Self-Taught Education Unit

Wetland Functions And Values

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Introduction

Throughout the state of Virginia there is a variety of wetland types which range from tidal marshes and swamps near the coast, to nontidal wetlands found anywhere from the coastal plain to the mountains. Wetlands are found in topographic depressions or along rivers, lakes, and coastal waters. Wetlands, in general, are areas that are wet or have wet soils during some part of the growing season. Wetland soils are **hydric** meaning they have an abundance of moisture. Wetlands are further characterized by the vegetation that they support which is adapted to grow in wet conditions, which is referred to as **hydrophytic** vegetation. Wetland vegetation may include grasses, herbaceous plants (non- woody), shrubs, and trees. **Tidal wetlands** are found along the coastline where they are influenced by daily tidal fluctuations and include vegetated marshes and swamps or nonvegetated mud and sand flats (Figures 1, 2, 3, 4). **Nontidal wetlands** are not influenced by

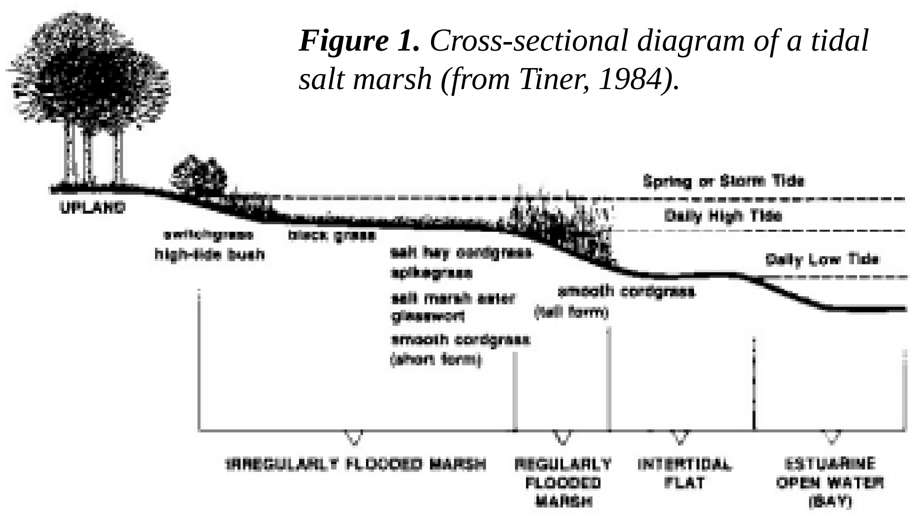


Figure 1. *Cross-sectional diagram of a tidal salt marsh (from Tiner, 1984).*

Figure 2. *Vegetated tidal wetland.*

Figure 3. *Non-vegetated mud flat.*

tidal inundation and may include marshes, swamps, bogs, and low-lying areas along the margins of rivers, streams and lakes. They can also be found in isolated upland depressions or areas where the water table stays near the land surface (Figures 5, 6). Nontidal and tidal wetlands share many of the same values and both are important in maintaining the health of the Chesapeake Bay and its living resources.

Wetlands were historically considered wastelands that harbored bothersome snakes and disease-carrying insects. They were considered useless for most farming or building because of the unstable, wet substrate. These lands were often drained or filled for farming, housing, and urban development. This view has changed significantly as the connection between wetlands, wildlife, water quality, and other ecological and economic values have been studied. Hunters, fishermen, trappers, and loggers have always benefited from the abundant supply of mammals, fish, waterfowl, and lumber harvested from wetlands.

Figure 4. *Tidal wetland.*

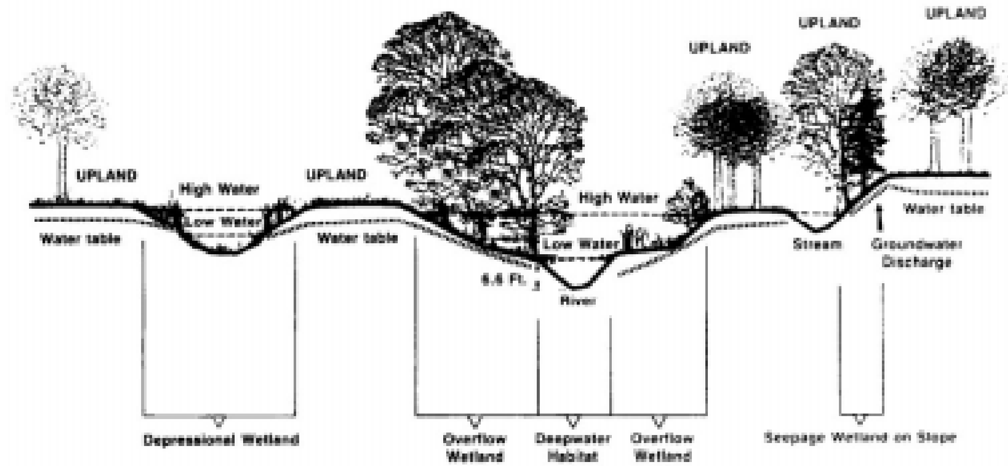


Figure 5. *Schematic diagram showing wetlands, deepwater habitats, and uplands on landscape. Note differences in wetlands due to hydrology and topographic location (adapted from Tiner, 1984).*

