Unit II:

Wetland Ecology

Unit II Wetlands
Introduction

A wetland is any area of land that is saturated with water for at least part of the growing season. An area is identified as a wetland by the type of soils and plants found there, and the presence of water. Wetlands are classified by a number of factors, including the types of plants found in them. For example, a palustrine scrub-shrub wetland, commonly called a shrub swamp, has shrubs as the predominant vegetation. A wetland may be any shape or size, coastal or inland, tidal or non-tidal, and may contain fresh, salty, or brackish water. It may be continuously wet, regularly flooded, infrequently wet, or even fairly dry throughout most of the year. Typically found in depressions on the landscape, wetlands can also be located high up on the sides of mountains. The most common types of wetlands are swamps and marshes. Ponds, lakes, creeks, streams, rivers, and estuaries are considered open water wetlands. Vernal pools are examples of wetlands that are fairly dry most of the year. Vernal pools are formed by spring rain or snowmelt and disappear with the onset of drier weather. Although they are wet for only a short period of time, they play a vital role in the life cycle of a number of plant and animal species, such as the spotted salamander and wood frog.

Every watershed contains wetlands. Wetlands result from different topographical, geological, and ecological features within watersheds and provide vital habitat for fish, birds, and other wildlife. One-third of U.S. threatened and endangered species are found in wetland areas. Wetlands are also important resources for people. They play an important role in shoreline stabilization, flood control, pollution abatement, food production, wildlife habitat, and surface and groundwater recharge. A special benefit is that they are beautiful natural areas for us to enjoy.

The Narrow River Watershed contains over 1,000 acres of wetlands, which amounts to twenty percent of the Watershed's undeveloped lands. Salt marshes, which account for 30% of the Watershed's wetlands, are crucial coastal ecosystems. They are periodically flooded by salt or brackish waters due to tidal cycles. This generates constant exchange and renewal of nutrients between the salt marsh and adjacent estuarine waters, making salt marshes the most productive of all vegetated wetlands. A salt marsh is a stressful environment for its inhabitants. Tides create constant fluctuations in salinity, water inundation, and temperature extremes. Plants and animals found in these marshes have special adaptations that allow them to live under these unique conditions. Salt marshes are dominated by salt-tolerant plants, called halophytes, forming a coastal "sea of grass" that filters and circulates nutrients. The Narrow River Watershed is also home to tidal brackish marshes, which are less saline than salt marshes. These marshes are the transitional areas between salt marshes and tidal freshwater marshes, providing habitat for a greater diversity of plant and animal species that are unable to tolerate the extreme conditions of a salt marsh. Most of the salt marshes in the Narrow River Watershed are located in the southern embayment, Pettaquamscutt Cove. The Cove is almost completely surrounded by broad expanses of salt marsh with several marsh islands present in the shallow waters. Smaller salt marsh patches and fringing marshes extend up the river on both sides as far north as Lacey ("Bridgetown") Bridge.

The majority of the wetlands in the Narrow River Watershed are inland, or freshwater, wetlands. Almost half of these freshwater systems are contiguous to the salt marshes bordering Pettaquamscutt Cove. The remaining freshwater wetlands are found along Mattatuxet River, Gilbert Stuart Stream, and in an extensive network of small streams and wetlands that reach every corner of the Watershed. According to the Rhode Island Freshwater Wetlands Act of 1971, ponds, streams, marshes, swamps, bogs, floodways, and areas subject to storm flow are considered wetlands. This also includes 100- to 200-foot-wide riverbank (riparian) wetlands, floodplains, and the land within 50 feet from the edges of ponds, swamps, bogs and marshes. In addition to providing significant resources for people and wildlife, these wetlands are valuable because the freshwater discharged to the River system enhances mixing, which is the basis for high productivity levels in the estuary.

References

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INTRODUCTORY DISCUSSION:

What is a wetland?

A wetland is an area of land that is saturated with water, at least part of the year during the growing season. This saturation directs what types of plants will grow there. The three factors that determine if a an area is a wetland are ***hydrology, soils***, and ***vegetation type.***

The ***Hydrology*** of an area is the most important factor. To establish the hydrology, or water regime, it needs to be determined how much, how often, and for how long is it inundated. When water is covering soil, it does not allow in any oxygen. Soil becomes anoxic or lacking oxygen. This directly influences what type of plants can grow there and how the soil will act. Open water areas, marshes, and fens usually have water permanently above the surface of the soil. Areas such as swamps and wet meadows may only have water above the soil surface during part of the growing season. Vernal, or seasonal, pools are only saturated in the winter and spring. The hydrology of an area can be difficult to determine at dry times of the year. Signs such as water marks on trees and rocks or saturated, decaying leaves are indications that the area is flooded at least part of the time.

Vegetation growth is determined by the amount of oxygen and moisture in the soil. Most plants cannot live in wetland soils because they cannot get enough oxygen to their roots. Only plants that are specially adapted manage. Plants such as fragrant water lilies, cattails, and pickerelweed survive with their roots completely submerged. They get oxygen to their roots through other means, such as ventricles in their stems or leaves. Some plants just don’t need much oxygen. These are commonly emergent plants, and are found in shallow water and marshes.

Other plants can tolerate their roots being wet for part of the year, but not the during the whole growing season. Shrubs such as high-bush blueberry, winterberry, and button bush are found along the edges of wetlands and the understories of swamps. Certain trees can also tolerate some wet conditions, but need to have their roots dry at least part of the time. Some have developed special structures, such as the knees on a mangrove tree. Trees that are commonly found in swamps in this region are the red maple and the Atlantic white cedar.

Wetland Soils are determined by color, texture, composition, and even smell. Wetland soils tend to be organic. Because of the lack of oxygen, little decomposition takes place. If soils are always flooded, a layer of poorly decomposed organic matter will continuously build up. This is referred to as peat. If soils are only periodically inundated, some decomposition will take place and soils will be finer, slimier. It will have a very dark color. Anaerobic bacteria activity produce sulfur as a byproduct. This is the rotten-egg smell often associated with a wetland.

Wetland soils that are normally inundated for long periods are usually gray or black. Soils that are only periodically inundated may have some red streaking or mottling. The red is from the oxidation or rusting of the iron in the soil. Iron only rusts in the presence of oxygen. Soils that are not inundated will have layers of rust colored particles.

Are there different types of Wetlands?

All wetlands are a type of ecosystem. Wetlands are characterized by the plants growing in them:
Open water occurs when the water depth is greater than 6 feet (2 meters) throughout the year. Most plants are unable to grow in water this deep, so it stays "open". Ponds, lakes, rivers, fast moving streams, and, of course, oceans are open water wetlands.
Emergent vegetation can grow in water that is less than 6 feet deep, but may still be continuously inundated. Marshes and fens have plant communities that are a mixture of persistent, such as cattails, and herbaceous, such as pickerelweed.
Woody vegetation tends to grow in areas that have less than 6 inches of water and may dry out for at least part of the year. Swamps, such as red maple swamps, are the most common inland wetlands.
Other characteristics used to classify wetlands are substrates, such as rocky shore or cobbled streambed; water regime, primarily tidal or non-tidal; and chemical properties, chiefly salinity and pH.

It is not unusual to have several types of wetlands in the same area. Ponds, lakes and rivers characteristically have marshes and swamps along gently sloped edges. Estuaries often have salt marshes, brackish marshes, and freshwater marshes adjacent to each other. These are referred to as *wetland complexes*, and provide a variety of habitats to form ecosystems that produce greater diversity of wildlife.

How do wetland ecosystems relate to the study of watersheds?

An ecosystem is a community of plants and animals interacting with one another and with the chemical and physical factors which make up their environment. A wetland is a type of ecosystem. Every watershed contains wetlands, resulting from different topographical, geological, and ecological features. Wetlands are important resources for humans as well as vital wildlife habitats.

When studying the significance of particular wetlands we examine their functions and values. ***Functions*** are self-sustaining, or inherent, properties of a wetland that exist in the absence of society. It's what they do. ***Values*** are the benefits to humans that derive from either one or more functions and the physical characteristics associated with a wetland. In other words - what is it worth to us? As an example, a <u>function</u> of wetlands is their ability to absorb large amounts of water during heavy rains. Their <u>value</u> to society is in flood prevention in developed areas. Examples of wetland functions and values are:

Functions:

- Flood water storage/water retention
- Shoreline stabilization
- Wave energy absorption
- Groundwater recharge/discharge
- Oxygen production
- Nutrient uptake and storage
- Sediment removal
- Sedimentation storage of toxic compounds
- Denitrification
- Wildlife habitat
- Fish and shellfish habitat
- Biomass productivity
- Wood production
- Food production

Values:

- Flood abatement
- Erosion control
- Drinking water recharge area
- Water quality improvement
- Air quality improvement
- Sediment/toxicant/pathogen retention
- Nutrient removal/ retention
- Nutrient transformation
- Pollution control
- Wood products
- Food products
- Open space
- Recreation
    - Fishing/Hunting
    - Canoeing/boating
    - Swimming
    - Birding
- Threatened or endangered species habitat
- Aesthetics
- Uniqueness
    - Archeological sites
    - Historical events
    - Unique plants or animals
    - Unique geological features
- Educational/Scientific research

ACTIVITY I: THE MYSTERY OF MISSY MITE'S MURDER

OBJECTIVE: Students will learn about several wetland animals and some of their adaptations for feeding and locomotion. Students will also become familiar with the use of wetland field guides.

METHOD: Students will be given clues and attempt to solve an ecological mystery by looking up information in pond guides and presenting that information verbally, in writing, and through drawings.

MATERIALS: ten suspect cards (see suggested list below); ten blank creature cards; ten copies of the Pond Life Golden Guide[1] or Wonderful Wacky, Water Critters[2]; crayons or markers and pencils

Suggested Suspects: water boatman, tadpole, Canada goose, pond snail, rainbow trout, river otter, damselfly nymph, mayfly nymph, crayfish, backswimmer*

* This is essential, because it turns out to be the most likely culprit!

BACKGROUND INFORMATION:

1. The main types of wetland creatures (and some examples of each) are:

   crustacean (crayfish, scuds, copepods)
   insect (damselfly nymph, backswimmer)
   mollusk (pond snail, freshwater clam)
   fish (rainbow trout, Atlantic salmon)
   amphibian (frog, salamander)
   reptile (painted turtle, water snake)
   bird (Canada goose, osprey)
   mammal (river otter, beaver, muskrat)

2. A nymph, or larva, is a juvenile form of an animal. A tadpole is the larval stage of a frog. A damselfly nymph is the juvenile stage of a damselfly. There are many amphibians and aquatic insects whose adult forms spend most of their time on land, but lay their eggs in the water as their larval forms live completely beneath the surface.

3. Debris, or detritus, refers to decaying matter, dead plants or animals.

PROCEDURE:

1. Arrange students into 10 groups of 2 or 3 and pass out all materials.

2. Show them the pictures of water mites on p. 113 in the Pond Life Golden Guide. Tell them that a certain beloved water mite, named Missy, was murdered (eaten) by one of the creatures represented on the suspect cards.

3. Explain that their task is to conduct thorough research of their suspects to find out if they may be the likely culprit. The only clue they have is that Sally Sideswimmer, the Scud, saw the culprit swim away in an unusual manner.

4. Go over the "types" of wetland creatures and other vocabulary that will help them in their research (see background information section).

5. The research should involve finding the suspect in the pond guide, drawing its portrait on the blank creature card, and "interviewing" the suspect. Suggested interview questions:

    1. What "type" of creature are you?
    2. What do you eat?
    3. How do you move in the water?

6. Have each pair share their drawing and findings. Discuss who seems to be the most likely culprit.

[1] Pond Life Golden Guides are available from any bookstore.
[2] Wonderful Wacky Water Critters is available from the University of Wisconsin Extension.

CREATURE CARD

CREATURE: ____________________

What type of creature is it? ____________________

What does it eat? ________________________________

How does it swim? ____________________________

ACTIVITY II: RECIPE FOR A WETLAND

OBJECTIVE: Students will understand key components ("ingredients") of a wetland ecosystem, be able to categorize them according to illustrate nutrient cycling.

METHOD: Students will develop a list ("recipe") of wetland components ("ingredients") through brainstorming, and help categorize and draw connections between these components through interactive discussion, in order to create a visual model of a wetland ecosystem on the blackboard.

MATERIALS: none

BACKGROUND INFORMATION:

1. Wetland ecosystems possess a great diversity of plant and animal life, all with specific food and habitat requirements. There are many different types of wetlands, such as saltmarsh, red maple swamp, wet meadow, lake, bog, stream, river, etc. For this activity, we will use a freshwater pond as a simple, typical ecosystem.

2. As diverse as wetland organisms may be, they all have the same four basic requirements for life: soil, water, sunlight, air.

3. The animals and plants are intricately related, feeding off of and surviving with each other.

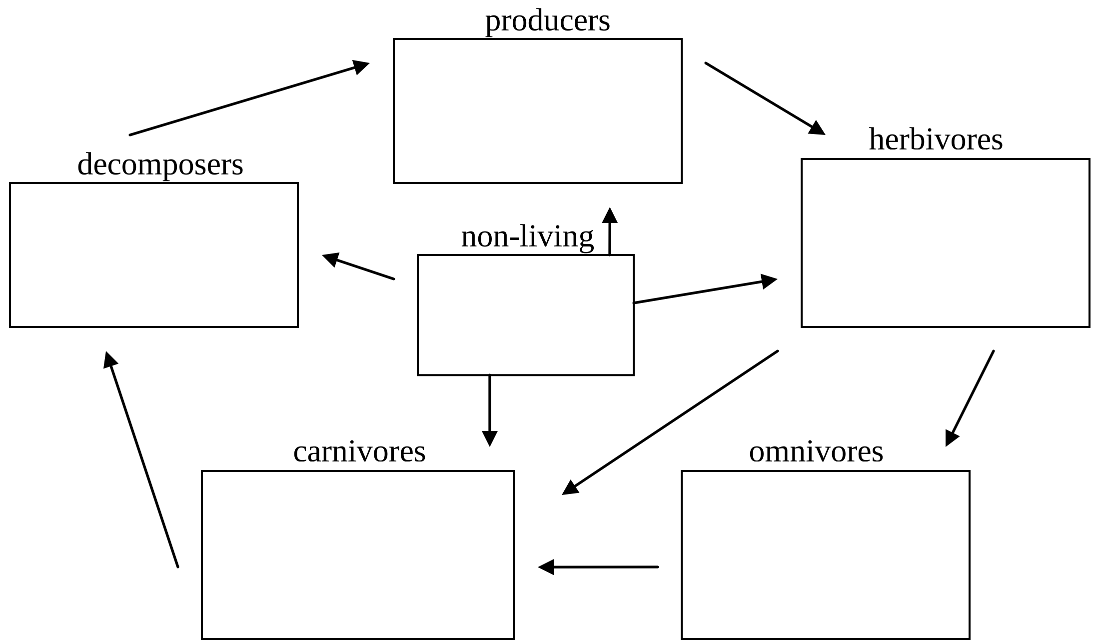
4. Food chains in the wetland all begin with <u>producers</u> (plants). Plants possess the amazing ability to use sunlight, water, and soil minerals to produce their own food.

5. <u>Herbivores</u> feed only on plants. <u>Carnivores</u> feed only on other animals. <u>Omnivores</u> feed on both plants and animals. All of these animals are collectively called <u>consumers</u>. They must eat, or consume food, and they form the inner links of the wetland food chain.

6. In order to complete the cycle, there must be organisms that can return the nutrients and energy from the consumers back into a useable form for the producers. <u>Decomposers</u> fill this vital link in the food chain. They break down dead plant and animal materials into the soil.

PROCEDURE:

1. Draw six large boxes on the blackboard, as shown below, but omitting labels and arrows, to provide the basic framework for a wetland model. The six boxes will represent producers, herbivores, omnivores, carnivores, decomposers, and the four basic non-living wetland "ingredients". Explain to the students that the diagram on the board will help show how different "ingredients" in a wetland are categorized and connected to each other.



2. Ask students to create a “recipe” for a wetland, by first brainstorming a list of “ingredients”.

3. As students come up with “ingredients”, write or draw their ideas on the board, placing them in the appropriate boxes. Some examples are:

Decomposers
mosquito larva
water boatman
mayfly nymph
pond snail
copepod
scud
leech
isopod

Herbivores
tadpole
water boatman
beaver
pond snail
copepod
Canada goose
wood duck
muskrat

Omnivores
mosquito larva
caddisfly larva
mayfly nymph
stonefly nymph
cranefly larva
crayfish

Carnivores
damselfly nymph
dragonfly nymph
predaceous diving beetle
salamander
mudpuppy
leech
sunfish
perch
frogs
turtles
great blue heron
trout
osprey
kingfisher
otter
water shrew
common water snake

Producers
water lily
cattail
sedge
algae
bulrush

4. After a few ideas are written or drawn on the board, students may begin to see where different “ingredients” belong. As they brainstorm, ask them which box they think their addition to the model belongs in.

5. Make sure each category box gets filled with plenty of examples of “ingredients”. The middle box should have inside it the four basic non-living resources that sustains all life: air, soil, sunlight, water.

6. After the model fills up with plenty of examples of “ingredients” in each category, ask students to help figure out captions for each box. What characterizes each box of “ingredients”? Why is each category important?

7. How are the organisms in the different boxes related? Ask students to help you draw arrows between boxes, depicting “who eats who”, or the flow of energy through the system. Discuss the meaning of the arrows between boxes, and the importance of nutrient cycling.

8. What would happen if one “ingredient” was removed? How about two or three? What would happen if a whole box of “ingredients” was removed?

9. Does the model you created depict all the food chains and cycles in the wetland? Discuss the complexity of wetland ecosystems.

ACTIVITY III: **FOOD CHAINS, PYRAMIDS, AND WEBS**

OBJECTIVE: To increase students' knowledge of wetland organisms; to teach the concepts of food chains, pyramids, and webs, including energy flow through ecosystems and interdependence between living and non-living components.

METHOD: Students will research, draw, and represent wetland components in order to roleplay food chains, pyramids, and webs, and interactively discuss the meaning of each.

MATERIALS: ten creature cards from Activity I, blank "ingredient cards (ten fewer than the number of students in the class), markers or crayons, Pond Life Golden Guide[1] or Wonderful Wacky, Water Critters[2], pencils, ball of string

BACKGROUND INFORMATION:

1. A food chain can be constructed to show the various organisms that energy passes through in an ecosystem.

2. A food pyramid is a model that depicts qualitatively the relative abundance of organisms at each trophic level in a community that is required to sustain the next higher level. Plants are at the base of the pyramid, the basic form of life that sustains all consumers. Plants obtain their energy from sunlight. Herbivores obtain their energy from eating plants. About 90% (this figure can vary from 60-98%) of the energy they obtain from their plant food is lost because they use it to survive. Only 10%, therefore, is passed on. The energy loss continues as herbivores are eaten by carnivores (e.g., a heron eats a fish). Thus there is less energy available to the carnivores that are higher up on the food chain, in the higher trophic levels. This means that it takes a lot more biomass of plants to sustain less biomass of herbivores, and even less biomass of carnivores; thus fewer higher level carnivores can be supported by the available energy in an ecosystem. The food pyramid model represents this energy loss.

3. Food chains and pyramids are oversimplified models; a heron eats many different types of fish and also eats other types of organisms such as crayfish. A food web shows the many possibilities for energy flow through an ecosystem. A food web also best illustrates that all components of an ecosystem are in an intricate balance and interdependent upon one another.

4. More diverse ecosystems, with many different species in each trophic level, tend to be more stable in the face of environmental disruption. For example, if one type of herbivore, such as water boatman, was wiped out by pollution, a pond with large numbers of other herbivores would be less affected than one where water boatmen were the most abundant plant eaters.

PROCEDURE:

A. Creating "Ingredient" Cards:

1. For this activity, every student will represent one component in the ecosystem. Ten will be the suspects from Activity I, "The Mystery of Missy Mite's Murder". Four will be sunlight, soil, air, and water. Assign one student to design four "ingredient" cards with these four elements, whose "type" is non-living.

2. Pass out the remaining blank "ingredient" cards to groups of two or three students, and assign each group an organism to research. Choose organisms from the list provided in Activity II, "Recipe for a Wetland". Make sure at least four or five groups are assigned producers, since no plants were suspects in Activity I. Try to assign a variety of organisms from different trophic levels.

3. Have students draw their organism on their "ingredient" card and fill out what type of organism it is and what it gets its energy from. As in Activity I, "the Mystery of Missy Mite's Murder", "type" refers to the animal's classification: amphibian, crustacean, insect, etc. Have students also write down their organism's trophic level on the card, such as producer, herbivore, carnivore, or decomposer. Trophic level: producer, herbivore, omnivore, carnivore, or decomposer.

4. When all are finished, distribute one creature or "ingredient" card to each student.

B. Food Chain Roleplay:

1. Ask students to get together in groups that represent food chains, in which there is only one "ingredient" per trophic level involved. Have each group share their food chain with the others. Examples:
    a. sun – algae – caddisfly larva – trout – otter (river)
    b. soil – cattails – muskrat – person (pond)

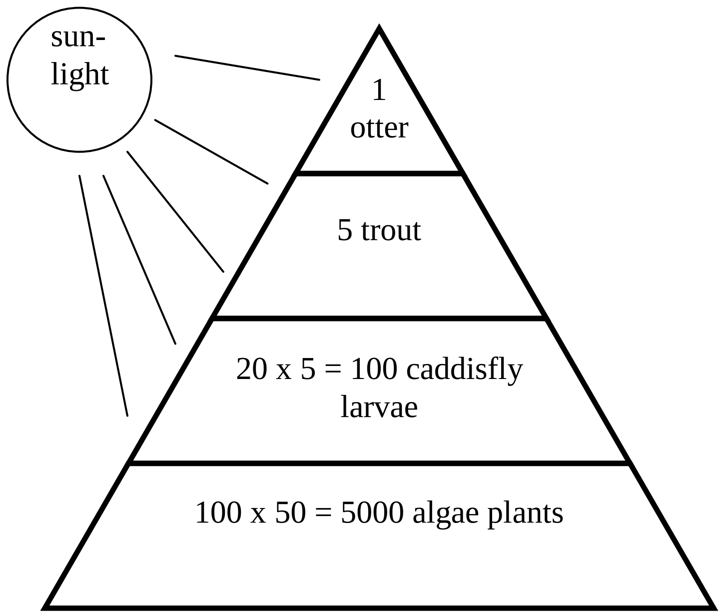
C. Food Pyramid Discussion:

1. Have one representative food chain, such as example a., above, remain standing. Write or draw the chain on the board.

2. Discuss that food chains are an oversimplification of what really happens in nature. Ask students to think about, in one day, how many algae plants would a caddisfly larva eat (50?), how many caddisfly larvae might a trout eat (20?), and how many trout would an otter eat (5?). Add these estimates to the food chain on the board. Don't worry about being correct, just ask students to make guesses so they can begin to think about the food pyramid concept.

3. Draw a pyramid shape on the board, with the appropriate number of levels that

corresponds to the particular food chain that is written on the board. Ask students how they might use the pyramid model to describe the food chain – ask them to place the "ingredients" in the food chain into levels in the pyramid. Starting with the highest level, ask students to fill in the appropriate estimate of organisms necessary to sustain each trophic level, based on the estimates made in part 3.



4. Why does it take so many algae to feed one otter? Discuss the concept of energy loss as you go from lower to higher trophic levels in an ecosystem.

<u>D. Wetland "Web of Life":</u>

1. Gather students in a circle, and have them hold up their "ingredient" or creature cards.

2. Discuss that both food chains and pyramids over-simplify what really happens in nature. How many different food chains did they form in part B? Are these food chains independent from each other? Does an otter only eat trout? Does a trout only eat caddisfly larvae?

