Freshwater Wetlands: Functions & Conservation

ENVIRTHON Workshop 2016
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What is a "Wetland"?

- **Legal Definition:**

  ....those areas that are inundated or saturated by surface or groundwater 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.

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Types of Freshwater Wetland systems:

- **Bogs, marshes, fens, swamps,**
- **Prairie potholes, vernal pools, pocosins,**
- **(Terms are not standardized in their usage)**

Freshwater wetlands are found in inland regions as opposed to salt marshes that are coastal in distribution.

Swamps

- Woody vegetation
- Groundwater Fed

Bogs

- Rainwater Fed
- Low nutrients

Marshes

- Nonwoody vegetation
- Surface water Fed

Inland (above) and coastal (left)

(freshwater vs. saltwater)

Basic Components of all wetlands:

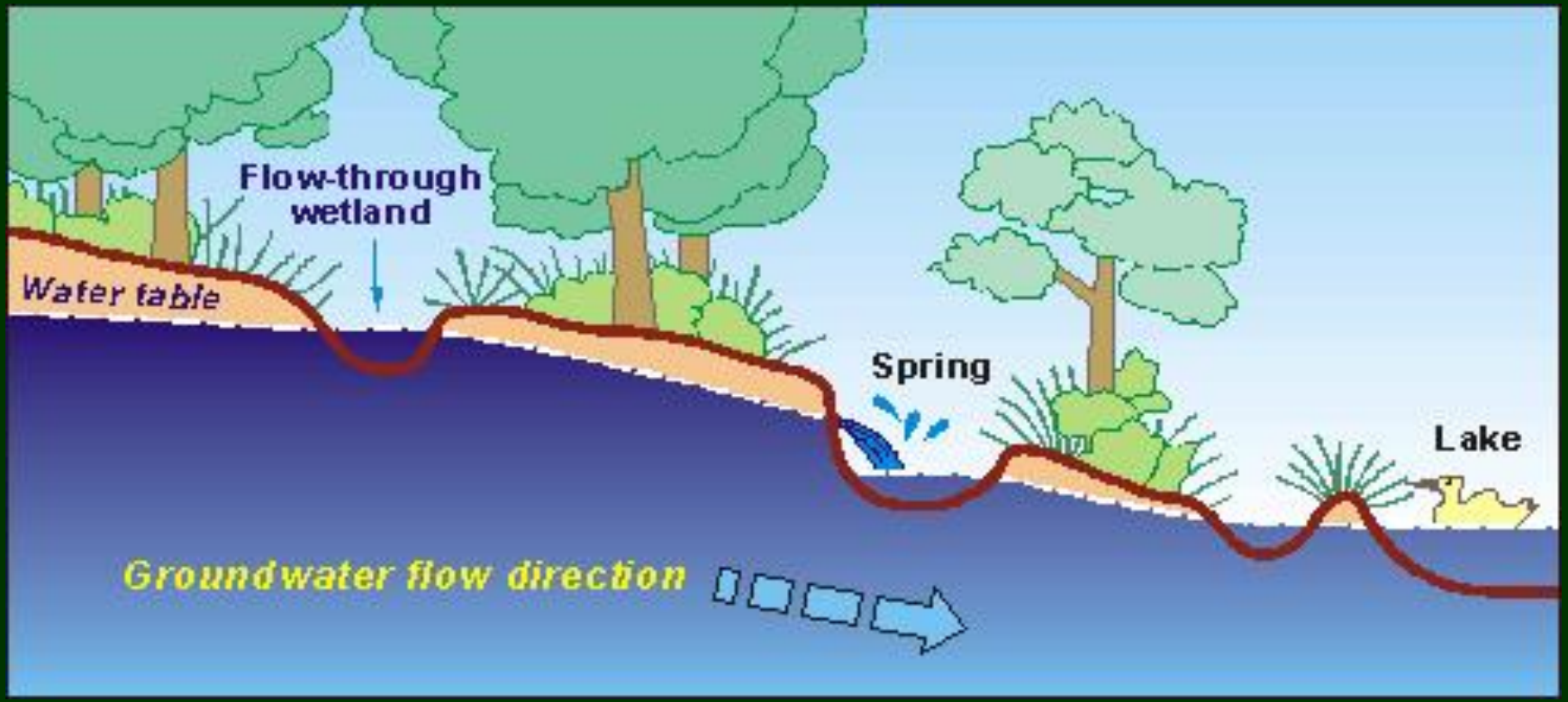
- **Wetland Hydrology**
  - **area must be sufficiently “wet”**
- **Specialized Vegetation**
  - **Area must have prevalence of *hydrophytic* plants species**
- **Saturated Soils**
  - **Area must have *hydric* soil that show evidence of long term saturation conditions**

Wetland Hydrology:

- **How do wetlands "stay" wet?**
  - **some wetlands receive mostly surface water inputs, others receive mostly groundwater inputs.**
- **How "wet" is "wet" ?**
  - **Water must be "at" or "above" the ground surface for a *significant portion* of the growing season. (This may amount to only 2 or 3 weeks in some colder regions.)**

Wetland Hydrology:

- **How do wetlands "stay" wet?**



Wetland Vegetation:

- **Wetland vegetation is called hydrophytic (meaning water-loving plant)**
- **These plant have special adaptations that allow them to survive in saturated (anaerobic) soils.**

