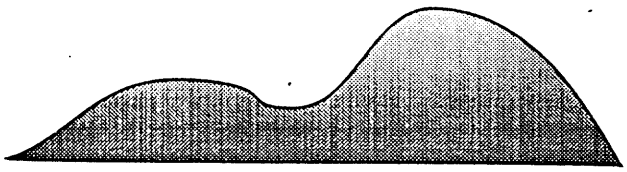
Adapted from *The Basic Essentials of Map & Compass* by Cliff Jacobson. Used with permission of the publisher, ICS Books, Inc.

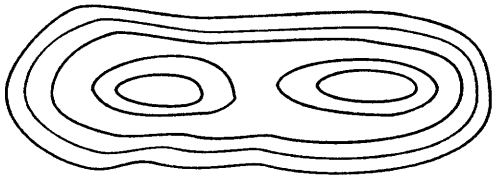
Contour Matching Worksheet

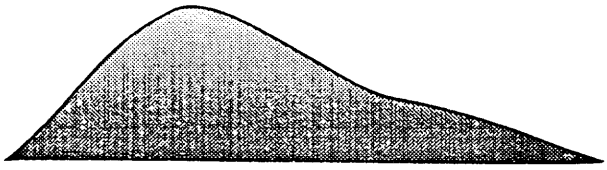


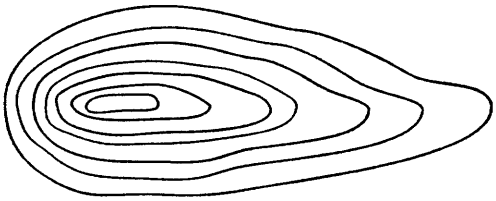


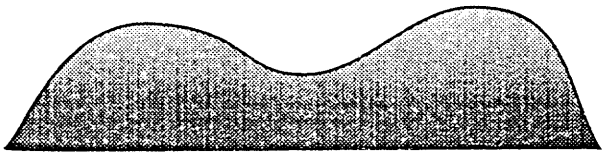


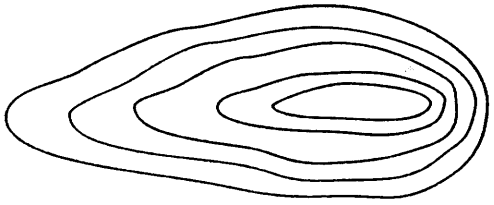


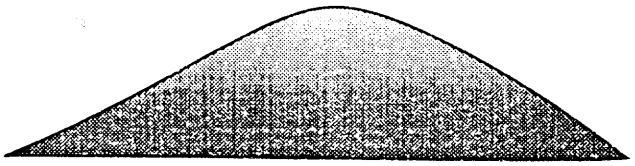


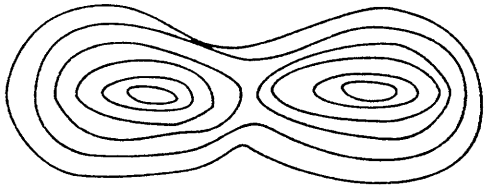


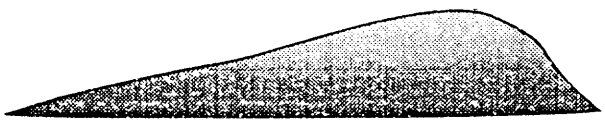












Activity 3: Visualizing an Acre

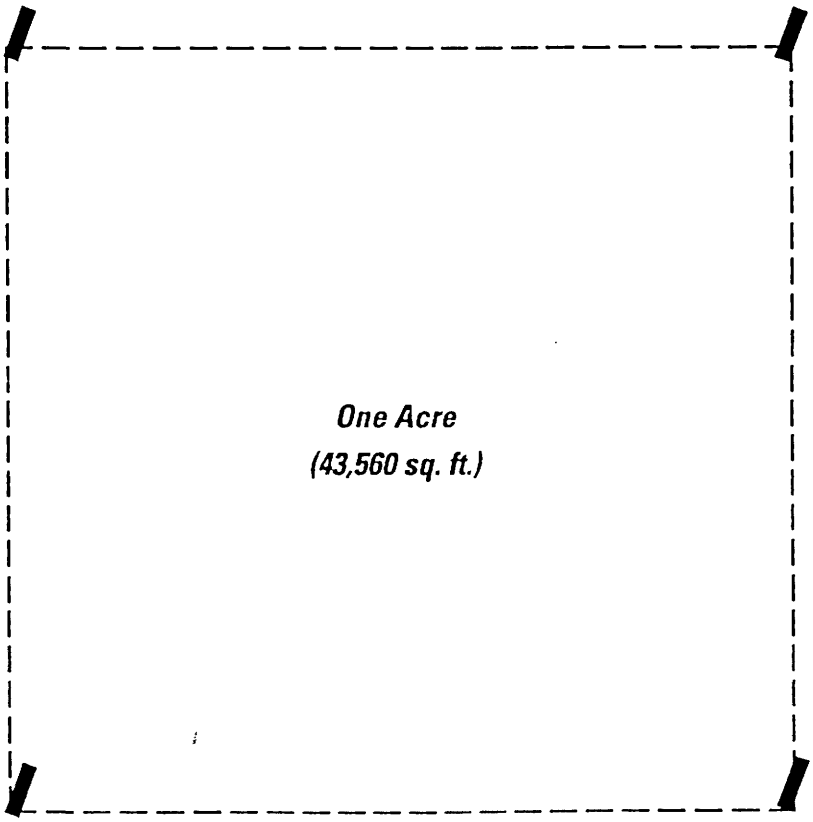
Overview Students stand along wooden stakes that form the four sides of an acre. This outdoor exercise allows them to visualize the actual dimensions of an acre.

Materials

- Wooden stakes (available at lumber or hardware stores)
- Measuring tape

Procedure

1. Stake out an area the size of one acre on a playing field outside the school (1 acre = 43,560 square feet). If your school is located in an urban setting with limited grounds, try staking out a smaller area – 1/2 acre or 1/4 acre.
2. Before going outside, ask the students if they can guess how large an acre actually is. Is it the size of the school parking lot, gymnasium, or the size of the classroom? Take a survey of the class to see how many think it is larger or smaller.
3. Once outside, ask the students to stand around the stakes facing towards the center, forming four sides of an acre. Remind them how large they originally thought an acre was. Also remind them of the wetland acreage lost in the U.S. (100 million) and in their particular state. Will they feel different about the loss of just a few acres of wetlands being filled for development now that they know the actual size of an acre?



Adapted with permission from Carol Johnson & Associates, Cambridge, Massachusetts.

Activity 4: Investigating Topographic Maps

Overview Using a topographic map, students will locate common natural and man-made features on topo maps and become familiar with the relationship between contour lines and elevation.

Materials

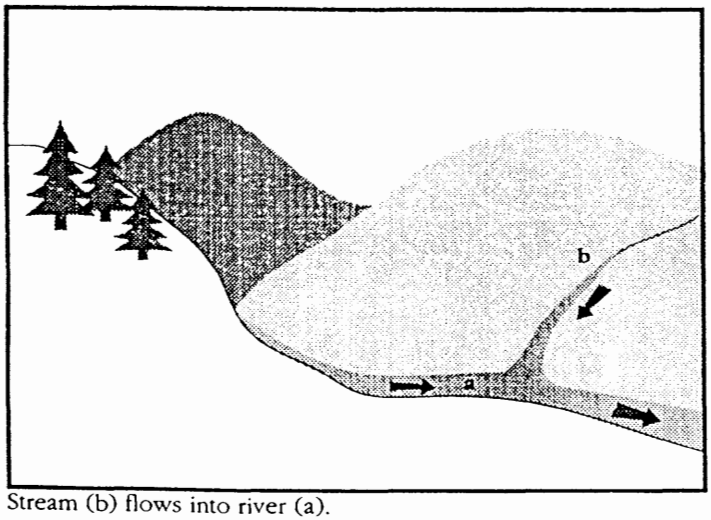
- Topographic map or community base map
- Crayons (black, brown, green, & blue)

Procedure

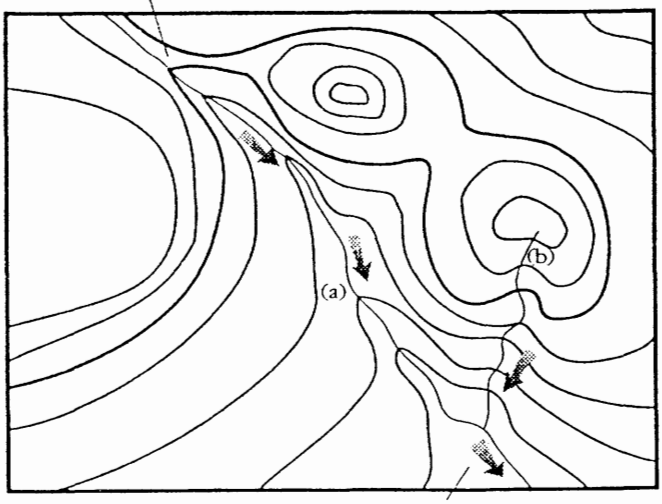
1. Divide the class into groups, preferably with no more than four or five students per group.
2. Pass out copies of the topographic map to each group. Using a topo map of your own community instead of the one in this guide will be more meaningful to students. Review briefly what contour lines are and how to read them (see diagram below).
3. Place three different points on the map and ask students to identify the elevation of each point.
4. Discuss the difference between uplands (higher elevations) and lowlands (lower elevations) and how wetlands are often found in low-lying areas. Ask the students to locate upland and lowland areas on the map. Have them find the highest and lowest points on the map.

   Point out the symbol for wetlands (⩲). Can they locate any wetlands? Color these green.
5. Identify other features on the map, both man-made and natural – buildings, waterways, etc. (see map symbols on page 80). Ask students to find their school and neighborhood on the map (if you're using a community base map). Do they notice any wetland symbols or waterways located near their school or home? Color the wetlands green and the waterways blue. Have any students seen or explored these areas? Does water flowing through the wetlands enter into streams or reservoirs?
6. Have students trace the path of a drop of water on this real-life map. Where does it flow? Does it flow through any wetlands?

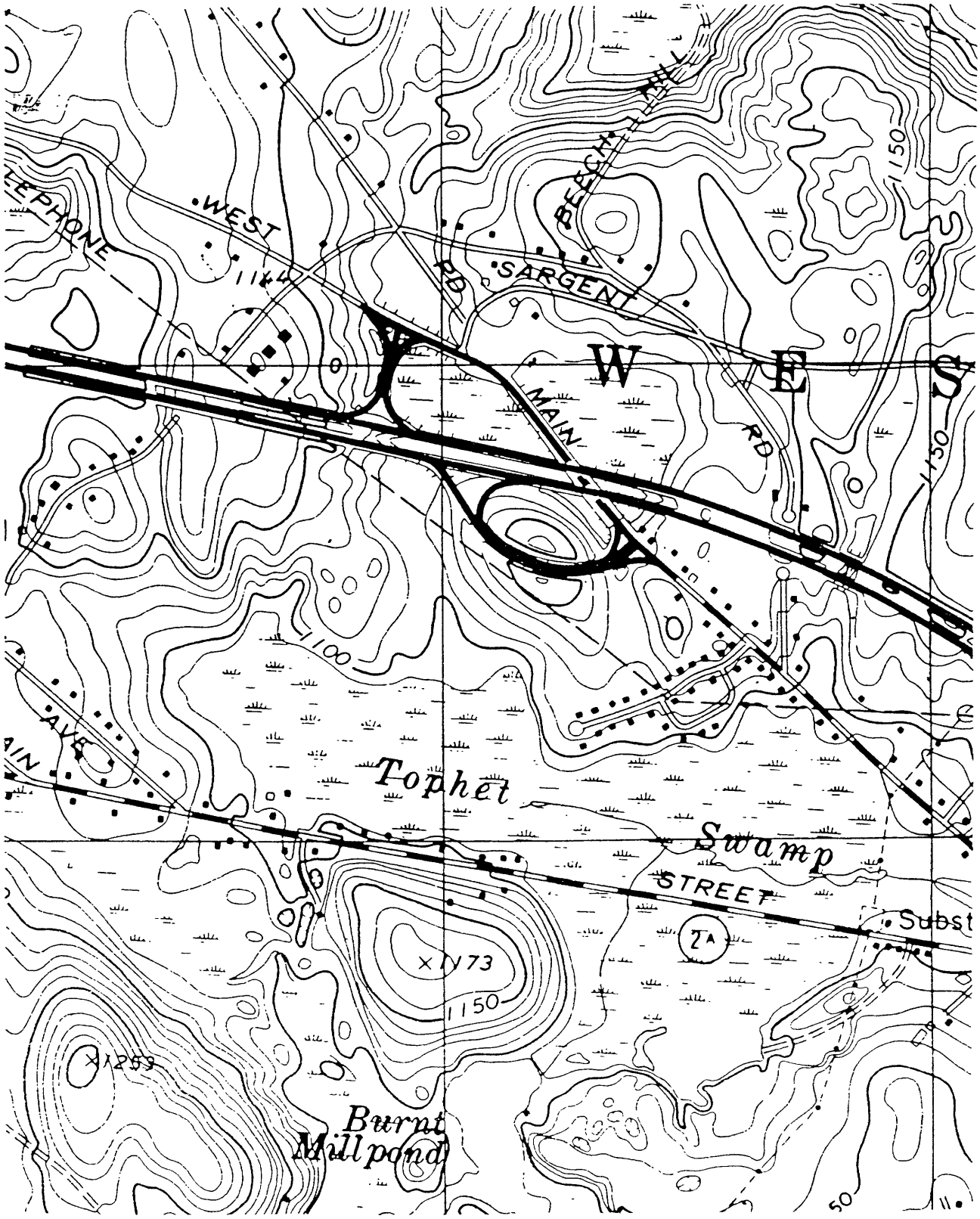
Tracing the path of a drop of water



Stream (b) flows into river (a).



Sample USGS Topographic Map



Chapter VI A Wetland Field Study

Using Wetlands as Outdoor Classrooms

Getting students out into a wetland is at the heart of *A World in Our Backyard.* The success of any learning program is to give students plenty of direct experience and hands-on activity. The field projects in this chapter give your students the opportunity to do just that – to investigate a number of wetland characteristics first hand: surveying wetland vegetation, soils, water and wildlife; documenting the wetland from an artist's perspective; investigating land uses along its periphery; and refining a base map upon which all collected information can be recorded.

Student instructions and data sheets have been provided for seven field activities:

Activity 1: *Plant Inventory*

Activity 2: *Soils Survey*

Activity 3: *Wildlife Inventory*

Activity 4: *Water Watchers*

Activity 5: *Sounds, Shapes, Colors, and Prose*

Activity 6: *Changes to the Wetland*

Activity 7: *Mapmakers*

Organizing the Field Study

A field study can be coordinated in a number of ways – from taking one day to simply explore a local wetland to conducting an intensive, yearlong stewardship project. Taking your students out in the field, even for just one class period, is valuable since it provides a concrete frame-of-reference for the information taught in the classroom. "Mucking about" gets students excited about and interested in the things they see, hear, feel, and smell. It engages them in the subject to be studied while having a lot of fun in the process. Ideally, students should be able to visit their wetland at least twice: first as an introduction to the topic before any classroom instruction and again in the middle of the study to reinforce concepts taught in class.