3. Introduce a ball of string and explain the concept of food webs and interdependence. Give one end of the string to the student representing the sun and ask him/her to pass the ball to one of the students holding up a plant card, stating that they are the sun, and plants get their food energy from them.

4. The person now holding the ball takes hold of the string and passes the ball to another student who represents an organism that depends on their plant for food energy. Help guide the students so that each member of the wetland is holding the string, and thus

becomes part of the web. Students can pass the ball of string to others who depend on them for food or to someone who they depend on for food.

5. Ask students how it feels to be a part of the web. What would happen to the wetland if one or more of the ingredients were removed? As you mention different ingredients, have those students tug gently on the web, and have those that feel the tug pass it along. Some things will be more directly affected than others, but they should get the idea that eventually all would be affected if any one component disappeared.

6. How do humans affect the "Wetland Web of Life?" In some instances, humans help to keep fish (and other) populations in check. In other instances, human activity hurts wetlands. How can we have less negative impact on the delicate ecological balance in wetland ecosystems?

[1] Pond Life Golden Guides are available from any bookstore.
[2]Wonderful Wacky Water Critters is available from the University of Wisconsin Extension.

Unit II: *Wetland Ecology*

* Introduction to Wetlands

Suggested background readings for teachers:

- • Wetlands of Rhode Island, Ralph W. Tiner, 1989; Chapter 2. pages 4-7. Start at Wetland Definition, stop at Wetland Classification.
- Classification of Wetlands and Deepwater Habitats of the United States, Cowardin et al., 1979; Chapter 7. Wetland Values, pages 52-64.
- Classification of Wetlands and Deepwater Habitats of the United States, Cowardin et al., 1979; Chapter 8. Wetland Protection, pages 67-69.
- A World in Our Backyards-A Wetlands Education and Stewardship Program, 1996l Chapter II. Wetland Types, pages 23-40
- Ecology of Red Maple Swamps (Biological Report 12), 1993. Chapter 2. The Physical Environment, pages 11-12
- Ecology of Red Maple Swamps (Biological Report 12), 1993. Chapter 8. Values, Impacts, and Management, pages 109-127
- A World in Our Backyards-A Wetlands Education and Stewardship Program, 1996l Chapter VII. Protecting Your Wetlands, pages 113-115
- What wetland functions and values are considered by the Corps in its Section 404 permit process? Page 4-5
- A World in Our Backyards-A Wetlands Education and Stewardship Program, 1996l Chapter VII. Protecting Your Wetlands, pages 113-115

CHAPTER 2.

U.S. Fish and Wildlife Service's Wetland Definition and Classification System

Introduction

To begin inventorying the Nation's wetlands, the Service needed a definition of wetland and a classification system to identify various wetlands types. The Service, therefore, examined recent wetland inventories throughout the country to learn how others defined and classified wetlands. The results of this examination were published as *Existing State and Local Wetlands Surveys (1965–1975)* (U.S. Fish and Wildlife Service 1976). More than 50 wetland classification schemes were identified. Of those, only one classification—the Martin, *et al.* system (1953)—was nationally based, while all others were regionally focused. In January 1975, the Service brought together 14 authors of regional wetland classifications and other prominent wetland scientists to help decide if any existing classification could be used or modified for the national inventory or if a new system was needed. They recommended that the Service attempt to develop a new national wetland classification. In July 1975, the Service sponsored the National Wetland Classification and Inventory Workshop, where more than 150 wetland scientists and mapping experts met to review a preliminary draft of the new wetland classification system. The consensus was that the system should be hierarchical in nature and built around the concept of ecosystems (Sather 1976).

Four key objectives for the new system were established: (1) to develop ecologically similar habitat units, (2) to arrange these units in a system that would facilitate resource management decisions, (3) to furnish units for inventory and mapping, and (4) to provide uniformity in concept and terminology throughout the country (Cowardin, *et al.* 1979).

The Service's wetland classification system was developed by a four-member team, i.e., Dr. Lewis M. Cowardin (U.S. Fish and Wildlife Service), Virginia Carter (U.S. Geological Survey), Dr. Francis C. Golet (University of Rhode Island) and Dr. Edward T. LaRoe (National Oceanic and Atmospheric Administration), with assistance from numerous Federal and state agencies, university scientists, and other interested individuals. The classification system went through three major drafts and extensive field testing prior to its publication as *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin, *et al.* 1979). Since its publication, the Service's classification system has been widely used by Federal, state, and local agencies, university scientists, and private industry and non-profit organizations for identifying and classifying wetlands. At the First International Wetlands Conference in New Delhi, India, scientists from around the world adopted the Service's wetland definition as an international standard and recommended testing the applicability of the classification system in other areas, especially in the tropics and subtropics (Gopal, *et al.* 1982). Thus, the system appears to be moving quickly towards its goal of providing uniformity in wetland concept and terminology.

Start Reading

Wetland Definition

Conceptually, wetlands usually lie between the better drained, rarely flooded uplands and the permanently flooded deep waters of lakes, rivers and coastal embayments (Figure 2). Wetlands generally include the variety of marshes, bogs, swamps, shallow ponds, and bottomland forests that occur throughout the country. They usually lie in depressions surrounded by upland or along rivers, lakes and coastal waters where they are subject to periodic flooding. Some wetlands, however, occur on slopes where they are associated with ground-water seepage areas. To accurately inventory this resource, the Service had to determine where along this natural wetness continuum wetland ends and upland begins. While many wetlands lie in distinct depressions or basins that are readily observable, the wetland-upland boundary is not always easy to identify. This is especially true along many floodplains, on glacial till deposits, in gently sloping terrain, and in areas of major hydrologic modification. In these areas, only a skilled wetland ecologist or other specialist can accurately identify the wetland boundary. To help ensure accurate and consistent wetland determination, an ecologically based definition was constructed by the Service.

Historically, wetlands were defined by scientists working in specialized fields, such as botany or hydrology. A botanical definition would focus on the plants adapted to flooding or saturated soil conditions, while a hydrologist's defintion would emphasize fluctuations in the position of the water table relative to the ground surface over time. Lefor and Kennard (1977) reviewed numerous definitions for inland wetlands used in the Northeast. Single

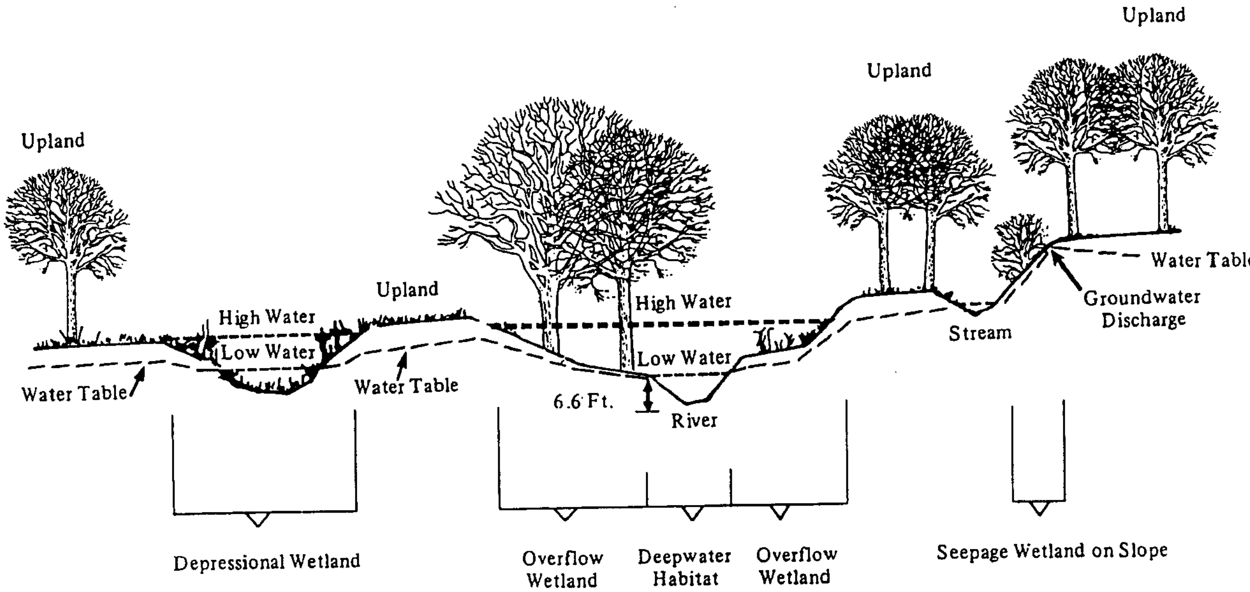


Figure 2. Schematic diagram showing wetlands, deepwater habitats, and uplands on the landscape. Note differences in wetlands due to hydrology and topographic position.

parameter definitions in general are not very useful for identifying wetlands. A more complete definition of wetland involves a multi-disciplinary approach. The Service has taken this approach in developing its wetland definition and classification system.

The Service has not attempted to legally define wetland, since each state or Federal regulatory agency has defined wetland somewhat differently to suit its administrative purposes (Table 1). Therefore, according to existing wetland laws, a wetland is whatever the law says it is. The Service needed a definition that would allow accurate identification and delineation of the Nation's wetlands for resource management purposes.

The Service defines wetlands as follows:

"*Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.*" (Cowardin, *et al.* 1979)

In defining wetlands from an ecological standpoint, the Service emphasizes three key attributes of wetlands: (1) hydrology—the degree of flooding or soil saturation, (2) wetland vegetation (hydrophytes), and (3) hydric soils. All areas considered wetland must have enough water at some time during the growing season to stress plants and animals not adapted for life in water or saturated soils. Most wetlands have hydrophytes and hydric soils present, yet many are nonvegetated (e.g., tidal mud flats). The Service has prepared a list of plants occurring in the Nation's wetlands (Reed 1988) and the Soil Conservation Service has developed a national list of hydric soils (U.S.D.A. Soil Conservation Service 1987) to help identify wetlands.

Particular attention should be paid to the reference to flooding or soil saturation during the growing season in the Service's wetland definition. When soils are covered by water or saturated to the surface, free oxygen is generally not available to plant roots. During the growing season, most plant roots must have access to free oxygen for respiration and growth; flooding at this time would have serious implications for the growth and survival of most plants. In a wetland situation, plants must be adapted to cope with these stressful conditions. If, however, flooding only occurs in winter when the plants are dormant, there is little or no effect on them.

Wetlands typically fall within one of the following four categories: (1) areas with both hydrophytes and hydric soils (e.g., marshes, swamps and bogs), (2) areas without hydrophytes, but with hydric soils (e.g., farmed wetlands), (3) areas without soils but with hydrophytes (e.g., seaweed-covered rocky shores), and (4) periodically flooded areas without soil and without hydrophytes (e.g., gravel beaches). All wetlands must be periodcially saturated or covered by shallow water during the growing season, whether or not hydrophytes or hydric soils are present. Completely drained hydric soils that are no

Table 1. Definitions of "wetland" according to selected Federal agencies and state statutes.

Organization (Reference)	Wetland Definition	Comments
U.S. Fish and Wildlife Service (Cowardin, *et al.* 1979)	"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."	This is the official Fish and Wildlife Service definition and is being used for conducting an inventory of the Nation's wetlands. It emphasizes flooding and/or soil saturation, hydric soils and vegetation. Shallow lakes and ponds are included as wetland. Comprehensive lists of wetland plants and soils are available to further clarify this definition.
U.S. Army Corps of Engineers (Federal Register, July 19, 1977) and U.S. Environmental Protection Agency (Federal Register, December 24, 1980)	Wetlands are "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."	Regulatory definition in response to Section 404 of the Clean Water Act of 1977. Excludes similar areas lacking vegetation, such as tidal flats, and does not define lakes, ponds and rivers as wetlands. Aquatic beds are considered "vegetated shallows" and included as other "waters of the United States" for regulatory purposes.
U.S.D.A. Soil Conservation Service (National Food Security Act Manual, 1988)	"Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils."	This is the Soil Conservation Service's definition for implementing the "Swampbuster" provision of the Food Security Act of 1985. Any area that meets hydric soil criteria is considered to have a predominance of hydric soils. Note the geographical exclusion for certain lands in Alaska.
State of Rhode Island Coastal Resources Mgmt. Council (RI Coastal Resources Mgmt. Program as amended June 28, 1983)	"Coastal wetlands include salt marshes and freshwater or brackish wetlands contiguous to salt marshes. Areas of open water within coastal wetlands are considered a part of the wetland. Salt marshes are areas regularly inundated by salt water through either natural or artificial water courses and where one or more of the following species predominate: [8 indicator plants listed]. Contiguous and associated freshwater or brackish marshes are those where one or more of the following species predominate: [9 indicator plants listed]."	State's public policy on coastal wetlands. Definition based on hydrologic connection to tidal waters and presence of indicator plants. *Note:* Original definition made reference to the occurrence and extent of salt marsh peat; it was probably deleted since many salt marsh soils are not peats, but sands.
State of Rhode Island Dept. of Environmental Mgmt. (RI General Law, Sections 2-1-18 et seq.)	Fresh water wetlands are defined to include, "but not be limited to marshes; swamps; bogs; ponds; river and stream flood plains and banks; areas subject to flooding or storm flowage; emergent and submergent plant communities in any body of fresh water including rivers and streams and that area of land within fifty feet (50') of the edge of any bog, marsh, swamp, or pond." Various wetland types are further defined on the basis of hydrology and indicator plants, including bog (15 types of indicator plants), marsh (21 types of plants), and swamp (24 types of indicator plants plus marsh plants).	Fresh Water Wetlands Act definition. Several wetland types are further defined. The definition includes deepwater areas and the 100-year flood plain as wetland. Minimum size limits are placed on ponds (one quarter acre), marsh (one acre), and swamp (three acres). Under the definition of "river bank," all land within 100 feet of any flowing body of water less than 10 feet wide during normal flow and within 200 feet of any flowing body of water 10 feet or wider is protected as wetland.

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longer capable of supporting hydrophytes due to a change in water regime are not considered wetland. Areas with completely drained hydric soils are, however, good indicators of historic wetlands, which may be suitable for restoration through mitigation projects.

It is important to mention that the Service does not generally include permanently flooded deep water areas as wetland, although shallow waters are classified as wetland. Instead, these deeper water bodies are defined as deepwater habitats, since water and not air is the principal medium in which dominant organisms live. Along the coast in tidal areas, the deepwater habitat begins at the extreme spring low tide level. In nontidal freshwater areas, this habitat starts at a depth of 6.6 feet (2 m) because the shallow water areas are often vegetated with emergent wetland plants.

End Reading for This Page

Wetland Classification

The following section represents a simplified overview of the Service's wetland classification system. Consequently, some of the more technical points have been omitted from this discussion. When actually classifying a wetland, the reader is advised to refer to the official classification document (Cowardin, *et al.* 1979) and should not rely solely on this overview.

The Service's wetland classification system is hierarchial or vertical in nature proceeding from general to specific, as noted in Figure 3. In this approach, wetlands are first defined at a rather broad level—the *SYSTEM*. The term *SYSTEM* represents "a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors." Five systems are defined: Marine, Estuarine, Riverine, Lacustrine and Palustrine. The Marine System generally consists of the open ocean and its associated high-energy coastline, while the Estuarine System encompasses salt and brackish marshes, nonvegetated tidal shores, and brackish waters of coastal rivers and embayments. Freshwater wetlands and deepwater habitats fall into one of the other three systems: Riverine (rivers and streams), Lacustrine (lakes, reservoirs and large ponds), or Palustrine (e.g., marshes, bogs, swamps and small shallow ponds). Thus, at the most general level, wetlands can be defined as either Marine, Estuarine, Riverine, Lacustrine or Palustrine (Figure 4).

Each system, with the exception of the Palustrine, is further subdivided into *SUBSYSTEMS*. The Marine and Estuarine Systems both have the same two subsystems, which are defined by tidal water levels: (1) Subtidal—continuously submerged areas and (2) Intertidal—areas alternately flooded by tides and exposed to air. Similarly, the Lacustrine System is separated into two systems based on water depth: (1) Littoral—wetlands extending from the lake shore to a depth of 6.6 feet (2 m) below low water or to the extent of nonpersistent emergents (e.g., arrowheads, pickerelweed or spatterdock) if they grow beyond that depth, and (2) Limnetic—deepwater habitats lying beyond the 6.6 feet (2 m) at low water. By contrast, the Riverine System is further defined by four subsystems that represent different reaches of a flowing freshwater or lotic system: (1) Tidal—water levels subject to tidal fluctuations, (2) Lower Perennial—permanent, flowing waters with a well-developed floodplain, (3) Upper Perennial—permanent, flowing water with very little or no floodplain development, and (4) Intermittent—channel containing nontidal flowing water for only part of the year.

The next level—*CLASS*—describes the general appearance of the wetland or deepwater habitat in terms of the dominant vegetative life form or the nature and composition of the substrate, where vegetative cover is less than 30% (Table 2). Of the 11 classes, five refer to areas where vegetation covers 30% or more of the surface: Aquatic Bed, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland and Forested Wetland. The remaining six classes represent areas generally lacking vegetation, where the composition of the substrate and degree of flooding distinguish classes: Rock Bottom, Unconsolidated Bottom, Reef (sedentary invertebrate colony), Streambed, Rocky Shore, and Unconsolidated Shore. Permanently flooded nonvegetated areas are classified as either Rock Bottom or Unconsolidated Bottom, while exposed areas are typed as Streambed, Rocky Shore or Unconsolidated Shore. Invertebrate reefs are found in both permanently flooded and exposed areas.

Each class is further divided into *SUBCLASSES* to better define the type of substrate in nonvegetated areas (e.g., bedrock, rubble, cobble-gravel, mud, sand, and organic) or the type of dominant vegetation (e.g., persistent or nonpersistent emergents, moss, lichen, or broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, needle-leaved evergreen and dead woody plants). Below the subclass level, *DOMINANCE TYPE* can be applied to specify the predominant plant or animal in the wetland community.

To allow better description of a given wetland or deepwater habitat in regard to hydrologic, chemical and soil characteristics and to human impacts, the classification system contains four types of specific modifiers: (1) Water Regime, (2) Water Chemistry, (3) Soil, and (4) Special. These modifiers may be applied to class and lower levels of the classification hierarchy.

CHAPTER 7.

Wetland Values

Introduction

Rhode Island's wetlands have been traditionally used for hunting, trapping, fishing, berry harvest, timber and salt hay production, and livestock grazing. These uses tend to preserve the wetland integrity, although the qualitative nature of wetlands may be modified, especially by salt hay production and timber harvest. Human uses are not limited to these activities, but also include destructive and often irreversible actions such as drainage for agriculture and filling for industrial or residential development. In the past, many people considered wetlands as wastelands whose best use could only be attained through "reclamation projects" which led to the destruction of many wetlands. To the contrary, wetlands in their natural state provide a wealth of values to society (Table 19). These benefits can be divided into three basic categories: (1) fish and wildlife values, (2) environmental quality values, and (3) socio-economic values. The following discussion emphasizes the more important values of Rhode Island's wetlands, with significant national examples also presented. For an in-depth examination of wetland values, the reader is referred to *Wetland Functions and Values: The State of Our Understanding* (Greeson, *et al.* 1979). In addition, the U.S. Fish and Wildlife Service has created and maintains a wetland values database which records abstracts for over 5000 articles.

Table 19. List of major wetland values.

Fish and Wildlife Values

- Fish and Shellfish Habitat
- Waterfowl and Other Bird Habitat
- Mammal and Other Wildlife Habitat

Environmental Quality Values

- Water Quality Maintenance
  - Pollution Filter
  - Sediment Removal
  - Oxygen Production
  - Nutrient Recycling
  - Chemical and Nutrient Absorption
- Aquatic Productivity
- Microclimate Regulator
- World Climate (Ozone layer)

Socio-economic Values

- Flood Control
- Wave Damage Protection
- Shoreline Erosion Control
- Ground-water Recharge
- Water Supply
- Timber and Other Natural Products
- Energy Source (Peat)
- Livestock Grazing
- Fish and Shellfishing
- Hunting and Trapping
- Recreation
- Aesthetics
- Education and Scientific Research

Fish and Wildlife Values

Fish and wildlife utilize wetlands in a variety of ways. Some animals are entirely wetland-dependent, spending their entire lives in wetlands. Others use wetlands only for specific reasons, such as reproduction and nursery grounds, feeding, and resting areas during migration. Many upland animals visit wetlands to obtain drinking water and food. In urbanizing areas, the remaining wetlands become important habitats—a type of refuge—for "upland" wildlife displaced by development (F. Golet, pers. comm.). Wetlands are also essential habitat for numerous rare and endangered animals and plants.

Fish and Shellfish Habitat

Due to their linkage with adjacent waters, Rhode Island's coastal and inland wetlands are important fish habitats. Estuarine wetlands are also essential habitats for grass shrimp, crabs, oysters, clams, and other invertebrates.

Approximately two-thirds of the major U.S. commercial fishes depend on estuaries and salt marshes for nursery or spawning grounds (McHugh 1966). Among the more familiar wetland-dependent fishes are menhaden, bluefish, flounder, white perch, sea trout, mullet, croaker, striped bass, and drum. Forage fishes, such as anchovies, killifishes, mummichogs, and Atlantic silversides, are among the most abundant estuarine fishes. Narragansett Bay and its associated wetlands are important spawning and nursery grounds for many fish species (T. Lynch, pers. comm.). Winter flounder spawn in the shallow shoals of the Bay on beds of sea lettuce (*Ulva lactuca*), with peak spawning taking place from January to March. These same beds are used in the spring by spawning tautogs. Other nearshore spawners include scup, butterfish, and squid. Coastal ponds serve as spawning areas for tomcod beginning in November. As many as 63 fish species use Narragansett Bay as a nursery ground, with highest use in the fall.

Coastal wetlands are also important for shellfish including bay scallops, grass shrimp, blue crabs, oysters, quahogs and other clams. A critical stage of the bay scallop's life cycle requires that larvae attach to eelgrass leaves for about a month (Davenport 1903). Blue crabs and grass shrimp are abundant in tidal creeks of salt marshes. Estuarine aquatic beds, in general, also provide important cover for juvenile fishes and other estuarine organisms (Good, *et al.* 1978).