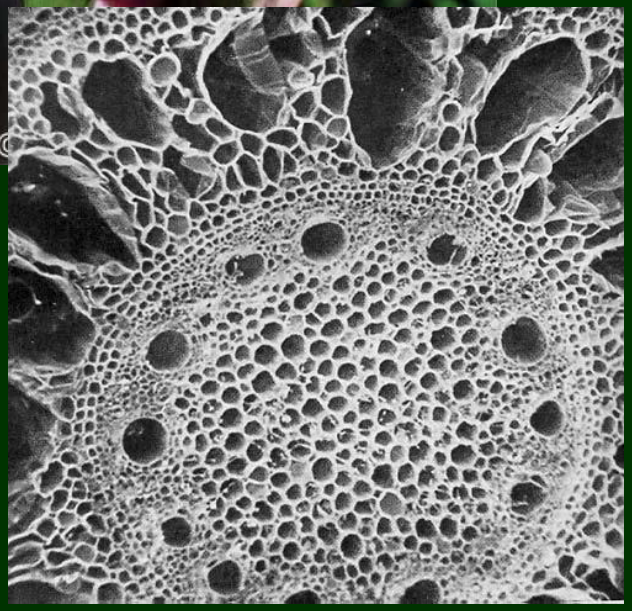
- **How do their roots respire (i.e., “breathe”) without air in the soil pores?**

Wetland Vegetation - Adaptations

1. **Shallow rooting systems (avoidance)**

Wetland Vegetation Adaptations:

2. *Aerenchyma* - special stem and root tissue with continuous "sponge-like" air spaces which allow oxygen to diffuse passively from the aerial parts of the plant down to lower plant organs (like a snorkel).



Wetland Vegetation Adaptations:

3. Anaerobic metabolism-
(true tolerance)

Without oxygen, fermentation occurs – producing alcohol.

Most plants cannot tolerate an accumulation of ethanol (alcohol) and they will die when it starts to build up.

Certain (but not all) wetland plants are adapted to tolerate this alcohol accumulation.

Wetland Soils:

Wetland soils are called *hydric* soils.

What happens to soils that stay saturated for long periods of time?

Wetland soils typically have thick, dark, organically-enriched topsoil due to the great slow-down in organic matter decomposition.

Wetland Soil Colors

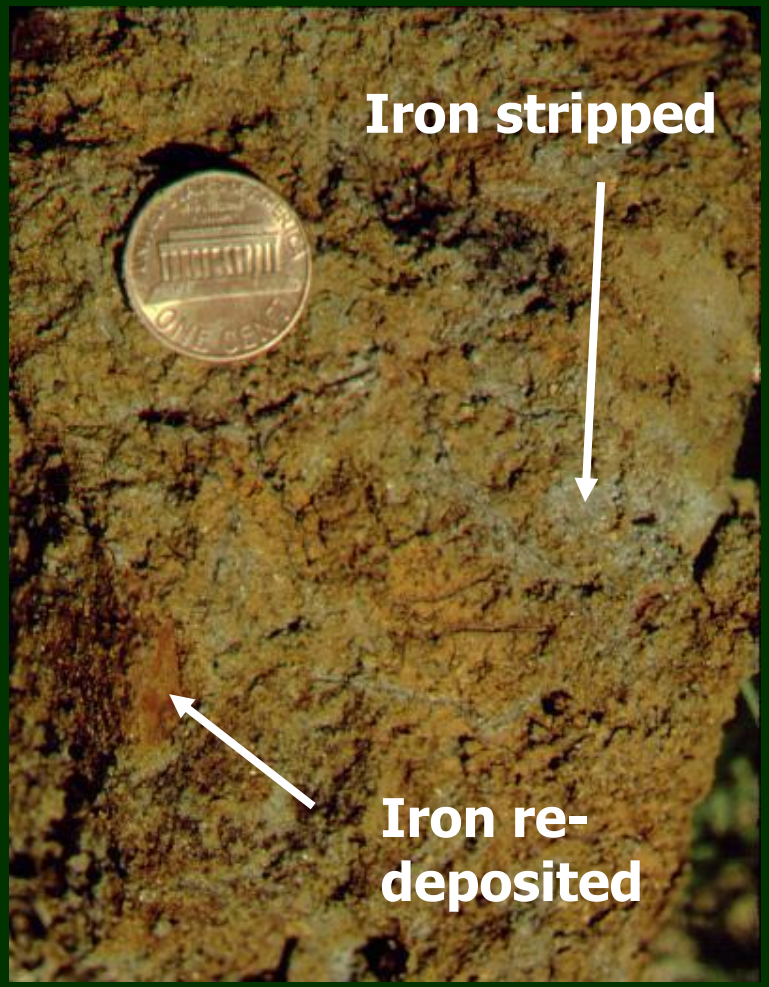
- **When soils are saturated, decomposition processes slow down markedly.**
- **This causes organic matter to accumulate in the soil, resulting in a dark color.**

Wetland Soil Colors

- **Gray colored subsoils usually indicate prolonged wetness.**
- **Changes in soil chemistry cause gray colors to form when iron (a primary coloring agent) is stripped away.**
- **Red/orange mottles form when stripped (dissolved) iron is exposed to oxygen.**

Wetland Soil Colors

- **Under prolonged anaerobic conditions, iron becomes soluble and is stripped from the soil grains.**
- **When dissolved iron encounters oxygen in the soil, it becomes oxidized and precipitates out as rusty mottles.**