Wetland Functions and Values

Ecological processes are usually described by function, such as wildlife habitat support or primary productivity. **Function** is an ecological process that may not directly benefit humanity. The further classification of a function by its **value** connotes usefulness to humans. However, in general these terms may be used interchangeably because functions may be values. (Tables 1, 2) The location of the wetland, the human population pressures on it, or the extent of the wetland

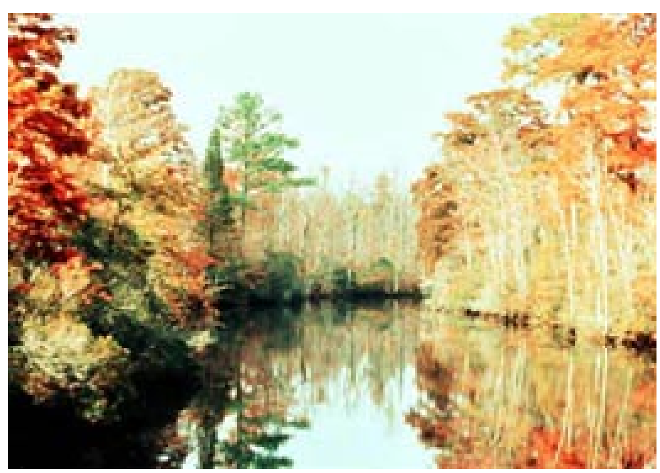


Figure 6. *Dragon Run Swamp.*

Table 1.

The term value imposes an anthropocentric orientation on a discussion of wetlands. The term is often used in an ecological sense to refer to functional processes, as for example when we speak of the "value" of primary production in providing the food energy that drives the ecosystem. But in ordinary parlance, the word connotes something worthy, desirable, or useful to humans.

may indicate the value of a functional ecologic process (Mitsch and Gosselink, 1986). For example, wildlife habitat may be important to humans because it provides wildlife for hunting, or nature study. Location may give the wetland value also, for example; a wetland may be important for water quality if it is located downstream of a pollution source, there it has the greatest potential for filtering pollutants.

Wetlands provide many ecological and socio-economic benefits including: water quality improvement, aquatic productivity, fish and wildlife habitat, shoreline erosion control, stormwater treatment, flood protection, potable water supplies, economically valuable resources, and recreation. Wetlands are diverse and cover a wide range of habitats. Because they do not all provide the same values or functions, generally it is difficult to determine the functions a wetland provides without site specific analysis. Variables to consider in assessing the functional values of a wetland may include: wetland type, soil characteristics, hydrology, size, and surrounding upland land use. This report gives an overview of wetland functions and values. (Table 3)

Table 2.

Perceived values arise out of the functional ecological processes, but are determined also by the location of a particular wetland, the human population pressures on it, and the extent of the resource.

Table 3.

Wetland Functions and Values

Environmental Quality Values

Water Quality Improvement
- **Pollutant removal (heavy metals, pathogens)**
- **Sediment trapping**
- **Nutrient uptake and recycling**
- **Oxygen production**
- **Wastewater treatment**
- **Stormwater treatment**

Aquatic and Terrestrial Productivity

Fish and Wildlife Habitat
- **Spawning and nesting sites**
- **Nursery areas for young**
- **Shelter from predators**
- **Foraging areas**

Socio-Economic Values
- **Shoreline erosion control**
- **Flood protection**
- **Groundwater recharge and discharge**
- **Natural products (timber, fish, waterfowl)**
- **Recreation (boating, fishing, hunting)**
- **Aesthetics**