- **Use an interdisciplinary approach in your study.** The topic of wetlands lends itself to a number disciplines: history, social studies, language arts, math, art, and of course, science. Investigate the wetland through history – how has the use of the wetland

changed over time? Can students chart the succession of plants and animals of this area? Have students document their observations of wetland characteristics through writing, art, and photography. Math skills are used in the mapping exercise, and in the water quality and velocity experiment.

- **The entire class might investigate one or two aspects of a wetland,** such as studying birds that depend on local wetlands during fall and/or spring migrations. A census of bird populations could be passed on to a local birding club. Students might organize a cleanup or restoration of a wetland that has served as a dumping ground for household trash and other debris.

- **Individual or small group projects are natural extensions of a larger thematic study**. Students can be organized into teams to study one specific aspect of the wetland – water quality (see box on next page), soils, plants, wildlife – and report their findings to the rest of the class. Within each team, students can take on certain roles – as recorder, equipment specialist, or surveyor. See the field activities 1-7 at the end of this chapter for different team project ideas.

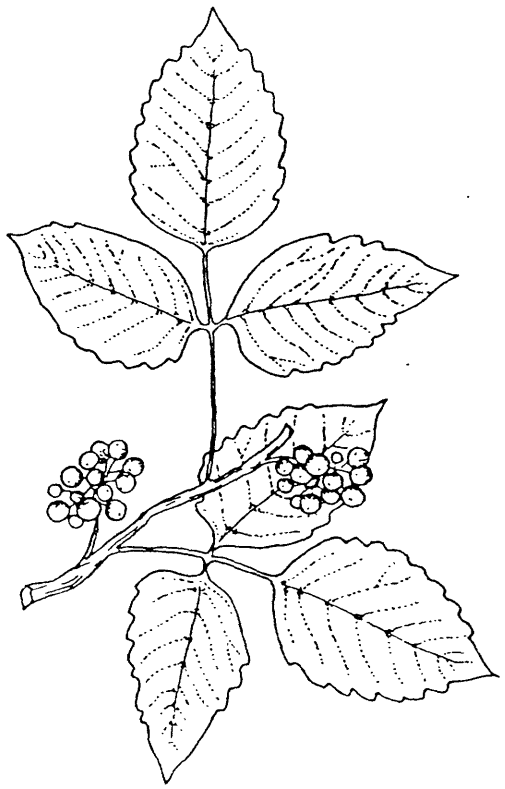
- **Field activities may take the form of environmental monitoring or stewardship projects.** Students may collect data that are helpful to the conservation commission, such as recording the location of reptile and amphibian populations or evidence of illegal dumping or filling. The Massachusetts Audubon Society is coordinating a statewide effort to document the presence of *herps* by collecting the results of volunteer surveys. The project will run through 1996. Contact the Mass. Audubon Society's Conservation Department for more information (617) 259-9500.

Securing the Interest of Your Students

Design experiences that create a 'need to know' in students. Walking into a wetland or performing an experiment in the classroom surfaces ***why?***, ***how?*** and ***what?*** questions. Getting students to begin their study by asking questions is guaranteed to lock them into the rest of the wetland study unit. There are a number of approaches you can to take to get your students invested in their field work:

- *Have students ask as many questions as they can think of.* As they walk through the wetland ask students to think aloud, forming their observations into questions. For example: Wetlands are inhabited by a diversity of plants and animals. Why does this plant or animal inhabit this wetland? Water flows through the area in some manner. Why does the water gather here? Wetlands are important ecosystems. How does the wetland purify my water? How is the wetland helpful during a flood?

- *Record the students' questions.* Take the list back to the classroom. Either you or your students can sort and categorize the questions to focus your study. Two or three questions may become the basis for a comprehensive study that includes water quality testing, plant and wildlife inventories, local development issues, or historical use of the wetland.
- You may want to approach the field trip as a way to *prove that a particular area is in fact a wetland.* Have students work in teams and collect information on water, plants, and soils that will prove your hypothesis.



Poison Ivy

Pre-Planning Checklist

✓ Once you've found a wetland to study, check with the town assessor's office to determine who owns the land – is it under town, state, or private ownership? If the wetland is privately owned, you should obtain the permission of the owner to visit the property.

✓ Before you take your students to the wetland, try to determine a few access routes from which to enter and exit. Varying your routes will help reduce the impact you may create by walking over wetland plants.

✓ Urge students to wear appropriate clothing – long-sleeve shirts, long pants, boots, raingear, and an extra pair of socks. A brown bag lunch should also be packed for the trip.

✓ Obtain permission from students' parents to take a field trip.

✓ Take plenty of chaperones. In general, one adult should be able to manage two groups of 4-5 middle school students at a time. For younger students, secure a chaperone for each group.

✓ Determine if there are any rest room facilities nearby or on route to the field site.

✓ **Make sure you and your students can identify poison ivy** (see illustration) **and poison sumac.**

✓ You might want to request a local wetlands expert (e.g., a member of the conservation commission) to assist you in making observations during the field trip, including evaluating the health of the wetland. Someone with extensive field experience can point out indicators of wetland degradation that, to the untrained eye, may go unnoticed. Examples of degradation include the presence of invasive species and evidence of erosion and sedimentation.

✓ Perform an *Observation Exercise* (see p. 93) in class before heading out to the field to heighten the students' awareness of the importance of good observation skills in field work.

✓ Obtain as many field guides as you can for yourself and the students. A list of suggested field guides is provided in the Appendix. A particularly useful field resource, *Maine Wetlands and Their Boundaries*, is available for $5 by writing the Maine Office of Community Development, 219 Capitol St., Station House Station 130, Augusta, ME, 04333, (207) 287-2656. Though specific to the state of Maine, this 72-page document includes color photos, illustrations, and descriptions of wetland communities, soil profiles, wetland vegetation, hydrologic indicators, and other useful field information applicable to wetlands in other states.

Establish the Ground Rules for Students

- Carry in, carry out! Leave nothing but footprints behind.
- Do not pick any plants or remove any organisms.
- Handle living organisms gently and with *wet* hands, always putting them back where they were originally found.
- Be careful to avoid disturbing nesting wildlife – many birds are sensitive to intrusion while raising young.
- Do not taste or eat anything.
- Anyone who causes another person to become excessively wet or muddy will be given indoor assignments only.

A Note on Water Quality Monitoring for the Teacher:

The topic of water quality monitoring is too expansive to cover in great detail in this guidebook. There are, however, a number of reference publications written for teachers that cover this subject in-depth:

Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools (6th edition). 1992. Mitchell, Mark and William Stapp. This manual contains instructions for eight chemical and physical water quality tests plus fecal coliforms and macroinvertebrates. Spiral-bound, 240 pages, numerous photographs and illustrations. Available for $9.95 by writing Dr. William B. Stapp, 2050 Delaware Drive, Ann Arbor, MI 48103. Make checks payable to William B. Stapp.

Pond and Stream Safari by Karen Edelstein. This guide for youths discusses the world of aquatic invertebrates and includes illustrations, activities, and instructions for building sampling equipment. Available for $12.75 through Cornell University, Resource Center, 7 Business and Technology Park, Ithaca, NY 14850. (607) 255-2080.

Water Quality Testing Equipment

The following companies carry a number of water quality testing kits and each has a catalog that can be ordered for more specific information:

LaMotte

LaMotte Chemical Products Company
P.O. Box 329
Chestertown, MD 21620
Tel: (800) 344-3100
Fax: (301) 778-6394

Hach

Hach Chemical Company
World Headquarters
P.O. Box 389
Loveland, CO 80537
Tel: (800) 227-4224
Fax: (303) 669-2932

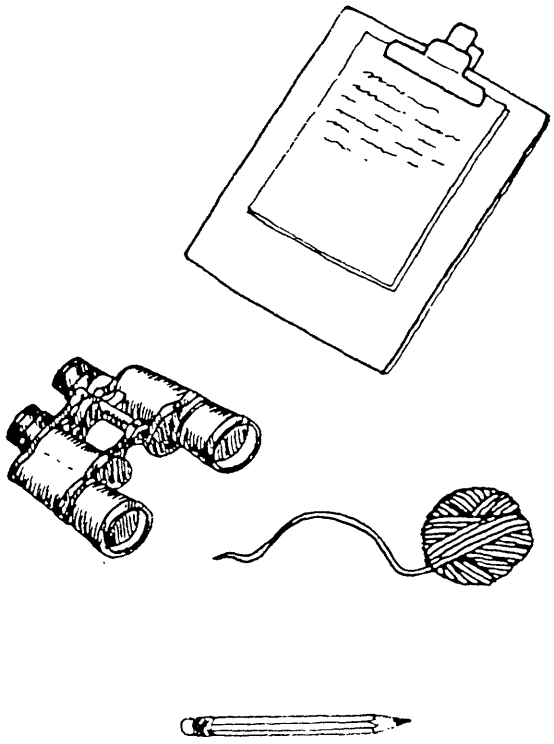
Disposal of Waste Materials

Most water quality monitoring kits provide a material safety data sheet (MSDS) on disposal of monitoring wastes. There are two things to keep in mind when disposing of these materials:

1) Know what you're handling. The MSDS will list all the materials contained in your testing kit. Check your MSDS specifically for products listed as *regulated* materials. Contact your local or state government for instructions on how to best dispose of these materials, as waste disposal regulations tend to vary from state to state.

2) Store *regulated* materials in separate containers.

For more information on disposal, contact:
Project Green (Global Rivers Environmental Education Network), 216 S. State St., Suite 4, Ann Arbor, MI 48104. (313) 761-8142.



Field Trip Materials & Equipment

First aid kit, camera, bug spray (applied in the parking lot or road, *not* in the wetland), clip boards, data sheets, pencils, insect nets, holding buckets or containers (white plastic or enamel works best), bug collection containers,* a ball of twine, wooden stakes, flagging tape, indelible marker, shovel or soil auger, baking tray, fish nets, binoculars, rubber boots. Ask your Parent/Teacher Organization if it can help you with the purchase of these last two items.

* *Bug boxes (1-by-1-by-1 inch) are available for $1.00 each from Museum Products, 84 Route 27, Mystic, CT 06355. (800) 395-5400.*

Observation Exercise

Discuss the importance of making careful observations before taking the class outside. Keen observation skills is the basis for excelling at science, art, writing, interpersonal relationships – just about everything!

Play a game with the class to test their powers of observation. Wear something different from normal, such as colored socks or a button. Before class, plant a paper towel soaked in rubbing alcohol or vinegar at the back of the room, color part of the blackboard with colored chalk, tape a random word on the wall, put up a map, etc. Pass out this questionnaire and tell students they must not look up from their desks until they are finished.

1. How many windows are there in this classroom?
2. What color are the teacher's socks?
3. What is written on the teacher's button?
4. How many plants are there in the classroom?
5. A map of what part of the world is hanging on the wall?
6. What color hair does the person have sitting in the seat behind you? (if you're in the last row, the teacher in the room next door)
7. What new word is hanging on the wall behind you?
8. What material is the front walk of the school made of?
9. What is the smell in the room today?
10. How many different sounds can you hear right now?
11. Are there any animals in the classroom? If so, what?
12. Name the five senses:

Follow up on this concept the day of your field trip by trying a similar exercise just as you approach the boundary of the wetland. Instruct the students to perform a "three-minute notice." Ask them to jot down on a piece of paper what they see, hear, smell, and feel about the wetland they've just entered for a three minute period. Once the three minutes are up, ask each student to describe to the class one or two of their observations.

Activity 1: Plant Inventory

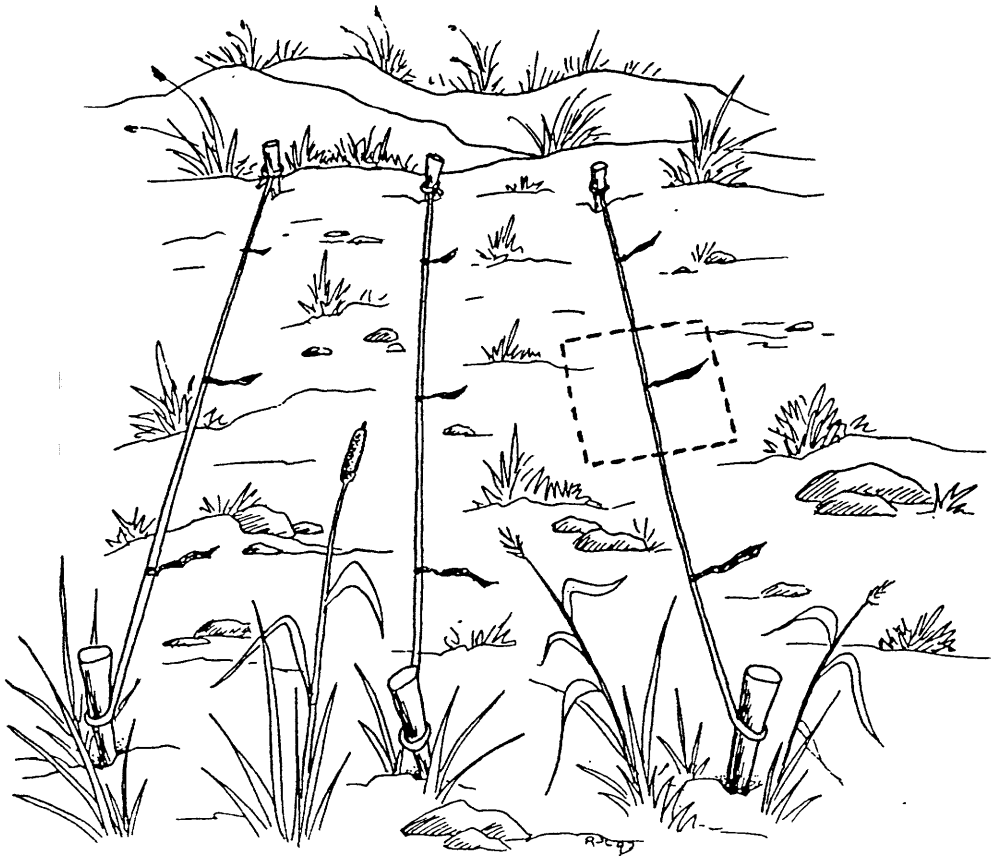
Tasks

1) Set up a plant transect *;
2) Identify as many different types of vegetation as possible in the wetland and
3) Compare upland and wetland species by observing differences in their structure.

* A *transect* is a method used to evaluate the landscape of a natural area by recording observations at regular intervals along a straight line and using that information to produce a *base map* of the site.