Wetland Soil Chemistry

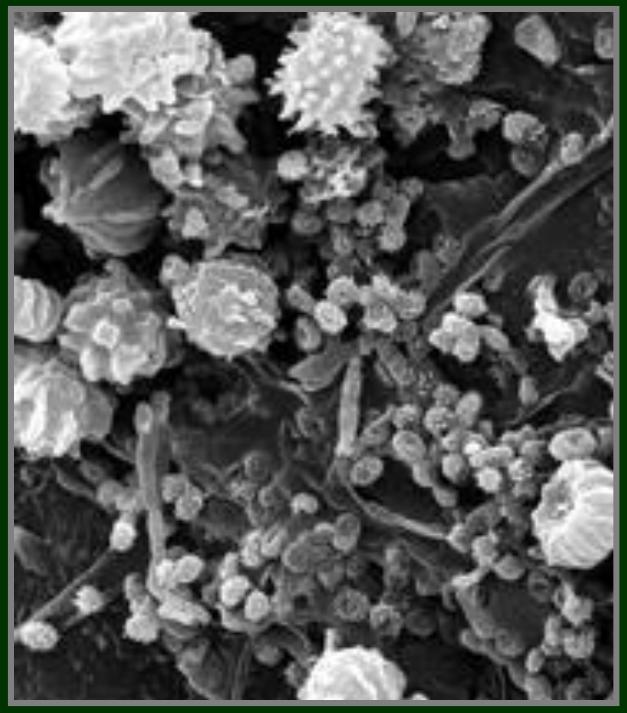
Oxygen transport through water-filled soil pores is 10,000 times slower than through air-filled pores.

As a result, oxygen is quickly depleted in saturated soils by the respiration needs of bacteria and plant root systems.

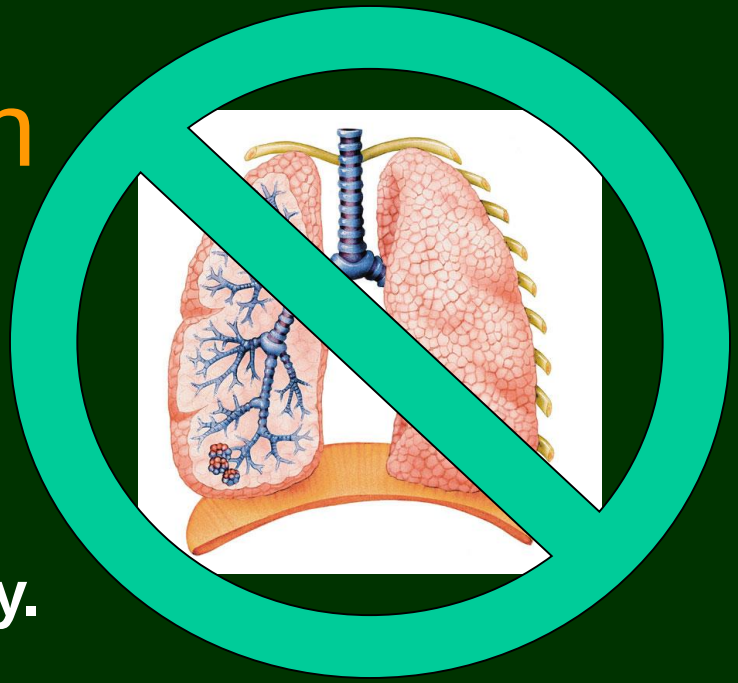
(It can not be replaced at the soil surface as fast as it is being used up below the surface.)

Soil Respiration

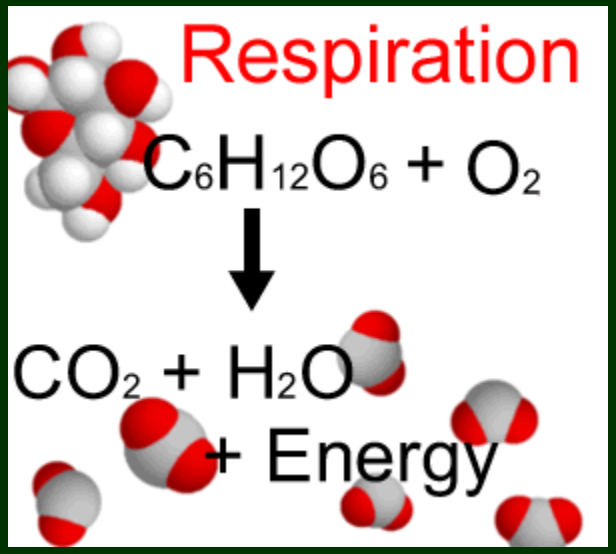
- The soil is ALIVE with respiring organisms.
- Bacteria, fungi, and others.
- Soil microorganisms are important for recycling of organic material, releasing nutrients through decay processes.
- Almost all of these organism need oxygen to survive!



Example: Respiration



-The process of having some compound (commonly oxygen) able to take on (or accept) the electrons produced when sugars are being broken down for energy.

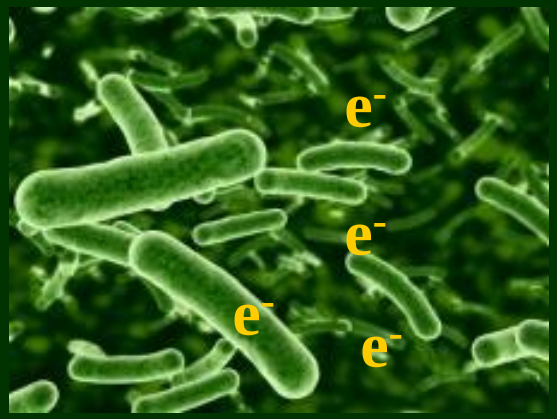


Respiration happens at the cellular level for all living organisms.

Wetland Soil Chemistry –cont.

"Breathing" - a.k.a. respiration - is really the simple process of having some compound (commonly oxygen) able to take on (or accept) the electrons produced when sugars are being broken down for energy and forming carbon dioxide.