Wetland Values to the Chesapeake Bay

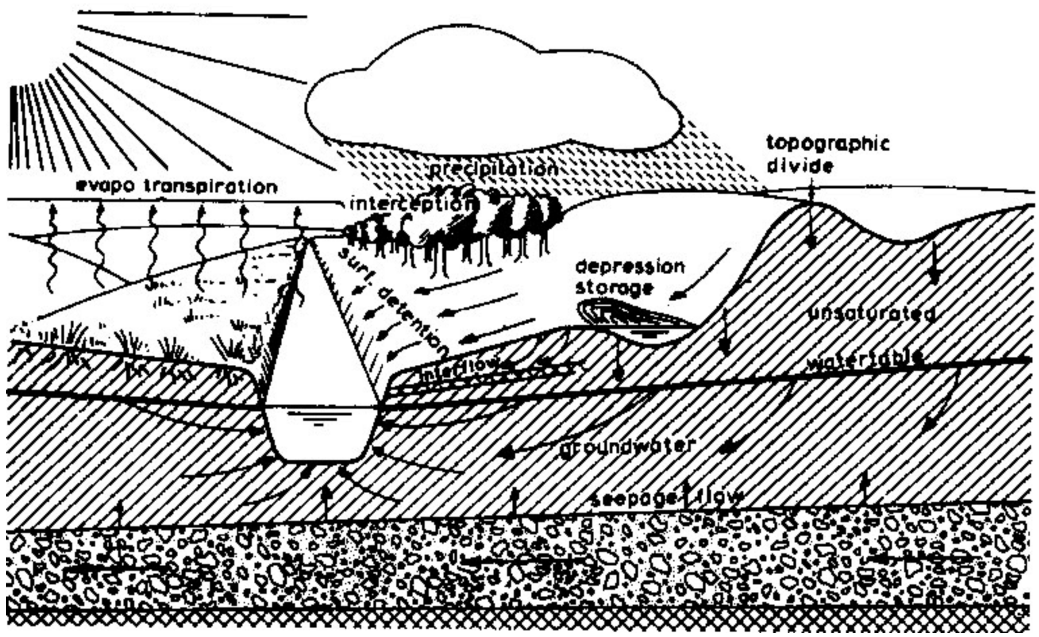


Figure 7. The riverine hydrologic cycle; note the subsurface flows (adapted from Clark, 1983).

In considering the values of wetlands, it is important to understand the coupling of wetlands with adjacent ecosystems, such as streams, rivers, lakes, bays, uplands, and floodplains. Of particular concern is the value Virginia's wetlands may play in improving or maintaining the Chesapeake Bay ecosystem. The entire Bay watershed should be considered in evaluating the cumulative function of wetlands. A **watershed** can be defined as all the area that drains by surface or subsurface flow into the water body being considered (Figure 7). The Chesapeake Bay watershed extends north through parts of New York State and west to the Appalachian mountains covering approximately 64,000 square miles (Chesapeake Bay Program, 1983) (Figure 8). Approximately 3% of the watershed is comprised of wetlands (Tiner, 1987). Any substance that is added to the land or water within this area has the potential to impact the water quality and ecology of the Bay system. For example, agricultural or lawn fertilizers applied in western Virginia or New York have the potential to impact the Bay either through surface flow or groundwater flow (Figure 7). Wetlands throughout this watershed have the potential to improve or maintain many ecological values in waters flowing toward the Bay, especially water quality.

Figure 8. Chesapeake Bay Watershed.

Water Quality Improvement

- **Pollutant removal**
- **Sediment trapping**
- **Nutrient cycling**
- **Wastewater treatment**

Table 4.

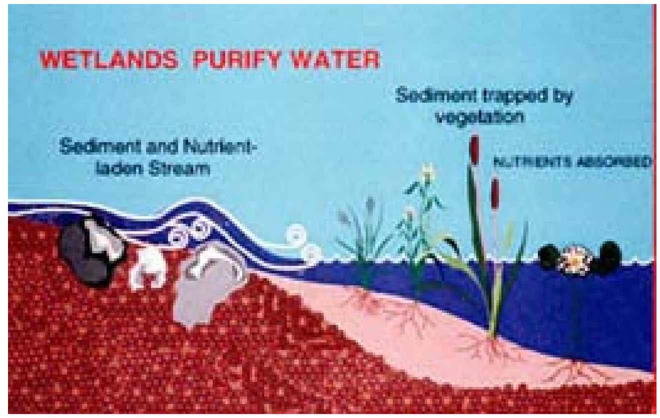


Figure 9. *Wetlands improve water quality.*

Water Quality

Located at the interface between terrestrial and aquatic systems, wetlands often intercept pollutants and nutrients in upland runoff before they reach an adjacent waterway (Figure 5). Substances that can affect water quality include nutrients, dissolved gases, heavy metals, pesticides, pathogens, and industrial wastes. The nutrients of most importance in wetland and aquatic systems are nitrogen and phosphorous. In excessive quantities, they can cause nuisance algal blooms and subsequent low oxygen levels; however, they are essential for growth of wetland plants. Dissolved oxygen is produced by plants and is necessary for aquatic animals to survive. The processes occurring in wetland systems that impact water quality are plant uptake and cycling, filtering, sedimentation, reduction in shoreline erosion, soil adsorption, and soil microbial activity. (Table 4, Figure 9)

Nutrient Uptake and Cycling

As wetland plants grow they take up **inorganic forms** of nutrients (nitrogen, phosphorous) as they die they release **organic** or detrital forms (decaying plant material) of nutrients. The result is a valuable cycling and transformation of nutrients in the ecosystem. The transformation from inorganic to organic forms of nutrients reduces potential problems from excessive nutrient loadings, while providing organic forms of nutrients that are more useful to aquatic animals (Figure 10).

The organic forms of nutrients provide the base of the detrital food web, which may support many commercially important fish, crabs, and shellfish (Elder, 1985). Detritus is consumed by many small invertebrates, juvenile fish, and oysters, which in turn are eaten by larger fish, birds, and crabs. This pattern of feeding is called a **food web** and is essential to the viability of the Chesapeake Bay and for providing fish for human consumption (Figure 11).