Materials

Paper, pencils, clipboards, twine, wooden stakes, flagging tape, measuring tape, plant field guides (see the *Appendix*), measuring tape, copies of plant illustrations from Chapter II.



plant transect

Procedure

1. Begin by setting up a transect. Use the twine and stakes to run a straight line across the wetland. Make sure the line crosses all representative zones of the wetland – from boundaries with upland areas to the edges of standing or running water (avoid running it *through* water). If your wetland is very small (less than half an acre), you can make several transects.
2. Mark off intervals on the twine every 10 to 15 feet with flagging tape. Stick to whatever interval you choose, even if there is a tree at the spot. Give each flagged station a number.

3. At each station, one student in the group should be designated the *measurer.* This person will stand over the flag and stretch his/her arms out wide, both parallel and perpendicular to the line. This distance is the dimension of the study area at each station.
4. Designate someone as a *data keeper* who will record the following information for each station:
   1) kinds of living plants;
   2) approximate plant heights (using measuring tape); and
   3) the number of each plant type.
5. Answer the *Making Observations* questions below for each station, if time allows.
6. Designate a person in your group to sketch a profile of each station.
7. Draw and/or photograph at least two plants per station.

Making Observations

- Are wetland plant roots visible?
- Are plants alive or dead?
- Is there anything unusual at the station that might influence the kinds of plants growing there – a wind-thrown tree, a large boulder, hummocky ground surface, etc.?
- Are there any unusual smells?
- Can you observe any differences between the wetland plants and upland species? Can you identify any upland plants or trees?
- Which species are able to live in both upland and wetland habitats?
- Is there any difference in the diversity of plants in the upland habitat compared to the wetland habitat?

Vegetation Data Sheet

Station #	Plant Types	Average Height (ft)	# Plants	$\frac{\text{\# plant types}}{\text{total \# plants}}$ = % total
Example: *1*	*willow, tree*	*12 ft*	*2*	

- On a separate sheet of paper sketch a profile of at least three of your stations.

Activity 2: Soil Survey

Tasks To observe soil profiles and record wetland soil characteristics.

Materials Shovels, baking pan, soil survey data sheet

Procedure

1. Choose three sites along the transect line to dig soil pits or cores. One sample should be closest to the upland boundary of the site, one midway through the wetland, and one close to standing or running water (if present).
2. Dig a pit at each site, about 1 to 2 feet square and at least 18 inches deep – or until you reach the water table.
3. Use all your senses (*except taste*) to make observations of the soils and record these on the data sheets.
4. Reconstruct a profile of each soil station on the baking pan to take back to the classroom.
5. Fill in the pits before leaving the site to prevent wildlife from falling and becoming trapped in them.

wetland soil profile

Making Observations

- Is the soil the same from top to bottom in the pit, or are there distinct layers, like a cake?
- What colors do you notice?
- How does the soil smell?
- Pinch the soil from different layers between your fingers and feel the texture – is it rough or smooth?
- Does the soil leave stains on your fingers?
- Is it wet, damp, or dry?
- Is there any identifiable plant material (leaves, stems, roots) in the upper soil layer?
- How deep do plant roots penetrate the soil?
- What organisms (insects, earth worms) are living in the soil?
- What are the differences between the three pits?

Soil Survey Data Sheet

	Soil Characteristics		
	Station 1	**Station 2**	**Station 3**
Number of soil layers			
Color			
Smell			
Texture (fine, gritty)			
Does it stain your fingers?			
Degree of wetness (wet, damp, dry)			
Presence of organics (leaves, roots)			
Presence of living organisms (insects, earth worms)			
Depth of plant roots			

Activity 3: Wildlife Inventory

Tasks Record direct and indirect observations of wetland wildlife.

Materials Field guides *, collection containers, wildlife data sheet, base map

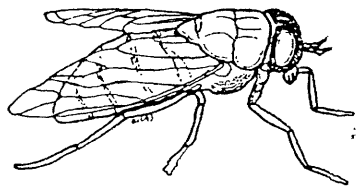
* Refer also to Chapter II for a reference list of the wetland wildlife you might expect to find in your wetland.

Procedure

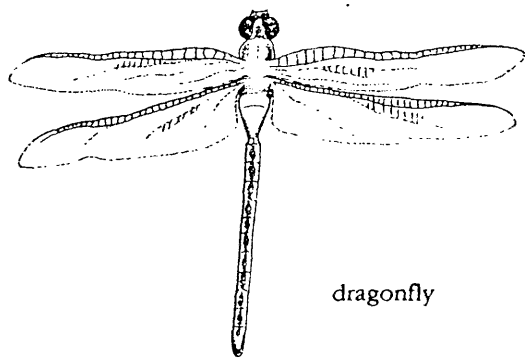
1. Equip as many people in your group as possible with field guides to help you identify birds, mammals, amphibians, reptiles, fish, and insects.
2. Begin your approach to the wetland area quietly to avoid scaring away wildlife.
3. Walk through the wetland and along its borders and look for signs of animal life. You will probably find less *direct* evidence of wildlife (*seeing* the beaver, woodpecker or vole) than *indirect* evidence (burrows in the ground, the tap-tap-tap sound on a tree, animal excrement called *scat*, remnants of a beaver dam, animal tracks, etc.).
4. If there is standing water on your site, look for insects, fish, and other aquatic organisms.
5. On the worksheet, list every organism or indirect evidence you observe and mark its location on the base map.
6. If you collect any specimens for study, be sure to pick them up with *wet* hands and include a piece of their habitat (e.g., bark, floating plants) with them in your collection container until you are ready to return them.

Making Observations

- What color is the specimen? What is its shape and size? Where specifically did you find it (in the water, under a rock or log)? How does it move? How does it breathe?
- Think about the role, or niche, of each organism in the wetland – is it a predator, is it prey, or is it both?
- Why is the animal found here? Is there any particular reason why it depends on a wetland for habitat?
- Why are food chains important?
- List at least three characteristics of a wetland habitat.



greenhead fly



dragonfly

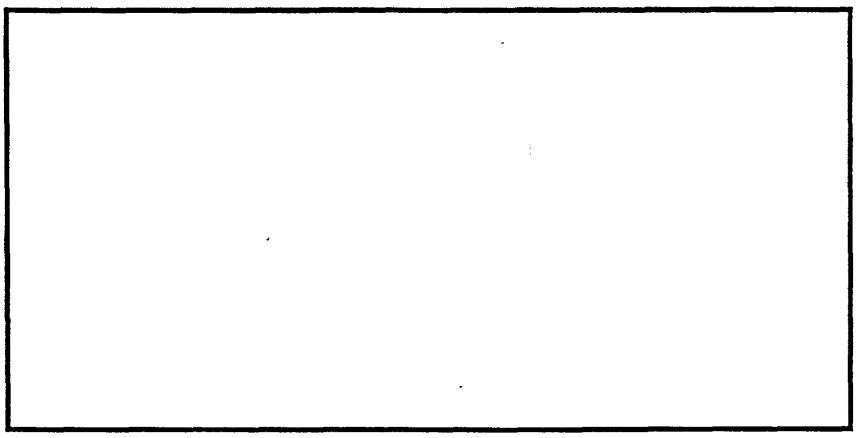
Wildlife Data Sheet

Name _____

Phyical characteristics _____

Where found _____

Drawing:



What it might eat (prey) _____

What might eat it (predator) _____

Other observations _____

_____

Back in class, use a field guide and try to identify one organism in each feeding level that you'd find in a wetland:

producer _____

herbivore _____

carnivore _____

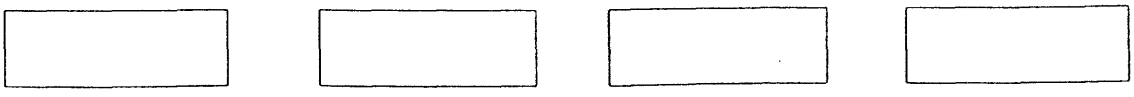
omnivore _____

scavenger _____

parasite _____

Using any of the organisms above, construct a wetlands food web:

Sun



Activity 4: Water Watchers

Tasks If there is a body of surface water at your site, your group will investigate characteristics of water – water velocity (for running water), temperature, dissolved oxygen, and pH. If your site has no visible standing water, skip to step 6.

Materials Thermometer, litmus paper, measuring tape, stopwatch, wiffle ball (or other buoyant object), sampling bottles, water watchers worksheet, water quality monitoring kit (optional).

Procedure

1. Choose three sites in the wetland area for sampling and mark their location on the base map.
2. Use the worksheets to record temperature of air and water, pH, and visibility. If your class has access to water quality monitoring kits, perform these activities now.
3. To record the velocity of running water, place a wiffle ball or other small, buoyant marker in the water. Designate someone as the timekeeper, and release the marker while starting the stopwatch. When the object has traveled a known distance (10 feet, for example) stop the stopwatch and record the time and distance traveled.
4. Calculate the water velocity by dividing the distance traveled by the time (Distance/ Time = Velocity). Record your results. Make sure to include appropriate units for your calculated velocity.
5. Next, use the *Evidence of Point & Nonpoint Source Pollution* handout to identify any strange or unusual materials in the water. Share this information with the group looking for activities impacting the wetland.
6. If there is no standing surface water on your site, you will have to do more observing and less testing. Try to figure out how water is getting to the wetland site and determine the following:
   - Where do you think the water on this site is coming from? In which direction does it seem to be traveling? Where does it go?
   - Are there any rivers or ponds nearby?
   - Are there high points of land nearby?
   - Are there any road drainages leading to the site?
   - Try to remember the weather lately – has it rained recently? If so, is there any evidence that water has been retained on your site?
   - What is the quality of the water coming onto the site?
   - Does the quality of the water seem to change as it enters the wetland?
   - How is nearby land being used?
7. If possible, dig a few pits in the ground and see if you can hit the water table. Record the depth to groundwater in three different locations.

Evidence of Point & Nonpoint Source Pollution in Waters

Condition	Possible Cause
Muddy water	Erosion of soil in upstream area; in tidal waters the cause could also be high winds.
Greenish color	Microscopic plant cells called algae. Algae growth may exceed normal limits due to excessive nutrients in the water. Nutrient sources include: fertilizers, pet waste, grass clippings, and leaves.
Yellow-brown to brown water	Acids released from decaying plants. Naturally occurs each fall when dead leaves collect in the stream. Common in streams, draining marsh or swamps.
Orange to red on stream bed	Results from bacterial action upon iron. May indicate a high erosion rate or industrial pollution.
Colored sheen on water surface	May indicate oil has entered the stream, particularly if the water surface also has an oily odor.
Foam	When foaming occurs in only a few scattered patches and is less than three inches high and is cream-colored, it is probably natural. If the foaming is extensive, white in color or greater than three inches, it may be due to detergents entering the stream.
Rotten egg odor	Could indicate sewage pollution, but in a wetland it is often the result of sulfides released from the soil.
Yellow coating on stream bed	May indicate polluted water draining from a coal mine.
Musky odor	May indicate presence of untreated sewage, livestock waste, or algae.
White cottony masses on stream bed	Could be *sewage fungus*. The presence of this growth indicates sewage or other organic pollution.
Blue-green algae	Could indicate sewage or other pollution if growth is excessive.

Adapted with permission from the Riverways *Adopt-A Stream* program materials, Mass. Dept. of Fisheries, Wildlife & Environmental Law Enforcement.

Water Watchers Worksheet

I : *Rate of water flow (velocity)*

Station #	Distance (ft)	Time (sec)	Velocity (ft/sec)

II : *Temperature, dissolved oxygen & pH of water* *

Station #	Temperature	Dissolved Oxygen	pH

air temperature _____

date of recording _____

* This data table map may be replaced by those included in water quality monitoring kits (e.g., Lemott or Hach).

Activity 5: Sounds, Shapes, Colors, and Prose

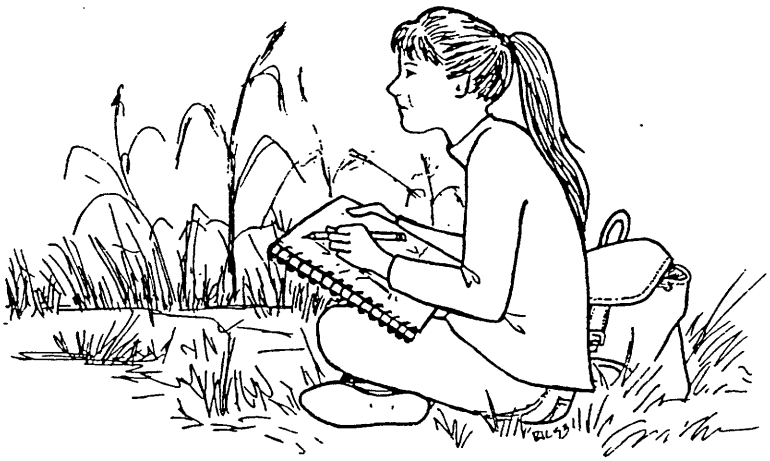
Tasks Make an artist's inventory of the wetland by describing, illustrating, and photographing its shapes, colors, and sounds.

Materials Sketch pads, writing paper, pens, colored pencils, tape deck, still or video camera.

Procedure If appropriate, divide your group into subgroups and perform the following:

Shapes/colors

- Describe the shape and color of the objects on top of the land.
- Describe and draw the biotic (living) component and the abiotic (non-living) component.
- How will the shapes and colors of the area change with the seasons?
- Pick one small feature (a plant, insect, fallen log) of the wetland that appeals to you and draw a picture of it.



Sounds

- What are the loudest sounds? The quietest sounds?
- What are the most distant sounds? The closest sounds?
- What are the most pleasant sounds? The most unpleasant ones?
- Can you differentiate between natural and "human generated" sounds?
- If you didn't know where you were, would your sense of hearing help you determine your location?

Writing

- Describe the different parts of the wetland; e.g., where it is wet, muddy, paved, overgrown, scary, pretty.
- Think about the *Wetland Metaphor* activity; do any of the metaphors apply out here?
- Describe the sensations of being outside.

Activity 6: Changes to the Wetland

Tasks Observe and document any impacts that people have made to the wetland interior and boundaries.

Materials *Changes to the Wetland* data sheet, pens or pencils, base map, camera (optional).

Procedure

1. Depending on the size of the wetland, you may want to split up into groups to investigate different areas. Use your *Changes to the Wetland* data sheet to look for and record specific land uses and any man-made structures located in or near the wetland. Make note of any impacts to the wetland that could have been caused by these activities, such as filling, dredging, erosion, pollution, etc. Be sure to record these activities on the base map.

   Look for Signs of Encroachment:

   - Are there areas that have been dug out (dredged) or filled in?
   - Has water been drained off the site?
   - Is water coming on to the site through culverts or drainage ditches?
   - How is the land used near the wetland? How might this affect the wetland?
   - Are there old stone walls or other historical remnants?
   - Have trees been removed?

2. Mark any of these findings on the base map.
3. If possible, document any evidence of harmful activity by photographing the portions of the wetland that show signs of filling, erosion, pollution, or improper development. These photos will be helpful as documentation to municipal officials, such as conservation commissions, who are interested in protecting community wetlands. Even if the alterations are not recent, this information represents a snapshot in time that is useful for later reference.