Organic matter +

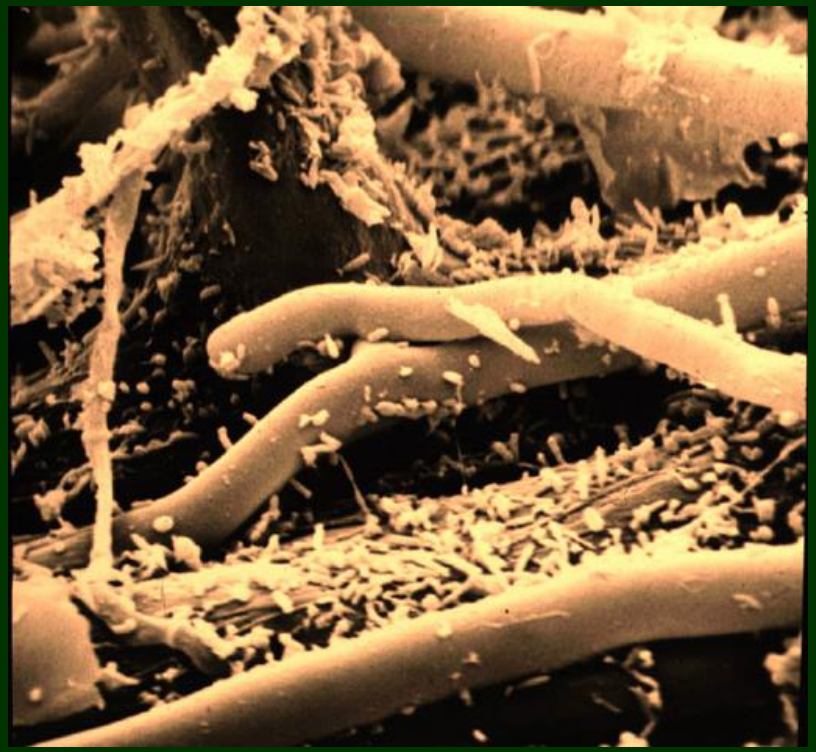


+ O_2 → Energy + CO_2

Wetland Soil Chemistry –cont.

When oxygen becomes unavailable in the soil, wetland plants rely on their adaptations.

Bacteria, on the other hand, must turn to other elements (or compounds) besides oxygen in order to “breathe”.



Wetland Soil Chemistry –cont.

When oxygen is no longer available to "accept" the electrons generated by respiration, other elements must be used. Only specialized bacteria can do this.

When oxygen is no longer available, specialized bacteria will utilize nitrate (NO_3) and then iron oxides (FeO).

Wetland Soil Chemistry –cont.

When nitrate is used by the bacteria an important wetland function occurs: *de-nitrification*

This process converts the dissolved nitrate into atmospheric nitrogen gas.

Wetland Soil Chemistry –cont.

After O_2, and then nitrate (NO_3-), most bacterial communities then turn to using iron for their respiration needs.

Ferric iron + e- → Ferrous iron

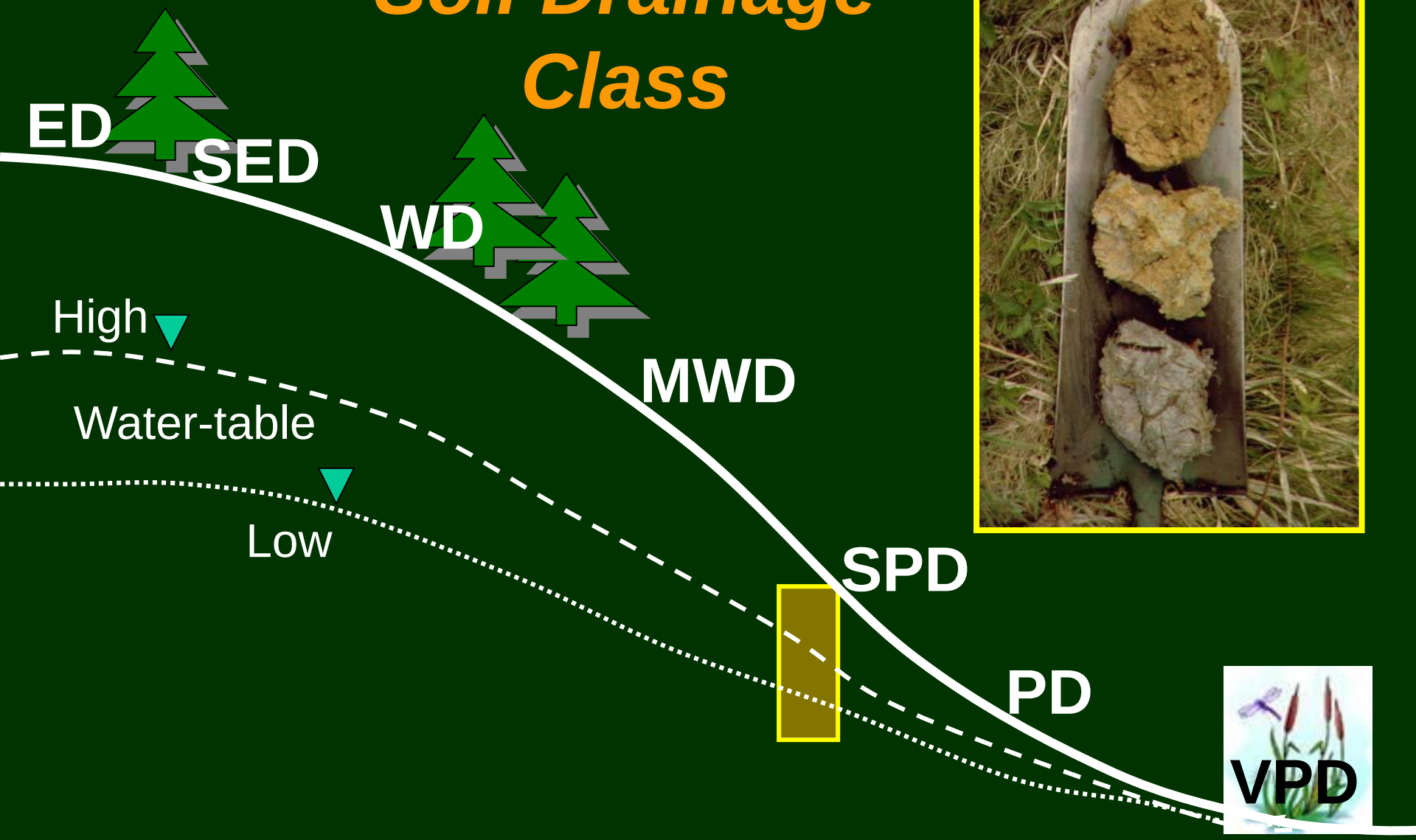
(Fe $^{3+}$, solid - rust) **(Fe $^{2+}$, dissolved -gray)**