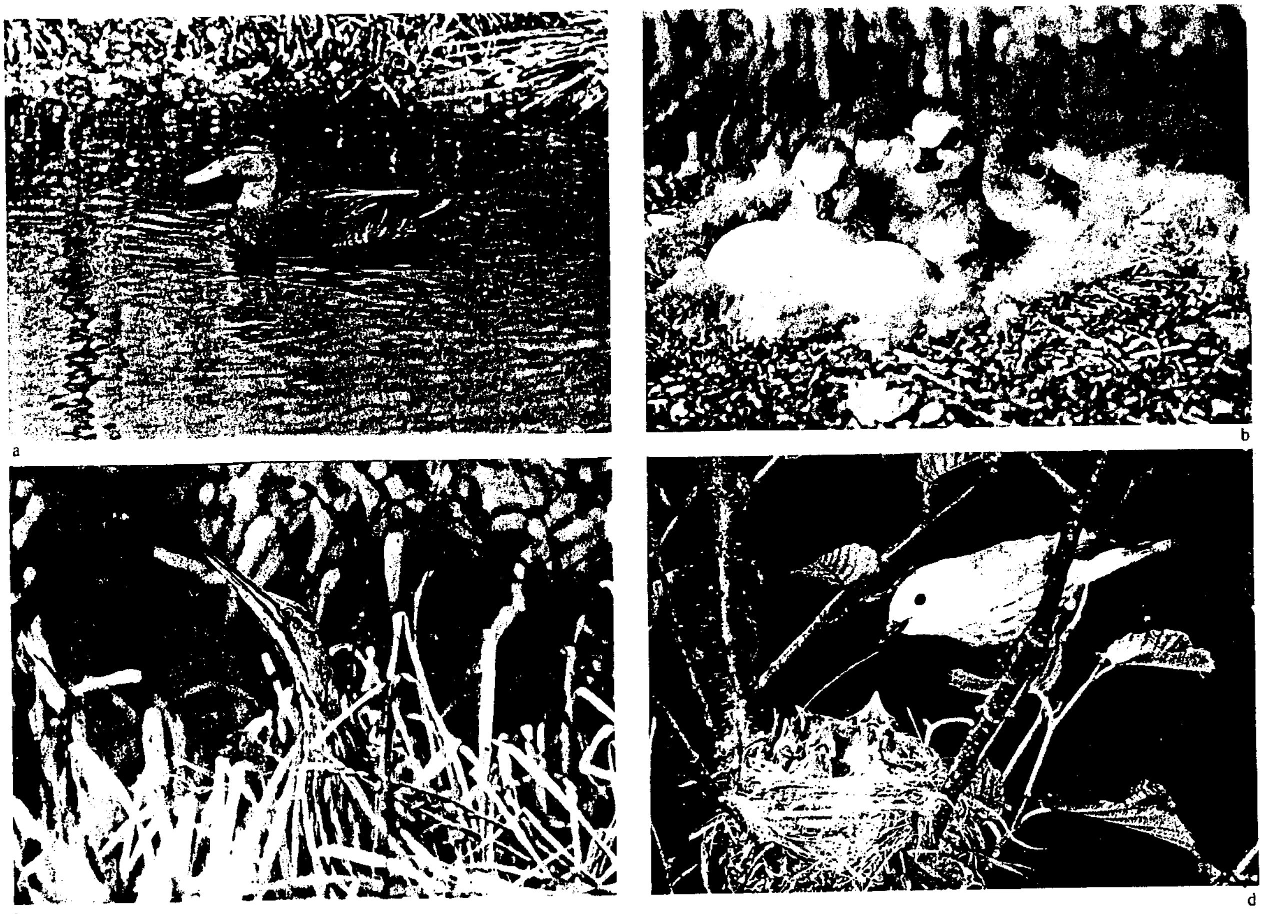

Figure 22. Migratory birds depend on Rhode Island wetlands: (a) black duck, (b) Canada goose goslings, (c) American bittern, and (d) yellow warbler.

Freshwater fishes also find wetlands essential for survival. In fact, nearly all freshwater fishes can be considered wetland-dependent because: (1) many species feed in wetlands or upon wetland-produced food, (2) many fishes use wetlands as nursery grounds, and (3) almost all important recreational fishes spawn in the aquatic portions of wetlands (Peters, *et al.* 1979). Many rivers and streams along Rhode Island's coast are spawning grounds for alewife and a few rivers are also used by sea-run brown trout, rainbow smelt, and American shad. Common fishes in Rhode Island's freshwater rivers, lakes, and ponds include northern pike, chain pickerel, largemouth bass, smallmouth bass, bluegill, common sunfish, yellow perch, brown bullhead, brook trout, rainbow trout, and white perch (Guthrie and Stolgitis 1977; RI DEM, pers. comm.). Northern pike spawn in early spring in flooded marshes and aquatic beds, while chain pickerel prefer aquatic beds. White perch are also early spring spawners, spawning in ponds and brackish coastal waters. Smallmouth bass spawn in about two feet of water from late May to early June. For all fish species, the presence of aquatic vegetation helps juvenile fishes avoid predator attacks, so wetlands are important nursery grounds.

Waterfowl and Other Bird Habitat

In addition to providing year-round habitats for resident birds, wetlands are particularly important as breeding grounds, over-wintering areas and feeding grounds for migratory waterfowl and numerous other birds (Figure 22). Both coastal and inland wetlands are valuable bird habitats.

Rhode Island's salt marshes are used for nesting by birds such as common terns, clapper rails, king rails, mallards, black ducks, blue-winged teals, mute swans, willets, herring gulls, great black-backed gulls, red-winged blackbirds, marsh wrens, sharp-tailed sparrows, and seaside sparrows. Red-winged blackbirds and seaside sparrows prefer stands of the short form of smooth cordgrass (*Spartina alterniflora*) which border permanent salt ponds, while marsh wrens prefer stands of the tall form of smooth cordgrass bordering tidal creeks and ditches (Reinert, *et al.* 1981). Moreover, the availability of open water and/or the short form smooth cordgrass community are directly related to the density of all breeding species. Bird breeding densities are over 2.5 times higher in un-

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ditched salt marshes than in ditched marshes (Reinert, *et al.* 1981). Wading birds, such as little blue herons, black-crowned night herons, glossy ibises, cattle egrets, snowy egrets and great egrets, also feed and nest in and adjacent to Rhode Island's coastal wetlands. Great blue herons feed in these wetlands, but nest inland. The U.S. Fish and Wildlife Service (Erwin and Korschgen 1979) has identified nesting colonies of coastal water birds in Rhode Island and other northeastern states. Ospreys also nest in wetlands along the coast.

Southern New England coastal marshes are important feeding and stopover areas for migrating raptors, waterfowl, shorebirds and wading birds. In Rhode Island, intertidal mudflats are principal feeding grounds for migratory shorebirds (e.g., sandpipers, plovers, and yellowlegs), while swallows can often be seen feeding on flying insects over the marshes. The U.S. Fish and Wildlife Service's winter waterfowl survey found an annual average of 9,700 scaup, 3,000 Canada geese, and 2,700 black ducks as well as hundreds of canvasbacks, mallards, mergansers, mute swans, scoters and other waterfowl overwintering in Rhode Island between 1980–1986.

Coastal beaches are used for nesting by piping plover (a Federal threatened species), American oystercatcher, and least tern. Rocky shores are nesting sites for gadwall, double-crested cormorant, roseate tern, and common tern (R. Enser, pers. comm.).

Rhode Island's inland wetlands are used by a variety of birds, including waterfowl, wading birds, rails and songbirds. Among the more typical species are black duck, wood duck, mallard, green-winged teal, Canada goose, mute swan, green-backed heron, great blue heron, least bittern, American bittern, Virginia rail, sora, common moorhen, spotted sandpiper, marsh wren, winter wren, red-winged blackbird, belted kingfisher, tree swallow, northern rough-winged swallow, Acadian flycatcher, willow flycatcher, eastern kingbird, warbling vireo, swamp sparrow, and woodcock. Most of these species are associated with freshwater marshes and open water bodies. Wood duck, Acadian flycatcher, barred owl, northern saw-whet owl, northern waterthrush, Louisiana waterthrush, Canada warbler, and white-throated sparrow nest in forested wetlands. Among the birds breeding in shrub swamps are woodcock and willow flycatcher. Lowry (1984) reported on numerous observations made over a seven-year period in red maple swamps and Atlantic white cedar swamps. Forty-four bird species were seen in the maple swamps, whereas only 25 species were found in cedar swamps. Similar results were reported for southern New Jersey by Wander (1980). Among the birds nesting or assumed to nest in the 30-acre Diamond Bog are mallard, black duck, wood duck, ruffed grouse, Virginia rail, ruby-throated hummingbird, red-winged blackbird, northern oriole, common grackle, common flicker, downy woodpecker, eastern kingbird, great-crested flycatcher, purple finch, American goldfinch, eastern phoebe, tree swallow, blue jay, black-capped chickadee, red-breasted nuthatch, northern waterthrush, common yellowthroat, Canada warbler, American robin, wood thrush, veery, cedar waxwing, black and white warbler, yellow warbler, ovenbird, song sparrow, and swamp sparrow (F. Golet, pers. comm.). (*Note:* Diamond Bog, located in the town of Richmond, is a mosaic of forested, scrub-shrub, and emergent wetlands with some open water.) In a study of eight red maple swamps in western Massachusetts, Swift (1980) found 46 breeding species. The most common breeders included common yellowthroat, veery, Canada warbler, ovenbird, northern waterthrush, and gray catbird. Anderson and Maxfield (1962) studied birdlife in a red maple-Atlantic white cedar swamp in southeastern Massachusetts and found the same species plus ruffed grouse, hairy woodpecker, downy woodpecker, blue jay, black-capped chickadee, American robin, wood thrush, black-and-white warbler, and common grackle.

Wetlands are, therefore, crucial for the existence of many birds, ranging from waterfowl and shorebirds to migratory songbirds. Some spend their entire lives in wetland environments, while others primarily use wetlands for breeding, feeding or resting.

Mammal and Other Wildlife Habitat

Many mammals and other wildlife inhabit Rhode Island wetlands. Muskrats are perhaps the most typical and widespread wetland mammal (Figure 23). Other furbearers inhabiting wetlands include river otter, mink, beaver, raccoon, skunk, red fox, fisher, and weasel. Hardwood swamps are reported to be the favorite habitat of raccoons in Rhode Island (Cronan and Brooks 1968). Beaver populations in the state have been growing since re-introduction in the 1950's. Beaver are most abundant in the Moosup River system in central western Rhode Island (C. Allin, pers. comm.). Smaller mammals also frequent wetlands such as eastern cottontail, New England cottontail, snowshoe hare, meadow vole, boreal red-backed vole, southern bog lemming, water shrew, and meadow jumping mouse, while large mammals may also be observed. White-tailed deer depend on Atlantic white cedar swamps for shelter and food during severe winters, but often use palustrine deciduous forested wetlands and scrub-shrub wetlands for resting and escape cover (Cronan and Brooks 1968; RI DEM, pers. comm.). Another group of mammals—bats—also use wetlands. They can often be seen in considerable numbers feeding over ponds, marshes, and other waterbodies in summer.

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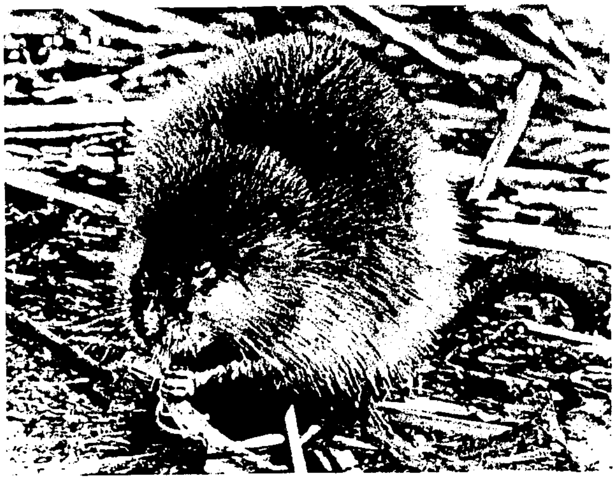

Figure 23. The muskrat is the most familiar and widespread wetland mammal in the state.

Besides mammals and birds, other forms of wildlife make their homes in wetlands. Reptiles (i.e., turtles and snakes) and amphibians (i.e., toads, frogs, and salamanders) are important residents. DeGraaf and Rudis (1983) described the non-marine reptiles and amphibians of New England including their habitat and natural history. Turtles are most common in Rhode Island's freshwater marshes and ponds and the more common ones include the eastern painted, spotted, box, stinkpot, wood, and snapping turtles. Common snakes found in and near wetlands include northern water, northern redbelly, eastern garter, eastern ribbon, eastern smooth green, and northern black racer. Among the more common toads and frogs in Rhode Island are Fowler's toad, American toad, northern spring peeper, green frog, bullfrog, wood frog, pickerel frog, and gray tree frog. Less common species include the northern leopard frog (a state special interest species) and the eastern spadefoot (state threatened) (R. Enser, pers. comm.). Adults of the red-spotted newt live in ponds with an abundance of submerged vegetation, while the juveniles are terrestrial. Many salamanders use temporary ponds or wetlands for breeding, although they may spend most of their years in upland or streamside habitats. Nearly all of the approximately 190 species of amphibians in North America are wetland-dependent at least for breeding (Clark 1979). Salamanders common in Rhode Island wetlands include the mudpuppy, spotted, northern dusky, and northern two-lined salamanders, while the four-toed and marbled salamanders are less common and are considered species of concern (R. Enser, pers. comm.).

Rare, Threatened, or Endangered Plants

Currently, the Rhode Island Natural Heritage Program is tracking 261 plant species that are rare, threatened, endangered, or of special interest or concern to the state due to their low numbers (R. Enser, pers. comm.). Of this list, approximately half (132 species) of the plants are considered wetland plants (Table 20). Among the wetland habitats where most of these plants occur are coastal plain pond shores (28 species), salt marshes, estuarine waters, and beaches (15 species), and bogs and fens (15 species).

Environmental Quality Values

Besides providing habitat for fish and wildlife, wetlands play a less conspicuous but essential role in maintaining high environmental quality, especially in aquatic habitats. They do this in a number of ways, including purifying natural waters by removing nutrients, chemical and organic pollutants, and sediment, and producing food which supports aquatic life.

Water Quality Improvement

Wetlands help maintain good water quality or improve degraded waters in several ways: (1) nutrient removal and retention, (2) processing chemical and organic wastes, and (3) reducing sediment load of water. Wetlands are particularly good water filters because of their locations between land and open water (Figure 24). Thus, they can both intercept runoff from land before it reaches the water and help filter nutrients, wastes and sediment from flooding waters. Clean waters are important to humans as well as to aquatic life.

First, wetlands remove nutrients, especially nitrogen and phosphorus, from flooding waters for plant growth and help prevent eutrophication or overenrichment of natural waters. Much of the nutrients are stored in the wetland soil. Freshwater tidal wetlands have proven effective in reducing nutrient and heavy metal loading from surface water runoff from urban areas in the upper Delaware River estuary (Simpson, *et al.* 1983c). Wetlands in and downstream of urban areas in Rhode Island probably also perform this function. It is, however, possible to overload a wetland and thereby reduce its ability to perform this function. Every wetland has a limited capacity to absorb nutrients and individual wetlands differ in their ability to do so.

Wetlands have been shown to be excellent removers of waste products from water. Sloey and others (1978) summarize the value of freshwater wetlands at removing nitrogen and phosphorus from the water and address management issues. They note that some wetland plants are so efficient at this task that some artificial waste treatment systems are using these plants. For example, the Max Planck Institute of Germany has a patent to create such

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Table 20. Plant species of special concern to Rhode Island that occur in wetlands (R. Enser, pers. comm.).

Plant Species	Common Name	State Status[1]
Equisetum fluviatile	Water Horsetail	State Special Interest
Equisetum hyemale	Rough Horsetail	Species of Concern
Lycopodium inundatum var. *robustum*	Northern Bog Clubmoss	State Endangered
Isoetes engelmannii	Engelmann's Quillwort	State Special Interest
Isoetes muricata	Pointed Quillwort	State Special Interest
Isoetes riparia var. *canadensis*	River Quillwort	State Special Interest
Matteuccia struthiopteris	Ostrich Fern	Species of Concern
Larix laricina	American Larch	State Threatened
Picea mariana	Black Spruce	Species of Concern
Sparganium minimum	Small Bur-reed	State Extirpated
Najas guadalupensis	Naiad	State Threatened
Scheuchzeria palustris	Pod Grass	State Endangered
Sagitarria graminea	Grassleaf Arrowhead	State Special Interest
Sagittaria subulata var. *gracillima*	River Arrowhead	State Extirpated
Sagittaria teres	Slender Arrowhead	State Endangered
Panicum philadelphicum	Philadelphia Panic Grass	State Special Interest
Spartina cynosuroides	Salt Reed Grass	State Special Interest
Tripsacum dactyloides	Northern Gamagrass	State Threatened
Zizania aquatica	Wild Rice	Species of Concern
Carex collinsii	Collin's Sedge	State Endangered
Carex exilis	Bog Sedge	State Threatened
Cyperus aristatus	Awned Cyperus	State Extirpated
Eleocharis equisetoides	Horse-tail Spike-rush	State Special Interest
Eleocharis melanocarpa	Black-fruited Spike-rush	State Endangered
Eleocharis tricostata	Three-angle Spike-rush	State Endangered
Eriophorum gracile	Slender Cotton-grass	State Threatened
Eriophorum vaginatum	Hare's Tail	State Endangered
Eriophorum viridicarinatum	Bog Cotton-grass	State Special Interest
Fuirena pumila	Umbrella Grass	State Endangered
Psilocarya scirpoides	Long-beaked Bald Rush	State Endangered
Rhynchospora inundata	Drowned Horned Rush	State Endangered
Rhynchospora macrostachya	Beaked Rush	State Threatened
Rhynchospora torreyana	Torrey's Beaked Rush	State Threatened
Scirpus etuberculatus	Untubercled Bulrush	State Endangered
Scirpus hudsonianus	Cotton Club Rush	State Extirpated
Scirpus longii	Long's Bulrush	State Endangered
Scirpus maritimus var. *fernaldii*	Saltmarsh Bulrush	State Special Interest
Scirpus robustus	Leafy Bulrush	State Special Interest
Scirpus smithii	Smith's Bulrush	State Threatened
Scirpus torreyi	Torrey's Bulrush	State Special Interest
Scleria reticularis	Reticulated Nut-rush	State Threatened
Orontium aquaticum	Golden Club	State Endangered
Xyris montana	Northern Yellow-eyed Grass	State Threatened
Xyris smalliana	Small's Yellow-eyed Grass	Species of Concern
Juncus debilis	Weak Rush	State Special Interest
Alectris farinosa	Colicroot	Species of Concern
Smilacina trifolia	Three-leaved False Solomon's Seal	State Extirpated
Streptopus roseus	Rosy Twisted Stalk	State Threatened
Trillium erectum	Purple Trillium	State Threatened
Lachnanthes caroliniana	Carolina Redroot	State Threatened
Arethusa bulbosa	Swamp Pink	Species of Concern
Calopogon tuberosus	Tuberous Grass Pink	Species of Concern
Corallorhiza trifida	Early Coralroot	State Special Interest
Cypripedium calceolus	Yellow Lady's-slipper	State Threatened
Liparis loeselii	Yellow Twayblade	State Threatened
Malaxis unifolia	Green Adder's Mouth	State Endangered
Platanthera blephariglottis	White-fringed Orchis	State Threatened
Platanthera ciliaris	Yellow-fringed Orchis	State Endangered
Platanthera flava var. *herbiola*	Pale Green Orchis	State Endangered
Platanthera hyperborea	Northern Green Orchis	State Threatened
Platanthera psycodes	Small Puple-fringed Orchid	State Special Interest
Spiranthes lucida	Shining Ladies'-tresses	State Extirpated
Saururus cernuus	Lizard's Tail	State Endangered
Salix pedicellaris	Bog Willow	State Extirpated
Ulmus rubra	Slippery Elm	State Special Interest
Arceuthobium pusillum	Dwarf Mistletoe	State Endangered
Polygonum glaucum	Seabeach Knotweed	State Threatened
Polygonum puritanorum	Pondshore Knotweed	State Endangered
Polygonum setaceum var. *interjectum*	Strigose Knotweed	State Extirpated
Atriplex glabriuscula	Smooth Orache	State Special Interest
Chenopodium leptophyllum	Goosefoot	State Special Interest
Suaeda maritima	Sea-blite	Species of Concern
Amaranthus pumilus	Seabeach Amaranth	State Extirpated
Honkenya peploides	Sea-beach Sandwort	Species of Concern
Anemone riparia	Large Anemone	State Extirpated
Ranunculus aquatilis	White Water Crowfoot	State Extirpated
Ranunculus cymbalaria	Seaside Buttercup	State Extirpated
Ranunculus flabellaris	Yellow Water Crowfoot	Species of Concern

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Table 20. *(Continued)*

Plant Species	Common Name	State Status[1]
Draba reptans	Carolina Whitlow-Grass	State Extirpated
Drosera filiformis	Thread-leaved Sundew	State Endangered
Podostemum ceratophyllum	Riverweed	State Extirpated
Parnassia glauca	Grass-of-Parnassus	State Extirpated
Saxifraga pensylvanica	Swamp Saxifrage	State Threatened
Dalibarda repens	Dewdrop	State Endangered
Crotalaria sagittalis	Rattlebox	State Threatened
Polygala cruciata	Cross-leaved Milkwort	State Threatened
Hypericum adpressum	Creeping St. John's-wort	State Threatened
Hypericum ellipticum	Pale St. John's-wort	State Special Interest
Viola incognita	Large-leaf White Violet	State Special Interest
Elatine americana	American Waterwort	State Special Interest
Rotala ramosior	Toothcup	State Endangered
Circaea alpina	Small Enchanter's Nightshade	Species of Concern
Epilobium palustre	Marsh Willow-herb	State Special Interest
Ludwigia sphaerocarpa	Round-fruited False Loosestrife	State Endangered
Myriophyllum alterniflorum	Alternate-flowered Water-milfoil	State Extirpated
Myriophyllum pinnatum	Pinnate Water-milfoil	State Extirpated
Angelica atropurpurea	Large Angelica	State Extirpated
Hydrocotyle verticillata	Saltpond Pennywort	State Endangered
Ligusticum scothicum	Scotch Lovage	State Threatened
Ptilimnium capillaceum	Mock Bishop's Weed	State Special Interest
Andromeda polifolia	Bog Rosemary	State Endangered
Gaultheria hispidula	Creeping Snowberry	State Special Interest
Gaylussacia dumosa var. *bigeloviana*	Dwarf Huckleberry	Species of Concern
Kalmia polifolia	Pale Laurel	State Endangered
Leucothoe racemosa var. *projecta*	Projecting Fetter-bush	Species of Concern
Rhododendron periclymenoides	Pinxter-flower	State Extirpated
Glaux maritima	Sea Milkwort	State Extirpated
Hottonia inflata	Featherfoil	State Special Interest
Fraxinus nigra	Black Ash	Species of Concern
Gentiana andrewsii	Closed Gentian	State Extirpated
Gentiana clausa	Bottle Gentian	State Special Interest
Gentianopsis crinita	Fringed Gentian	State Threatened
Sabatia kennedyana	Plymouth Gentian	State Endangered
Sabatia stellaris	Sea Pink	State Threatened
Physostegia virginiana	False Dragon-head	State Special Interest
Stachys hyssopifolia	Hyssop-leaf Hedge-nettle	State Endangered
Agalinis maritima	Seaside Gerardia	Species of Concern
Limosella australis	Mudwort	Species of Concern
Utricularia biflora	Two-flower Bladderwort	State Threatened
Utricularia geminiscapa	Paired Bladderwort	State Special Interest
Utricularia gibba	Humped Bladderwort	State Special Interest
Utricularia intermedia	Flatleaf Bladderwort	State Special Interest
Utricularia minor	Small Bladderwort	State Extirpated
Utricularia resupinata	Reversed Bladderwort	State Threatened
Utricularia subulata	Zigzag Bladderwort	State Threatened
Viburnun nudum	Swamp-haw	State Threatened
Lobelia dortmanna	Water Lobelia	Species of Concern
Bidens connata	Swamp Beggar-ticks	State Special Interest
Bidens coronata	Tickseed Sunflower	State Special Interest
Coreopsis rosea	Pink Tickseed	State Threatened
Eupatorium leucolepis var. *novae-angliae*	New England Boneset	State Endangered
Sclerolepis uniflora	Sclerolepis	State Endangered

[1]Definitions of State Status:

"State Endangered" are native species in imminent danger of extirpation from Rhode Island; these species meet one or more of the following criteria:

1. A species currently listed, or proposed by the U.S. Fish and Wildlife Service as Federally endangered or threatened.
2. A species with 1 or 2 known or estimated total occurrences in the state.
3. A species apparently globally rare or threatened, and estimated to occur at approximately 100 or fewer occurrences range-wide.

"State Threatened" are native species which are likely to become state endangered in the future if current trends in habitat loss or other detrimental factors remain unchanged; these species meet one or more of the following criteria:

1. A species with 3 to 5 known or estimated occurrences in the state.
2. A species with more than 5 known or estimated occurrences in the state, but especially vulnerable to habitat loss.

"State Special Interest" are native species not considered to be State Endangered or State Threatened at the present time, but occur in 6 to 10 sites in the state.

"Species of Concern" are native species which do not apply under the above categories but are additionally listed by the Natural Heritage Program due to various factors of rarity and/or vulnerability.