Changes to the Wetland

Types of Development Located Along the Wetland Boundaries:

Urban: _____

_____

Suburban: _____

_____

Rural: _____

_____

Agricultural: _____

_____

Industrial: _____

_____

Commercial: _____

_____

Residential: _____

_____

Be on the lookout for the following human activities and building structures – draw them on the base map of your wetland:

* Discharge pipes
* Construction work
* Parking lots
* Roadways / driveways
* Buildings
* Woods / open space
* Landfills
* Steep slopes
* Lawns
* Farming / pasture
* Logging
* Highways
* Stored equipment spilling over into the wetland from nearby property
* Dumping
* Unpermitted vehicle access
* Alteration to fencing

Activity 7: Mapmakers

Tasks Refine the measurements of the wetland base map.

Materials Compass, protractor, tape measure, graph paper, stakes, compass reference text,* paper, pens.

Procedure

1. You will first need to determine the average walking pace of one person in your group. The walking pace will be used to measure the area of your wetland. With a tape measure extended, have one person walk naturally while another student measures the distance of each pace (a typical adult pace is about 3 feet). You will use the following equation to determine the distance between each staked area in the wetland:

   (measured pace) x (number of steps taken between each stake) = the distance between stakes

2. Place stakes around the wetland boundary so that a student can walk a straight line between stakes. Number each stake, and pace off the distance between stakes.
3. Designate at least two students as *pacers* for each measurement; combine the total and divide by two to get an average. Record the distances. Repeat these measurements around the wetland.
4. Once you have measured the distances between each stake, determine a scale for your base map (the graph paper), such as 1 inch = 10 feet or 1 inch = 100 feet. Plot your measurements on the graph paper, using a protractor to transfer the compass bearings. Make sure the map includes a compass rose or a north arrow.
5. Once the wetland boundaries and map scale are established, mark the major landscape features on the map, such as nearby roads, buildings, streams, etc. Work with the other groups to incorporate their data on the map as well.

* Refer to the following publication for assistance in map and compass reading:
The Basic Essentials of Map & Compass by Cliff Jacobson. ICS Books, Inc., Merriville, IN. 1988.

Activity 8: Bringing It All Together – Making a Field Guide

Students will have gathered quite a bit of information about their wetland and can put this information to good use in the wetland protection activities that follow in Chapter VII.

Objective Students will work together to assimilate the qualitative and quantitative information they have gathered in the field so it can be shared with others. (Bear in mind that the there is another important layer of information to follow concerning the history of land use and the ways to protect wetlands; however, the class should first consolidate the results of their field work.)

Procedure Look at a few field guides * (birds, insects, amphibians, etc.). Discuss the purpose of field guides – they organize information so that it is useful to other people. How can the class organize all its field information so that someone could learn about its wetland by reading the class's field guide? A table of contents might include:

a. directions to the wetland

b. what region of the country your wetland is found in; what type of wetland it is

c. map of the wetland

d. water: where does it come from and where does it go?

e. soil characteristics

f. plant species and communities

g. animal species, niches, and habitat

h. changes to the wetland

i. sounds, colors, and prose

The class can be divided into groups to assemble each chapter. The groups might be the same as the field groups with a few students pulled out for introductory sections. Have students share their information with the mapmakers. The class might choose to put all data on one map or to use mylar to create a series of overlay maps.

* See the *Appendix* for a list of suggested field guides.

Chapter VII Protect Your Wetlands

Wetlands need our protection – we've already lost over half of them since colonial times. Wetland loss through the mid 1970's was due primarily to the conversion of wetlands for agricultural purposes and large-scale development projects. Today, however, wetlands are being destroyed in a more insidious fashion: small, piecemeal "bites" or *cumulative impacts* occur to wetland systems every day by large and small development projects. Because most of these impacts are small and numerous – a house here, a shopping mall there – it is difficult to account for and combat their cumulative effect.

To better protect our remaining wetlands, the public needs to become more aware of its community's wetlands: what they are, their functions, how they are threatened, and how citizens can play a role in protecting them. A few individuals (e.g., your students) acting on behalf of the wetlands in your community can do a lot to discourage or prevent wetland losses. This chapter provides you with information about the various regulatory and educational protection options available to help your students become wetlands advocates.

To begin a wetland education and stewardship program, students themselves must be knowledgeable about the issues. If they want their ideas to count, they also need to communicate to the right people. Citizen advocacy enables students to effectively apply their knowledge, but only if they have their facts straight and know to whom to talk. Before initiating an education or stewardship project, review the following questions with your students:

- Why are wetlands valuable?
- What is unique about the wetlands in your area?
- What activities threaten wetlands?
- Who regulates the use of wetland areas in your state and in the local community?
- How can you play a role in protecting your community's wetlands?

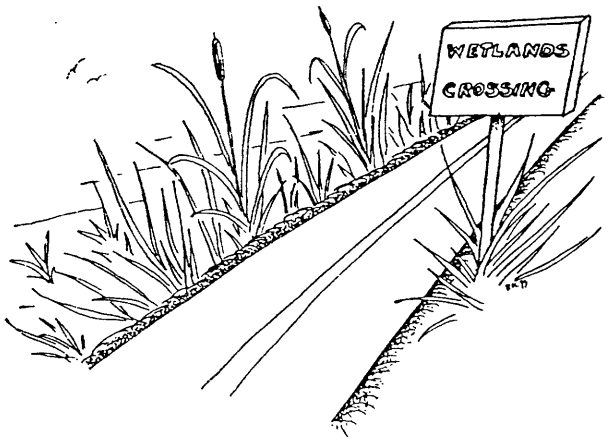
Activity 1: Create a Wetlands Awareness Program

Objective Encourage students to become active wetland educators and advocates in their communities. There are a number of ways your students can "get the word out" about the importance of wetlands. Try out one or more of the education, advocacy, and citizen monitoring activities below.

1) Education and Advocacy

Community

1. Newspaper articles. Have the students write an article about their wetland, the activities they have undertaken, and what they have learned. Submit it to a local or regional newspapers.
2. Assign students to conduct a survey to learn how their neighbors feel about wetlands and the need for protecting them. Have the students use the *Introductory Wetlands Questionnaire* on page 124 to interview members of their immediate neighborhood, or have them create their own survey. Students should report to the class with their results. You might want to tally these results and use them as a supplement for a newspaper article.



3. Construct *wetland crossings* signs along roadways and/or bridges that cross through wetlands in order to increase public awareness of wetlands in town. Contact your local Department of Public Works and Conservation Commission for assistance.
4. Students can create public information fact sheets about wetlands in general or about the specific wetland they have studied. Have them explain specific wetland functions, indicate existing threats, and what protective measures citizens can take. These materials can be distributed at a number of locations: the library, town/city hall, local supermarkets, as part of an Earth Day celebration, etc.

Peers

1. Constructing interpretive trail markers that identify wetland plants is educational and fun. Students can follow up on this project by leading field trips through the wetland for other classes and/or family hikes.
2. Students may develop a wetland slide show from photos taken in the field and make a presentation to an elementary school class.
3. Have students create posters about their wetland to submit in a poster contest within the school or as part of the EPA's Ecology Poem & Poster contest (through grade 6 only).

2) Citizen Monitoring Programs

Building A Database

Students can conduct an inventory of the flora and fauna found in their wetland and gather enough data to produce a local field guide. See Chapter VI, page 108 for ideas on preparing a field guide.

Wetland Watch Patrol

Identify certain students (or involve the whole class, if possible) as "wetland watchers" to keep an eye out for possible impacts or encroachment on your wetland. See the *Changes to the Wetland* data sheet in Chapter VI for a list of potential impacts to check for. Students could work in shifts, alternating every few weeks or so. Evidence of pollution or land alteration (e.g., littering and illegal filling) should be reported to local or state authorities. Refer to the *Wetland Protection Directory*, page 119 to determine who to contact.

Certification of Vernal Pools

As you learned in Chapter II, vernal pools are a special type of wetland habitat. The pools are sometimes difficult to identify because they are often small and are not always visibly wet. Your local conservation commission may be familiar with the location of these wetlands in your community and may help you find them. The Commonwealth of Massachusetts protects these wetlands under the state Wetland Protection Act, but only if the pools have been certified by the state's Division of Fisheries & Wildlife. Citizens in this state are encouraged to become active in assisting with the vernal pool certification process. To become involved, contact the Mass. Division of Fisheries & Wildlife's Natural Heritage Program for more information at (617) 727-9194.

High school students in Reading, Massachusetts have formed the *Vernal Pool Association.* These students certify vernal pools and raise funds to further their protection. Contact Leo Kenney for more information by writing to: Vernal Pool Association, Reading Memorial High School, 62 Oakland Road, Reading, MA 01867, (617) 944-8200.

Certified: A Citizen's Step-by-Step Guide to Protecting Vernal Pools, discusses vernal pool natural history and the certification process. Copies may be purchased for $11 (includes postage and handling) from the Massachusetts Audubon Society. Mass. Audubon has also produced *Vernal Pool Lessons & Activities* for teachers, available for $8. Both materials can be ordered through the Mass. Audubon Educational Resources Office, South Great Road, Lincoln, MA 01773, (617) 259-9500.

Routine Cleanups

Removing litter for aesthetic purposes or habitat improvement is a fun and very gratifying way of improving wetland quality. Keep notes on the kind of trash you find – where does it come from? Can you deduce the source? Is there any action you can take to prevent this kind of trash from ending up in the wetland again? If most of it's from a certain fast-food restaurant, how about getting them to place more trash cans at their facility? If it's plastic that comes in with the tide, how about educating boaters about the effects of marine debris? Have the students brainstorm ideas and try out potential solutions.

You can conduct a safe, successful, and enjoyable cleanup by doing a little planning, using common sense, and following a few safety tips:

- Notify the conservation commission early of your cleanup plans. They may have a lot of information about wetlands in your area: the best access points, areas that need the most attention, provide clean up supplies (gloves, bags), or assist with removing collected refuse.
- Know whose land you're cleaning up. Check with the town assessor's office to determine ownership and obtain written permission from landowners to cross private property. Do not enter posted areas without permission.
- Determine how you'll access the area and cause the least impact to wetland plants and soils.
- Plan ahead on how you will dispose of all the trash you collect. How will you transport it from the site, and where will the trash be accepted? Check with your town/city manager to possibly receive permission to dispose of the collected refuse free of charge.
- Supply students with gloves, garbage bags, insect repellant (only if necessary) and refreshments at the end of the event.
- **Familiarize yourself and students with poison ivy and poison sumac.** Also watch out for brambles and ticks. Wear long pants, long sleeved shirts, and rubber or waterproof boots, if available.
- All students should be under the supervision of an adult.
- Watch out for sharp objects (nails, pipes, etc.) that may be submerged in soggy soils.
- Take a camera to document your event and send photos to your local newspaper.

Adapted with permission from the Riverways *Adopt-A-Stream* program materials, Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement.

Protecting Wetlands Through the Regulatory Process

To introduce your students to land use principles, provide them with an overview of wetland regulations and indicate who is in charge at the local, state, and federal level. They can write to local and state officials, keep up with their activities through the media, and find out what zoning and planning offices have in store for the future.

Wetland Regulations

Wetland protection regulations are found on the federal, state and local government levels. These laws regulate different types of potentially harmful activities proposed in wetlands. Federal wetland regulations establish a minimum level of protection; however, when developing their own wetland protection programs, states often opt to establish stricter protection measures.

The federal and state protection programs often differ in how they define a wetland (i.e., the areas protected by law), the kinds of activities they regulate, and the exemptions from regulation. Unfortunately, because federal and state wetlands regulations are complex and difficult to interpret, citizens may be discouraged from getting involved in the regulatory process.

On the local level, some communities may establish more stringent measures to protect wetlands, either by including more areas under jurisdiction or by regulating certain activities. Therefore, getting involved in your local wetland regulatory process is usually the most effective way to protect your community's wetlands.

Federal Programs

Several federal programs are involved in wetland protection:

The Clean Water Act is a major piece of legislation first passed by Congress in 1970 that protects the nation's waters from excessive pollution. It contains two sections pertaining to wetlands:

Section 404 — The Section 404 program is administered jointly by the Army Corps of Engineers (Corps) and the Environmental Protection Agency (EPA). Section 404 regulates the discharge of dredged or fill material into "waters of the United States," which is defined to include most wetlands. Anyone proposing such a discharge must apply for a §404 permit from the Corps before any work can be performed. Dredge and fill activities are often associated with depositing dirt and sand for buildings, highway, dam, and dike construction.

Section 401 — Before an applicant can receive §404 permit approval from the Corps, a *§401 water quality certification* must also be granted by the state where the work is being performed. Denying water quality certification enables the state to prohibit an environmentally harmful project that does not meet the state's wetland protection criteria. This regulatory measure is particularly crucial for those states lacking their own wetland protection regulations. A very useful reference on this subject is available free through EPA – *Wetlands & Section 401 Certification: Opportunities and Guidelines for States and Eligible Indian Tribes.*

Endangered Species Act — Administered by the U.S. Fish & Wildlife Service, the Act requires federal agencies to protect federally-listed, threatened and endangered species by maintaining existing habitats. This Act is particularly relevant to wetlands since 45% o listed, threatened and endangered animal species and 25% of plant species use wetlan habitats during at least a portion of their life cycle.

National Environmental Policy Act (NEPA) — NEPA was the first big piece of environmental legislation that Congress adopted in 1970. It requires all federally funded development projects to go through an evaluation of potential environmental impacts. Information required by NEPA oft involves the assessment of wetland impacts

Administered by EPA, NEPA requires the preparation of environmental impact

statements for those development projects that pose significant impacts to the environment and involve the use of federal funds. Information required by NEPA from the project applicant often involves the assessment of potential impacts to wetlands.

State Protection

Most states protect wetlands by relying on their involvement with Section 401 of the Clean Water Act or by developing their own wetland regulations. In developing wetland protection programs, states may adhere to federal standards or develop more strict wetlands regulations.

All coastal states in the U.S. have laws protecting their coastal wetlands; however, only 13 states have established regulations to protect inland wetland resources, even though 95% of all U.S. wetlands are inland wetlands.

Fortunately, all six New England states have wetland protection regulations in place (including both inland and coastal, where applicable). A few of the states, such as Massachusetts, require local municipal boards, known as conservation commissions, to implement regulations at the local level. New Hampshire, on the other hand, relies on specially appointed state boards to oversee activities in wetlands.

In many parts of the country, county government is more prominent than town government, and wetland regulations would be found at this level.

Local Protection

The following is a list of various municipal boards and local officials responsible for land use decisions affecting wetlands. This list is particularly applicable to the six New England states:

Planning Board — a group that oversees community growth by developing local plans and regulations to guide the location of primary land-uses (business, agriculture, residential). These regulations protect sensitive natural resources such as water supplies, wetlands, flood plains, open space, and historical sites. Planning boards must also adopt regulations for subdivision plan review, including erosion and sedimentation controls, stormwater management, groundwater protection, and other protective measures.

Conservation/Wetland Commissions — a group of community volunteers that works to achieve community conservation goals, including the administration of state and local wetland regulatory programs and protection of natural resources within the community. These commissions are established by state laws dictating their legal functions and roles.