Studies show that most soils must be saturated (without oxygen) for about three weeks before bacteria start using iron for respiration.

- **Under well-drained soil conditions, oxygen is able to move through the soil pore spaces.**

When the soil is saturated (and all the pores are full of water), oxygen becomes quickly depleted.

Soil Drainage Class



Wetland Functions:

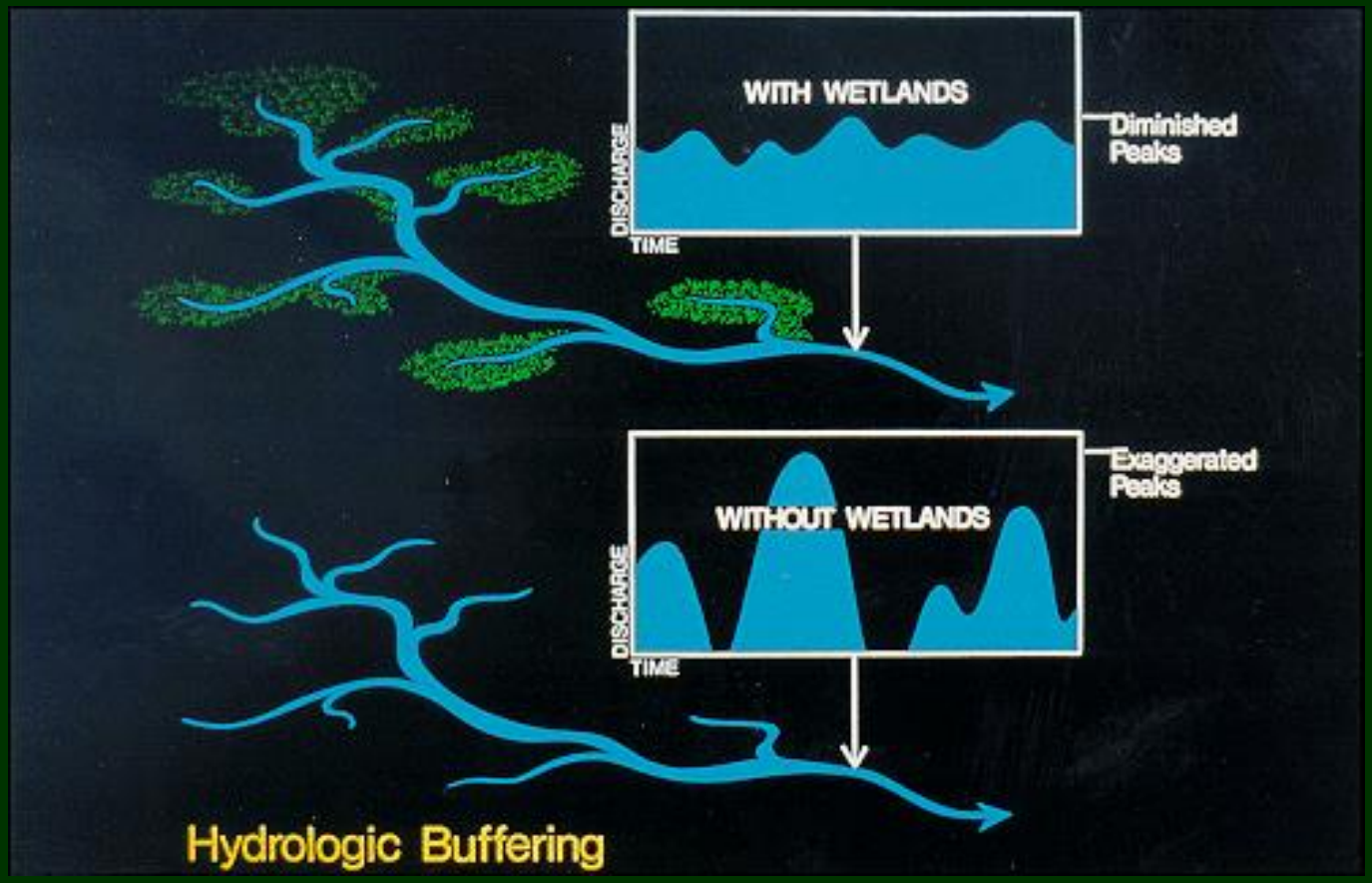
Why should we care about wetlands? ….
What functions do wetlands perform?

