Chapter I Wetland Science

The Extent of the Resource:

Wetland Statistics

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

WHAT ARE WETLANDS?

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

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

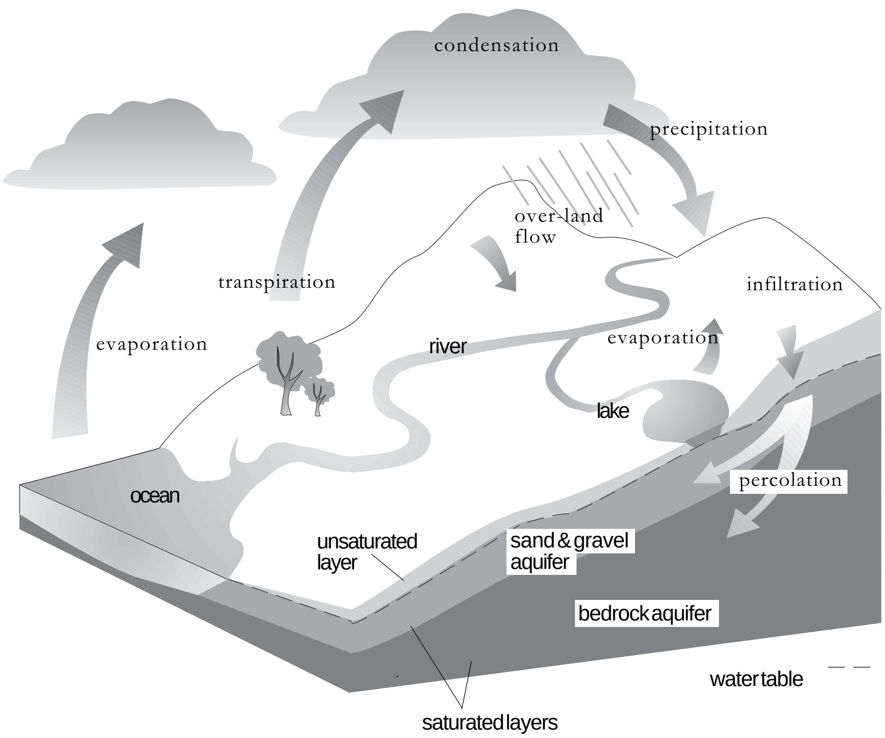
Wetlands also vary considerably in their appearance and size. Regional and local differences in vegetation, hydrology, water chemistry, soils, topography, and climate contribute to the variety of wetland types found around the world. Some wetlands are inundated with water year round while others are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

THE WATER CYCLE: THE CONNECTION BETWEEN WETLANDS & WATERSHEDS

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

Precipitation (rain) falls to the ground and, due to gravity, tends to keep moving towards the lowest point in the landscape. Water may *infiltrate* (penetrate) the soil surface, *percolate* through the soil and eventually become part of either an underground water system (*aquifer)* or a surface water system (e.g., river). As the sun heats the earth's surface, water molecules *evaporate* from the land and sea as water vapor and return to the upper atmosphere. Plants also give off water through *transpiration*, a loss of water vapor from the leaf surface. As water molecules rise and come into contact with cooler air, *condensation* occurs (gaseous water turns to liquid water). The cycle repeats as water once again falls to the earth's surface in the form of precipitation (7/8 of which falls directly into the ocean).

The Water Cycle:



The Watershed

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

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

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

Getting Your Students Involved:

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

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

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

Wetland Characteristics

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

Hydrology

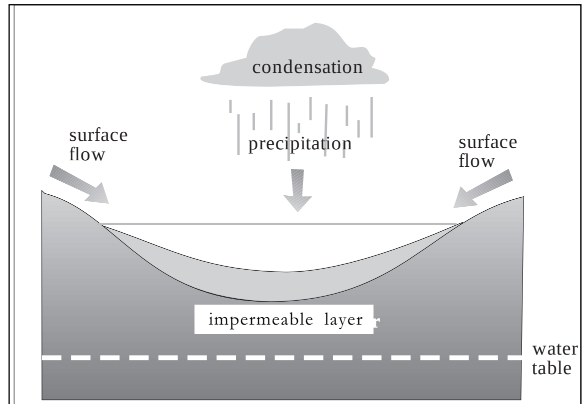
Hydrology, the circulation and distribution of water, is the driving force behind the formation of wetlands. Hydrology, particularly in conjunction with landscape position, determines a wetland's water depth, flow patterns, and the duration and frequency of flooding or saturation. Topography, proximity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