"State Extirpated" are native species which have been documented as occurring in the state but for which current occurrences are unknown. When known, the last documentation of occurrence is included. If an occurrence is located for a State Extirpated species, that species would automatically be listed in the State Endangered category.

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Figure 24. Wetlands are important for water quality improvement as well as flood water storage. Their location between the upland and the water facilitates these functions.

systems, where a bulrush (*Scirpus lacustris*) is the primary waste removal agent. Numerous scientists have proposed that certain types of wetlands be used to process domestic wastes and some wetlands are already used for this purpose (Sloey, *et al.* 1978; Carter, *et al.* 1979; Kadlec 1979). It must, however, be recognized that individual wetlands have a finite capacity for natural assimilation of excess nutrients and research is needed to determine this threshold (Good 1982). In the meantime, it may be prudent to use artificial wetlands for treatment of secondary wastes and then run the tertiary products into a natural wetland, rather than having natural wetlands process the entire wasteload. Godfrey and others (1985) discuss ecological considerations of using wetlands to treat municipal wastewaters.

Perhaps the best known example of the importance of wetlands for water quality improvement is Tinicum Marsh (Grant and Patrick 1970). Tinicum Marsh is a 512-acre freshwater tidal marsh lying just south of Philadelphia, Pennsylvania. Three sewage treatment plants discharge treated sewage into marsh waters. On a daily basis, it was shown that this marsh removes from flooding waters: 7.7 tons of biological oxygen demand, 4.9 tons of phosphorus, 4.3 tons of ammonia, and 138 pounds of nitrate. In addition, Tinicum Marsh adds 20 tons of oxygen to the water each day.

Swamps also have the capacity for removing water pollutants. Bottomland forested wetlands along the Alcovy River in Georgia have been shown to filter impurities from flooding waters. Human and chicken wastes grossly pollute the river upstream, but after passing through less than 3 miles of swamp, the river's water quality is significantly improved. The value of the 2,300-acre Alcovy River Swamp for water pollution control was estimated at $1 million per year (Wharton 1970). In New Jersey, Durand and Zimmer (1982) have demonstrated the capacity of Pine Barrens wetlands to assimilate excess nutrients from adjacent agricultural land and upland development. Rhode Island's wetlands undoubtedly function similarly to these wetlands.

Wetlands also play a valuable role in reducing turbidity of flooding waters. This is especially important for aquatic life and for reducing siltation of ports, harbors, rivers and reservoirs. Removal of sediment load is also valuable because sediments often transport adsorbed nutrients,

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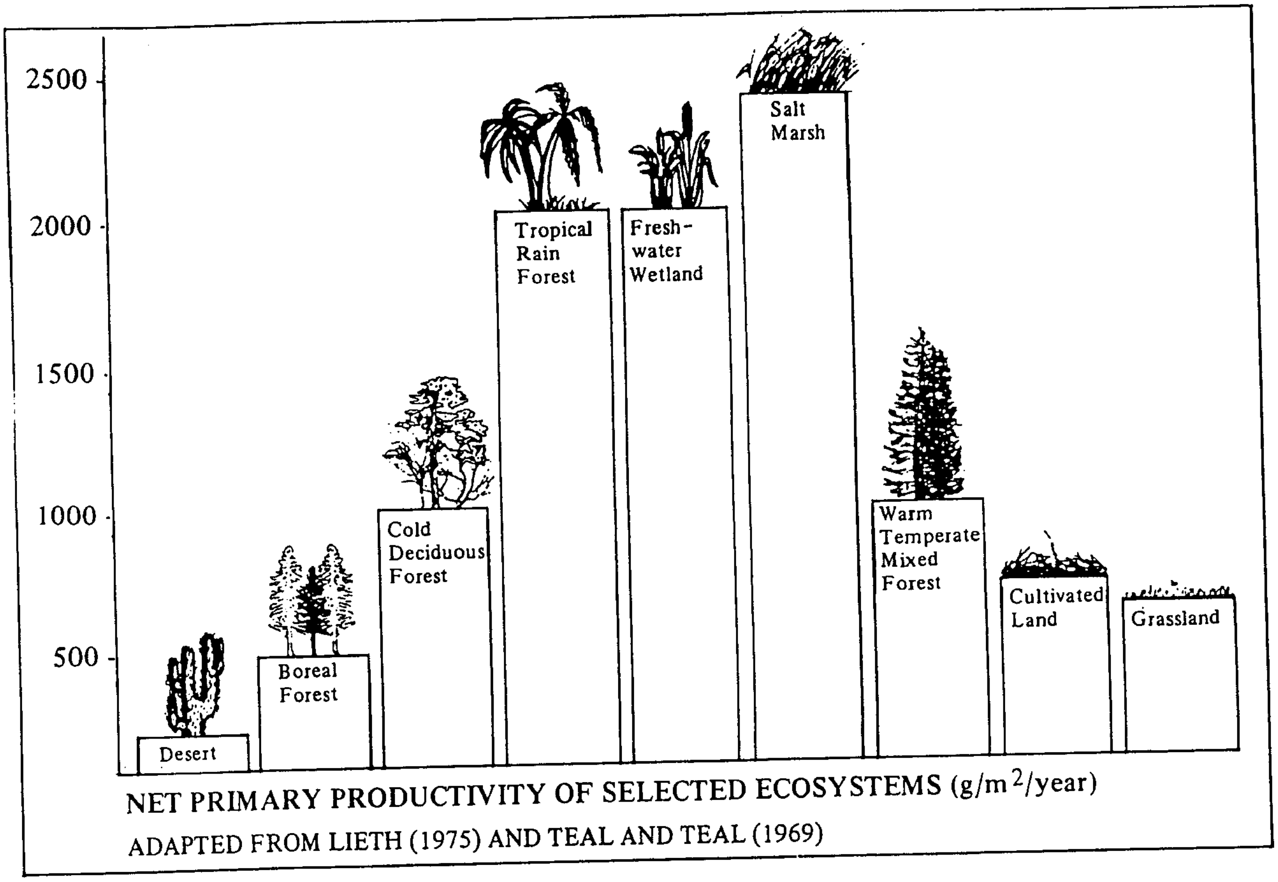

Figure 25. Relative productivity of wetland ecosystems in relation to other ecosystems (redrawn from Newton 1981). Salt marshes and freshwater marshes are among the world's most productive systems.

pesticides, heavy metals and other toxins which pollute our Nation's waters (Boto and Patrick 1979). Depressional wetlands should retain all of the sediment entering them (Novitzki 1978). In Wisconsin, watersheds with 40 percent coverage by lakes and wetlands had 90 percent less sediments in water than watersheds with no lakes or wetlands (Hindall 1975). Creekbanks of salt marshes typically support more productive vegetation than the marsh interior. Deposition of silt is accentuated at the water-marsh interface, where vegetation slows the velocity of water, causing sediment to drop out of solution. In addition to improving water quality, this process adds nutrients to the creekside marsh which leads to higher plant density and plant productivity (DeLaune, *et al.* 1978).

The U.S. Army Corps of Engineers has investigated the use of marsh vegetation to lower turbidity of dredged disposal runoff and to remove contaminants. In a 50-acre dredged material disposal impoundment near Georgetown, South Carolina, after passing through about 2,000 feet of marsh vegetation, the effluent turbidity was similar to that of the adjacent river (Lee, *et al.* 1976). Wetlands have also been proven to be good filters of nutrients and heavy metal loads in dredged disposal effluents (Windom 1977).

Recently, the ability of wetlands to retain heavy metals has been reported (Banus, *et al.* 1974; Mudroch and Capobianca 1978; Simpson, *et al.* 1983c). Wetland soils have been regarded as primary sinks for heavy metals, while wetland plants may play a more limited role. Waters flowing through urban areas often have heavy concentrations of heavy metals (e.g., cadmium, chromium, copper, nickel, lead, and zinc). The ability of freshwater tidal wetlands along the Delaware River in New Jersey to sequester and hold heavy metals has been documented (Good, *et al.* 1975; Whigham and Simpson 1976; Simpson *et al.* 1983a, 1983b, 1983c). Wetlands along heavily industrialized rivers in Rhode Island probably are retaining various heavy metals also. Additional study is needed to better understand retention mechanisms and capacities in wetlands.

Aquatic Productivity

Wetlands are among the most productive ecosystems in the world and they may be the highest, rivaling our best cornfields (Figure 25). Wetland plants are particularly efficient converters of solar energy. Through photosynthesis, plants convert sunlight into plant material or biomass and produce oxygen as a by-product. Other mate-

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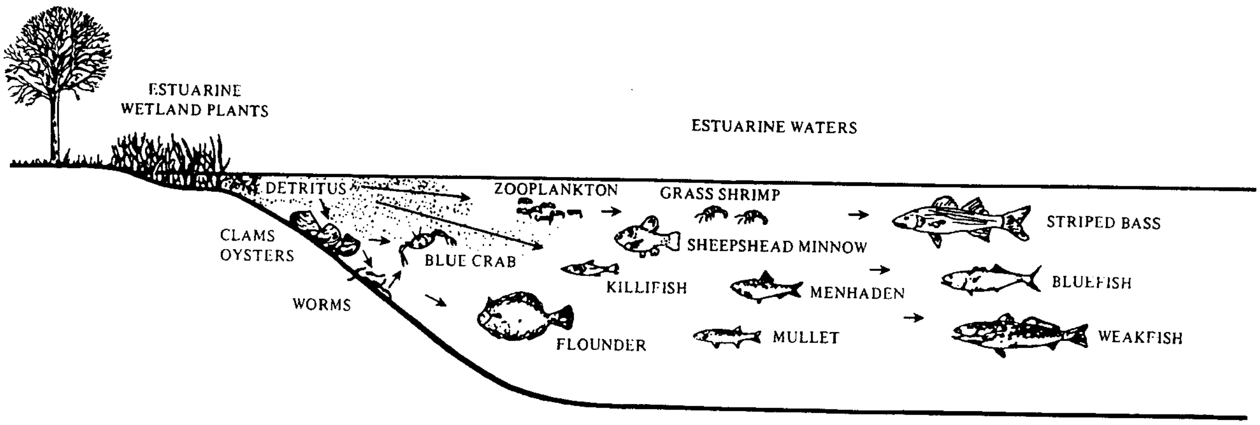

Figure 26. Simplified food pathways from estuarine wetland vegetation to commercially and recreationally important fishes and shellfishes.

rials, such as organic matter, nutrients, heavy metals, and sediment, also are captured by wetlands and either stored in the sediment or converted to biomass (Simpson, *et al.* 1983a). This biomass serves as food for a multitude of animals, both aquatic and terrestrial. For example, many waterfowl depend heavily on seeds of marsh plants, while muskrats eat cattail tubers and young shoots. Surprisingly, one of the favorite winter foods of the eastern cottontail is the tender new growth of red maples (Cronan and Brooks 1968).

Although direct grazing of wetland plants may be considerable in freshwater marshes, their major food value to most aquatic organisms is reached upon death when plants break down to form "detritus." This detritus forms the base of an aquatic food web that supports higher consumers, e.g., commercial fishes. This relationship is especially well-documented for coastal areas. Animals like zooplankton, shrimp, snails, clams, worms, killifish, and mullet eat detritus or graze upon the bacteria, fungi, diatoms and protozoa growing on its surfaces (Crow and Macdonald 1979; de la Cruz 1979). Forage fishes (e.g., anchovies, sticklebacks, killifishes, and silversides) and grass shrimp are the primary food for commercial and recreational fishes, including bluefish, flounder, weakfish, and white perch (Sugihara, *et al.* 1979). A simplified food web for estuaries in the Northeast is presented as Figure 26. Thus, wetlands can be regarded as the farmlands of the aquatic environment where great volumes of food are produced annually. The majority of non-marine aquatic animals also depend, either directly or indirectly, on this food source.

Socio-economic Values

The more tangible benefits of wetlands to society may be considered socio-economic values and they include flood and storm damage protection, erosion control, water supply and ground-water recharge, harvest of natural products, livestock grazing and recreation. Since these values provide either dollar savings or financial profit, they are more easily understood by most people.

Flood and Storm Damage Protection

In their natural condition, wetlands serve to temporarily store flood waters, thereby protecting downstream property owners from flood damage. After all, such flooding has been the driving force in creating these wetlands to begin with. This flood storage function also helps to slow the velocity of water and lower wave heights, reducing the water's erosive potential. Rather than having all flood waters flowing rapidly downstream and destroying private property and crops, wetlands slow the flow of water, store it temporarily and slowly release stored waters downstream (Figure 27). Wetlands, thereby, help reduce the peak flood heights as well as delay the flood crest. This becomes increasingly important in urban areas, where development has increased the rate and volume of surface water runoff and the potential for flood damage (Figure 28).

In 1975, 107 people were killed by flood waters in the U.S. and potential property damage for the year was estimated to be \$3.4 billion (U.S. Water Resources Council 1978). Almost half of all flood damage was suffered by farmers as crops and livestock were destroyed and productive land was covered by water or lost to erosion. Approximately 134 million acres of the conterminous U.S. have severe flooding problems (Figure 29). Of this, 2.8 million acres are urban land and 92.8 million acres are agricultural land (U.S. Water Resources Council 1977). Many of these flooded farmlands are wetlands. Although regulations and ordinances required by the Federal Insurance Administration reduce flood losses from urban land, agricultural losses are expected to remain at present levels

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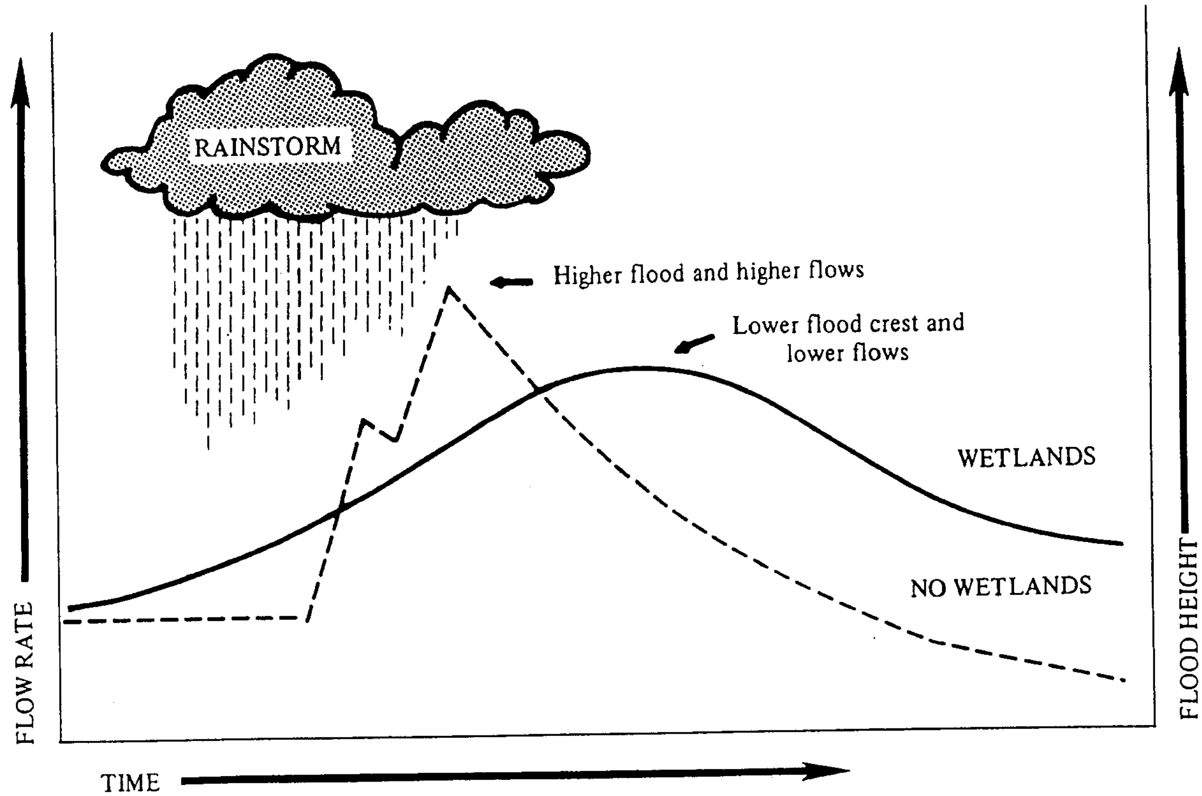

Figure 27. Wetlands help reduce flood crests and slow flow rates after rainstorms (adapted from Kusler 1983).

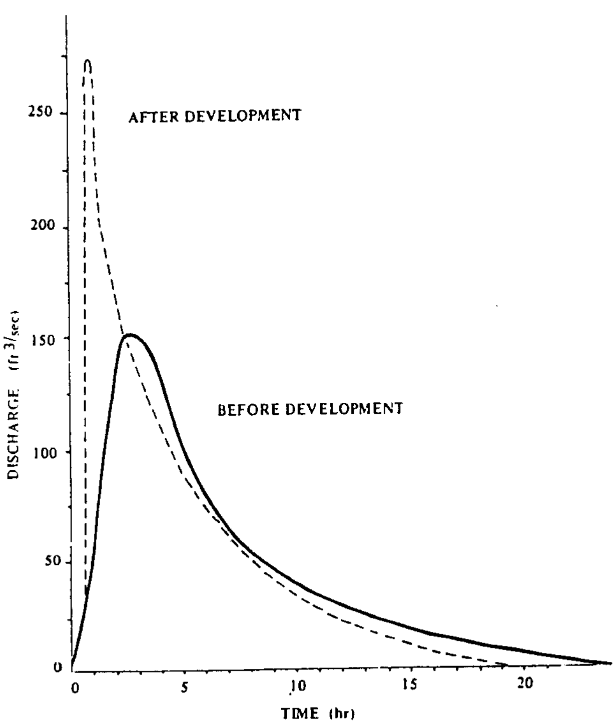

Figure 28. Urban development increases peak discharge in rivers. Comparisons of hydrographs for a watershed before and after development (redrawn from Fusillo 1981).

or increase as more wetland is put into crop production. Protection of wetlands is, therefore, an important means to minimizing flood damages in the future.

The U.S. Army Corps of Engineers have recognized the value of wetlands for flood storage in Massachusetts. In the early 1970's, they considered various alternatives to providing flood protection in the lower Charles River watershed near Boston, including: (1) a 55,000 acre-foot reservoir, (2) extensive walls and dikes, and (3) perpetual protection of 8,500 acres of wetland (U.S. Army Corps of Engineers 1976). If 40 percent of the Charles River wetlands were destroyed, flood damages would have increased by at least $3 million annually. Loss of all basin wetlands would cause an average annual flood damage cost of $17 million (Thibodeau and Ostro 1981). The Corps concluded that wetlands protection—"Natural Valley Storage"—was the least-cost solution to future flooding problems. In 1983, they completed acquisition of approximately 8,500 acres of Charles River wetlands for flood protection.

This protective value of wetlands has also been reported for other areas. Undeveloped floodplain wetlands in New Jersey protect against flood damages (Robichaud and Buell 1973). In the Passaic River watershed, annual property losses to flooding approached $50 million in

Figure 30. Cows often graze in wet meadows.

1981). These situations may hold true for Rhode Island and other states. Wetland protection and ground-water pollution control could be instrumental in helping to solve current and future water supply problems.

Ground-water Recharge

Ground-water recharge potential of wetlands varies according to numerous factors, including wetland type, geographic location, season, soil type, water table location and precipitation. In general, most researchers believe that most wetlands do not serve as significant ground-water recharge sites (Carter, *et al.* 1979). A few studies, however, have shown that certain wetland types may help recharge ground-water supplies by adding water to the underlying aquifer or water table. Shrub wetlands in the Pine Barrens may contribute to ground-water recharge (Ballard 1979). Depressional wetlands, like cypress domes in Florida and prairie potholes in the Dakotas, may also contribute to ground-water recharge (Odum, *et al.* 1975; Stewart and Kantrud 1972).

Floodplain wetlands also may do this through bank water storage (Mundorff 1950; Klopatek 1978). In urban areas where municipal wells pump water from streams and adjacent wetlands, "induced infiltration" may draw in surface water from wetlands into public wells. This type of human-induced recharge has been observed in Burlington, Massachusetts (Mulica 1977). These studies and others suggest that certain wetlands do help recharge ground-water and that additional research is needed to better assess the role of different types of wetlands in performing this function.

Harvest of Natural Products

A variety of natural products are produced by wetlands including timber, fish and shellfish, wildlife, peat moss, cranberries, blueberries, and wild rice. Wetland grasses are hayed in many places for winter livestock feed. During other seasons, livestock graze directly in numerous New England wetlands (Figure 30).

In the 49 continental states, an estimated 82 million acres of commercial forested wetlands exist (Johnson 1979). These forests provide timber for such uses as home construction, furniture, newspapers and firewood. Most of these forests lie east of the Rockies, where oak, gum, cypress, elm, ash and cottonwood are most important. The standing value of southern wetland forests is $8 billion. These southern forests have been harvested for over 200 years without noticeable degradation, thus they can be expected to produce timber for many years to come, unless converted to other uses. Rhode Island's forested wetlands provide timber for fuelwood and building construction. Braiewa (1983) reported on the biomass and fuelwood production of red maple stands in the state.

Many wetland-dependent fishes and wildlife are also utilized by society. Commercial fishermen and trappers make a living from these resources. From 1956 to 1975, about 60 percent of the U.S. commercial landings were fishes and shellfishes that depend on wetlands (Peters, *et al.* 1979). Nationally, major commercial species associated with wetlands are menhaden, salmon, shrimp, blue crab and alewife from coastal waters and catfish, carp and buffalo from inland areas. In Rhode Island, the 1985 commercial harvest of wetland-dependent coastal fishes (i.e., flounders, bluefish, weakfish, 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 according to National Marine Fisheries Service commercial catch and value data. The fisheries value of Rhode Island's coastal ponds is discussed by Lee (1980). Recreational fishing and shellfishing are important activities for many Rhode Island residents.

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Figure 29. Wetland destruction accelerates flood damages.

1978 and the Corps of Engineers is considering wetland acquisition as an option to prevent flood damages from escalating in the future (U.S. Army Corps of Engineers 1979). A Wisconsin study projected that floods may be lowered as much as 80 percent in watersheds with many wetlands compared with similar basins with few or no wetlands (Novitzki 1978). Pothole wetlands in the Devils Lake basin of North Dakota store nearly 75 percent of the total runoff (Ludden, *et al.* 1983).

Rhode Island's wetlands also serve as temporary storage basins for retaining flood waters, thereby reducing potential flood damages. The 3,000-acre Great Swamp, Chapman Swamp and numerous other wetlands provide great flood storage for the Pawcatuck River in Washington County and without these wetlands flooding of downstream uplands would be enormous. The Pawtuxet River system, in marked contrast, has fewer wetlands (many wetlands were filled) and less flood storage area. Consequently, Warwick and Cranston experience serious flooding problems. Annual flood losses in 1978 for the Pawtuxet River basin were about $1.5 million. Corps of Engineers projections for 1990 suggest that increased urbanization in the basin would raise flood losses to $3.6 million for a 20-year flood and $5.5 million for a 50-year flood (F. Golet, pers. comm.).

Shoreline Erosion Control

Located between watercourses and uplands, wetlands help protect uplands from erosion. Wetland vegetation can reduce shoreline erosion in several ways, including: (1) increasing durability of the sediment through binding with its roots, (2) dampening waves through friction, and (3) reducing current velocity through friction (Dean 1979). This process also helps reduce turbidity and thereby helps improve water quality.