A. Flood control

– de-synchronizing peak flows

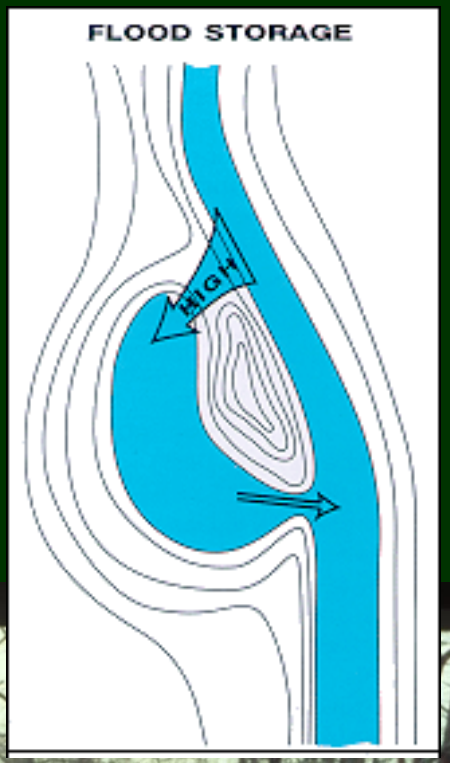
Wetlands act as sponges that absorb up to 80% of peak storm discharge that would otherwise rush downstream.

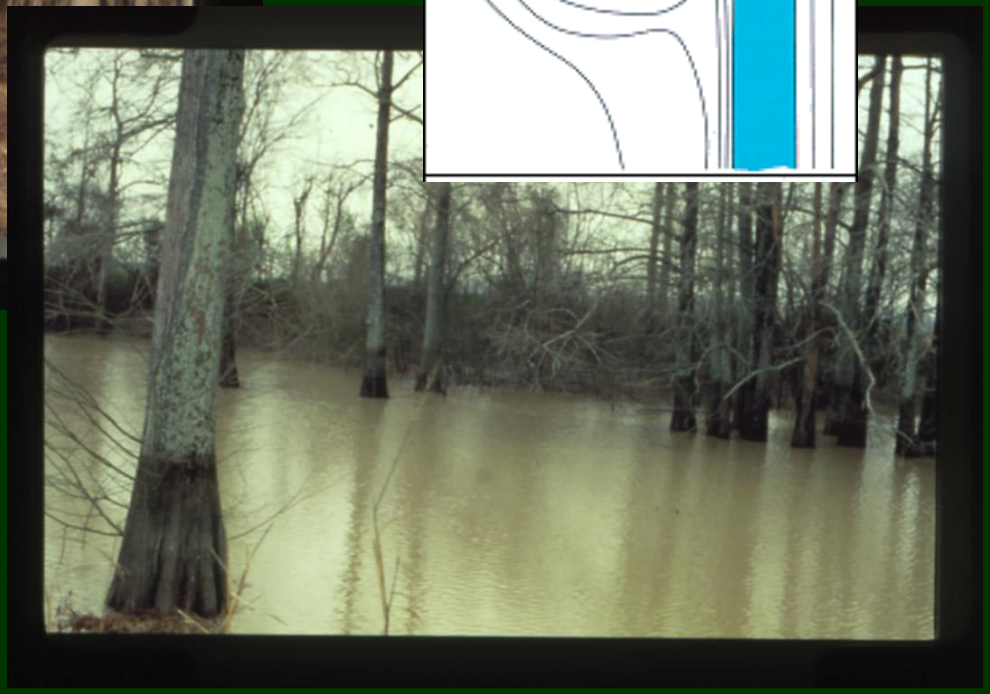
Wetland Functions: Flood Control



Without wetlands, streams quickly fill with run-off water, leading to erosion damage along banks and extra water volume leads to flooding.

Wetland Functions:





Flood Control

Wetland Functions: Sediment Removal

Backwater zones let suspended sediments settle, while waters filter through soil and return slowly to stream channel.

Vegetation stems slow moving waters, causing suspended sediments to drop out.

Wetland Functions: Sediment Removal

Many sediments (particularly clays) may have toxic substances adhered to their surfaces. (Ex., road oils and greases)

These settle out of the water with the sediments.

Wetland Functions: Nutrient Removal

- **Nutrient uptake by plants and retention by soils.**

  Slow decomposition processes create a nutrient "*sink*". Wetlands reduce nutrient concentrations in water by 50-90%

  ... They are sometimes called the "kidneys" of the landscape.

Wetland Functions: Nutrient Removal

-- If excessive nutrients are added, (particularly nitrogen & phosphorus), it may cause **eutrophication** – nutrient enrichment pollution and/or lead to shift in natural species composition of wetland. (Loss of species diversity)

"Constructed wetlands" may be better for treating large pollution loads.