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

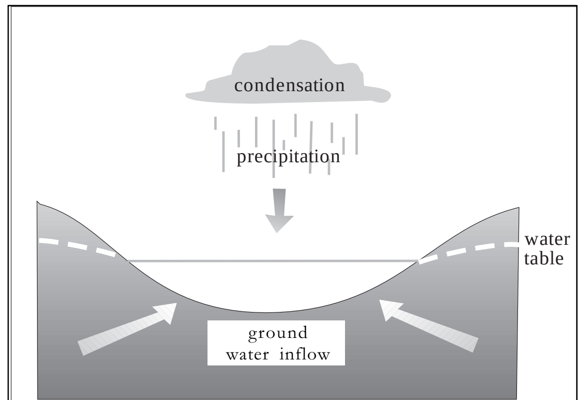
- direct precipitation;
- surface water runoff from brooks, streams, and rivers;
- underground water sources such as groundwater or springs. In low-lying areas, groundwater may lie just below the soil surface (*high water table*), keeping soils saturated from below. Springs or *seeps* are places where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

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

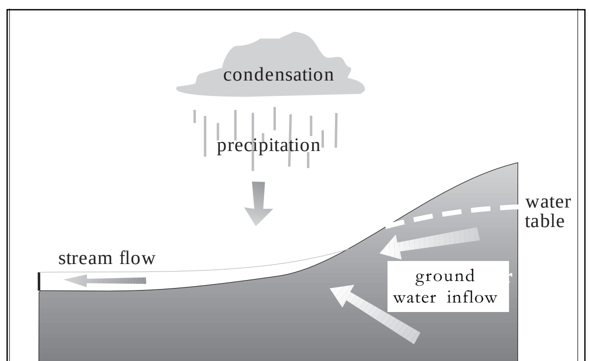
Where does the water in wetlands come from?