Board of Health — oversees many community health issues, including the design, placement, and construction of septic systems which significantly affect the quality of streams, lakes, wetlands, and drinking water supplies. Boards of health can establish health codes that prohibit septic system components (tank, pipes, and leach field) from being placed in a wetland or require septic systems to be located a specific distance away from wetlands.

Zoning Board of Appeals — hears all petitions for zoning variances and may also hear applications for special permits.

Building Inspector — responsible for assuring that all local development projects conform to local zoning ordinances or bylaws, including zoning bylaws that protect wetlands and other natural resources.

Local Water Supply Officials — are primarily responsible for the development and maintenance of public water supply systems and for ensuring that they meet state and federal drinking water standards.

In addition to wetland regulations, there are other local regulatory options available to help protect wetlands:

Zoning — is a regulatory tool that divides a community into various land use districts and allows only certain activities to be onducted in each district (residential, commercial, industrial, or agricultural). A zoning bylaw (town) or ordinance (city) further specifies which activities or structures are allowed within each district. Bylaws and ordinances must be approved by a town meeting or city council vote before they become law.

Overlay Districts — protect a community's sensitive natural resources, (e.g., wetlands and groundwater) by limiting or preventing development in all districts where the resource is located.

Wetland Bylaws — are often stricter versions of state wetland regulations. They differ from zoning in that they do not contain a clause that enables an individual to obtain a variance. Variances grant an individual permission to ignore a zoning bylaw in specific circumstances and carry out the proposed activity. These waivers are granted when an individual can demonstrate that the bylaw results in a case of hardship.

Bylaws do not prevent activities in wetlands but control them through building design requirements and buffer zones. Conservation commissions and/or planning boards are responsible for administering and enforcing these bylaws in most New England communities.

Building Design Requirements — are specific methods of building or using land so that wetlands and other sensitive resources remain unaltered during and after construction. This is done by controlling or preventing erosion, sediment runoff, hydrology changes, and pollution. Common design requirements include: the use of hay bale dikes and/or silt fabric fences, temporary sedimentation basins, mulching, grease traps, and establishment of buffer zones.

Buffer Zones — are specified distances established between a development project and a wetland. A town or city might require a 100 foot *setback*, meaning that the edge of the house, parking lot, etc. could be no closer than 100 feet to the wetland.

For More Information

The Federal Wetlands Protection Program in New England: A Guide to Section 404 for Citizens and States, U.S. EPA Region 1. Available for $5 through the New England Interstate Training Center (NEIETC), 2 Fort Road, S. Portland, ME 04106. (207) 767-2539.

A Citizen's Guide to Protecting Wetlands (Stock No. 79961), National Wildlife Federation, March, 1989. Available for $10.25 through the National Wildlife Federation, 1400 16th Street, N.W., Washington, DC 20036-2266. (800) 432-6564.

Wetlands and Water Quality: A Citizen's Handbook for Protecting Wetlands, Lake Michigan Federation, Chicago, 1990. (312) 939-0838.

Guiding Growth & Change: A Handbook for the Massachusetts Citizen, Sarah Peskin. Massachusetts Audubon Society, Lincoln, MA. March 1976.

Getting Your Students Involved:

- Hold a mock town meeting where students take the roles of neighbors, developers, town officials, and environmentalists to discuss the options involved in a proposed development project impacting wetlands. (See Activity 2)
- Develop a *Wetland Protection Directory* of local, state, and federal officials who make land use decisions affecting wetlands (See Activity 3).
- Interview a local official about your community's wetlands. Ask them questions that help the class rate the community's wetland protection capability. (See Activity 4)

Activity 2: A Wetlands Public Hearing

Objective Students will gain first-hand experience in understanding the complex nature of making land use decisions by analyzing and making recommendations for a planned residential development project which will involve the filling of wetlands as proposed.

Materials Copies of original site plan, background information sheet and student worksheets for each group; paper, pencils.

Procedure

Day 1

1. Break students into groups of approximately five per group, assigning a role for each – developers, conservation commissioners, etc. Hand out copies of the "student worksheets" and original site plan to all students.
2. Explain that each group will be role playing one of the participants in the proposed development scenario described on the "Background Information" sheet. Have each student read through this information now.
3. Tell the students that their opinions on this project will be sought by the conservation commission during a public hearing. Direct them to analyze the site plan from the perspective of the role they are playing and to prepare to argue a case for whether the plan should be left unaltered or should be modified. Encourage students to make notations or draft changes on the site plan itself. A spokesperson should be elected from each group to present their recommendations to the entire class. Allow at least 15 - 20 minutes for individual group discussions.
4. Have each group's spokesperson present their recommendations during the public hearing for why and how the site plan should or should not be changed. All students should take notes on each presentation for future reference.

Day 2

1. Have each group revisit the original site plan and redesign it based on the alternatives brought up in the class discussion the previous day.
2. Have each group present their redesigned plans to the whole class then present the sample "ideal" site plan and have the entire class nominate which of their plans would best incorporate the ecological, social, and economic concerns of all groups involved in the public hearing process.

Portions of this activity are adapted with permission from *Ecolands* curriculum.

Background Information Sheet

A developer in your community, Mr. Smith, owns a 30 acre parcel of land that contains 10 acres of a red maple swamp. He has decided to build a housing development of 25 (1) acre lots on this property, but has planned to fill in 5 acres of the wetland to put in an access road and accomodate additional housing lots. In order to begin construction, he needs the conservation commission and planning board to approve his plan.

There are, however, many groups of people in the community that have an interest in this project: several neighbors living near the parcel, a local watershed association, the conservation commission, and planning board. The conservation commission will review this project by seeking input from other people in the community, as well as making their own determination about how the land can be developed with the least amount of environmental impact.

Conservation Commission's Environmental Assessment of the Red Maple Swamp on Mr. Smith's property:

Plant species: red maple, white ash, winterberry, spice bush, high bush blueberry, swamp honeysuckle, impatiens, cinnamon fern, royal fern, skunk cabbage, marsh marigold (spring), jewelweed (fall).

Wildlife habitat values: Red maple swamps, with their abundance of woody and herbaceous vegetation, contain the three essentials for wildlife habitat: food, cover, and water. Direct or indirect evidence was found indicating the presence of the following species that use this wetland for habitat:

Birds: common yellowthroat, cedar waxwing, tree swallow, red-shouldered hawk

Amphibians: blue-spotted salamander (state-listed species), wood frogs, spring peepers, wood turtle

Mammals: white-tailed deer, raccoon

Developer: Mr. Smith; his engineering consultant; and his financial supporters

Your role: You (Mr. Smith) have submitted an application to the conservation commission and planning board to develop a residential subdivision on a 30 acre parcel of land in town. Of the 30 acres of land, 10 acres is wetland, 5 of which you have proposed to fill to complete your project. You have hired a consultant to design the site plan, taking into consideration any environmental impacts to wetlands, drinking water supplies, traffic and safety issues.

Things to consider in your role:

- You expect to make a lot of money from this project and need to compensate those people who have provided financial assistance to complete the project.
- You want to maximize the number of lots you can sell on this parcel. You have proposed to put 25 (1) acre lots on 30 acres of land, and need to be able to defend the need for this many houses.
- You have chosen to place the access road through the most narrow portion of the wetland to produce the least amount of impact.

Conservation Commission

Your role: The conservation commission (also referred to as the "con comm") is the group of local officials responsible for upholding the state wetland protection laws. You are currently reviewing the application submitted by Mr. Smith.

Things to consider in your role:

- the amount of wetlands to be filled. Is it really necessary to place the access road straight through the wetlands? Does there seem to be any other alternatives the developer can consider? See if you can come up with some suggestions for avoiding the wetlands fill altogether, or minimize the total number of acres impacted.
- what are the values of this wetland? Should you deny the project based on the value of this particular site?
- if filling wetlands is unavoidable, you can require the developer to *mitigate* for the wetland loss, such as setting aside other wetlands for permanent conservation or "creating" more wetlands on other land in the community. However, creating forested wetlands is technically very difficult, and often fails to replicate the *same* values of the wetland that was destroyed.
- how can the wetlands be least impacted during construction? (Use of hay bales and silt fences to prevent erosion, for example).

Neighbors #1

Your role: You have lived next to the proposed development site for a few years, but have never really wanted to go anywhere near it. The area looks wet, mucky and dark and has no appeal to you whatsoever. You actually encourage that this "wasteland" be filled in for the reasons given below.

Things to consider in your role:

- You feel the area is probably breeding grounds for all the mosquitoes that invade your backyard barbeques during the summer.
- Some of you have little children that play outside, and you're concerned that they might come into contact with some animals living in the wetland, such as raccoons that could spread rabies.

Neighbors #2

Your role: You have lived next to the proposed development site for many years and know the area well. You and other neighbors are fond of the songbirds that inhabit the area and enjoy the call of the spring peepers in the springtime.

Things to consider in your role:

- you enjoy stocking your birdfeeder for the many songbirds that inhabit your neighborhood. The wetland seems to provide good breeding habitat for these birds and you fear the local populations will decline if this wetland is impacted.
- you moved to this part of town because of the natural beauty of the surrounding landscape – conservation land on one side of your property and the wetland on the other. For aesthetic reasons, the wetland is valuable as a last refuge of peace and quiet in a community that is quickly running out of open space.

Local Watershed Association

Your role: You work for a regional organization that advocates the protection of wetlands for many reasons – water quality protection, flood storage and wildlife habitat. You are concerned about the impacts the project will have on the loss of habitat from this red maple swamp, specifically the vernal pools utilized by the blue spotted salamander for breeding. This species is already on your state's list of species of special concern.

Things to consider in your role:

- Consider how Mr. Smith might be able to avoid filling wetlands in the first place.
- Using the following data to back you up, prepare an argument for why the filling of the wetland should be avoided to protect the habitat of the blue-spotted salamander.

Importance of Protecting Vernal Pool Habitat

Vernal pools are typically small, shallow depressions in the land that collect water from runoff or intercept a high groundwater table. Despite their small size, vernal pools support a diverse community of species from microscopic organisms to amphibians (salamanders and frogs) and reptiles (turtles and snakes). Vernal pools typically disappear during the hot, dry months of summer and fill again with autumn rains. Due to this periodic lack of water, vernal pools cannot support fish populations. Since fish readily devour the eggs and larvae of most amphibians, the absence of fish is crucial to the successful breeding of many amphibians.

The Blue-spotted salamander is an example of an *obligate* species – one that has come to depend almost completely on vernal pools for breeding habitat because of their inability to withstand fish predation. During the first warm and rainy nights of the spring, hundreds of salamanders emerge from their burrows to migrate en masse to their traditional breeding sites. However, when vernal pools are filled or otherwise destroyed, local populations of many species are in jeopardy of extinction unless other vernal pools are present nearby to serve as new breeding sites.

Natural History of the Blue-spotted Salamander

Identification: dark-colored salamander marked with irregular blue or bluish white spots on the sides of the trunk and tail. Usually has flecks of the same color on its back.

Size: Four to six inches in length.

Egg Masses: Number of eggs per mass highly variable. Normal range appears to be between
6 and 30. They are found either attached to stems and twigs or to leaves on pool bottoms.

Life History: Migration begins on the first mild rainy nights of the spring, usually late March in southern Massachusetts, later in the northern parts of the state. The eggs hatch in four to eight weeks and the larvae usually transform between late July and September.

Planning Board

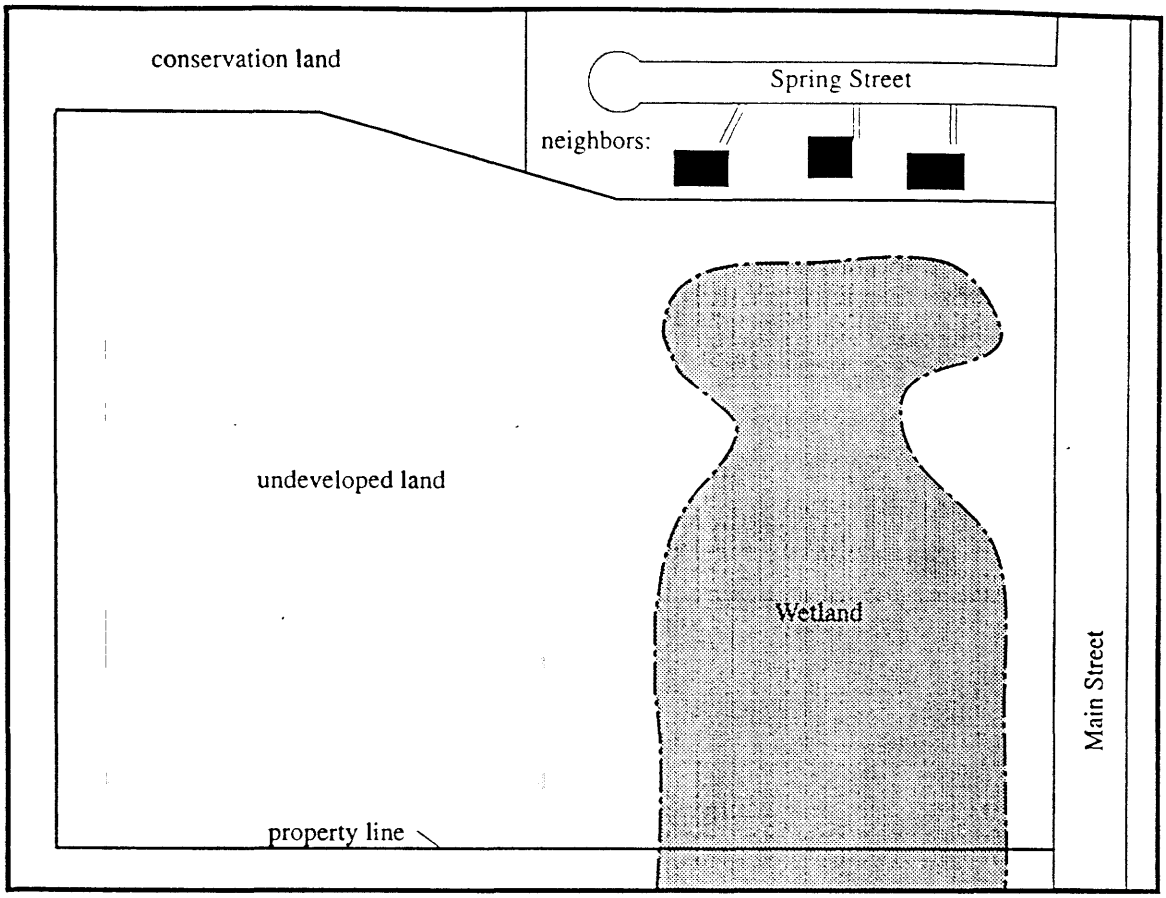
Your role: The local planning board is responsible for reviewing plans for development projects and granting their approval or denial.