Obviously, trees are good stabilizers of river banks. Their roots bind the soil, making it more resistant to erosion, while their trunks and branches slow the flow of flooding waters and dampen wave heights. The banks of some rivers have not been eroded for 100 to 200 years due to the presence of trees (Leopold and Wolman 1957; Wolman and Leopold 1957; Sigafoos 1964). Among the freshwater grass and grass-like plants, common reed (*Phragmites australis*) and bulrushes (*Scirpus* spp.) have been regarded as the best at withstanding wave and current action (Kadlec and Wentz 1974; Seibert 1968). Common three-square (*Scirpus pungens*) often forms fringing marshes along the margins of many Rhode Island lakes and ponds. Along the coast, salt marshes of smooth cordgrass (*Spartina alterniflora*) are considered important shoreline stabilizers because of their wave dampening effect (Knudson, *et al.* 1982). While most wetland plants need calm or sheltered water for establishment, they will effectively control erosion once established (Kadlec and Wentz 1974; Garbisch 1977). Wetland vegetation has been successfully planted to reduce erosion along U.S. waters. Willows (*Salix* spp.), alders (*Alnus* spp.), ashes (*Fraxinus* spp.), cottonwoods and poplars (*Populus* spp.), maples (*Acer* spp.), and elms (*Ulmus* spp.) are particularly good stabilizers (Allen 1979). Successful emergent plants include reed canary grass (*Phalaris arundinacea*), common reed, cattails (*Typha* spp.), and bulrushes in freshwater areas (Hoffman 1977) and smooth cordgrass along the coast (Woodhouse, *et al.* 1976).

Water Supply

Most wetlands are areas of ground-water discharge and their underlying aquifers may provide sufficient quantities of water for public use. In neighboring Massachusetts, 40 percent to 50 percent of the wetlands may indicate the location of productive underground aquifers—potential sources of drinking water. At least 60 municipalities in the state have public wells in or very near wetlands (Motts and Heeley 1973). Prairie pothole wetlands store water which is important for wildlife and may be used for irrigation and livestock watering by farmers during droughts (Leitch

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Nationally, furs from beaver, muskrat, mink, nutria, and otter yielded roughly $35.5 million in 1976 (Demms and Pursley 1978). Louisiana is the largest fur-producing state and nearly all furs come from wetland animals. In Rhode Island, muskrat harvest was valued at near $60,000 in 1980 and only about $6,500 in 1988 due to declining pelt prices (L. Suprock and M. Lapisky, pers. comm.). Currently, muskrats are an under-harvested resource.

Recreation and Aesthetics

Many recreational activities take place in and around wetlands. Hunting and fishing are popular sports. Waterfowl hunting is a major activity in wetlands, but big game hunting is also important locally. In 1980, 5.3 million people spent $638 million on hunting waterfowl and other migratory birds (U.S. Department of the Interior and Department of Commerce 1982). Moreover, nearly all freshwater fishing is dependent on wetlands. In 1975 alone, sportfishermen spent $13.1 billion to catch wetland-dependent fishes in the U.S. (Peters, *et al.* 1979). Fishing was reported to be the second most popular leisure sport in America in a 1985 Gallup Poll (Sport Fishing Institute 1986). Fishing was the top activity for adult men with 44 percent participating. Since 1977, there has been a steady increase in the percent of Americans fishing.

Other recreation in wetlands is largely non-consumptive and involves activities like hiking, nature observation and photography, and canoeing and other boating. Many people simply enjoy the beauty and sounds of nature and spend their leisure time walking or boating in or near wetlands and observing plant and animal life. This aesthetic value is extremely difficult to place a dollar value upon, although people spend a great deal of money traveling to places to enjoy the scenery and to take pictures of these scenes and plant and animal life. In 1980, 28.8 million people (17 percent of the U.S. population) took special trips to observe, photograph or feed wildlife. Moreover, about 47 percent of all Americans showed an active interest in wildlife around their home (U.S. Department of the Interior and Department of Commerce 1982).

Summary

Marshes, swamps and other wetlands are assets to society in their natural state. They provide numerous products for human use and consumption, protect private property and provide recreational and aesthetic appreciation opportunities. Wetlands may also have other values yet unknown to society. For example, a microorganism from Pine Barrens swamps of southern New Jersey has been recently discovered to have great value to the drug industry. In searching for a new source of antibiotics, the Squibb Institute examined soils from around the world and found that only one contained microbes suitable for producing a new family of antibiotics. From a Pine Barrens swamp microorganism, scientists at the Squibb Institute have developed a new line of antibiotics which will be used to cure diseases not affected by present antibiotics (Moore 1981). This represents a significant medical discovery. If these wetlands were destroyed or grossly polluted, this discovery might not have been possible.

Destruction or alteration of wetlands eliminates or minimizes their values. Drainage of wetlands, for example, eliminates all the beneficial effects of the wetlands on water quality and directly contributes to flooding problems (Lee, *et al.* 1975). While the wetland landowner can derive financial profit from some of the values mentioned, the general public receives the vast majority of wetland benefits through flood and storm damage control, erosion control, water quality improvement and fish and wildlife resources. It is, therefore, in the public's best interest to protect wetlands to preserve these values for themselves and future generations. Since over half of the Nation's original wetlands have already been destroyed, the remaining wetlands are even more valuable as public resources.

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CHAPTER 8.

Wetland Protection

Introduction

A variety of techniques are available to protect our remaining wetlands, including land-use regulations, direct acquisition, conservation easements, tax incentives, public education, and the efforts of private individuals and corporations. These techniques are discussed in numerous sources including Kusler (1983), Burke and others (1989), and Rusmore and others (1982).

Wetland Regulation

Several Federal and state laws or programs regulate certain uses of Rhode Island wetlands. The more significant ones include the Rivers and Harbors Act of 1899 and the Clean Water Act of 1977 at the Federal level and the Coastal Resources Management Program (1977) and Fresh Water Wetlands Act of 1971 at the state level. Key points of these laws are outlined in Table 21. In addition, Executive Order 11990—"Protection of Wetlands"—requires Federal agencies to develop guidelines to minimize destruction and degradation of wetlands and to preserve and enhance wetland values.

The foundations of Federal wetland regulations are Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. Federal permits for many types of construction in wetlands are required from the U.S. Army Corps of Engineers, but normal agricultural and silvicultural activities are exempt from permit requirements. The Service plays an active role in the permit process by reviewing permit applications and making recommendations based on environmental considerations, under authority of the Fish and Wildlife Coordination Act. Although the Federal laws in combination apply to virtually all of Rhode Island's wetlands, the U.S. Army Corps of Engineers' 1982 regulations for Section 404 of the Clean Water Act reduced its effectiveness for protecting wetlands. In particular, the widespread use of "nationwide permits" and the lack of strong enforcement were major weak points. Under the nationwide permit system, there was no required reporting or monitoring system, consequently there was no record of wetland loss and no effort to promote environmental or other public interest concerns. In Rhode Island, many wetlands lie above designated headwaters or exist in isolated basins and they were not protected under the 1982 regulations. Numerous lawsuits were filed nationwide against the Corps by concerned environmental organizations over the 1982 regulatory changes. Under an out-of-court settlement agreement (National Wildlife Federation vs. Marsh), the Corps issued regulations in November 1986 requiring closer Federal and state review of proposals to fill wetlands. Implementation of these new regulations needs to be monitored to assess their effectiveness of protecting wetlands.

Wetlands are regulated by the State of Rhode Island under two programs: (1) Coastal Resources Management Program and (2) Fresh Water Wetlands Program. The former program is administered by the Coastal Resources Management Council and deals with a wide range of coastal resources of which coastal wetlands are but one part (Olsen and Seavey 1983). The latter program is administered by the Department of Environmental Management (DEM). Both programs require permits for regulated activities in these wetlands.

Besides the Federal and state permit programs, Section 401 of the Federal Clean Water Act gives the state another powerful tool to protect wetlands. Any Federal permit or license which may involve a discharge to waters of the United States requires a Section 401 water quality certification from the state. The state reviews these permits to see if they meet state water quality standards. If they do not, then 401 certification is denied and the Federal permit cannot be issued. Consequently, DEM has the authority to issue, condition, waive or deny water quality certification for Federal permits including Section 404 permits. This program provides the state with another powerful tool to protect wetlands.

Wetland Acquisition

Wetlands may also be protected by direct acquisition or conservation easements. Many wetlands are owned by public agencies or by private environmental organizations, although the majority are privately-owned.

The U.S. Fish and Wildlife Service's National Wildlife Refuge System was established to preserve important migratory bird wetlands at strategic locations across the country. Four National Wildlife Refuges are located in Rhode Island: Trustom Pond (642 acres), Ninigret (408 acres), Sachuest Point (242 acres), Block Island (46 acres), and Pettaquamscutt Cove (26 acres). The State of Rhode Island possesses much wetland acreage. Many wildlife management areas include some large wetland complexes, such as Great Swamp (South Kingstown/ Kingston), Burlingame (Charlestown), and Blackhut (Burrillville). Wetlands are also located in various state parks and other conservation areas in Rhode Island (e.g., Audubon Society's Norman Bird Sanctuary in Middletown).

Future Actions

In an effort to maintain and enhance remaining wetlands, many opportunities are available to both government and the private sector. Their joint efforts will determine the future course of our Nation's wetlands. Major options have been outlined below:

Government Options

1. Strengthen Federal, State and local wetlands protection.
2. Ensure proper implementation of existing laws and policies through adequate staffing and improved surveillance and enforcement programs.
3. Increase wetland acquisition in vulnerable areas.
4. Remove government subsidies for wetland drainage.
5. Scrutinize cost-benefit analyses and justifications for flood control projects that involve channelization or other alteration of wetlands and watercourses.
6. Provide tax incentives to private landowners to encourage wetland preservation.
7. Increase support for the Water Bank and Conservation Easement Programs.
8. Increase the number of marsh creation projects, especially related to mitigation for unavoidable wetlands losses by government-sponsored water resource projects; this should include restoration of degraded or former wetlands.
9. Enhance existing wetlands through improving water quality and establishing buffer zones.
10. Monitor wetland changes especially with reference to effectiveness of State and Federal wetland protection efforts and periodically update the National Wetlands Inventory in problem areas.
11. Increase public awareness of wetland values and the status of wetlands through various media and environmental education programs.
12. Conduct research to increase our knowledge of wetland values and ecology.

Private Options:

1. Rather than drain or fill wetlands, seek more environmentally compatible, alternative uses of those areas, e.g., timber harvest, waterfowl production, fur harvest, hay and forage, wild rice production, and hunting leases.
2. Donate wetlands to private or public conservation agencies for tax purposes.
3. Maintain wetlands as open space and seek appropriate tax relief.
4. When selling property that includes wetlands, consider incorporating into the property transfer, a deed restriction or a covenant preventing future alteration and destruction of the wetlands and an appropriate buffer zone.
5. Work in concert with government agencies to help educate the public on wetland values, threats, and losses, for example.
6. Construct ponds in upland areas and manage them for wetland and aquatic species.
7. Purchase Federal and State duck stamps which support wetland acquisition.
8. Support in various ways, public and private efforts to protect and enhance wetlands.

Public and private cooperation is needed to secure a promising future for our remaining wetlands. In Rhode Island, as competition for wetlands between development and environmental interests increases, ways have to be found to achieve economic growth, while minimizing adverse environmental impacts. This is vital to preserving wetland values for our future generations and for fish and wildlife species.

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From:
A World In Our Backyard
A Wetlands Education and Stewardship Program
New England Interstate Water Pollution Control Commission

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

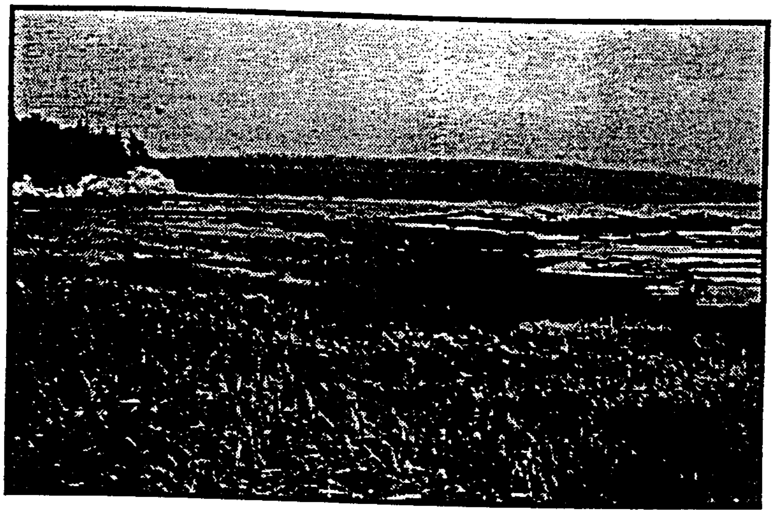
The following categories of wetlands are those common to New England. You can use this section to help you identify the type of wetland you'll be visiting on your field trip. You can also use the illustrations in this chapter to identify plants characteristic of each wetland type.

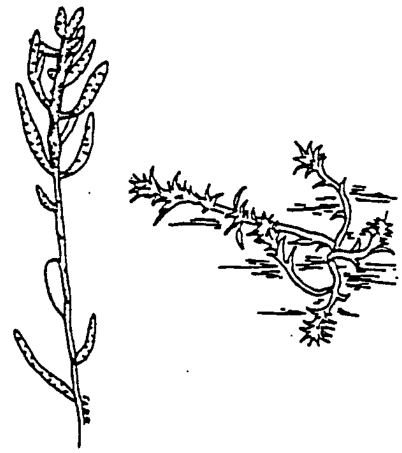
Forested wetlands are the most common wetland type in New England.

21

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.



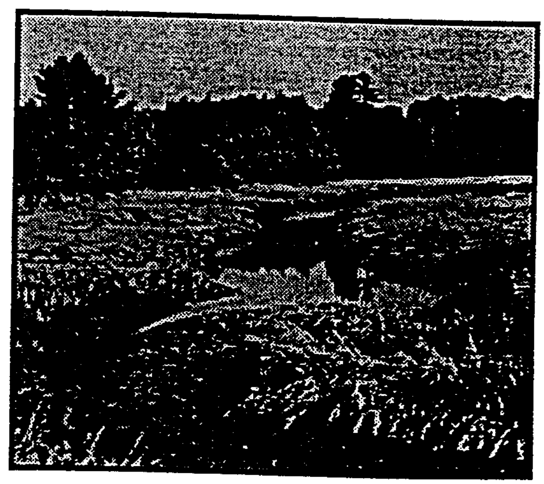


saltwort/glasswort

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.

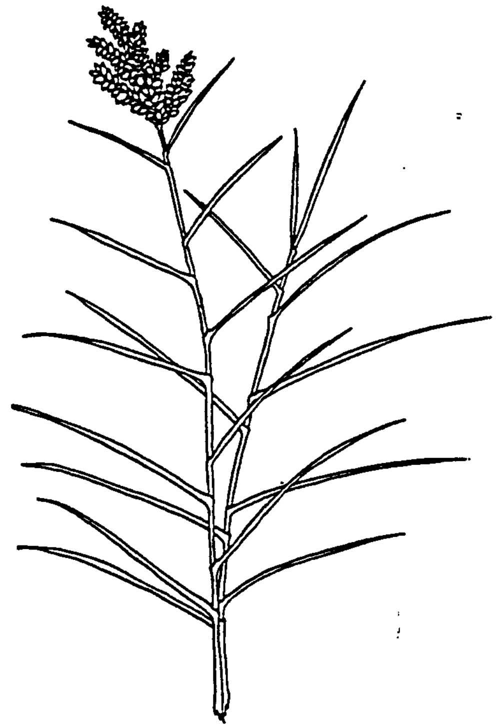


Tidal Brackish Marshes

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 europaea*


spike grass


sea lavender


smooth cordgrass

23

Inland Wetlands

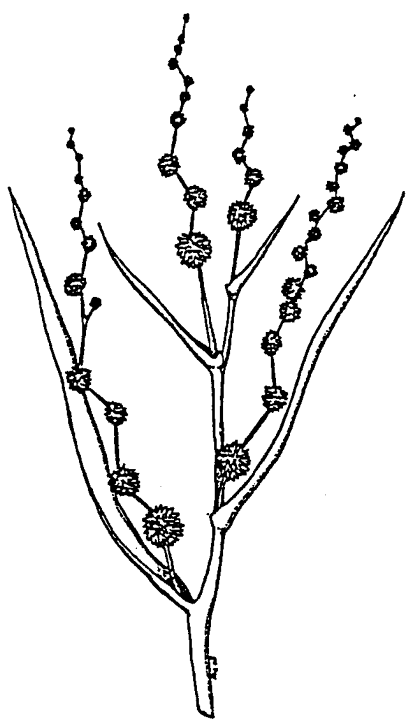
The majority of wetlands in the United States (95%) are inland wetlands. They occur throughout the interior of the country and are commonly found along the banks of rivers and streams, the margins of lakes and ponds, or as isolated depressions surrounded by dry land. The following are freshwater wetland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

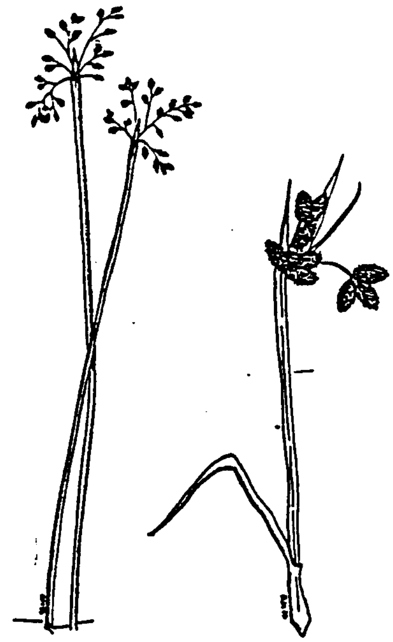
arrow arum



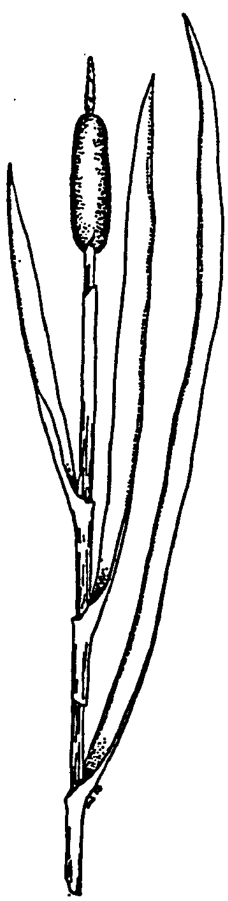
burreeds

Characteristic Plants for Freshwater Marshes

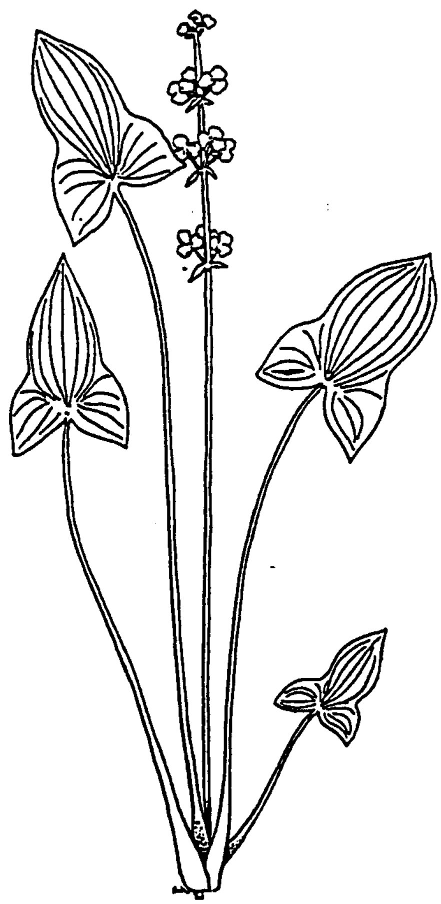
Common name	*Scientific name*
soft-stem bulrush	*Scirpus validus*
sedges	*Carex spp.*
burreeds	*Sparganium eurycarpum*
rushes	*Juncus spp.*
broad-leaved cattail	*Typha latifolia*
narrow-leaved cattail	*Typha angustifolia*
arrow arum	*Peltandra virginica*
arrowheads	*Sagittaria latifolia*
wild rice	*Zizania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



soft-stem bulrush



broad-leaved cattail



arrowhead

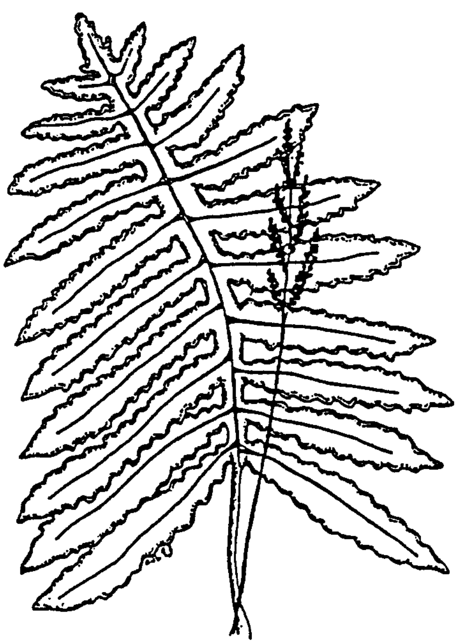
wild rice

25

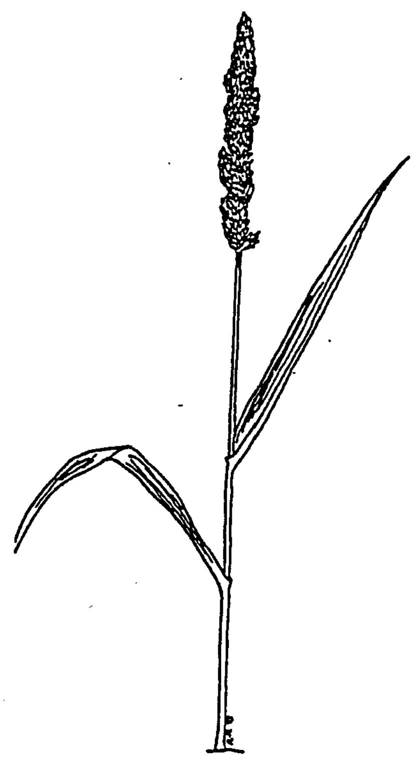
Wet Meadows

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



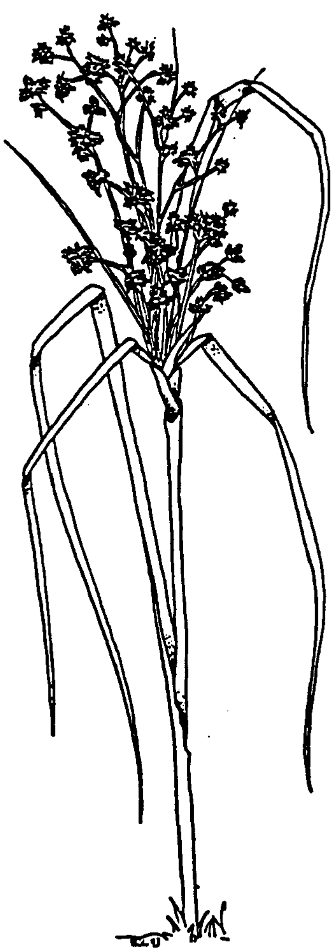
sensitive fern



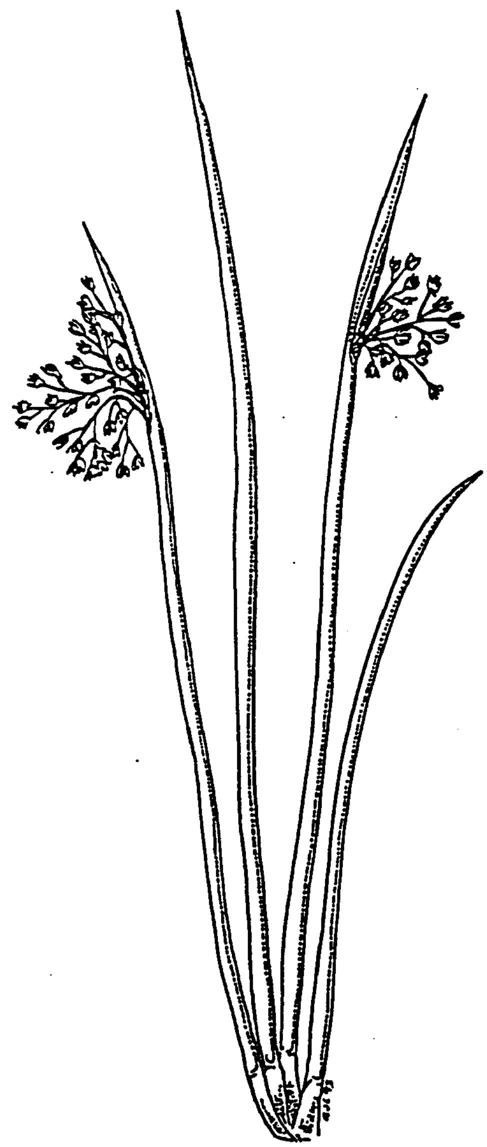
reed-canary grass

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

27

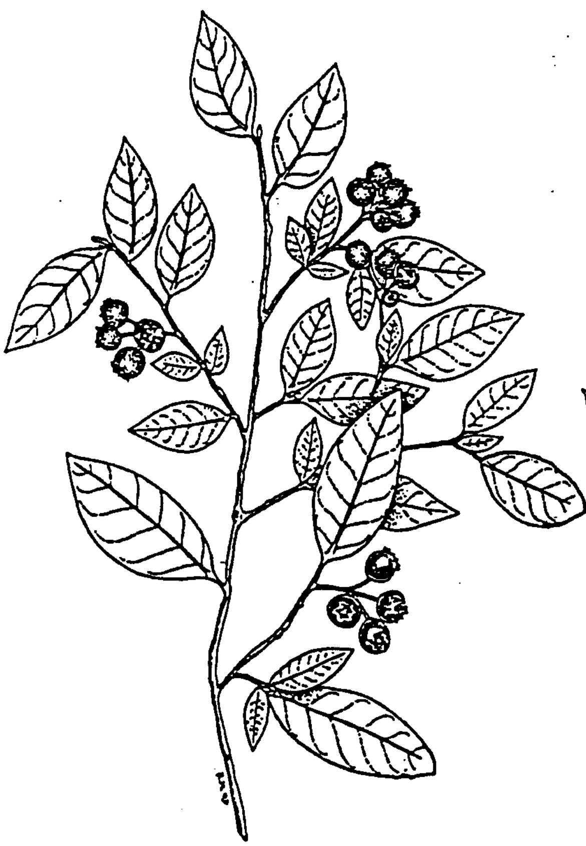
Swamps

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.