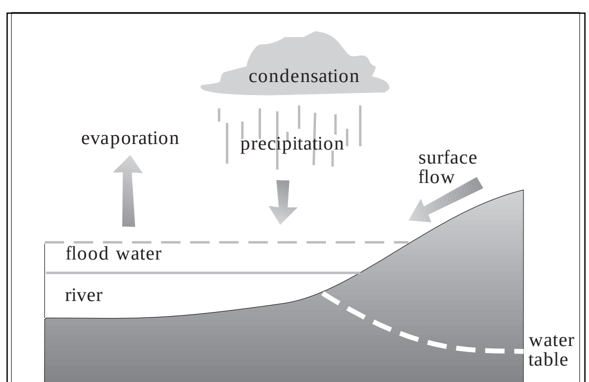
Surface water depression



Ground water depression



Seeps



Flooding

Wetland Soils

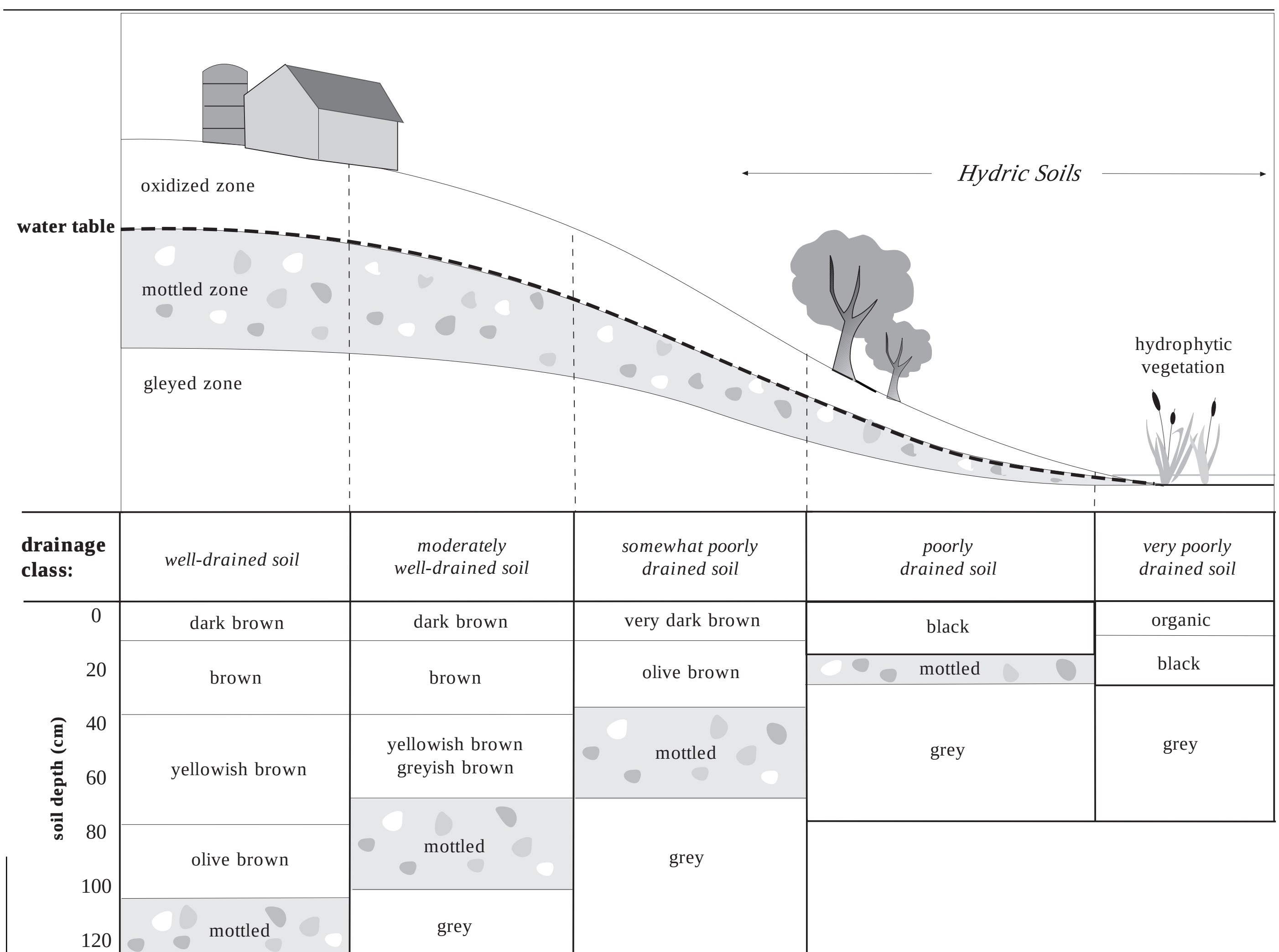
Wetland soils, called *hydric soils*, develop under low oxygen or *anaerobic* conditions created by permanent or periodic inundation or saturation. As water fills the air spaces between soil particles, the rate at which oxygen can diffuse through the soil decreases significantly. This lack of oxygen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

Drainage

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

Soil Composition

Based on their composition, hydric soils are classified as either *organic* or *mineral* soils.



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

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

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

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

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

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

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

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

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

Getting Your Students Involved:

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

Wetland Plants

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

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

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

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

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

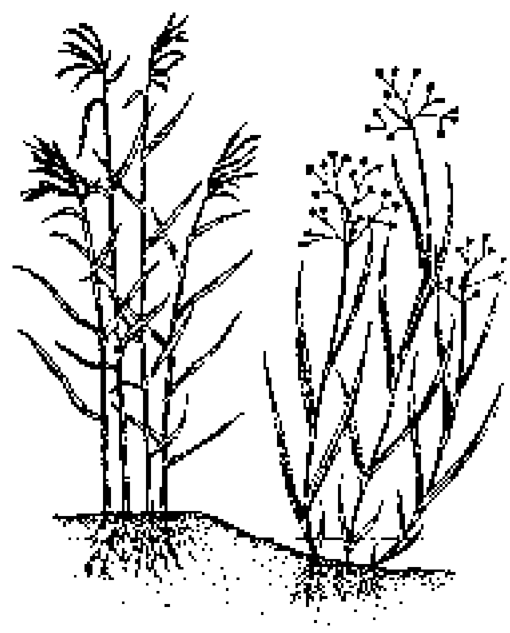
4) Hydrophytes living in saline environments develop structural barriers to prevent or control the entry of salts at the root surface and have organs specialized to excrete salts through glands embedded in the leaf.

Types of Plants

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

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

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



Emergent

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

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

Getting Your Students Involved:

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

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

For More Information

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