Eutrophication

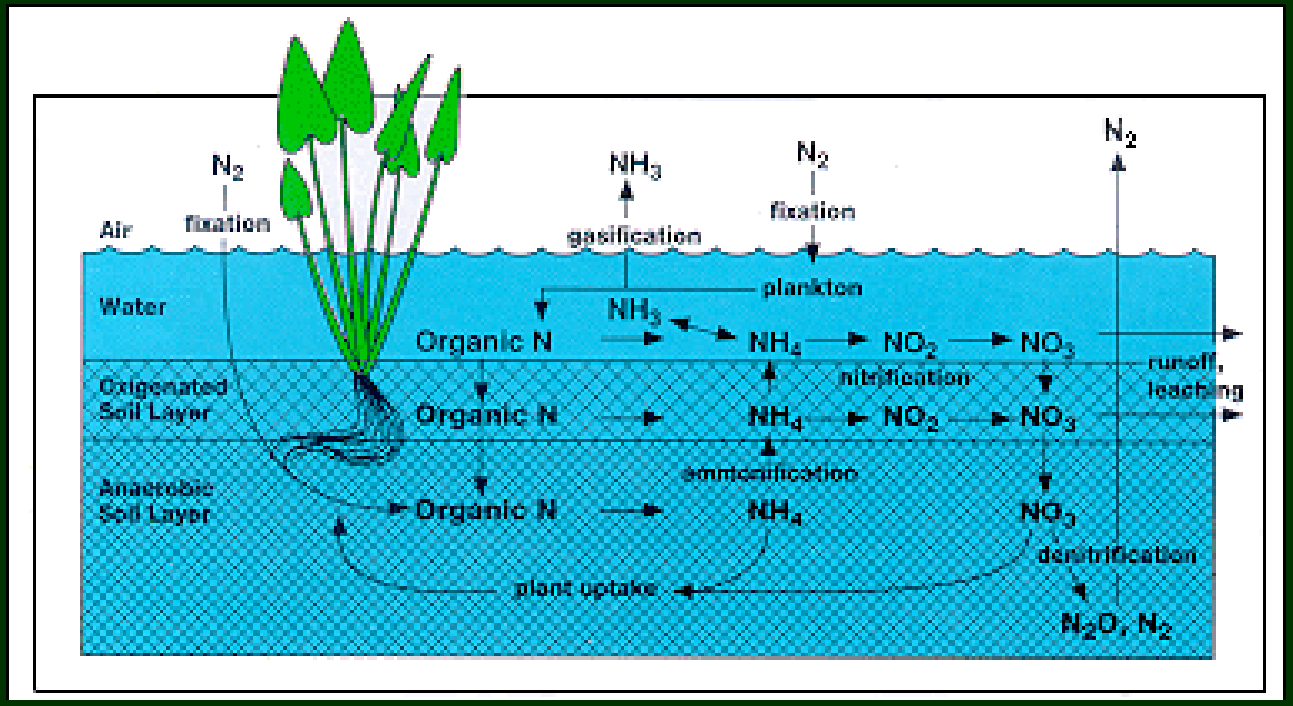
Nutrient Pollution

- Nitrogen
- Phosphorus

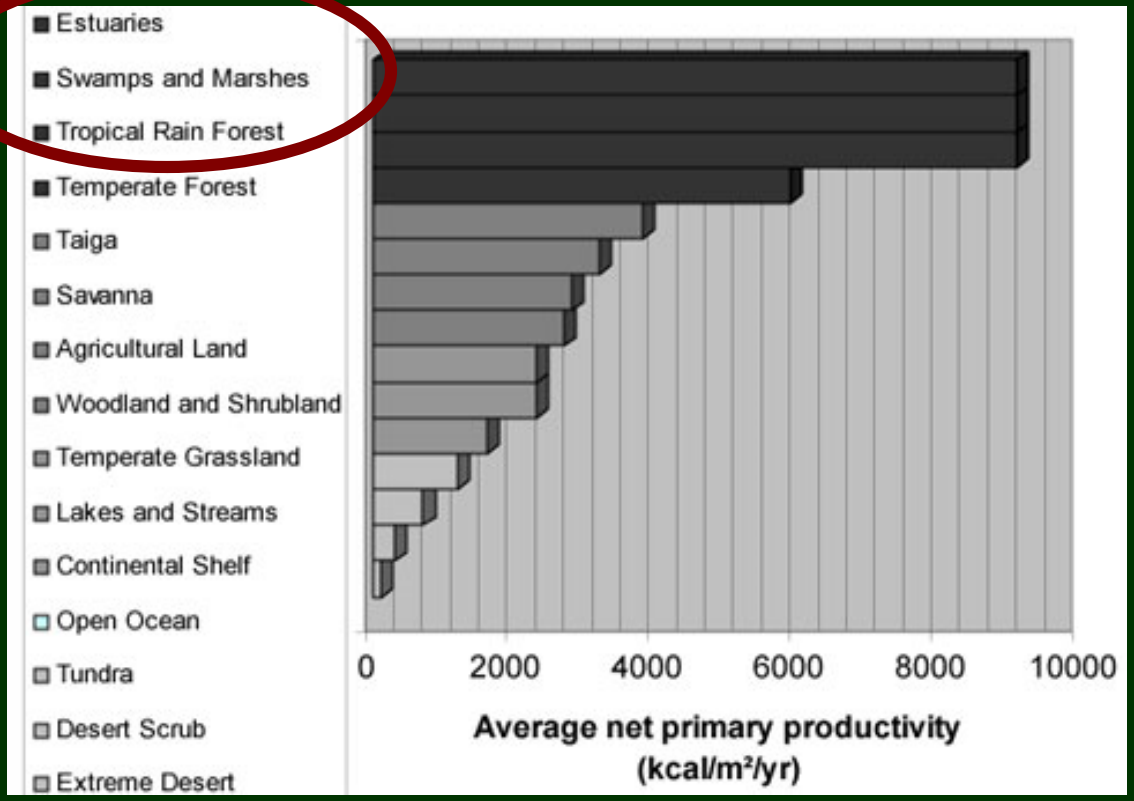
Oxygen Consumption due to decomposing plants and algae

Wetland Functions: Nutrient Cycling

-- In addition to "storing" nutrients, wetlands also cycle them (example: returning nitrogen to the atmosphere through denitrification process.)