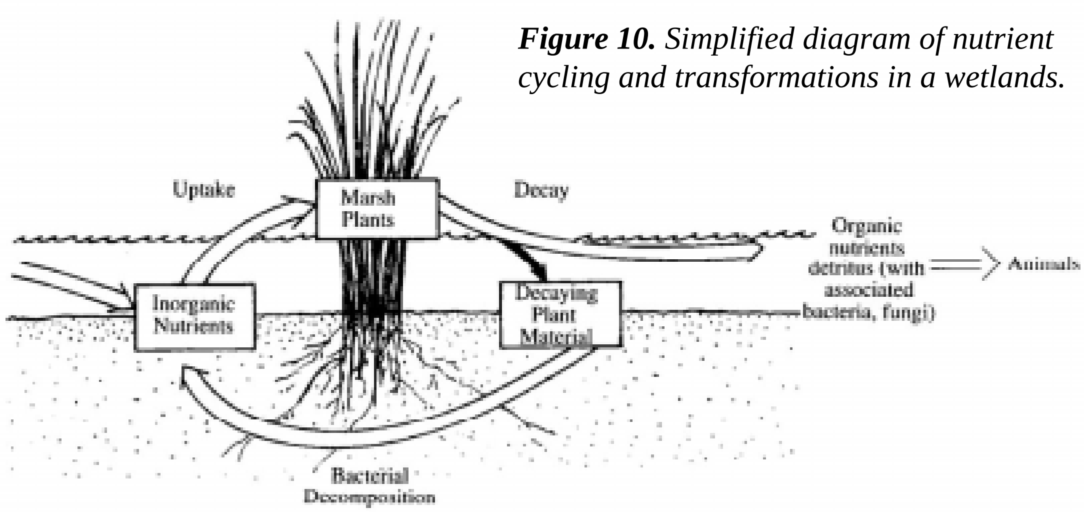
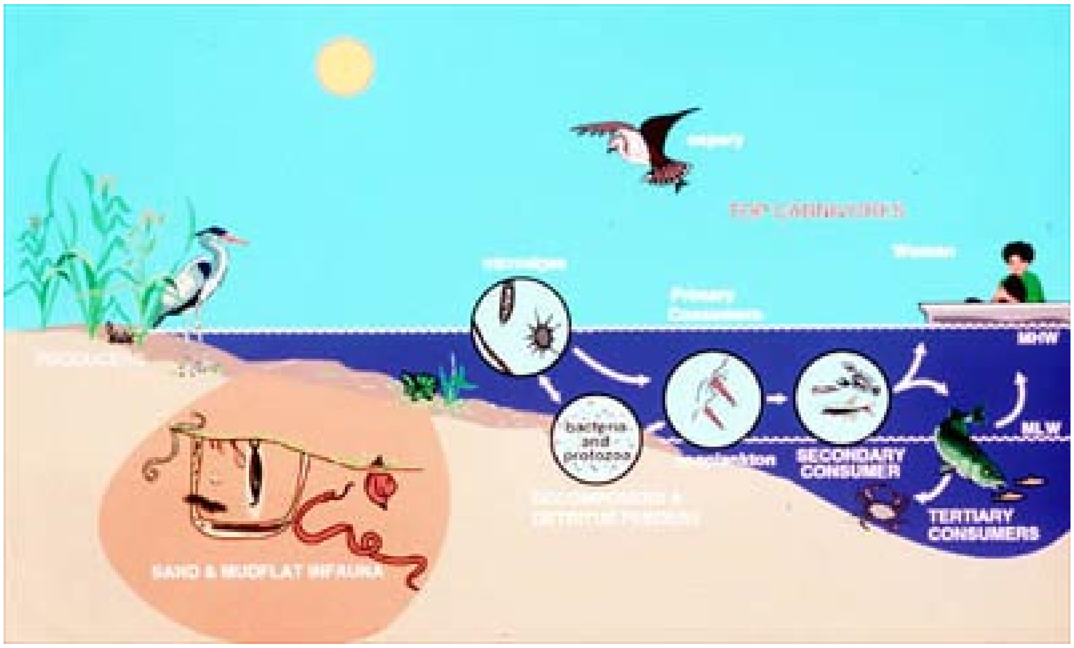


Figure 10. *Simplified diagram of nutrient cycling and transformations in a wetlands.*

Figure 11. *Estuarine food web.*



Excessive nutrients may come from septic system leakage, sewage effluent, runoff from fertilized lawns and farms, and stormwater outflows. Uncontrolled inputs of nutrients may contribute to decreased water clarity by stimulating algal blooms. As the algae bloom dies and decomposes, it may also reduce the oxygen content in the water.

Some wetlands function as nutrient sinks in which the net output of nutrients is less than the net input. Most wetlands are at least seasonal sinks for nutrients, taking them up during the growing season. This wetland function can be very important in managing urban and agricultural runoff with high concentrations of nutrients which may degrade downstream water quality. The research of Cerco and Kuo (1979) concluded that a tidal marsh creek that received effluent from a poultry processing plant significantly reduced levels of nutrients and increased levels of dissolved oxygen. A review by Van der Valk et al. (1979) of 17 studies showed that freshwater wetlands trapped nutrients during the growing season. Even a slight increase in the amount of wetlands in an agricultural watershed reduced the amount of nitrogen leaving the watershed (Jones et al., 1976).