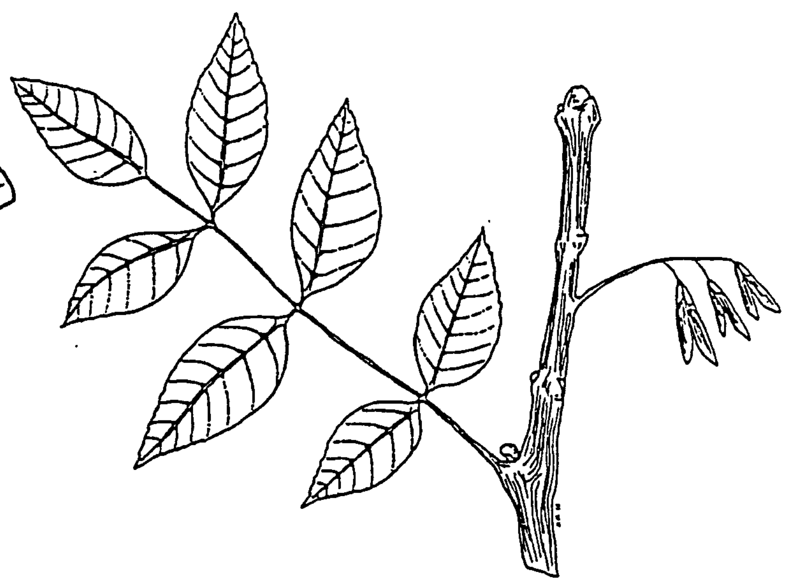
Forested Wetlands

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

winterberry holly



highbush blueberry

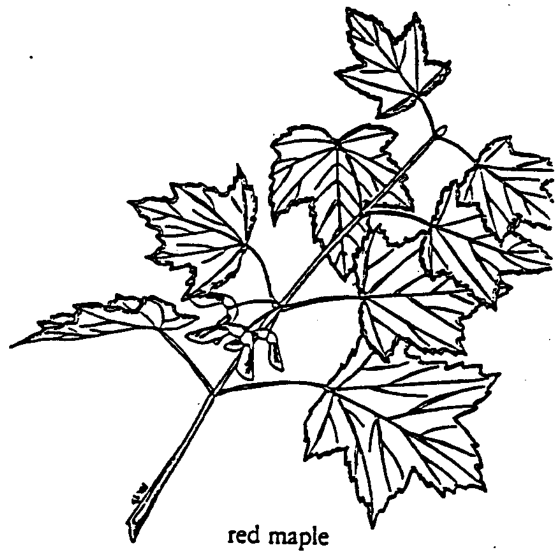


green ash

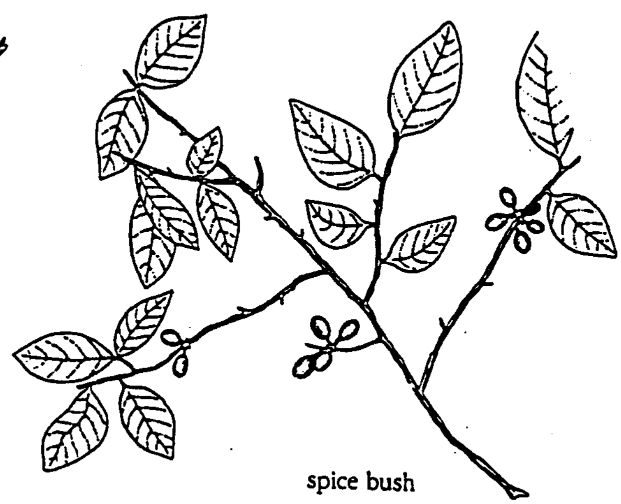
Characteristic Plants for Forested Wetlands

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

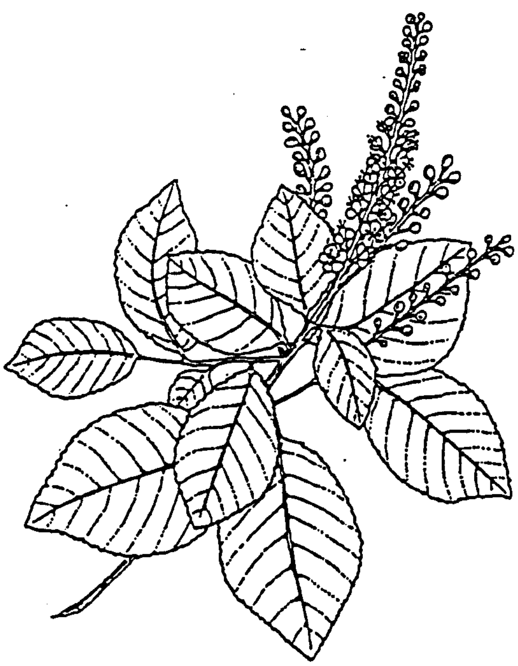

spice bush

29

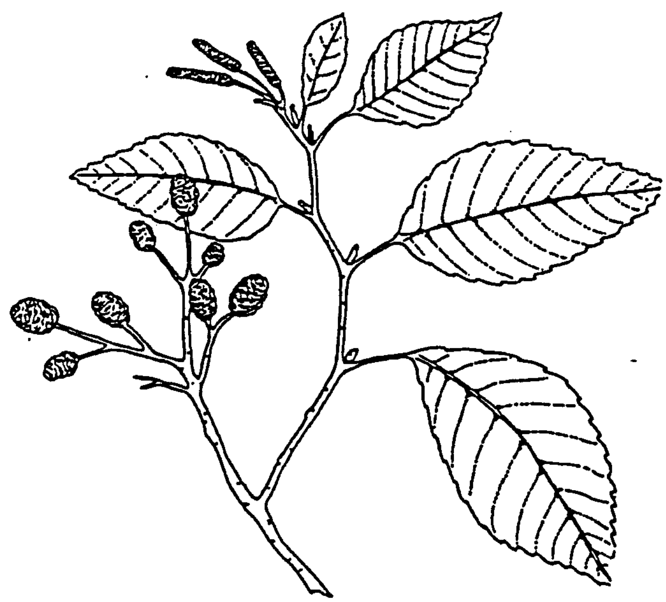
Shrub Swamps

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

buttonbush



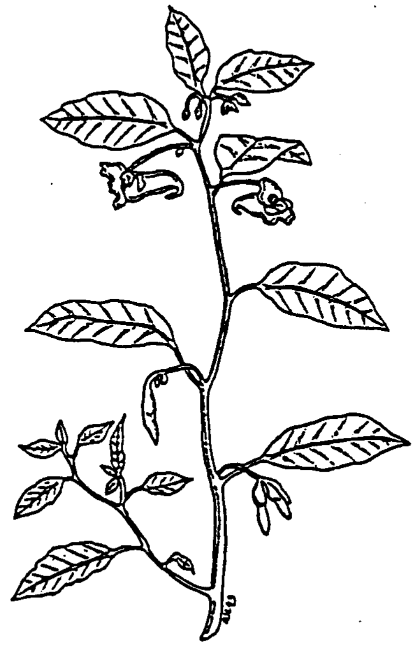
sweet pepperbush



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

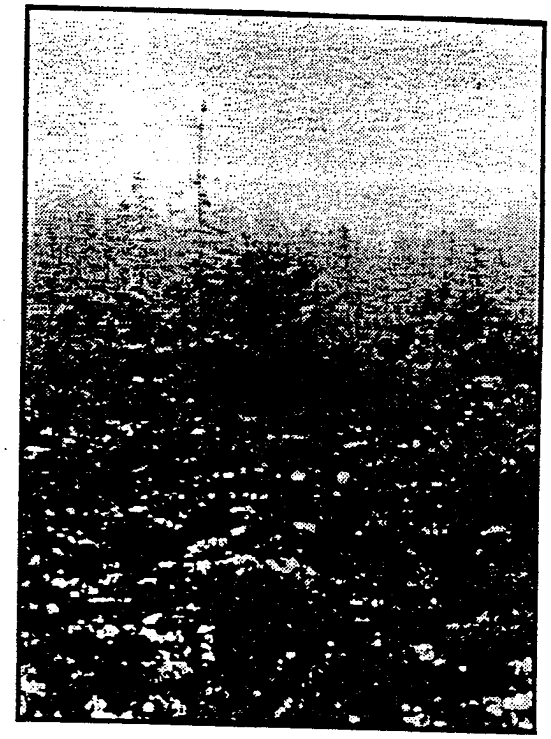
skunk cabbage

marsh marigold

31

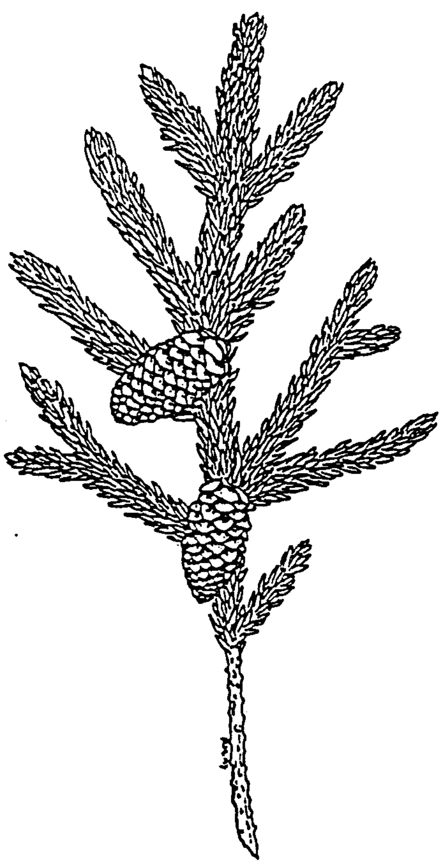
Bogs and Fens

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.

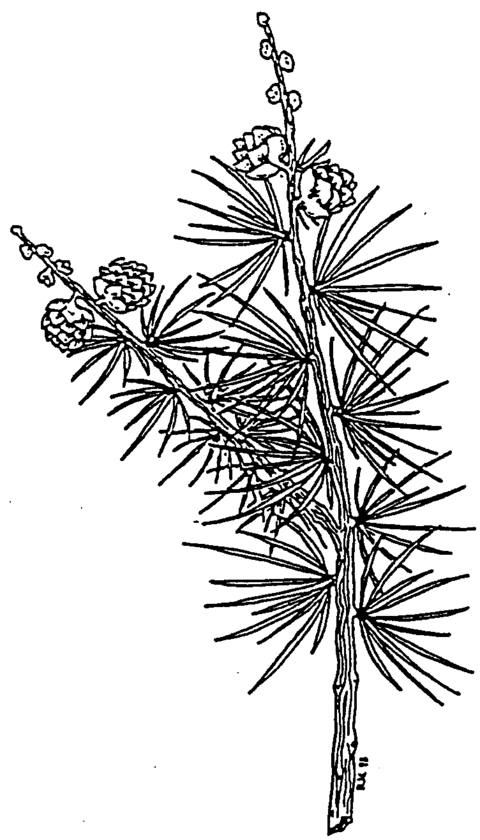


Bogs may eventually fill entirely with peat, giving way to the creation of a spruce or white cedar forest.

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

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.

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tem, swamps may augment domestic and municipal water supplies. Hydrogeologic studies have shown that heavy pumping of wells located in stratified drift aquifers may induce recharge of water from the surface, or from the soils, of overlying wetlands (Motts and O'Brien 1981; Ozbilgin 1982). While this gain of groundwater may be beneficial from an engineering standpoint, the loss of water from the wetland may be detrimental to fish and wildlife, recreation, and other wetland functions and values.

Except for surface-water depression wetlands that are perched above the regional groundwater table, natural recharge in most red maple swamps is likely to be a relatively brief seasonal phenomenon (O'Brien 1977). It occurs mainly during the late summer or early fall when, due to cumulative evapotranspiration losses, groundwater levels have dropped below the wetland surface, and groundwater discharge has ceased. O'Brien calculated that one red maple swamp in eastern Massachusetts recharged the regional groundwater body with 7 million gallons of water during a 6-week period in the fall; he noted that recharge could be significant during dry periods. In most cases, however, the volume of groundwater recharge in red maple swamps probably is far less than in the surrounding uplands—depending on the slope and soil permeability of the uplands—particularly on an annual basis.

Red maple swamps lying on slopes or in basins that intersect the regional groundwater table are predominantly areas of groundwater discharge. These swamps exist precisely because groundwater is emerging at the surface in the form of springs or seeps. The discharge of groundwater is important in itself because this water supplements public surface-water supplies, maintains fish and wildlife habitats, and improves the water quality of lakes and streams degraded by excess nutrient loads, toxic chemicals, or thermal discharges (Adamus 1986). Groundwater discharge maintains base flow of streams and keeps stream and lake temperatures low during the late summer, when both of these conditions are critical to aquatic invertebrates and cold-water fishes. Note, however, that evapotranspiration losses from swamps may lower base flow of streams during dry periods (Miller 1965).

Aside from recharge and discharge considerations, the spatial association of wetlands and groundwater aquifers is of great significance. Motts and O'Brien (1981) determined that, on an area basis, about two-thirds of Massachusetts wetlands overlie potential high-yield aquifers, and that at least 60 communities in that state obtain water from wells located in or near wetlands. Because the best location for municipal wells, from a purely hydrologic standpoint, is often near wetlands, and because wetlands are often hydrologically linked to underlying aquifers, Motts and O'Brien concluded that the protection of wetlands and their surroundings from pollution should be a integral part of any groundwater management program.

Water Quality Improvement

Since the mid-1970's there has been a great deal of research on the pollution-abatement potential of wetlands (e.g., Tilton et al. 1976; Kadlec and Kadlec 1979; Godfrey et al. 1985; Nixon and Lee 1986). This research has shown that many types of wetlands retain, remove, or transform pollutants and thus improve the quality of surface water. This pollution-abatement function is accomplished through physical settling, plant uptake, adsorption by soil particles, complexing with other chemicals in the soil, and microbial transformation (Burton 1981; Nixon and Lee 1986).

Most of the research on the water quality improvement function of forested wetlands has occurred outside of the glaciated Northeast. Hardwood swamps in various parts of the United States have been shown to significantly reduce concentrations of nitrogen and phosphorus in surface water during periods of inundation (Kitchens et al. 1975; Mitsch et al. 1979; Brinson et al. 1981b), and the potential capacity of forested wetlands for removing pesticides and heavy metals is believed to be high (Winger 1986). Only two papers have reported on the water quality improvement capacity of northeastern red maple swamps. In a comparison of grass- and forest-vegetated filter strips in Rhode Island, Groffman et al. (1991) demonstrated that denitrification rates were significantly greater ($P < 0.05$) in poorly drained soils of red maple swamps than in well drained soils of adjacent upland forests. In a second Rhode Island study, Gold and Simmons (1990) found that removal of nitrate from groundwater generally exceeded 80% in both poorly drained and very poorly drained soils of red maple swamps throughout the year. In almost all cases, nitrate attenuation was significantly higher ($P < 0.05$) in the swamps than in the moist (somewhat poorly drained and moderately well drained) forest soils of the bordering upland. Both studies concluded that forested wetlands are likely to be more effective than upland forests as sinks for nitrate. Prolonged anaerobic soil conditions and high soil organic matter content appear to be mainly responsible for the greater denitrification potential of the swamp soils; at the same time, high water tables bring groundwater contaminants closer to the surface where they may be picked up by plant roots.

Red maple swamps are so abundant in the Northeast, particularly in more urbanized sections such as northern New Jersey, southeastern New York and southern New England, that both point and nonpoint discharges of a wide variety of pollutants into these wetlands have been common occurrences. The most widespread problems are stormwater runoff and resulting goundwater contamination from residential subdivisions, highways, commercial and industrial sites, farms, and construction sites, as well as discharge of effluent from belowground sewage disposal systems into soils bordering wetlands. Judging from the preliminary findings in Rhode Island swamps and research results from wetland forests in other regions, it is reasonable to assume that red maple swamps receiving such pollutants perform a water quality improvement function of value to society. Given the abundance of these wetlands, the overall influence on water quality in the region may be significant.

Wildlife Habitat

The importance of red maple swamps as wildlife habitat was addressed in detail in Chapter 7. These swamps are important as breeding areas, seasonal feeding areas, and year-round habitat for a wide variety of birds, mammals, and amphibians; they may also provide important habitat for certain reptiles and invertebrates, but little research has been done on those taxa. The value of individual red maple swamps for particular wildlife species and for the entire wildlife community depends on several factors, including vegetation structure, water regime, surrounding habitat types, degree of human activity in or near the swamp, wetland size, and proximity to open water bodies and other wetland types (Golet 1976).

While red maple swamps are essential habitat for wetland-dependent species such as the northern waterthrush, they are also of great importance to facultative species, which are often considered upland wildlife. Examples include white-tailed deer, ruffed grouse (*Bonasa umbellus*), crows, American woodcock (*Scolopax minor*), several species of hawks and owls, raccoons, opossums, cottontails, squirrels, and a host of songbirds. In some urban areas, red maple swamps constitute the most significant natural habitat still available to these types of wildlife. The importance of these swamps to upland wildlife will undoubtedly increase as urbanization continues.

The social value of the wildlife habitat function of red maple swamps stems from wildlife-related activities such as hunting, birdwatching, nature study, and wildlife photography. The opportunity to observe wildlife in a natural setting is a vital part of the natural heritage value of wetlands. These pursuits are discussed later in this section.

Wood Products

In the north-central states and in the South, wetland forests are of great commercial value for lumber and pulpwood (Johnson 1979). In the Northeast, the commercial harvest of wood products in wetlands is less intensive, because of both the lower quality of the wood in many wetland forest trees and the greater availability of high-quality upland forest species. Black spruce, northern white cedar, and tamarack are species with significant commercial value, particularly where they occur in large stands. In Maine, black ash and red maple also are considered important timber species in wetlands (Widoff 1988).

The energy crisis of the 1970's in the United States prompted a reassessment of the value of many natural sources of fuel, including cordwood. Braiewa et al. (1985) demonstrated in Rhode Island that average annual biomass production of red maple on moderately well drained to very poorly drained sites (2,382 kg/ha) closely paralleled production of mixed hardwoods on moderately well drained sites (2,316 kg/ha), and greatly exceeded the production of mixed oaks on well drained sites (1,630 kg/ha). They estimated total cordwood production to be 105 cords/ha in a 55-year-old, seed-origin stand of red maple, and 50 cords/ha in a 46-year-old, sprout-origin stand. The authors concluded that southern New England red maple stands on imperfectly drained soils have high biomass production potential and should not be overlooked as a wood resource.

Large-scale commercial harvesting of wood products from northeastern red maple swamps is hindered by the relatively small size of many swamps, the complex pattern of private owner-

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ships, and state and federal wetland protection laws. The impacts of logging on other functions and values of these wetlands, such as wildlife habitat, open space, and recreation, must be carefully considered.

Sociocultural Values

Red maple swamps are also valuable to society for their scenic beauty, their contribution to biotic diversity, and their use as recreation and open-space areas. This collection of wetland values has been variously referred to as sociocultural or heritage values (Niering 1979) and aesthetic, recreational, and landscape values (Smardon 1988).

The scenic or aesthetic value of red maple swamps is most obvious at the landscape level during early fall when the brilliant yellow, red, and orange foliage of the swamps provides striking contrast to the upland vegetation whose foliage has not yet changed from the predominantly green shades of summer. Although red maple has the greatest visual effect because of its predominance, other species such as black gum and ashes may also be striking. Mixed stands of hardwoods and conifers offer a unique contrast in fall foliage in some swamps. Red maple swamps border major highways throughout the Northeast, and each fall these bright autumn colors are seen daily by thousands of motorists. Red maple swamps clearly are a distinctive part of the scenic beauty that characterizes this region.

The aesthetic value of red maple swamps can be appreciated on a more subtle level as well: in the flowers of the spicebush, which form a yellow haze in the understory of hillside seepage swamps and along upland drainageways in early spring; in the curious hoodlike inflorescence and broad green leaves of the skunk cabbage; in the lush growth of cinnamon ferns interspersed with dark pools of water, invoking images of the primeval forest (Fig. 1.1); in the fragrant aroma of sweet pepperbush flowers (Fig. 8.1) in late summer; or in the bright red fruits of the common winterberry throughout fall and winter. These also are common sights along northeastern roads and hiking trails; they are the details that create visual diversity in a predominantly forested landscape.

The public engages in a variety of forms of recreation in red maple swamps. Depending upon the water regime and the proximity of the swamps to open water, hunters may pursue waterfowl, deer, ruffed grouse, rabbits, squirrels, or even ring-necked pheasants (*Phasianus colchicus*) in these habitats. Red maple swamps are frequented by birdwatchers as well, especially during late spring when migrating warblers and other songbirds feed on insects attracted to the flowers and breaking leaf buds of red maple trees. Canoeing, hiking, and photographing nature are other forms of recreation that may be pursued in and along the edges of red maple swamps. Picking native highbush blueberries is another activity that is part of the cultural heritage associated with these forested wetlands.