Things to consider in your role:

- examine the width (40 ft) of the proposed access road crossing the wetland. Does it really have to be that wide? What justification does Mr. Smith's consultant give for the width of the road? Does it comply with your town code?
- examine the size of the lots (1 acre). Can you think of ways to reduce the amount of space on the site to build houses? (Hint: you may want to use your zoning bylaw to recommend the developer consider a *cluster development.*)

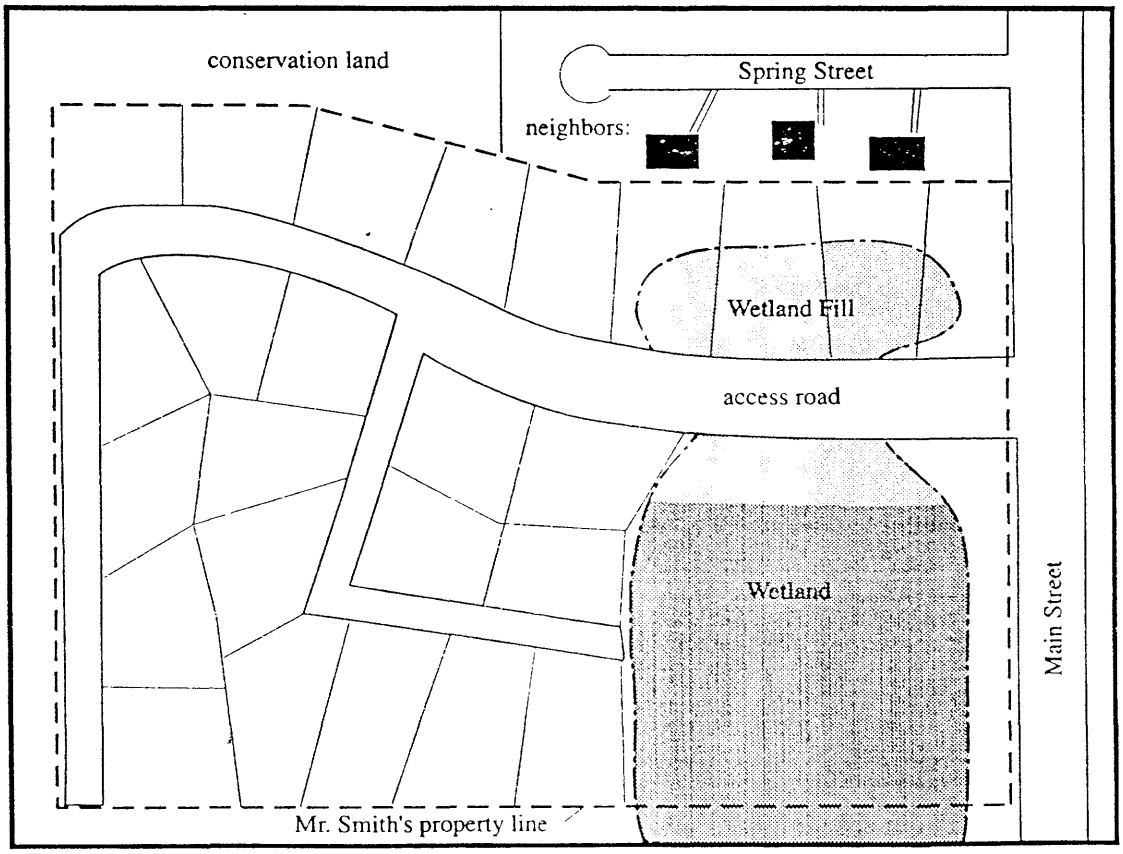
Pre-Site Plan

- 30 acres undeveloped land
- 10 acres wetlands



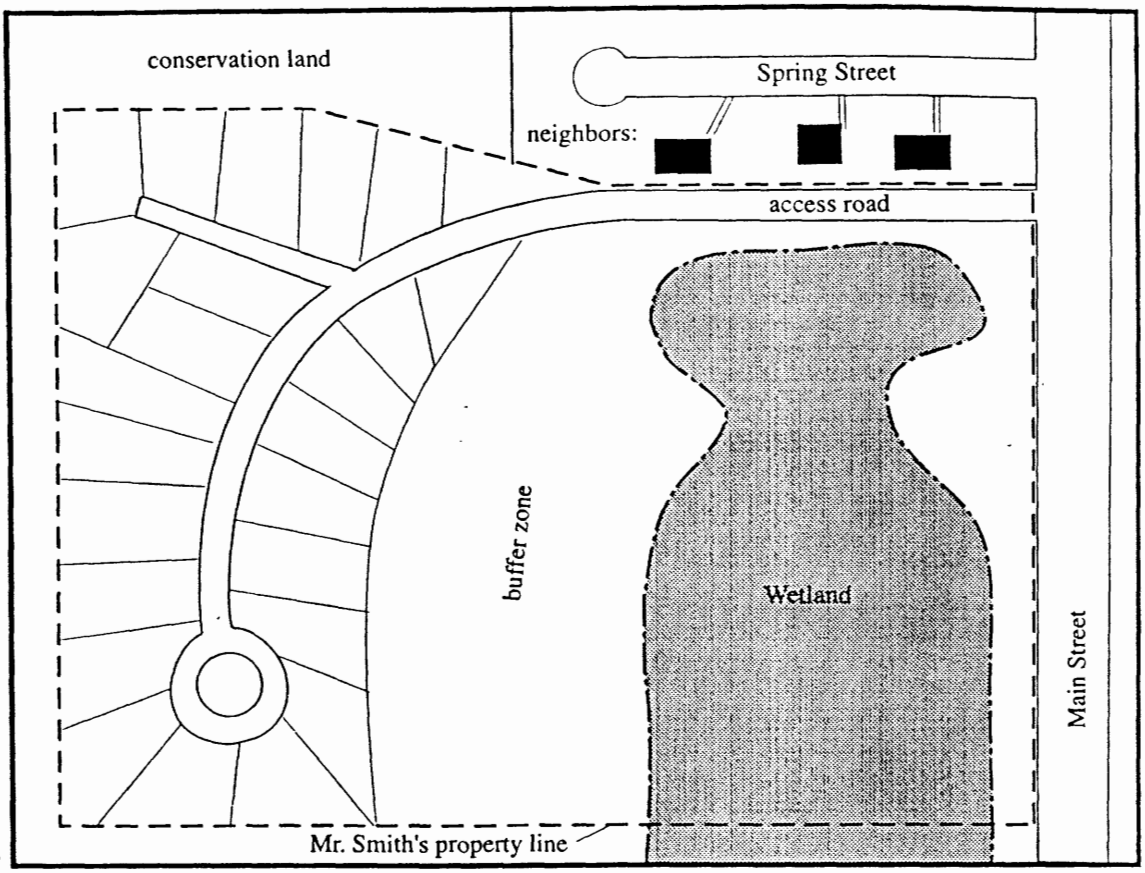
Original Site Plan

- 30 acre site
- (25) 1 acre lots
- 5 acres proposed wetland fill
- 40 ft. wide access road



Ideal Site Plan

- 30 acre site
- (25) 1/2 acre lots
- cluster development
- no wetland fill
- 25 ft. wide access road
- buffer zone



Activity 3: Develop a Wetland Protection Directory

Objective

To acquaint students with the different levels of government (local, county, state, and federal) and the officials within these agencies that make land use decisions affecting wetlands.

Background

There is probably a small world of organizations and individuals in your community who are involved in one way or another with wetlands. Very few middle school students are aware of this world outside the schoolyard. One of the primary goals of this package is to break down the walls between school and community and to promote dialogue between the two.

Materials

Phonebook, paper, pens

Procedure

1. Divide the class into groups, and assign each group one or a few of the local, state, or federal officials listed on the side of this page. Look to the *blue pages* section of the phone book for the addresses of the local, state, and federal agencies.
2. Have students write a letter to their assigned official, inquiring about their role in land use decision-making and/or wetlands protection.
3. As the students receive responses to their written requests, have the whole class create a chart or bulletin board about each of the officials and how they're responsible for protecting wetlands.
4. It is important to remind students that these officials are very busy and that they shouldn't expect a 100% or immediate response for every letter mailed.

Extensions

1. Have the students scan the local and state newspapers for articles on the environment, particularly wetlands issues. Are any of the people in your directory mentioned or interviewed in these articles?
2. Request that one or several of your local officials come to speak to the class about their role in making land use decisions that affect wetlands and have students prepare to interview them. For example, a Department of Public Works employee could explain what a catch basin looks like and how grease traps protect wetlands. See the *Interview with a Local Official* activity in this chapter for other sample questions to ask during an interview.

Wetlands Protection Directory

Local

- *Board of Selectmen*
- *Planning Board*
- *Conservation Commission*
- *Zoning Board of Appeals*
- *Board of Health or Health Officer*
- *Department of Public Works*
- *Building Inspector*
- *Local Environmental Groups & Land Trusts*
- *Hunting & Fishing Clubs*
- *Regional Planning Agency*
- *Watershed Associations*
- *Soil & Water Conservation Districts*

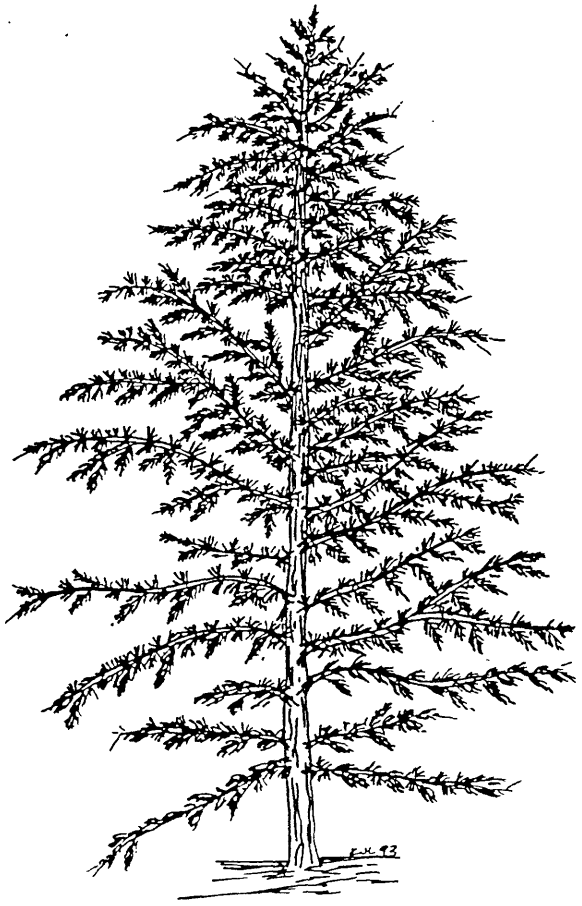
State

- *Agricultural Extension Officer*
- *Water companies*
- *Department of Environmental Protection*
- *Fish & Wildlife Department*
- *Recreation & Parks*

Federal

- *Environmental Protection Agency*
- *Army Corps of Engineers*
- *Fish & Wildlife Service*
- *Soil Conservation Service*
- *National Marine Fisheries Service*
- *Legislators*
- *State Representatives*
- *State Senators*
- *U.S. Representatives*
- *U.S. Senators*

3. Wetland Mentors – have students interview and/or write bibliographies about local wetland advocates or well-known environmental activitists.
4. Contact the Conservation Commission and/or Planning Board to find out if any design standards are currently being used in development projects to protect wetlands. Visit a site and photograph them.
5. Have the students decide what criteria they will use to rate the town's wetland protection capability based on the results of the interview.



Activity 4: Rate Your Community's Wetlands Protection Capability: An Interview with a Local Official

Objective Students will interview a conservation commission or planning board member to determine how well their community is protecting its wetlands and other natural resources.

Procedure

1. Request a visit by a municipal official – conservation commissioner, planning board member, etc. – to your class or incorporate this interview with a visit to town hall.
2. A few days prior to the interview, work with your class to brainstorm interview questions. Ask the students what they'd most like to learn from this interview, what they want to know about their community's wetlands, etc. If your class has already selected a particular wetland to adopt, they should inquire about any development issues that may be coming up that could affect this particular parcel. Refer to the sample questions listed below for more interview ideas.

Sample Interview Questions

1. What kind of wetlands do we have in this town/city? Are they small and isolated or large wetland systems?
2. Are these places fun to visit?
3. What kinds of wildlife live there?
4. What is the general condition of our wetlands? Are they healthy or polluted?
5. What are the local laws, if any, that protect wetlands? What activities are permitted; which are prohibited?
6. Are there exceptions to the laws? Can people "get around" the rules?
7. What could our city or town be doing better to protect wetlands?
8. What is the biggest problem(s) affecting our wetlands, in your opinion?
9. How did you become involved in local government? What is your background?
10. Do you think we should be protecting all of our wetlands or only some of them?
11. Is there anything we can do to protect our community's wetlands?

Use the following sample questions to design an interview that involves older students.

Does Your Community Have:

1. Floodplain zoning?
2. A local wetlands bylaw?
3. Cluster zoning provisions (where houses are sited close together and land is saved for open space)?
4. Zoning which prohibits industrial uses, landfills, and hazardous waste sites next to wetlands or other water bodies?
5. Health codes (Board of Health regulations) that regulate placement of underground storage tanks and/or hazardous materials?
6. Board of Health regulations that regulate the placement of septic tanks by providing a specified distance from:
   - wells and reservoirs?
   - rivers?
   - the water table?
7. Maps of rivers and surrounding lands and related wetlands?
8. A land acquisition program to purchase or protect wetlands or other water bodies?
9. Coordination with state agencies or private land trusts to purchase open spaces, particularly wetlands, and along other water bodies?
10. An approved open space plan which includes recommendations for wetland and water resource protection?
11. A program by the Board of Assessors to give tax breaks to those who have conserved land by placing permanent Conservation Restrictions on the land?
12. A reduced road salt program?
13. Addressed any particular concerns relevant to specific wetlands or other water bodies? If so, what have they done?
14. An official water conservation program explaining the importance of reducing water use to:
    - reduce the need for additional water sources?
    - reduce wastewater?
15. A program to actively encourage industry and business to conserve and recycle water?

Scoring

(count each **yes** as 5 points)

55 – 75	good
35 – 55	improving
25 – 35	fair
under 25	needs more protection

Adapted with permission from the Riverways *Adopt-A-Stream* program materials, Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement.

Introductory Wetlands Questionnaire

1. What is a wetland? _____

2. Have you ever explored a wetland? _____

   Would you like to? _____

3. Where would you go to find one in your neighborhood? _____

4. What would you expect to find there? _____

5. What is "good" about wetlands? _____

6. What is "bad" about wetlands? _____

7. Are wetlands important for any reason? _____

   For animals? _____

   For people? _____

Chapter VIII How to Adopt a Wetland

You may be wondering how you and your class can become a part of EPA's *Adopt-a-Wetland Program.* This program has two components:

1) To recognize the wetland protection efforts of schools across New England, EPA will send one *Adopt-a-Wetland Certificate* to every class that qualifies. This certificate recognizes the dedication and hard work put forth by students to improve their environment, and also acknowledges that their efforts are important and appreciated by environmental protection professionals.
2) EPA Region I is also interested in helping teachers share their classroom and field experiences with each other. Please summarize any ideas or experiences you would like to share with other teachers in your certificate application. These "wetland teaching tips" will be compiled for a forthcoming wetland educator newsletter to be distributed to those participating in the *Adopt-A-Wetland Program.*

How can your class qualify for an Adopt-A-Wetland Certificate?