Plants may also take up heavy metals, and other chemical pollutants and incorporate them into their leaves, roots, and stems (Kadlec and Kadlec, 1979; Boto and Patrick, 1979). As the plant dies, the pollutants may be buried and removed from the system or returned to the water column. If the plant is consumed by an animal the pollutants may be passed up the food web.

Wetland Soil Processes

Wetland soils have been shown to be more important at removing nutrients from the overlying water than plant uptake. Sather et al. (1990) states that chemical adsorption or adhesion by detritus and chemical precipitation appear to remove more phosphorus than plant uptake. Bacteria at the water sediment interface remove significant amounts of nitrogen from the water column (Sather et al., 1990). Soil microbes such as bacteria are also important in degrading pesticides, resulting in reduced potential risk even if the soils are disturbed (Boto and Patrick, 1979).

Filtering and Sedimentation

Wetlands are sites of increased sedimentation, which improves water quality by reducing suspended solids and increases bank stabilization through the accumulation of sediment. Wetland vegetation and the associated root mass act to slow water flow, which results in settlement and deposition of suspended sediments, and the associated pollutants, and nutrients (Boto and Patrick, 1979). Riparian areas have been shown to retain 80 percent of sediment runoff from adjacent agricultural lands (Richardson, 1989). Wetlands located in depressions may retain all the sediment entering them (Novitzki, 1979). Benefits are realized by increased water clarity and reduced siltation in downdrift oyster beds, fish spawning and nursery areas, seagrass beds, and navigation channels (Anderson et al., 1978) (Figure 12).

Figure 12. *Sediment-laden run off.*

As sediments are removed from the water column, so are attached nutrients, heavy metals, and other toxins. Mitsch et al. (1979) found that large amounts of phosphorous were deposited with river sediments during river flooding in a swamp. Most wetland sediments accumulate faster than they are removed. This accumulation rate allows the wetland to retain a significant portion of the nutrients and other pollutants buried in the soil (Sather et al., 1990). Heavy metals and other toxic substances attached to sediment particles will become immobile through burial in sediments until they become disturbed through dredging or lowering of the water table (Boto and Patrick, 1979).

Wastewater Treatment

Naturally occurring and artificially made wetlands have been utilized as an economically viable alternative in waste- water treatment. It has been shown that some wetlands are successful at reducing nutrients, heavy metals, and bacteria from sewage effluent and other waters (Grant and Patrick, 1970; Sloey et al., 1978; Kadlec and Kadlec, 1979). In Monterey, a town in western Virginia, a bulrush wetland was the most economical alternative for accomplishing secondary wastewater treatment. (Virginia Natural Resources Newsletter, 1989). Freshwater wetlands filter 60 - 90 percent of the suspended solids from wastewater addition studies (Richardson, 1989). Boyt et al. (1976) studied a hardwood swamp that had been receiving sewage effluent for 20 years and reported a 98 percent reduction in phosphorous and 90 percent reduction in nitrogen in the outflow waters. Coliform bacteria may also show significant reductions in sewage effluent after passing through a wetland (Spangler et al., 1976). Coliforms are an indicator of human fecal matter which may contain pathogens. Some wastewater heavy metals that are incorporated in plant tissue can be passed up the food web as organisms feed on the plant parts (Windom, 1976; Roman, 1981).

Stormwater Management

Stormwater runoff is becoming widely recognized as a significant contributor to water pollution problems. Stormwater runoff may contain many pollutants, among them are fuel and chemical spillage, lawn fertilizers and herbicides, vehicle drippings (oil, gas, antifreeze), sediment from erosion or construction activities, and sewage from failing systems. Urban areas are beginning to implement natural methods of reducing these pollutant loads, including vegetated drainage ways and detention basins with their associated wetland border. The Commonwealth's Best Management Practices (BMP) Manual for urban areas suggests using wetlands for natural biological treatment of stormwater (Virginia State Water Control Board, 1979b). Directing stormwater runoff through a wetland can be considered a filtering process analogous to running dirty water through a coffee filter. The filtering process is accompanied by complex biological and chemical reactions that occur in the wetland, resulting in significant reductions in total pollutants (Figure 13).

In summary, establishment or maintenance of wetland buffer zones may significantly improve water quality in the adjacent and downstream water bodies. Wetlands can improve water quality by five mechanisms: 1) plant nutrient uptake and cycling, 2) soil processes, 3) bacterial processes, 4) sedimentation, 5) reduction in shoreline erosion (discussed later) (Table 5).