Biotic diversity, particularly the presence of rare, threatened, unique, or unusual plants and animals, is itself an aspect of our natural heritage to which red maple swamps contribute. As noted previously, many species of plants and animals found in red maple swamps are classified in threatened or endangered conservation status categories by state agencies (see Appendixes B and D). Still, documentation of the flora and fauna (especially invertebrates) in red maple swamps has been limited; more detailed surveys are needed throughout the Northeast.

Pollen preserved for thousands of years in the sediments beneath red maple swamps provides tangible evidence of the changes in climate and plant communities that have occurred in the Northeast since the retreat of the glaciers (Beetham and Niering 1961). Thus, some red maple swamps may have considerable value for research and education.

In highly urbanized areas of the Northeast, red maple swamps also provide a natural, low-cost form of open space. Frequently, the term open space is limited to aesthetics and recreational value, but in many cases its chief value may be in reducing the visual and psychological impacts of urbanization on humans and their quality of life. Public parks, athletic fields, agricultural land, and other undeveloped uplands also provide open space, but wetlands are particularly well suited to this purpose for several reasons: (1) they perform a variety of other functions, such as flood storage and water quality improvement, that are highly valued by society; (2) they are unsuitable for most other land uses because of their wetness; and (3) they are frequently distributed in a linear pattern, paralleling watercourses, which maximizes human contact with undeveloped parts of the landscape. Red maple swamps are especially effective open-space areas (Fig. 8.2); the trees and shrubs provide a tall, visual screen between developed areas and help to reduce noise emanating from

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Fig. 8.1. Sweet pepperbush (*Clethra alnifolia*) in flower.

major highways or commercial and industrial zones. For all of the above reasons, the argument to preserve red maple swamps as open-space areas is both logical and compelling.

Human Impacts

Since European settlement of the glaciated Northeast began over 350 years ago, thousands of hectares of wetlands have been filled, drained, impounded, polluted, or otherwise altered. In the core of urban centers such as New York City, Boston, Providence, and Hartford, most natural wetlands probably had been eliminated prior to the late nineteenth century. Except for agricultural effects, which were highly significant in certain parts of the region, wetland losses in most rural areas were less severe until the rapid increase in urbanization that began in the mid-1900's. Passage of state and federal wetlands protection laws and regulations has slowed the rate of conversion, but weak enforcement, minimum legal size limits, and other exemptions have allowed certain wetlands to be altered without a permit. For these reasons, losses of inland wetlands are still occurring at a significant rate in many areas of the Northeast.

Documentation of the extent and causes of inland wetland losses is lacking for most of this region. Statistics are available only for southeastern Massachusetts (Larson et al. 1980; Tiner and Zinni 1988), southern Rhode Island (Golet and Parkhurst 1981), central Connecticut (Tiner et al. 1989), and Pennsylvania (Tiner and Finn 1986).

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Fig. 8.2. Red maple swamp providing open space amidst residential and industrial development. Such urban swamps also are important for recreation, nature study, flood storage, water quality improvement, and wildlife habitat. *Outlined areas* labelled "u" represent upland habitats.

Table 8.1. *Examples of gross loss rates for inland vegetated wetlands in the glaciated Northeast. Losses include changes from wetland to nonwetland, wetland to open water, and wetland to farmland (including cranberry bog).*

Location	Percent loss	Study period	Source
Pennsylvania			
Northern Poconos	15	1950's-70's	Tiner and Finn (1986)
Northwestern region	5	1950's-70's	Tiner and Finn (1986)
New Jersey			
Passaic County	15	1940-78	Tiner (1985)
Central Passaic River basin	50	1940-78	Tiner (1985)
Rhode Island			
South Kingstown	1	1939-72	Golet and Parkhurst (1981)
Massachusetts			
Bristol County[a]	7	1951-71	Larson et al. (1980)
Plymouth County[b]	2	1977-86	Tiner and Zinni (1988)
15 communities[c]	4	1951-77	Organ (1983)
Connecticut			
Central region[d]	0.6	1980-86	Tiner et al. (1989)

[a]Only nonforested wetlands were included in this study.
[b]Study area included most of Plymouth County and small sections of Norfolk, Bristol, and Barnstable counties.
[c]Communities were scattered across the state, and represented a wide range of physiographic characteristics and population densities.
[d]Study area included two-thirds of Hartford County and smaller portions of New Haven, Tolland, and Middlesex counties.

Information on losses of forested wetlands is even more scarce. Because forested wetlands predominate throughout the Northeast, the loss of these wetlands is assumed to be at least as great as that for other types of inland wetlands. With minor exceptions, such as timber harvesting, the causes of forested wetland alteration also are similar to those for other inland wetland types.

Rates of Wetland Loss

Loss rates reported for inland vegetated wetlands in the glaciated Northeast vary widely with geographic location and with the geographic scope of individual studies (Table 8.1). The greatest losses have occurred near major metropolitan areas. For example, nearly 50% of the wetland area in the central Passaic River basin of northern New Jersey was destroyed between 1940 and 1978; losses in Passaic County as a whole approached 15% during that period (Tiner 1985). The 4% loss of palustrine vegetated wetland between 1951 and 1977 in 15 communities scattered across the state of Massachusetts (Organ 1983) is probably an average figure for southern New England over that period. In Bristol County, Mass., however, 7% of the inland nonforested wetlands were lost over roughly the same period (1951–71). Recent studies show that the rate of wetland conversion in southeastern Massachusetts—and undoubtedly in other areas of the Northeast as well—remains significant even after implementation of state and federal regulatory programs. Tiner and Zinni (1988), for example, found that over 2% (513 ha) of the palustrine vegetated wetland in the Plymouth County area of Massachusetts was converted to upland, to open water, or to managed cranberry bogs between 1977 and 1986. More than 260 ha of forested wetlands were lost during that 9-year period.

Principal Causes of Wetland Loss

Although documentation is lacking, conversion of wetlands for agriculture, the construction of impoundments for hydropower and water supply, and the cutting of swamp timber for lumber, fence posts, and fuelwood were probably the dominant forms of inland wetland alteration in the Northeast prior to the mid-1800's. Since that time, and especially since World War II, urbanization has emerged as the predominant force impacting wetlands in most parts of this region. The extent and causes of wetland loss have been documented in several areas of southern New England (Table 8.2).

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Table 8.2. *Relative importance (% of total loss) of various causes of inland wetland loss in southern New England. Losses include changes from wetland to nonwetland, wetland to open water, and wetland to farmland (including cranberry bog).*

Cause	15 communities, Massachusetts[a] (1951–77)	Bristol County, Mass.[b] (1951–71)	Plymouth County, Mass.[c] (1977–86)	Southern Rhode Island[d] (1939–72)	Central Connecticut[e] (1977–86)
Agriculture	17	20	64		1
Impoundments	1	15	15	2	19
Highway construction	21	12	1	38	14
Residential development	21	9	3	20	10
Commercial development	25[f]	3	4	6	14
Recreational facilities	7	11	4	6	11
Public facilities	2	1	1	10	
Dumps and landfills		10			
Industry	—[g]	8		1	
Mineral extraction	1	1		6	6
Peat harvesting					
Dam removal					6
Other and undetermined	6	9	8	11	19
Total loss (ha) during study period	442	244	513	28	99
Size of study area (km^2)	1,300	1,435	1,641	159	1,997

[a] Study by Organ (1983); communities varied widely in physiography and population density.
[b] Only nonforested wetlands were inventoried (Larson et al. 1980).
[c] Study area included most of Plymouth County and small sections of Norfolk, Bristol, and Barnstable counties (Tiner and Zinni 1988).
[d] Data from South Kingstown, R.I. (Golet and Parkhurst 1981).
[e] Study by Tiner et al. (1989).
[f] Value includes commercial and industrial development.
[g] Included in data for commercial development.

A brief review of the most significant causes of wetland loss follows. All of these agents of change affect red maple swamps throughout the Northeast, but the relative importance of each varies geographically.

Agriculture

Conversion of wetlands for agriculture was a major cause of inland wetland loss in many areas of the Northeast historically, and it is still an important factor today, most notably in New York, New Jersey, and parts of southern New England. As of 1968, the State of New York had more than 14,000 ha of drained mucklands—farmed wetlands with organic soils or mineral soils high in organic matter content (Tiner 1988). The bulk of these drained wetlands are located in the Lake Ontario basin and in southeastern New York. Muckland farming and drainage for pasturage have been significant causes of wetland loss in Middlesex, Sussex, and Warren counties in northern New Jersey as well (Tiner 1985).

Most of the managed cranberry bogs in the Northeast have been developed in former palustrine vegetated wetlands. Larson et al. (1980) found a net increase of 28 ha of cranberry bogs in Bristol County, Mass., between 1951 and 1971. In nearby Plymouth County, 172 ha of vegetated wetlands were converted to cranberry bogs between 1977 and 1986 (Tiner and Zinni 1988). Nearly 100 ha of those new bogs were produced from forested wetlands, the majority of which were red maple swamps (Fig. 8.3). Other forested wetlands in the vicinity were impounded to provide irrigation water for the cranberry bogs. Overall, conversion to agriculture (cranberry bogs or cropland) was responsible for 64% of the wetland loss measured by Tiner and Zinni (Table 8.2). In some areas of New England, where agricultural practices have been abandoned, the lack of maintenance of drainage ditches has caused the land to revert to wetland (Office of Technology Assessment 1984).

Fig. 8.3. Southern New England red maple swamp cleared for cranberry bog expansion.

Construction of Impoundments

Major impacts to vegetated wetlands occurred when thousands of dams were constructed on northeastern streams for hydropower, industrial and public water supply, flood control, and recreation. Where impoundments were small, and associated streams were high-gradient, the losses of wetland probably were small at any single site, but the cumulative impacts of these dams must have been considerable. Where constructed lakes were large, such as Flagstaff Lake in Maine, thousands of hectares of swamp were inundated (Widoff 1988). Widoff estimated that losses of vegetated wetland to impoundments in Maine may exceed 12,000 ha, nearly 30% of the total wetland loss—second only to wetland losses from urbanization. Tiner (1985) listed reservoir construction as a major cause of wetland loss in New Jersey as well. In trend analysis studies of wetlands in southeastern Massachusetts (Larson et al. 1980; Tiner and Zinni 1988), construction of impoundments was found to be responsible for about 15% of vegetated wetland losses. The principal functions of these water bodies were municipal water supply and water storage for irrigation of cranberry bogs.

Highway Construction

Although road construction can be considered one facet of urbanization (see below), it is treated separately here because of its importance. Highway construction represents one of the most significant causes of wetland alteration in the Northeast, both directly through wetland filling and draining, and indirectly by improving access to formerly isolated areas and thus stimulating secondary incursions into wetlands. Construction of interstate highways through northern New Jersey, for example, has filled large areas of wetland and, at the same time, fragmented major wetland complexes, permitting the continued expansion of the New York metropolitan area (Tiner 1985). This same phenomenon can be observed in the vicinity of any of the major urban areas in the Northeast.

In rural areas, filling due to highway construction may represent one of the primary causes of wetland loss. Road-building was the most frequent type of impact identified in a random survey of 100 Vermont wetlands (Wanner 1979). Between 1951 and 1971, nearly 30 ha of inland wetland were directly lost to road construction in Bristol County, Mass.; another 36 ha of wetland were converted from one wetland type to another as the new roads altered wetland water regimes (Larson et al. 1980). In South Kingstown, R.I., road construction accounted for almost 40% of the wetland loss between 1939 and 1972 (Golet and Parkhurst 1981). In Maine, Widoff (1988) estimated that roads were responsible for about 10% of the state's total wetland loss.

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Urbanization

In most areas of the Northeast, urbanization (including highway construction) is now responsible for more inland wetland losses than all other causes combined. In major metropolitan areas, it has been the principal factor for decades. The impact of urbanization on wetlands in any geographic area usually is closely related to the population density of that area. Once again, northern New Jersey is a prime example. The Office of Technology Assessment (1984) reported that 20–50% of Troy Meadows and three large swamps (Great Piece, Little Piece, and Hatfield) in the Passaic River basin have been destroyed as a result of highway construction and subsequent commercial, industrial, and residential development. The effects of urbanization are noticeable even in the most rural parts of the Northeast. Construction of interstate highways has spawned a series of resort communities in areas such as the Poconos of northeastern Pennsylvania (Tiner 1984), upstate New York, and the White Mountains of New Hampshire. Significant wetland losses have occurred in some of those areas as a result.

Data gathered in southern New England trend analysis studies (Table 8.2) suggest that residential and commercial development and the development of recreational facilities such as golf courses and athletic fields frequently contribute heavily to wetland losses in rural and suburban areas undergoing rapid population increases. Once again, road construction is an integral part of such urbanization. In Maine, as in much of the Northeast, the impacts of urbanization were historically greatest in coastal wetlands and along major rivers (Widoff 1988). Current losses are most common in small (less than 4 ha) inland wetlands in southern Maine where population growth has been most dramatic. Widoff ranked residential and commercial development as the single most important cause of vegetated wetland loss in Maine; she estimated that urbanization has been responsible for nearly 40% (more than 16,000 ha) of the total losses.

Peat Harvesting

One additional agent of wetland destruction in some areas of the Northeast is the harvesting of peat, primarily for horticultural use. Peat harvesting is a major industry in states such as Minnesota and North Carolina, but it has been practiced to some degree in several of the northeastern states as well. It is an important cause of wetland loss in the Poconos of northeastern Pennsylvania (Tiner 1984). In Maine, this industry peaked during the 1930's and 1940's, but most operations closed down for economic reasons (Widoff 1988). Widoff estimated that 2% (910 ha) of Maine's vegetated wetland loss may be due to peat harvesting.

Peat harvesting for horticulture generally is carried out in *Sphagnum* bogs, which contain large quantities of poorly decomposed fibric peat. This type of peat has the highest moisture retention capacity and so is most valuable as a soil conditioner. Since red maple swamps have mineral soils or well-decomposed (sapric) to moderately well-decomposed (hemic) organic soils, they are of little value as a source of horticultural peat. During the 1970's, when the United States experienced a brief, but severe, shortage of fossil fuels, considerable attention was focused on the possible use of peat as a supplementary energy source. The uncertainty of continued fossil fuel availability suggests that pressures to harvest peat from northeastern wetlands for energy production may increase. Sapric and hemic peats generally have higher energy value per unit of weight than fibric peat (Farnham 1979). For this reason, red maple swamps and other types of forested wetlands with organic soils may be seriously considered as potential sources of energy-producing peat in future years.

Other Forms of Wetland Alteration

Although direct losses clearly have the greatest impact on the wetland resource, other alterations beside total destruction may also significantly affect the structure and functions of wetlands and their value to society. The following paragraphs identify some of these additional forms of alteration.

Tree Cutting

Cutting of wetland trees for fuel and fence posts was common in the Northeast prior to the decline of agriculture in the late nineteenth century. Widoff (1988) noted that timber harvesting is still widespread in Maine wetlands during the winter. In southern Rhode Island (Golet and Parkhurst 1981) and in New Jersey (Tiner 1985), selective cutting of Atlantic white cedar has converted some mixed wetland forests to predominantly red maple. Larson et al. (1980) speculated that much of the shrub swamp and shallow marsh in their southeastern Massachusetts study area was formerly forested wetland that had been cleared for

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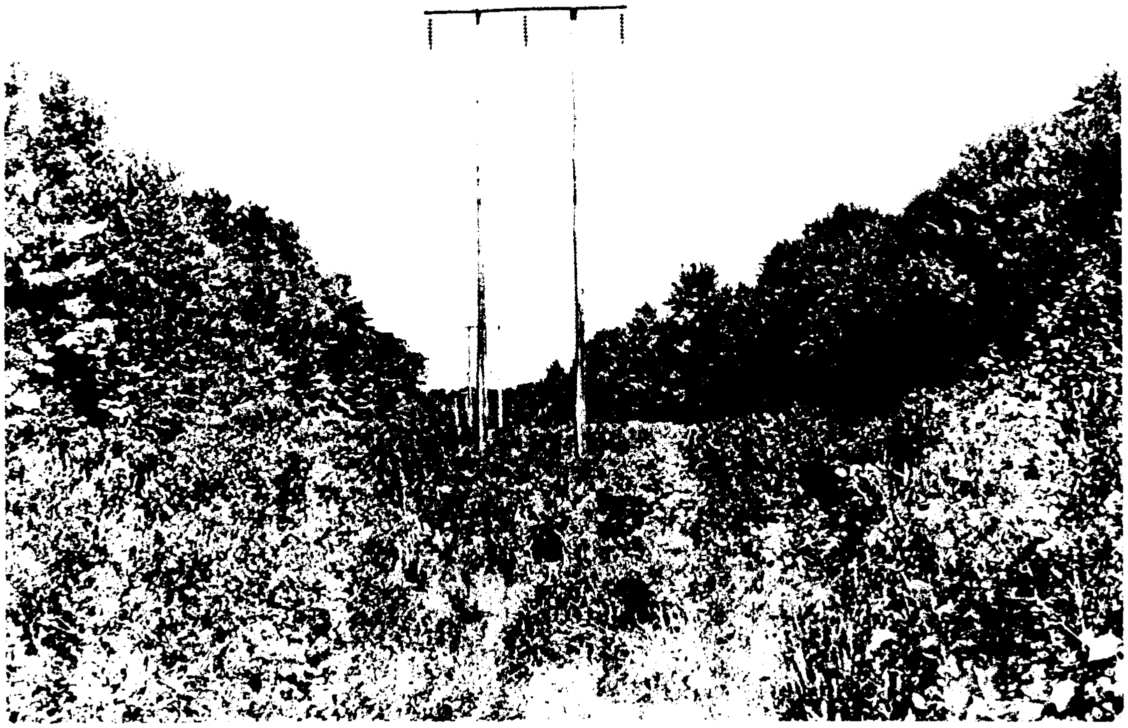

Fig. 8.4. Electric utility lines passing through a former red maple swamp. Forested swamp flanks the powerline on either side while shrub swamp dominates the right-of-way.

agricultural purposes. In northeastern Connecticut, red maple swamps were sometimes clear-cut for fuelwood during the first half of the twentieth century (Grace 1972).

Clearing of forested wetland for utility rights-of-way is a major form of alteration that is growing in importance throughout the Northeast (Fig. 8.4). In a sample of 100 Vermont wetlands surveyed in 1974, 14% had been affected by transmission lines (Wanner 1979). The impacts of cutting usually are compounded by wetland filling for the construction of power line maintenance roads.

The degree of impact of timber removal on wetland functions and values depends on the intensity of cutting. Clear-cuts radically alter habitat values and may result in slightly higher water levels during the summer because of reduced transpiration losses; selective cutting may have far less impact. Timber harvesting for wood products is not currently a major form of alteration in red maple swamps, but increasing energy costs and elimination of upland forests by urbanization may heighten the importance of this activity in the future.

Water Level Manipulation

Human-induced changes in the water regime of a red maple swamp may have major impacts on the floristic composition and structure of the plant community, its habitat values, and its scenic and recreational values. Prior to the passage of wetland protection regulations, changes in wetland water regimes were a common consequence of highway construction. Culverts that were incorrectly designed, improperly installed, or omitted altogether frequently resulted in impoundment of water on the upstream side of the road and a reduction in surface-water flow to the downstream side. Such impoundment commonly converted red maple swamps to marshes or shrub swamps. These impacts are less common today where wetland regulations are strictly enforced; however, sediment accumulation in culverts under roads may cause gradual changes in water regimes with the same ultimate result (Golet and Parkhurst 1981). Nearly 60% of the human-induced changes in inland wetlands of South Kingstown, R.I., between 1939 and 1972 were retrogressive; raised water levels were the cause in most cases.

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Groundwater withdrawal by large municipal wells has been a suspected cause of water level declines in a number of swamps in southern New England (D. Albro, Rhode Island Department of Environmental Management, Providence, personal communication; F. Golet, personal observation), but none of these cases has been documented through field measurement. Heavy withdrawal of surface water from streams and lakes for irrigation of crops also may lower water levels in adjacent swamps, particularly in dry summers. Reductions in surface-water hydroperiods in both instances could adversely affect the habitat value of forested swamps for amphibians, waterfowl, and wetland-dependent songbirds such as the northern waterthrush. In some southern New England communities, extensive networks of ditches have been constructed in red maple swamps for the purpose of mosquito control.

Stormwater and Wastewater Discharges

The addition of stormwater runoff and wastewater effluent to red maple swamps may alter both the hydrologic regime and water quality (Fig. 8.5). The volume of storm water runoff entering wetlands from surrounding upland areas may increase dramatically as those areas are urbanized. The increase in impervious surface area (highways, parking lots, rooftops) that accompanies urbanization decreases groundwater recharge and increases runoff. Increased runoff can

Fig. 8.5. Stormwater discharge in a red maple swamp. Such discharges may alter both water regime and water quality in these wetlands.

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sessment of wetland functions and values, impact assessment, and mitigation. The following discussion highlights some of the key management issues affecting red maple swamps in the glaciated Northeast.

Boundary Delineation

Wetland identification and delineation are a critical first step in the regulatory process. This step determines which parcels of land are subject to regulation and defines the area within which values and environmental effects will be assessed. In some instances, the transition from wetland to upland is abrupt, the changes in vegetation and soils are obvious, and the location of the wetland boundary is subject to little debate. In other cases, where the slope of the moisture gradient is gradual, no well-defined break may be apparent. The task of boundary location is especially difficult in many red maple swamps because the dominant plants in the swamps are usually facultative species (FACW, FAC, or FACU) that also grow in the adjacent uplands. Swamps located on hillsides or over perched groundwater systems pose a particular problem because changes in surface elevation may not directly correspond to variations in soil moisture.

"Multiparameter" approaches to wetland delineation (e.g., Environmental Laboratory 1987; Federal Interagency Committee for Wetland Delineation 1989) generally assume that vegetation, soils, and hydrologic criteria are perfectly correlated. Actually, empirical data on relations among these three classes of variables are lacking for most wetland types (Allen et al. 1989). Even if the criteria set forth in a particular method are strongly correlated, the accuracy of the method will be limited, if only because the criteria themselves are gross simplifications of nature (Scott et al. 1989).

Allen et al. (1989) tested the agreement between the hydric status of soils, as determined from the national hydric soils list (U.S. Soil Conservation Service 1987), and the average wetland indicator status (Reed 1988) of plants growing in the transition zones of three Rhode Island red maple swamps. They found that herb layer vegetation exhibited the most clearly defined moisture gradient, correlated best with hydric soil status, and permitted the most precise discrimination between upland and wetland. A moisture-related gradient was reflected in the tree layer also, but it was not as consistent as in the herb layer. In the two shrub layers examined, the predominance of facultative species along the entire length of most wetland-to-upland transects obscured moisture-related gradients in vegetation. For this reason, the shrub layers were found to be of little value in locating a wetland–upland vegetation break. Local variations in surface elevation and soil properties often caused the status (wetland vs. upland) of contiguous sample plots to alternate, even in the herb layer; in such instances, the wetland boundary was more aptly represented as a zone, rather than a line. Boundary zones derived from herb layer data ranged in width from 5 to 46 m.

The development of standard hydrologic criteria for wetland delineation is probably unfeasible because of the complex variability in hydrologic conditions over time and the lack of long-term measurements at specific sites. As already noted, boundary determination using only vegetation may be difficult to achieve in many red maple swamps because of the high proportion of facultative species. For these reasons, it seems appropriate to place major emphasis on the hydric status of soil in the delineation of red maple swamps (Allen 1989). This conclusion is consistent with the hierarchy of decisions in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee for Wetland Delineation 1989). In the Northeast, most hydric soils are very poorly drained or poorly drained (Tiner and Veneman 1987). Consistent inclusion of these two drainage classes of soils within regulated wetlands is logical also from the standpoint of wetland functions and values and hazards to development.