While EPA wants to encourage all manner of wetland studies, the Agency is especially interested in creating an incentive for students to progress from study to action: to have students put what they have learned into practice. Thus, students need to demonstrate to EPA that they have conducted at least one stewardship-oriented activity that helps to protect or improve the quality of a local wetland. The size and location of the wetland does not matter, and the magnitude of the action itself is not critical. What *is* important is that students translate classroom learning into community action by protecting an environment in their backyard. Your class can qualify for an *Adopt-A-Wetland Certificate* by performing one or more of the following:

- conducting a wetlands education campaign in the school and/or community, e.g., producing a field guide;
- constructing "wetlands crossing" signs along roadways or bridges;
- certifying vernal pools;
- cleaning up a wetland;
- patrolling the wetland on a routine basis to look for evidence of dumping and other illegal activities; or
- any other activity that protects or improves the quality of a nearby wetland.

Because this program is administered through EPA's New England regional office, **certificates will only be available for classes in the six New England states** (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont). If you live outside this area, contact the EPA office in your region to determine if similar education programs are offered. Addresses and phone numbers for the EPA regional offices are listed in the *Appendix*.

What do you need to do next?

Fill out the certificate application and evaluation form. Describe what your class has done to protect a local wetland. If possible, include information that documents your efforts – a letter from your conservation commission, principal or mayor and newsclips, photos, or sections from your field guide. Send this information to:

EPA Region I
Wetland Protection Section
JFK Federal Building
Boston, MA 02203
ATTN: *Adopt-A-Wetland Program*

In order to make improvements to the guidebook in future editions, we would appreciate your feedback on the effectiveness of both the guide and videos. Completing and returning the evaluation form with your certicate application will automatically place you on the *Adopt-A-Wetland* mailing list.

How long will it take to receive a Certificate?

Review of your application and distribution of a certificate could take up to four weeks, depending on the number of applications received. If you have any questions please contact the EPA Region I Wetland Protection Section at (617) 565-4868.

Adopt-A-Wetland Certificate Application

Teacher's name _____

School address _____

_____

Phone number _____ *Grade level* _____

Location of your wetland (town & state) _____

_____

Approximate size of wetland (in acres) _____

Ownership information (e.g., private, state park, land trust) _____

_____

Summary of stewardship project(s). (Please feel free to include additional pages) _____

_____

_____

_____

_____

How did you first learn about the *Adopt-A-Wetland Program*? _____

_____

Do you have any ideas or successful wetland activities that you would like to share with other teachers? _____

_____

_____

Did you experience any obstacles to studying wetlands (in or outside the classroom) that you'd like to mention? _____

_____

_____

Please send this form to:

EPA Region I • Wetland Protection Section • JFK Federal Building
Boston, MA 02203 • Attn: Adopt-A-Wetland Program

Evaluation Form

For "A World in Our Backyard" Curriculum Guidebook & Videos

Name _____ *Grade(s)* _____

School _____

Background Information:

Do you find the writing style of the guide to be clear and easy to read? Are any portions of the text too technical?

_____

_____

_____

Are there any topics that need to be covered in greater detail? Is there any extraneous information?

_____

_____

_____

Do you find the design and format of the guide easy to follow?

_____

_____

_____

How informative and useful were the videos in helping you teach about wetlands?

_____

_____

_____

How well do the activities in this guide tie into your existing curriculum?

_____

_____

_____

How did you use this guidebook – for a full wetlands unit, for resource information only, to conduct a field trip, for indoor activities, to adopt a wetland, etc.?

Activities:

Did the activities convey the background information to students adequately?

Are there any activities that worked particularly well? Others that did not?

Did you encounter specific problems with any of the activities (e.g., set up, obtaining materials, unclear procedures, getting maps, etc.)?

Were the activities suitable for your grade level? If not, how should they be modified?

How could the activities be improved?

Will you likely use the activities again? _____

_____

_____

The guide is currently written to have the background information separate from the activities. Would it be more helpful to have the background information included within the activity procedures?

_____

_____

Would it be helpful to index the activities by subject (e.g., geology, history, social studies)?

_____

_____

_____

Are there any other people who may want a copy of this package that we should place on our *Adopt-A-Wetland* mailing list? _____

_____

_____

Please send this form to:

EPA Region I • Wetland Protection Section • JFK Federal Building
Boston, MA 02203 • Attn: Adopt-A-Wetland Program

Appendix

Wetland Education Directory

Environmental Protection Agency Regional Offices

EPA Headquarters Wetland Protection Hotline:
1 (800) 832-7828

U.S. EPA Region II: NJ, NY, PR, VI
Wetlands Section
26 Federal Plaza, Room 837
New York, NY 10278
(212) 264-5170

U.S. EPA Region III: DE, MD, PA, VA, WV
Wetland Protection Section
841 Chestnut St.
Philadelphia, PA 19107
(215) 597-9301

U.S. EPA Region IV: AL, FL, GA, KY, MS, NC, SC, TN
Wetlands Regulatory Section
345 Courtland St., N.E.
Atlanta, GA 30365
(404) 347-4015

U.S. EPA Region V: IL, IN, MI, MN, OH, WI
Wetlands and Watersheds Section
77 West Jackson Blvd.
Chicago, IL 60604
(312) 886-0243

U.S. EPA Region VI: AR, LA, NM, OK, TX
Wetland Protection Section
1445 Ross Ave., Suite 900
Dallas, TX 75202
(214) 655-2263

U.S. EPA Region VII: IA, KS, MO, NE
Wetland Protection Section
726 Minnesota Ave.
Kansas City, KS 66101
(913) 551-7573

U.S. EPA Region VIII: CO, MT, ND, SD, UT, WY
Wetland Protection Section
999 18th St.
500 Denver Place
Denver, CO 80202-2405
(303) 293-1570

U.S. EPA Region IX: AZ, CA, HI NV, Pacific Islands
Wetlands and Coastal Planning Section
75 Hawthorne St.
San Francisco, CA 94105
(415) 744-1971

U.S. EPA Region X: AK, ID, OR, WA
Wetlands Section
1200 Sixth Ave.
Seattle, WA 98101
(206) 553-1412

U.S. Fish and Wildlife Service Regional Environmental Education Contacts

Region 1
Dick Kuehner
U.S. Fish and Wildlife Service
Eastside Federal Complex
911 N.E. 11th Avenue
Portland, OR 97232-4181
(503) 231-6176

Region 2
Frank Bryce
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, NM 87103
(505) 766-8044

Region 3
Susanne Trapp/Tom Worthington
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, MN 55111
(612) 725-3924

Region 4
Donna Stanek
U.S. Fish and Wildlife Service
Richard B. Russell Federal Building
75 Spring Street, SW
Atlanta, GA 30303

Region 5
Sarah Bevilacqua
U.S. Fish and Wildlife Service
300 Westgate Center Drive
Hadley, MA 01035-9589
(413) 253-8515

Region 6
Sheri Fetherman
U.S. Fish and Wildlife Service, Region 6
Box 25486, Denver Federal Center
Denver, CO 80225
(303) 236-8150

Region 7
Beverly Farfan
U.S. Fish and Wildlife Service
1011 East Tudor Road
Anchorage, AK 99503-6199

State Fish & Game Agencies

Contact your state's fish and game department for information about wetlands specific to your state:

Alabama, Div. of Game and Fish, 64 N. Union St., Montgomery 36130 (205/ 261-3465)

Alaska, Dept. of Fish and Game, P.O. Box 3-2000, Juneau 99802 (907/465-4100)

Arizona, Game and Fish Dept., 2222 W. Greenway Rd., Phoenix 85023 (602/942-3000)

Arkansas, Game and Fish Commission, #2 Natural Resources Dr., Little Rock 72205 (501/223-6300)

California, Dept. of Fish and Game, 1416 9th St., Sacramento 95814 (916/445-3531)

Colorado, Div. of Wildlife, 6060 Broadway, Denver 80216 (303/297-1192)

Connecticut, Dept. of Environmental Protection, Wetlands Management Section, Inland Water Resources Division, 79 Elm St., Hartford 06106-5127 (203/566-5599)

Delaware, Div. of Fish and Wildlife, P.O. Box 1401, Dover 19903 (302/736-5295)

District of Columbia, Dept. of Conservation and Regulatory Affairs, Environmental Control Division/ Fisheries, 5010 Overlook Ave., SW, Washington, DC 20032 (202/767-7370)

Florida, Game and Freshwater Fish Commission, Farris Bryant Bldg., 620 S. Meridian, Tallahassee 32399-1600 (904/488-1960)

Georgia, State Game and Fish Div., Floyd Towers East, Suite 1366, 205 Butler St., SE, Atlanta 30334 (404/656-3530)

Guam, Dept. of Agriculture, Agana 96910 (671/734-3941)

Hawaii, Div. Aquatic Resources, 1151 Punchbowl St., Honolulu 96813 (808/548-4000)

Idaho, Fish and Game Dept., 600 S. Walnut, Box 25, Boise 83707 (208/334-5159)

Illinois, Dept. of Conservation, Lincoln Tower Plaza, 524 S. Second St., Springfield 62701-1787 (217/782-6302)

Indiana, Div. of Fish and Wildlife, 607 State Office Bldg., Indianapolis 46204 (317/232-4080)

Iowa, Dept. of Natural Resources, Wallace State Office Bldg., East Ninth and Grand Ave., Des Moines 50319 (515/281-8666)

Kansas, Dept. of Wildlife and Parks, Box 54A, R.R. 2, Pratt 67124 (316/672-5911)

Kentucky, Dept. of Fish and Wildlife Resources, #1 Game Farm Rd., Frankfort 40601 (502/564-3400)

Louisiana, Dept. of Wildlife and Fisheries, P.O. Box 98000, Baton Rouge 70809 (504/765-2800)

Maine, Dept. of Inland Fisheries and Wildlife, 284 State St., Station #41, Augusta 04333 (207/289-2766).

Dept of Environmental Protection, Wetlands Unit, Bureau of Land Quality Control, State House Station #17, Augusta, ME 04333 (207/287-2111)

Maryland, Dept. of Natural Resources, Tawes State Office Bldg., Annapolis 21401 (301/974-3041)

Massachusetts, Dept. of Fisheries, Wildlife and Environmental Law Enforcement, Div. of Fisheries and Wildlife, 100 Cambridge St., Boston 02202 (617/727-3151).

Dept. of Environmental Protection, Div. of Wetlands and Waterways, 1 Winter St., 8th Floor, Boston, MA 02108 (617/292-5695)

Michigan, Dept. of Natural Resources, Stevens T. Mason Bldg., Box 30028, Lansing 48909 (517/373-2329)

Minnesota, Dept. of Natural Resources, 500 Lafayette Rd., St. Paul 55155-4020 (612/296-6157)

Mississippi, Dept. of Wildlife, Fisheries, and Parks, P.O. Box 451, Jackson 39205 (601/961-5315)

Missouri, Dept. of Conservation, 2901 N. Ten Mile Dr., P.O. Box 180, Jefferson City 65102 (314/751-4115)

Montana, Dept. of Fish, Wildlife, and Parks, 1420 E. Sixth Ave., Helena 59620 (406/444-3186)

Nebraska, Game and Parks Commission, P.O. Box 30370, 2200 N. 33rd, Lincoln 68503 (402/464-0641)

Nevada, Dept. of Wildlife, Box 10678, Reno 89520 (702/789-0500)

New Hampshire, Fish and Game Dept., 2 Hazen Dr., Concord 03301 (603/271-3421).

Wetlands Bureau, New Hampshire Wetlands Board, 64 N. Main St., P.O. Box 2008, Concord 03301-2008 (603/271-2147)

New Jersey, Div. of Fish, Game, and Wildlife, CN 400, Trenton 08625 (609/292-9410)

New Mexico, Natural Resources Dept., Villagra Bldg., Santa Fe 97503 (505/827-7899)

New York, Div. of Fish and Wildlife, 50 Wolf Rd., Albany 12233 (518/457-5691)

North Carolina, Wildlife Resources Commission, Archdale Bldg., 512 N. Salisbury St., Raleigh 27611 (919/733-3391)

North Dakota, State Game and Fish Dept., 100 North Bismark Expressway, Bismarck 58501 (701/221-6300)

Ohio, Div. of Wildlife, Fountain Square, Columbus 43224 (614/265-6300)

Oklahoma, Dept. of Wildlife Conservation, 1801 N. Lincoln, P.O. Box 53465, Oklahoma City 73152 (405/521-3851)

Oregon, Dept. of Fish and Wildlife, Box 59, Portland 97207 (503) 229-5551)

Pennsylvania, Fish Commission, P.O. Box 1673, Harrisburg 17105 (717/657-4518)

Pennsylvania, Game Commission, 2001 Elmerton Ave., Harrisburg 17110-9797 (717/787-4250)

Puerto Rico, Dept. of Natural Resources, P.O. Box 5887, Puerta De Tierra, San Juan 00906 (809/722-8774)

Rhode Island, Dept. of Environmental Management, County Government Center, Wakefield 02879 (401/789-3094).

Div. of Groundwater and Freshwater Wetlands, Freshwater Wetlands Program, 291 Promenade, Providence 02908 (401/277-6820)

South Carolina, Wildlife and Marine Resources Dept., Rembert C. Dennis Bldg., Box 167, Columbia 29202 (803/734-3888)

South Dakota, Dept. of Game, Fish and Parks, Sigurd Anderson Bldg., 445 E. Capitol, Pierre 57501-3185 (605/773-3718)

Tennessee, Wildlife Resources Agency, Box 40747, Ellington Agricultural Center, Nashville 37204 (615/781-6552)

Texas, Parks and Wildlife Dept., 4200 Smith School Rd., Austin 78744 (512/389-4800)

Utah, State Div. of Wildlife Resources, 1596 NW Temple, Salt Lake City 84116 (801/533-9333)

Vermont, Fish and Game Dept., 103 S. Main Street, 10 South, Waterbury 05676 (802/244-7331).