Figure 13. *Contaminated outfall; point source pollution.*

Table 5. (below)

Natural Marsh Investigations: Effects of a Natural Wisconsin *Typha* Marsh on a Stream Receiving Secondary Effluent

	Spring Creek Above Outfall	Spring Creek 200m Below Outfall	Channel Below Brillion Marsh	Treatment Plant Effluent
BOD (mg/l)				
Mean	**7.7**	**35.0**	**3.5**	**109.3**
Coliforms (x10^3)				
Mean	**47.0**	**240.0**	**6.0**	**43.0**
Turbidity (JTU)				
Mean	**8.7**	**17.7**	**4.0**	**43.0**
Total Phosphorus (mg/l)				
Mean	**1.2**	**4.28**	**1.41**	**10.3**

Primary Production

Wetland productivity provides the source of many wetland functions, including nutrient recycling, fish and wildlife food and habitat, and food web support. All life is ultimately dependent on the photosynthetic production of plant material by **primary producers** (Table 6). Photosynthetic production of plant tissue converts the sun's energy into a form which can be used by animals. In this process, nutrients and carbon dioxide are taken up and oxygen is released. Primary producers include grasses, shrubs, trees, macro-algae, and floating microscopic plants (phytoplankton). Wetland plants produce more plant material than some of our most productive cultivated farm fields (Teal and Teal, 1969) (Figure 14). Numerous wetland plant adaptations allow for maximum growth rates that are less common or impossible for terrestrial plants, which may be water or nutrient limited (Wetzel, 1989).

Aquatic Productivity

- **Detritus production**
- **Benthic algae**

Table 6.

Watersheds which drain wetland regions export more organic material than do watersheds that do not have wetlands (Mitsch and Gosselink, 1986).

Wetzel (1989) compared the productivity rates across a wetland gradient beginning on the uplands and moving into the open water. He reported that the photosynthetic production of organic matter was greatest in the wetland area (Figures 15, 16). The upland forest and plants produced less than half the amount of organic matter that the wetland produced.

A portion of wetland production is directly consumed by animals such as mammals, birds, and insects. The most significant portion is consumed as detritus which is decaying plant material that is colonized by microorganisms (bacteria, protozoa, and fungi). The attached microbes increase the nutritional content of the plant material, resulting in a highly nutritious and readily available food source for many aquatic organisms including fish, crabs, shellfish, and zooplankton (microscopic animals) (Figure 17). The fungi and bacteria in swamps produce vitamin B12, which is

Figure 14. *Net primary productivity of selected ecosystems ($g/m^{2}/yr$)*

Figure 15. *Photosynthetic marine algae.*

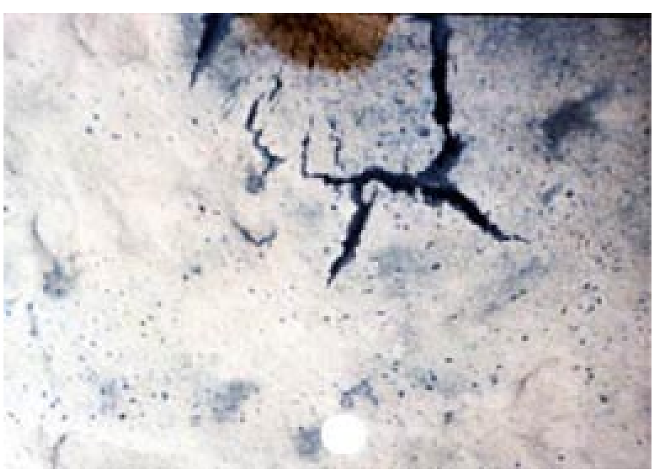


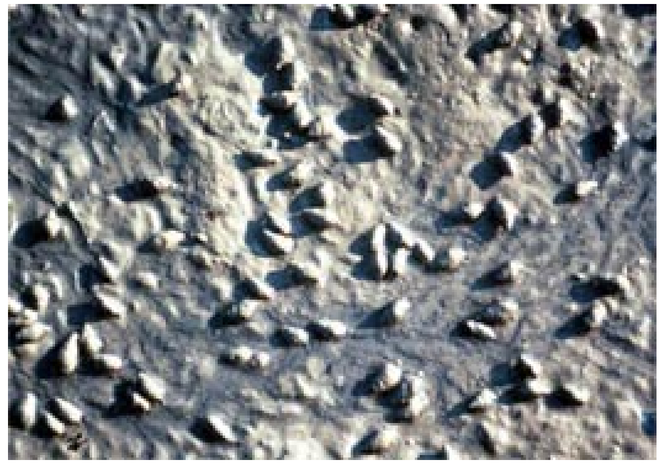
Figure 16. *Algae "mat" on mud flat surface.*

Figure 17. *Rackline of detritus— dead plant material.*

Table 7.

Fish and Wildlife Habitat
• **Wetland food webs**
• **Spawning and nesting sites**
• **Nursery areas for juveniles**
• **Shelter from predators**

Figure 18. *Mud snails feeding on a mud flat.*



necessary for aquatic invertebrates and fish growth (Burkholder, 1956). Floodplain swamp forests are among the most productive ecosystems due to periodic flooding that supplies organic matter, water, nutrients, and clay (Bates, 1989).