Mitigation by Replacement or Enhancement

Since the mid-1980's, the term "wetland mitigation" has become synonymous with wetland replacement or enhancement (Golet 1986). Replacement entails the creation of new wetland from upland to compensate for the wetland destroyed in a particular project. Enhancement proposals generally seek to compensate for wetland losses by changing a remaining part of the wetland that is to be altered, or changing a nearby wetland, in a manner that enhances certain functions or values. For example, conversion of one area of forested wetland to marsh by artificially raising the water level might be proposed as a means of increasing the wetland's value for waterfowl and compensating for the filling of a second area of wetland for development purposes. Mitigation by replacement

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and enhancement has been a highly controversial topic in recent years, for both scientific and philosophical reasons (Golet 1986; Larson and Neill 1987; Thompson and Williams-Dawe 1988). Kusler et al. (1988) presented a comprehensive review of mitigation issues, approaches, and policies. Important issues surrounding this topic are outlined below.

The scientific standard for determining whether mitigation is truly replacing the lost wetland should be functional performance (Larson and Neill 1987); that is, the replacement wetland should be able to perform the same functions as the wetland destroyed. Adamus (1988) took the additional step of recommending that replacement wetlands have the same or higher ratings for every function. To fully restore lost habitat values, replacement wetlands should be of the same type as the wetland destroyed, and should be located as near the original wetland as possible so that the benefits of the original wetland are still enjoyed locally.

In the northeastern United States, proposals for mitigation of forested wetland habitat losses usually involve either the creation of new wetland habitats, most commonly ponds or marshes, or the conversion of existing shrub or forested wetland to marsh through manipulation of water levels. Applicants, and sometimes regulatory agencies as well, have attempted to justify such out-of-kind replacement and enhancement by stating that these practices result in greater wildlife habitat diversity, and that marshes are less abundant than swamps and more valuable to wetland-dependent wildlife such as waterfowl. In actuality, out-of-kind replacement and enhancement are the only alternatives available in such cases because it has not been demonstrated that viable forested wetlands can be created from upland. The development of a mature forested wetland would take at least 40–50 years, even under natural conditions where wetland soils were already established. For this reason, both the technical feasibility and the practicality of swamp replacement must be questioned.

Net losses of wetland are characteristic of habitat mitigation projects involving wetland enhancement, because the goal of these projects is to compensate for outright losses of wetland by altering or improving the habitat characteristics of existing wetlands. The use of enhancement methods to mitigate losses of forested wetland habitat is often doubly damaging because forested habitat is lost both during the proposed development project and during the enhancement process (e.g., as wetland forest is converted to marsh).

Protection of Buffer Zones

Regulation of land use in upland areas bordering wetlands is critical to the maintenance of wetland functions and values (Clark 1977; Roman and Good 1986; Brown and Schaefer 1987). Natural, undisturbed surroundings reduce the adverse effects of development on wetlands and contribute directly to certain wetland functions such as wildlife habitat. Where land use in adjacent uplands is restricted by wetland regulatory agencies, these areas are commonly referred to as wetland buffer zones. A wide variety of functions and values have been recognized for wetland buffer zones; some of the major ones are outlined below.

Functions and Values of Buffer Zones

Surrounding uplands are essential habitat for both wetland wildlife species, which reside primarily in the wetland, and upland species, which use the wetland on an occasional basis or for breeding (Golet and Larson 1974; Golet 1976; Porter 1981; Brown and Schaefer 1987). Wood ducks, for example, sometimes nest in the cavities of trees that are located in adjacent upland forests. Upland species such as white-tailed deer and ruffed grouse are commonly observed along the upland edge of forested wetlands where cover is dense. Wetland-dependent upland species, including certain salamanders and toads, reside in upland habitats near swamps most of the year, but require the wetlands for breeding. In addition to providing wildlife habitat directly, undisturbed surrounding uplands also reduce the impact of noise and other human activity on wetland wildlife. Natural buffer zones may provide a refuge for wildlife during periods of exceptionally high water as well (Brown and Schaefer 1987).

Only Husband and Eddleman (1990) have examined wildlife use in upland habitats directly adjacent to red maple swamps. Between March and November in 1989, and March and August in 1990, selected groups of vertebrates were censused in the transition zone extending from red maple swamps into the adjacent upland forest at four sites in southern Rhode Island. During these periods, 14 species of amphibians, 3 species of reptiles, and 14 species of mammals were captured (Table 8.3). The most remote, least disturbed site had the highest number and diversity of reptiles and amphibians, while the most disturbed sites had the highest number and diversity of mammals. Three species

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of mammals classified as "state-rare" were captured: water shrew, smoky shrew (*Sorex fumeus*), and southern bog lemming (*Synaptomys cooperi*). Forty-nine species of birds were observed during June and July; of these, 19 were Neotropical migrants of potential concern to wildlife management (Table 8.3).

Undisturbed buffer zones perform several important hydrologic functions. They may reduce the velocity of storm-water runoff, thereby allowing infiltration of water into the soil and reducing the volume of runoff entering wetlands during major storm events. This storm water abatement function prevents the drastic fluctuations in wetland water levels that may be hazardous to ground-nesting birds and other wildlife. As noted above, large-scale paving of upland areas surrounding wetlands reduces groundwater recharge, which, in turn, may lower summer water levels in wetlands where groundwater was a major inflow component prior to development. Thus, buffer zones may play an important role in wetland hydrology. Upland areas directly adjacent to wetlands may also serve as supplementary flood storage areas.

While wetlands themselves frequently play an important role in the removal, retention, and transformation of a wide variety of surface-water pollutants, there is undoubtedly a limit to the amount they can process without adverse effects on wildlife, the plant community, and other ecosystem components. For this reason, every attempt should be made to minimize the inflow of pollutants to wetlands. Establishment of natural, undisturbed buffer zones around wetlands helps greatly

Table 8.3. *Birds and mammals observed in the transition zone between red maple swamp and upland forest in Rhode Island (from Husband and Eddleman 1990). See Table 7.2 for amphibians and reptiles.*

Birds
- American crow
- American goldfinch
- American redstart[a]
- American robin
- Belted kingfisher
- Black-and-white warbler[a]
- Black-capped chickadee
- Black-throated green warbler[a]
- Blue jay
- Blue-winged warbler[a]
- Brown creeper
- Brown-headed cowbird
- Canada warbler[a]
- Carolina wren
- Chestnut-sided warbler[a]
- Chipping sparrow
- Common yellowthroat
- Downy woodpecker
- Eastern kingbird[a]
- Eastern phoebe
- Eastern wood-pewee[a]
- European starling
- Gray catbird[a]
- Great crested flycatcher[a]
- Hairy woodpecker
- Hermit thrush
- House wren
- Northern cardinal
- Northern flicker
- Northern mockingbird
- Northern waterthrush[a]
- Ovenbird[a]
- Pine warbler
- Purple finch
- Red-eyed vireo[a]
- Red-winged blackbird
- Rose-breasted grosbeak[a]
- Ruby-crowned kinglet
- Ruffed grouse
- Rufous-sided towhee
- Scarlet tanager[a]
- Song sparrow
- Swamp sparrow
- Tufted titmouse
- Veery[a]
- White-breasted nuthatch
- White-eyed vireo[a]
- Wood thrush[a]
- Yellow warbler[a]

Mammals
- Eastern cottontail
- Long-tailed weasel
- Masked shrew
- Meadow jumping mouse
- Meadow vole
- Northern short-tailed shrew
- Smoky shrew
- Southern bog lemming
- Southern red-backed vole
- Star-nosed mole
- Virginia opposum
- Water shrew
- White-footed mouse
- Woodland jumping mouse

[a] Neotropical migrant.

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by capturing sediment, reducing nutrient loads, and filtering other pollutants before they reach the wetland (Brown and Schaefer 1987).

A considerable body of experience has developed on pollution attenuation in artificial buffer strips (Clark 1977). Research on natural systems is more limited, but recent findings are encouraging. For example, forested buffer zones in Maryland and North Carolina have been shown to remove as much as 80% of the excess nitrogen and phosphorus from agricultural runoff (Hall et al. 1986). In a 2-year study conducted in southern Rhode Island, Gold and Simmons (1990) injected a "spike" of nitrate, copper, and a tracer into the ground up-gradient from forested upland and red maple swamp monitoring stations at three sites. They found complete attenuation of copper in the groundwater at all stations. Nitrate removal ranged from 14 to 87% in the forested upland, where soils were moderately well drained or somewhat poorly drained; in the swamp, it was almost complete in both poorly drained and very poorly drained soils. The highest attenuation occurred where groundwater levels were closest to the surface. The authors concluded that forested buffer zones can protect wetland and surface-water systems from water quality degradation throughout the year; however, long-term performance may vary because plant uptake and microbial immobilization of nitrate are temporary nutrient sinks.

One of the unique aspects of many buffer zones is the high species richness of both plants and animals (Porter 1981). As a transitional area between wetland and upland, the buffer zone commonly contains species that are representative of both communities (Anderson et al. 1980; Davis 1988). Moisture is characteristically abundant in this zone, but not limiting to plant growth; as a result, forest productivity is often higher there than in more droughty upland soils (Braiewa et al. 1985). Upland habitats along the wetland edge have also been cited as the main source for seeds contributing to the spatial heterogeneity of wetlands (Brown and Schaefer 1987).

The Issue of Buffer Width

One of the most vigorously contested issues in public hearing rooms throughout the Northeast in recent years has been the minimum width of buffer zone required to safeguard wetland ecosystems from the adverse impacts of development. Proposals have ranged widely, from as much as 150 m to as little as 15 m. There has been so little research on the basic characteristics and functions of wetland buffer zones that the development of scientifically valid criteria for determining buffer zone width has been difficult (Jordan and Shisler 1988). As a result, buffer zone widths established by regulatory agencies often have been arbitrary.

The Rhode Island Freshwater Wetlands Act (G.L., Chap. 2-1, Sect. 18 et seq.), passed in 1971, was the first inland wetlands law to include a buffer; all land within 15 m of the edge of ponds, marshes, swamps, and bogs is considered part of those wetlands and is regulated accordingly. New Jersey's Freshwater Wetlands Protection Act (NJ S.A. 13:9B-1 et seq.), which was passed in 1987, contains the most sophisticated treatment of buffer zones (termed transition areas in the law) to date. The act requires that all freshwater wetlands be classified as exceptional, intermediate, or ordinary. Exceptional wetlands, which provide habitat for threatened or endangered species or which border trout production waters, have a 46-m transition area. Transition areas are not required for ordinary wetlands, which include ditches, swales, detention basins, and isolated wetlands less than 465 m^2 in area with development along at least 50% of their borders. All other wetlands, which are considered to be of intermediate value, have 15-m transition areas.

A major contribution toward the development of buffer zone criteria was made by researchers in the New Jersey pinelands (Roman and Good 1985). In their buffer delineation model, buffer width is determined by numerically rating both the natural quality, values, and functions of a wetland and the potential for site-specific, cumulative, and watershed-wide impacts of development. Indices for relative wetland quality and relative environmental effects are averaged, and the resulting buffer index is translated into a buffer width by using a conversion table. This is the only quantitative procedure that rates both wetland values and impacts.

Working in the Wekiva River Basin of central Florida, Brown and Schaefer (1987) also developed quantitative criteria for buffer delineation. Key functions addressed were water quality maintenance, water quantity maintenance, and wildlife habitat. Buffer width was determined from existing scientific data on soil erodibility, depth to the water table, and the habitat requirements of representative wildlife species known to inhabit the area. Buffer zone widths were calculated for each function, and the largest width was considered to be controlling in any given area. Buffer widths

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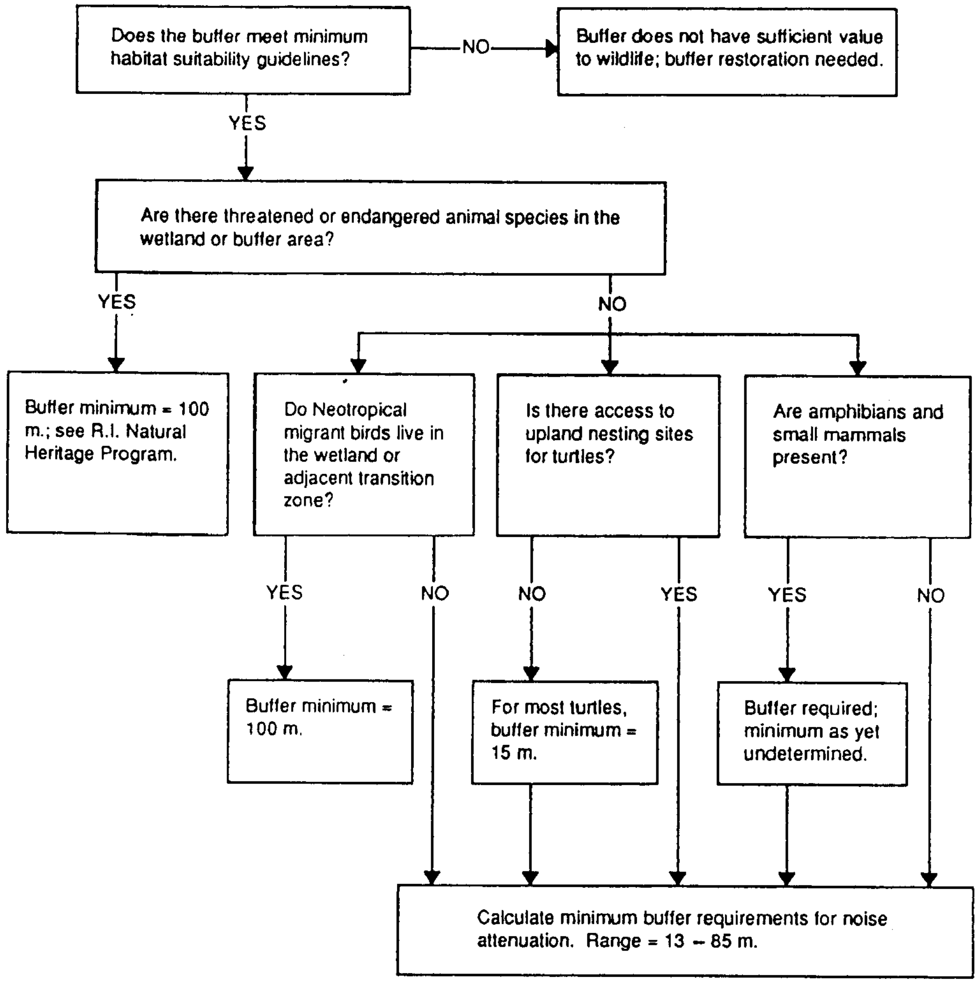

Fig. 8.6. Wetland buffer width model developed for wildlife habitat functions in Rhode Island red maple swamps (after Husband and Eddleman 1990).

ranged from as little as 13 m for water quality maintenance in areas with low slope and low soil erodibility to as much as 163 m for individual wetland-dependent animals of most species living in the watershed.

Husband and Eddleman (1990) developed a preliminary buffer width model for Rhode Island red maple swamps using four wildlife habitat factors outlined in the Wekiva River basin study (Brown and Schaefer 1987): (1) habitat suitability, (2) wildlife spatial requirements, (3) access to upland or transitional habitats, and (4) noise impacts on wildlife life functions. Buffer widths calculated for these four variables ranged from 13 m for noise attenuation under optimal conditions (i.e., forested buffer and residential noise) to 100 m for spatial requirements of forest interior bird species, small mammals, and reptiles and amphibians. A buffer exceeding 100 m was recommended for swamps with threatened or endangered species. Figure 8.6 outlines the decisions leading to a final buffer width determination in the Rhode Island model.

Exempted Wetlands

One additional problem hindering wetland protection is the wetland loss that results from exemptions on the basis of wetland size or type. As noted earlier in this report, several northeastern states have size minima for protection. In Rhode Island, swamps smaller than 1.2 ha are not regulated as stringently as larger swamps (G.L., Chap. 2-1, Sect. 20). In New York, the minimum size limit for all regulated wetlands is 5 ha unless the wetland can be shown to be of unusual local importance (Riexinger 1986). In Maine, inland wetlands are protected only if they are 4 ha or larger (Title 38,

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M.R.S.A., Sect. 480A). Research by Merrow (1990) on breeding-bird communities in red maple swamps demonstrated that swamps as small as 0.5 ha support wetland-dependent species such as the northern waterthrush. Swamps smaller than the size minima listed above clearly may have significant public value for flood storage, water quality improvement, wildlife habitat, scenic value, and open space, particularly in urban areas. And, although individual losses of small wetlands may seem minor, the cumulative effects on flood levels, water quality, wildlife populations, and the quality of human life may be highly significant.

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What wetland functions and values are considered by the Corps in its Section 404 permit process?

The 13 functions and values that are considered by the Regulatory Division for any Section 404 wetland permit are listed below. The list includes eight functions and five values. Values are grouped together at the end of the list.

These are not necessarily the only wetland functions and values possible. Nor are they so precisely defined as to be unalterable. However, they do represent the best working "palette" of descriptors which can be used to paint an objective representation of the wetland resources associated with a proposed project.

GROUND WATER RECHARGE/DISCHARGE— This function considers the potential for a wetland to serve as a groundwater recharge and/or discharge area. Recharge should relate to the potential for the wetland to contribute water to an aquifer. Discharge should relate to the potential for the wetland to serve as an area where ground water can be discharged to the surface.

FLOODFLOW ALTERATION (Storage & Desynchronization) — This function considers the effectiveness of the wetland in reducing flood damage by attenuation of floodwaters for prolonged periods following precipitation events.

FISH AND SHELLFISH HABITAT — This function considers the effectiveness of seasonal or permanent waterbodies associated with the wetland in question for fish and shellfish habitat.

SEDIMENT/TOXICANT/PATHOGEN RETENTION — This function reduces or prevents degradation of water quality. It relates to the effectiveness of the wetland as a trap for sediments, toxicants or pathogens.

NUTRIENT REMOVAL/RETENTION/TRANSFORMATION — This function relates to the effectiveness of the wetland to prevent adverse effects of excess nutrients entering aquifers or surface waters such as ponds, lakes, streams, rivers or estuaries.

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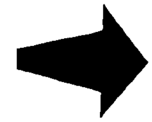
PRODUCTION EXPORT (Nutrient) — This function relates to the effectiveness of the wetland to produce food or usable products for human, or other living organisms.



SEDIMENT/SHORELINE STABILIZATION — This function relates to the effectiveness of a wetland to stabilize stream banks and shorelines against erosion.

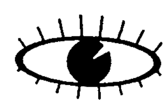
WILDLIFE HABITAT — This function considers the effectiveness of the wetland to provide habitat for various types and populations of animals typically associated with wetlands and the wetland edge. Both resident and/or migrating species must be considered. Species lists of observed and potential animals should be included in the wetland assessment report.

RECREATION (Consumptive and Non-Consumptive) — This value considers the effectiveness of the wetland and associated watercourses to provide recreational opportunities such as canoeing, boating, fishing, hunting and other active or passive recreational activities. Consumptive opportunities consume or diminish the plants, animals, or other resources that are intrinsic to the wetland, whereas non-consumptive opportunities do not.

EDUCATIONAL/SCIENTIFIC VALUE — This value considers the effectiveness of the wetland as a site for an "outdoor classroom" or as a location for scientific study or research.

UNIQUENESS/HERITAGE — This value relates to the effectiveness of the wetland or its associated waterbodies to produce certain special values. Special values may include such things as archeological sites, unusual aesthetic quality, historical events, or unique plants, animals, or geologic features, etc.

VISUAL QUALITY/AESTHETICS — This value relates to the visual and aesthetic qualities of the wetland.



THREATENED or ENDANGERED SPECIES HABITAT — This value relates to the effectiveness of the wetland or associated waterbodies to support threatened or endangered species.

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DEFINING FEATURES OF THE BASIC FRESHWATER WETLAND TYPES OF SOUTHERN NEW ENGLAND

Type	Dominant Life Forms	Soil	Water Regimes*	pH*	Other Features
OPEN WATER	Surface Plants Submergents Some areas may be unvegetated (<30% cover)	Not soil	Permanently Flooded Intermittently Exposed	Circumneutral	Water usually more than 1 m deep.
MARSH	Robust Emergents Subshrub Emergents Nonpersistent Emergents	Mineral Sapric	Permanently Flooded Intermittently Exposed Semipermanently Flooded Seasonally Flooded	Circumneutral	Surface plants and submergents common subordinates. Small patches of open water common in deeper marshes.
WET MEADOW	Narrow-leaved Persistent Emergents Grasses, sedges + rushes	Mineral Sapric	Seasonally Flooded Temporarily Flooded Saturated	Circumneutral Acid	Substrate firm underfoot. Tussock-forming plants and broad-leaved herbs common. Eupatorium
SWAMP	Shrubs Trees	Mineral Sapric Hemic	Semipermanently Flooded Seasonally Flooded Temporarily Flooded Saturated	Circumneutral Acid	Pronounced mound-and-pool microtopography often. Diversity of woody and herbaceous plants.
FEN	Narrow-leaved Persistent Emergents Low Compact Shrubs Robust Emergents (less common)	Hemic Fibric	Seasonally Flooded Saturated tend to be flooded c̄ nutrient rich groundwater	Not as acid as bog Circumneutral Acid	Quaking substrate Little microrelief. X *Sphagnum* scarce or absent.
BOG	Narrow-leaved Persistent Emergents Low Compact Shrubs Scrub (stunted trees)	Organic ~~Fibric~~	Saturated	Acid	100% cover of *Sphagnum*, ofter forming raised cushions. Quaking substrate. Insectivorous plants common.

*Defined in Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et al. 1979).

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Area of Rhode Island Wetlands and Deepwater Habitats*

Prepared by Nick Miller
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Statewide

TYPE	DESCRIPTION	ACRES	% of RI	Riverine	Lacustrine	Palustrine	Estuarine	Total Freshwater
ROW	Riverine Nontidal Open Water	1,831.8	0.26%	1,831.8				
LOW	Lacustrine Open Water	17,518.1	2.52%		17,518.1			
POW	Palustrine Open Water	4,480.6	0.64%			4,480.6		
EMA	Emergent Wetland: Marsh/Wet Meadow	4,341.1	0.62%			4,341.1		
EMB	Emergent Wetland: Emergent Fen or Bog	229.2	0.03%			229.2		
SSA	Scrub-Shrub Swamp	9,605.8	1.38%			9,605.8		
SSB	Scrub-Shrub Wetland: Shrub Fen or Bog	2,060.3	0.30%			2,060.3		
FOA	Forested Wetland: Coniferous	10,899.6	1.57%			10,899.6		
FOB	Forested Wetland: Deciduous	60,693.9	8.72%			60,693.9		
FOD	Forested Wetland: Dead	225.1	0.03%			225.1		
RTW	Riverine Tidal Open Water	7.4	0.00%	7.4				
EOW	Estuarine Open Water	8,175.0	1.17%				8,175.0	
ERS	Marine/Estuarine Rocky Shore	671.3	0.10%				671.3	
EUS	Marine/Estuarine Unconsolidated Shore	2,874.0	0.41%				2,874.0	
EEM	Estuarine Emergent Wetland	4,014.3	0.58%				4,014.3	
ESS	Estuarine Scrub-Shrub Wetland	93.2	0.01%				93.2	
UPL	Upland	568,163.8	81.65%					
	Total (acres):	695,884.4		1,839.2	17,518.1	92,535.5	15,827.8	111,892.8
	Total (%):		100.00%	0.26%	2.52%	13.30%	2.27%	16.08%

*Data are based on photo-interpretation of 1988 1:24,000-scale aerial photographs and stored in the Rhode Island Geographic Information System (RIGIS); minimum map unit = 1/4 acre. The areas of Narragansett Bay and the Pawcatuck River Estuary have been excluded from all calculations.

University of Rhode Island

RIGIS

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% of listed, threatened and endangered animal species and 25% of plant species use wetland 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 often involves the assessment of wetland impacts.

Administered by EPA, NEPA requires the preparation of environmental impact

Zoning — is a regulatory tool that divides a community into various land use districts and allows only certain activities to be conducted 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)

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:

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