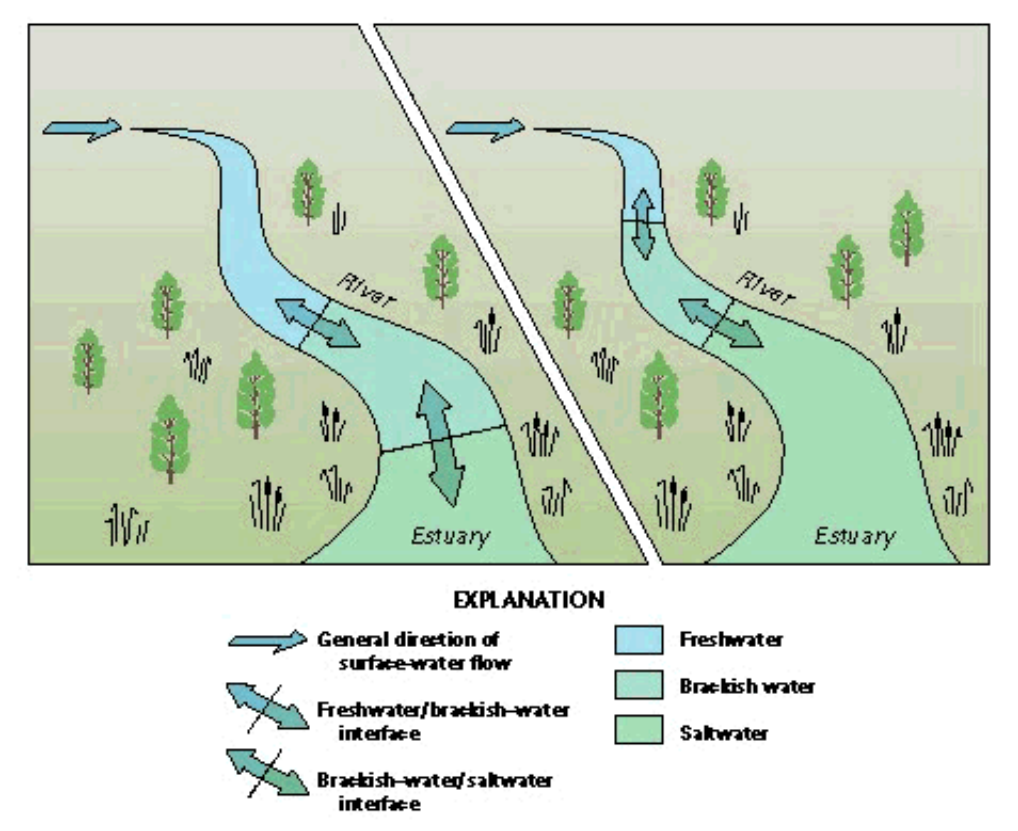
Wetland Functions: Primary Production



Primary production is very high in wetlands, providing food source for many organisms both inside wetland and beyond.

Wetland Functions: Nutrient Export

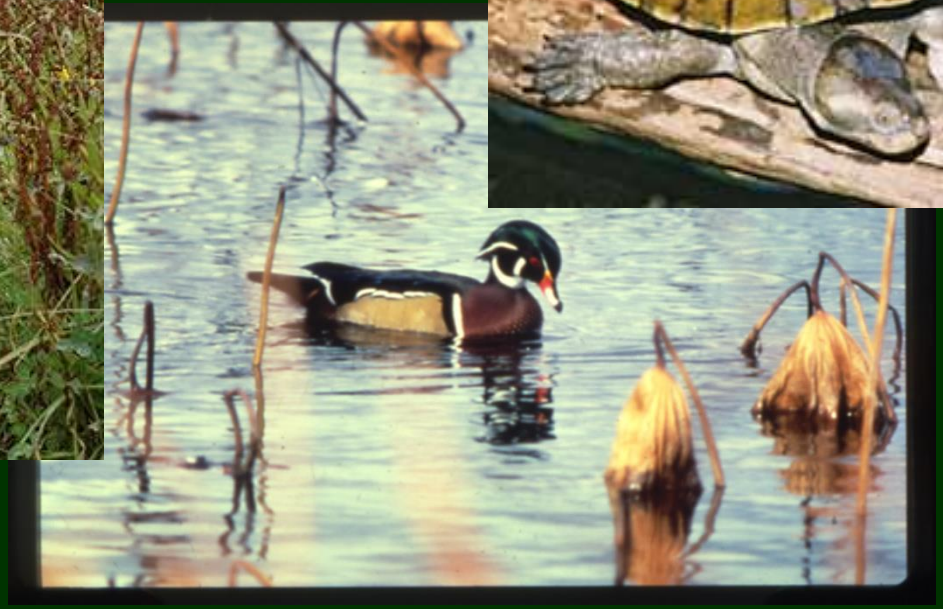
Detritus (dead organic material) carried from wetland into stream system providing food source for that system.



This occurs in stream-side wetlands and in river estuaries.

Wetland Functions: Wildlife Habitat

Habitat – wetlands provide habitat for many species of plants, wildlife, waterfowl, fisheries, etc.



Wetland Protection

- Lands that meet the legal definition of “Wetlands” are protected to varying degrees by Federal, State, and local regulations.
- Each layer of regulation can provide increased protections, but it cannot supercede or reduce the overlying regulations. (State laws can be MORE restrictive than Federal laws, but NOT LESS.)
- There is a recognized methodology used to delineate wetlands, to identify areas that are subject to regulation and protection.

Wetland Protection

- In Massachusetts, most agricultural activities are exempt from the Wetland Protection Act and its regulations.
- Wetland filling and draining is prohibited.
- Best management practices in agriculture are intended to minimize soil erosion impacts and nutrient pollution.

Questions?