Agency of Natural Resources, Wetlands Bureau, Building 10 North, 103 South Main St., Waterbury 05676 (802/241-3770)

Virginia, Dept. of Game and Inland Fisheries, 4010 W. Broad St., Box 11104, Richmond 23230 (804/257-1000)

Washington, Dept. of Fisheries, 115 General Administration (206/753-6623), Dept. of Wildlife, 600 N. Capitol Way, Olympia 98504 (206/753-5700)

West Virginia, Div. of Wildlife Resources, 1900 Kanawha Blvd., E. Charleston 25305 (304/348-2771)

Wisconsin, Dept. of Natural Resources, Box 7921, Madison 53707 (608/266-2621)

Wyoming, Game and Fish Dept., 5400 Bishop Blvd., Cheyenne 82002 (307/777-7631)

New England Project WILD Coordinators

Connecticut

Diane Chisnall-Joy
Environmental Curriculum Coordinator
Dept. of Environmental Protection
79 Elm Street, P.O. Box 5066
Hartford, CT 06102-5066
(203) 566-8108

Maine

Lisa Kane
Project WILD Coordinator
Dept. of Inland Fisheries
284 State Street
Augusta, ME 04333
(207) 289-3303

Massachusetts

Marion Larson
Project WILD Co-Coordinator
Division. of Fisheries & Wildlife
Field Headquarters
Westboro, MA 01581
(508) 792-7270

New Hampshire

Judy Silverberg
Project WILD Coordinator
Fish and Game Department
2 Hazen Drive
Concord, NH 03301
(603) 271-3212

Rhode Island

Chris Dudley
Project WILD Coordinator
Division of Fish & Wildlife
P.O. Box 218
West Kingston, RI 02892
(401) 789-0281

Vermont

Mark Scott
Project WILD Coordinator
Dept. of Fish & Wildlife
103 S. Main Street
Waterbury, VT 05676
(802) 241-3700

Wetlands to Visit in New England

Connecticut

- Hayes Meadow Tidal Marsh, Fairfield Beach Road, Fairfield
- Milford Point, Milford
- Steward B. McKinney National Wildlife Refuge, P.O. Box 1030, Westbrook, CT 06498 (203) 399-2513.

Maine

- Back Cove, Portland
- Biddeford Pool, Biddeford
- Borestone Mountain, P.O. Box 112, Monson 04464 (207) 997-3607
- The Great Heath, Columbia
- Hirundo Wildlife Refuge, RFD1, Box 449, Old Town 04468 (207) 394-4681
- Josephine Newman Wildlife Sanctuary, Georgetown
- Meadow Mountain Preserve, Warren
- Moosehorn National Wildlife Refuge, P.O. Box 1077, Calais 04619 (207) 454-3521.
- Morse Mountain Preserve, Phippsburg
- Prouts Neck Bird Sanctuary, Scarborough
- Rachel Carson National Wildlife Refuge, Route 2, Box 751, Wells 04090 (207) 646-9226.
- Rachel Carson Salt Pond Preserve, Bristol
- Saco Heath, Saco
- Scarborough Marsh Nature Center, Scarborough
- Steve Powell Refuge and Wildlife Management Area, Perkins Township
- Sunkhaze Meadows National Wildlife Refuge, 1033 South Main St., Old Town 04468 (207) 827-6138.
- Webhannet River Marsh, Wells
- Wells Estuarine Research Reserve, Wells
- White Mountain National Forest, Evans Notch Ranger District, RR2, Box 2270, Bethel (207) 824-2134

Also refer to ***The Maine Atlas and Gazetteer****, Delorme Mapping Co., P.O. Box 298, Freeport, ME 04032. This brochure provides a complete list of nature preserve with foot trails, including a short description of what you'll find at each site and how to get there.*

Massachusetts

- Arcadia Wildlife Sanctuary, 127 Combs Rd., Easthampton 01027 (413) 584-3009
- Ashumet Holly Wildlife Sanctuary, 286 Ashumet Rd., E. Falmouth 02536 (508) 563-6390
- Black Pond Nature Preserve, Norwell. *A property of the Nature Conservancy with parking, marked trails and discovery guide.* (617) 423-2545.
- Broadmoor Wildlife Sanctuary, 280 Elliot St., South Natick 01760 (508) 655-2296
- Felix Neck Wildlife Sanctuary, P.O. Box 494, Vineyard Haven 02568 (508) 627-4850
- Great Meadows National Wildlife Refuge, Weir Hill Road, Sudbury 01776 (508) 443-4661
- Ipswich River Wildlife Sanctuary, 87 Perkins Row, Topsfield 01983 (508) 887-9264
- Monomoy National Wildlife Refuge, Wikis Way, Morris Island, Chatham 02633 (508) 945-0594.
- Moose Hill Wildlife Sanctuary, 293 Moose Hill St., Sharon 02067 (617) 784-5691
- Parker River National Wildlife Refuge, Northern Blvd., Newburyport 01950 (508) 465-5753
- Ponkapoag Pond and Great Cedar Swamp, Blue Hills Reservation, Canton (617) 828-7490.
- Silver Hill Bog, Silver Hill Road, Lincoln. (617) 259-8850. *28 acres of bog and wetland with limited parking, board walks and paths.*
- South Shore Wildlife Sanctuaries, 2000 Main St., Marshfield 02050 (617) 837-9400
- Wachusett Meadow Wildlife Sanctuary, 113 Goodnow Rd., Princeton 01541 (508) 464-2712
- Wellfleet Bay Wildlife Sanctuary, Route 6, S. Wellfleet 02663 (508) 349-2615

New Hampshire

- Great Bay National Wildlife Refuge, 601 Spaulding Turnpike, Suite 17, Portsmouth, NH 03801 (603) 431-7511.
- Lake Umbagog National Wildlife Refuge, Box 279, Erroll, NH 03579 (603) 482-3415.
- Pondicherry, Whitefield/Jefferson (at Whitefield Airport, off Rt. 3)
- Hampton Saltmarshes, Depot Road (from jct. Rts. 1 & 88), Hampton Falls Village, Hampton
- Paradise Point, North Shore Road, Hebron (603) 774-3516
- Abe Emerson Marsh, Patten Hill Road (off Main St.), Candia
- Smith Pond Bog, Rt. 202 (opposite Gage Hill Road), Hopkinton
- Hebron Marsh, N. Shore Road (off Rt. 3A), Hebron
- Ponemah Bog, Rhodora Drive (off Stearns Road, from Rt. 122), Amherst
- Meetinghouse Pond, Meetinghouse Pond Road (off Rt. 124), Marlborough
- Hoyt, Horseleg Hill Road (off Rt. 153), East Madison

Rhode Island

- Colt Sate Park, Bristol
- Ninigret National Wildlife Refuge, Shoreline Plaza, Rt 1A, P.O. Box 307, Charlestown, RI 02813 (401) 364-9124.
- Audubon Society of Rhode Island Sanctuaries (401) 231-6444.
- Fisherville Brook Wildlife Refuge, Pardon Joslin Road, Exeter
- Parker Woodland, 1670 Maple Valley Road, Greene, RI
- Ruecker Wildlife Refuge, Seapowet Ave., Tiverton
- Touissett Marsh Wildlife Refuge, Touissett Road, Warren

Vermont

- Missisquoi National Wildlife Refuge, P.O. Box 163, Swanton, VT 05488 (802) 868-4781. *The wetland trail begins behind the refuge headquarters.*
- LaPlatte River Marsh, Shelburne. *The Vermont Nature Conservancy maintains an easy walking trail along the edge of the wetland.*
- Ethan Allen Homestead Wetlands Trail, Burlington. *The Winooski Valley Park District recently completed a boardwalk through a wetland adjacent to the Winooski River. Also nice trail system in floodplain forest.*
- Montshire Museum, Norwich. *The museum maintains a trail system behind museum that includes a wetland area.*
- Centennial Woods, Burlington. *The University of Vermont maintains a trail system through the Centennial Woods Natural Area, includes trials along beaver wetland and stream.*
- Shelburne Pond, Shelburne. *The University of Vermont also owns this natural area. There are trails beginning at the fishing access area. Also wonderful for canoe or small motor boat access to the bog, marshes and shrub swamp.*
- Hapgood Pond, Peru. *The U.S. Forest Service maintains trails around the pond through several wetland areas. Additional trails will be constructed through wetlands in near future.*
- Colchester Bog, Colchester. *A trail runs along the abandoned railroad bed through the center of the bog. The Town of Colchester has plans to upgrade it in 1994 for pedestrian and mountain bike use as a recreational path.*

Wetland Education Resources

Field Guides

Maine Wetlands and Their Boundaries, by Ralph Tiner. This 72-page document is available for $5 by writing the Maine Department of Economic & Community Development, Office of Community Development, 219 Capitol St., State House Station 130, Augusta, ME 04333 (207) 624-6800.

The Field Guide to Wildlife Habitats of the Eastern United States, Janine M. Benyus. Simon & Schuster, Inc., New York, NY. 1989.

Walking the Wetlands, Janet Lyons and Sandra Jordan. John Wiley & Sons. 1989.

Pond and Stream Safari – A Guide to the Ecology of Aquatic Invertebrates, Karen Edelstein, Cornell University Cooperative Extension, 1993. Available for $12.75 through the Media Services Resource Center, Cornell University, 7 Cornell Business and Technology park, Ithaca, NY 14850.

OBIS Pond Guide, Dave Buller, 1980. A guide for identifying plants and animals found in and around the pond and other freshwater sites. Available for $3.95 through the Outdoor Biology Instructional Strategies, Delta Education, P.O. Box 915, Hudson, NH (800) 258-1302.

Water Quality Indicators Guide: Surface Waters, USDA Soil Conservation Service (stock #001-000-04560-1). An easy to use guide that describes how to identify and solve water quality problems caused by sediment, animal wastes, nutrients, pesticides and salts. No chemical testing equipment required. Available for $8 through the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

Pond Life: A Guide to Common Plants and Animals of North American Ponds and Lakes, George K. Reid, Ph.D. Golden Press, New York, NY. 1987.

Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast, Dennis Magee. University of Massachusetts Press. Amherst, MA. 1981.

A Field Guide to Coastal Wetland Plants of the Northeastern United States, Ralph Tiner. University of Massachusetts Press. Amherst, MA. 1987.

Winter Botany, William Trelease. Dover Publications. New York, NY.

A Field Guide to the Mammals, William Henry Burt. Houghton Mifflin, Boston, MA. 1976.

A Field Guide to the Insects of America North of Mexico, Donald Borror. Houghton Mifflin, Boston, MA.

Amphibians and Reptiles of New England, Richard DeGraaf and Deborah Rudis. University of Massachusetts Press, Amherst, MA. 1983.

Other Useful References

National Geographic Magazine, October 1992, *Our Disappearing Wetlands.* Back issues ($2.65/copy) may be ordered by calling 1-800-447-0647 or writing National Geographic Society, Single Copy Magazine Dept., 1145 17th St., NW, Washington, DC 20036.

The Basic Essentials of Map & Compass, Cliff Jacobson. ICS Books, Inc. Merrillville, IN. 1988.

Voices of the Night, Peter Kellogg and Arthur Allen. Houghton Mifflin, Boston, MA. Tape recording of the vocalizations of frogs of eastern North America.

Endangered Species, Endangered Wetlands: Life on the Edge. J. Scott Feierabend. National Wildlife Federation. September, 1992.

Investigating Nature Through Outdoor Projects. Brown, V. Harrisburg, PA: Stackpole Books, 1983.

Listening to Nature. J. Cornell. Nevada City, CA: Dawn Publications, 1987.

The Sense of Wonder. Carson, R. New York: Harper & Row, 1965.

A Citizen's Guide To Protecting Wetlands. National Wildlife Federation. March, 1989.

Wetlands Curricula

Aquatic WILD
Project WILD
5430 Grosvenor Lane
Bethesda, MD 20814
(301) 493-5447

Discover Wetlands: A Curriculum Guide
Washington State Department of Ecology
Wetlands Section
Mail Stop PV-11
Olympia, WA 98504

Field Manual for Water Quality Monitoring: An Environmental Education Program for Schools
7th edition
William B. Stapp
2050 Delaware Ave.
Ann Arbor, MI 48103

Naturescope: Wading Into Wetlands
National Wildlife Federation
1400 16th St., NW
Washington, DC 20036-2266

Pawcatuck Watershed Education Program
Curriculum Guide
Southern Rhode Island Conservation District
Depot Building
5 Mechanic Street
Hope Valley, RI 02832
(401) 539-7767

Vernal Pool Lessons & Activities
Massachusetts Audubon Society
Educational Resources Office
South Great Road
Lincoln, MA 01773
(617) 259-9500

Welcome to the Wetlands: An Activity Book for Teachers
Society for Environmental Education
New Orleans, LA 70187-0610

WOW! The Wonders of Wetlands
Environmental Concern, Inc.
Education Department
P. O. Box P
St. Michaels, MD 21663
(410) 745-9620

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Feierabend, J.S. 1992. Endangered Species, Endangered Wetlands: Life on the Edge. National Wildlife Federation, Washington, D.C. 49 pp.

Frayer, W.E., T.J. Monahan, D.C. Bowden, and F.A. Grabill. 1983. Status and Trends of Wetlands and Deepwater Habitats in the Conterminous U.S., 1950's to 1970's. Department of Forests and Wood Sciences, Colorado State University, Fort Collins. 32 pp.

Frome, M.L. and E. Shenkman (editors). 1990. Wetlands Protection: A Handbook for Local Officials. Pennsylvania Department of Environmental Resources, Harrisburg, PA. 99 pp.

Goldman-Carter, J. 1989. A Citizen's Guide to Protecting Wetlands. National Wildlife Federation, Washington, D.C. 64 pp.

Gosselink, J.G., C.C. Cordes, and J.W. Parsons. 1979. An Ecological Characterization Study of the Chenier Plain Coastal Ecosystem of Louisiana and Texas. FWS/OBS-78/9-78/11 (3 volumes). Office of Biological Services, U.S. Fish and Wildlife Service, Slidell, LA.

Gray, R., R. Tuttle, R.D. Wenberg, et. al. 1992. Engineering Field Handbook: Wetland Restoration, Enhancement, or Creation. U.S. Department of Agriculture, Soil Conservation Service, Washington, D.C. 79 pp.

Jacobson, C. 1988. The Basic Essentials of Map and Compass. ICS Books, Inc., Merrillville, IN. 67 pp.

Kjellstrom, B. 1976. Be Expert With Map and Compass. Charles Scribner's Sons, New York, NY.

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MacDonald, P.O., W.E. Frayer, and J.K. Clauser. 1979. Documentation, Chronology, and Future Projections of Bottomland Hardwood Habitat Loss in the Lower Mississippi Alluvial Plain. Volume I, Basic Report. U.S. Fish and Wildlife Service, Ecological Services, Vicksburg, MI. 133 pp.

Magee, D.W. 1981. Freshwater Wetlands: A Guide to Common Indicator Plants of the Northeast. University of Massachusetts Press, Amherst, MA. 245 pp.

Massachusetts Audubon Society. 1985. Groundwater Information Flyer #4: Local Authority for Groundwater Protection. Mass. Audubon Society, Lincoln, MA. 18 pp.

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An Activity Guide to Wetland Education. Vermont Agency of Natural Resources, Waterbury, VT. 7th Printing. January, 1990.

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Bog in a Box Project: A Teacher's Guide. Massachusetts Horticultural Society, Cambridge, MA. 1993.

Discover Wetlands: A Curriculum Guide. Brian Lynn, Washington State Department of Ecology. July, 1988.

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Marshes, Estuaries, and Wetlands: Ocean-Related Curriculum Activities. Andrea Marrett, Sea Grant Marine Education Project, Pacific Science Center, Seattle, WA. 1982.

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WETNET: An Environmental Curriculum Dealing with Wetlands. Adirondack Teacher Center, Ray Brook, NY. 1992.

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