Figure 19. *Oysters growing on a mud flat.*

Fish and Wildlife Habitat

Wetlands are used by a large variety of birds, fish, mammals, and invertebrates for food, shelter, and spawning and nesting sites (Table 7). Among the most valued food items in wetlands are plant leaves, detritus, tubers, seeds, snails, clams, worms, frogs, and insects (Figure 18). Approximately two-thirds of the fish and shellfish species that are harvested commercially are associated with wetlands (Mitsch and Gosselink, 1986) (Figure 19). These species include: blue crab, oyster, clam, shrimp, striped bass, menhaden, bluefish, flounder, sea trout, spot, and croaker (Figure 20). Rozas and Hackney (1984) found 29 species of fish in a tidal marsh and suggested that shallow marsh areas are a preferred habitat because of reduced competition, slow currents, scarcity of predators and an abundant food supply.

In 1967-1968, 95% of Virginia's annual fish harvest was shown to be at least partially dependent on wetlands (Wass and Wright, 1969). Blue crabs use tidal marsh creeks as shelter from predators during

Figure 20. *Juvenile fish using wetlands as habitat.*

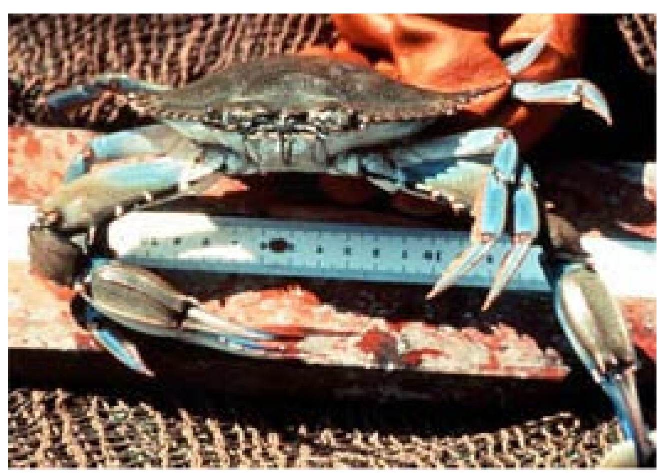


Figure 21. *Blue crab.*

Figure 22. *Fiddler crab on mud flat.*

Figure 23. *Fiddler crabs feeding at wetland fringe.*

molting (Hines et al., 1987). Juvenile blue crabs and 14 species of fish were more abundant on flooded salt marsh surfaces than in nonvegetated subtidal areas (Zimmerman and Minello, 1984a) (Figure 21). Some species, such as mummichogs (minnows) and fiddler crabs, utilize wetlands throughout their lifespan (Figures 22, 23). Other species, such as striped bass, spawn in waters adjacent to tidal freshwater marshes similar to those along the Pamunkey River (McGovern and Olney, 1988). Many coastal fish, including spot, menhaden, and mullet, use wetlands as nursery areas for their juvenile stage (Weinstein, 1979). The diet of menhaden has been shown to consist of 30% marsh derived detritus and 70% plankton (Deegan et al., 1990).

Mitsch and Gosselink (1986) reported that virtually all of the freshwater fish and shellfish are partially dependent on wetlands. Freshwater fish depend on wetlands for food, nursery grounds, and spawning. Almost all recreational freshwater fish spawn in the aquatic portions of wetlands, often spawning in marshes bordering lakes or in riparian forests during flooding (Peters et al., 1979, Mitsch and Gosselink, 1986). Common fish that utilize freshwater wetlands include pickerel, sunfishes, bass, crappies, bullheads, carp, herring, white perch and American shad.

Several anadromous fish (those which migrate from saltwater to freshwater to spawn) spawn in wetlands of the freshwater portions of rivers. For example, the blueback herring spawns on the hardwood forest floor during flooding (Adams, 1970), and the American shad spawns in freshwater streams (Tiner, 1985). Striped bass migrate to fresh water areas to spawn allowing the juveniles to utilize tidal fresh wetlands as nursery and feeding areas (Odum et. al. 1984). Bottomland hardwoods of the southeastern U.S. are important to fish that use them for spawning, feeding, and hiding (Sather et al., 1990). Estuarine and marine fish and crabs have been reported to migrate into freshwater wetlands for food, spawning, and nursery areas (Conner and Day, 1982) (Figure 24).

Figure 24. *Nursery grounds of river herring.*

Wetlands provide a critical habitat for many birds including waterfowl, migratory songbirds, and shorebirds. Some species may utilize wetlands year round while others use them seasonally for breeding, feeding, resting, or over- wintering. Wetland nesting birds include redwinged blackbirds, green herons, least bitterns, mallards, black ducks, wood ducks, and Virginia rails (Tiner, 1985) (Figure 25). Migratory waterfowl are dependent on wetlands for feeding during their seasonal stopovers. Metzgar et al., (1973) estimated that the Bay's wintering population of waterfowl has been more than one million (Figures 26, 27). Various shore and wading birds use wetlands as a food source and a location for nest sites. Atlantic coast salt marshes are used for nesting by birds such as laughing gulls, Forster's terns, clapper rails, willets, and marsh hawks (Tiner, 1984). Coastal wetlands are also used as foraging and nest sites for wading birds such as the herons and egrets (Tiner, 1984) (Figures 28, 29, 30). Other birds utilizing nontidal wetlands may include towhees, chickadees, titmouses, warblers, tanagers, vireos, flycatchers, and sparrows (Tiner, 1985). Predaceous birds such as hawks, bald eagles, ospreys, and owls also feed and nest in wetlands. Wetland seeds and tubers provide essential winter food for ducks and geese (Weller, 1979). Bottomland forested wetlands are primary wintering grounds for waterfowl, as well as important breeding areas for wood ducks, herons, egrets, and wild turkeys (Tiner, 1984).

Muskrats, beavers, rabbits, river otters, raccoons, mice, and white-tailed deer are among the furbearers utilizing wetlands (Figure 31). Muskrats may feed on plant parts including belowground tubers;

Figure 25. *Redwing blackbird nest.*

Figure 26. *Canvasback ducks overwinter in wetland.*

Figure 27. *Canada geese foraging in wetland.*

Figure 28. *Great blue heron hunting minnows along tidal shoreline.*

Figure 29. *Egret rookery.*

Figure 30. *Shore birds feeding in shallow water.*

Figure 31. *Raccoon hunting in wetland.*

Figure 32. *Muskrat lodge.*

they may also feed on invertebrates found in wetlands such as clams and mussels. Muskrat lodges are often made of tall robust plants such as big cordgrass and cattails (Figure 32). White-tailed deer depend on wetlands for winter shelter, food, cover and breeding (Tiner, 1985).

Another major component in wetland wildlife populations are the reptiles (turtles, snakes) and amphibians (frogs, salamanders). Almost all amphibians depend on wetlands for breeding. They lay eggs in water where their larvae develop and feed on algae as well as other foods (Weller, 1979). Frogs often found in wetlands include green, bull, and leopard frogs, and spring peepers (Tiner, 1985). Amphibians are numerous in some wetlands; 1,600 salamanders and 3,800 frogs and toads were found in a gum tree pond less than 100 feet wide in Georgia (Wharton, 1978). Amphibians are a prime food source for larger animals such as raccoons, herons, mink, bitterns, and fish (Weller, 1981). Turtles and snakes use freshwater wetlands for food and cover and move to drier land to deposit eggs. Turtles are most common in freshwater marshes and ponds, the most common being box, snapping, painted, pond, and mud turtles (Clark, 1979). Water snakes are the most abundant snake in wetlands, though cottonmouths, garter, and mud snakes are also found.

Wetlands are also important in maintaining species diversity which is critical to ecosystem balance. Diversity is a measure of the variety of species present in an ecosystem. High species diversity provides resilience to potentially catastrophic events such as disease or environmental disturbance. Of the nation’s endangered and threatened species, 50 percent of the animals and 28 percent of the plants are dependent on wetlands for their survival (Niering, 1988). Preservation of wetland plants is also important for maintaining direct potential benefits in the fields of agriculture and medicine (Niering, 1988). As Ehrlich and Ehrlich (1981, in Niering, 1988) state:

"The natural ecological systems of Earth, which supply these vital services, are analogous to the parts of an aeroplane that make it a suitable vehicle for human beings. But ecosystems are much more complex than wings or engines. Ecosystems, like well-made aeroplanes, tend to have redundant subsystems and other `design' features that permit them to continue functioning after absorbing a certain amount of abuse. A dozen rivets, or a dozen species, might never be missed. On the other hand, a thirteenth rivet popped from a wing flap, or the extinction of a key species involved in the cycling of nitrogen, could lead to a serious accident."

For the survival of many fish and wildlife, it is critical to preserve not only the wetland habitat in which the species is most common, but also a portion of the adjacent areas. Maximum wildlife usage may be dependent on preservation of upland buffer areas adjacent to wetlands (Adamus, 1990). Certain species are dependent on adjacent upland or aquatic areas for some part of their life history such as breeding, feeding, protection, or raising young. For example, trees and shrubs along a wetland edge make valuable nesting sites, song perches, and cover for birds. The upland adjacent to a wetland may be favored by wildlife for feeding, denning, nesting, cover, roosting, or breeding (Porter, 1981). Upland buffers in urban areas may provide the necessary shield and concealment from human activities to allow for wildlife usage (Porter, 1981). The combination of the wetland and upland fringe provides an abundance of food close to good cover.

Shoreline Erosion Control

Wetlands located at the interface between upland and aquatic habitats have the potential to reduce upland erosion by reducing wave energy and current velocity. (Table 8) As water moves across the reduced slope of shallow waters and wetlands, the energy dissipates. As friction or drag from the bottom increases the erosive force declines. This action occurs in nonvegetated as well as vegetated wetlands. Wave height and current speed are reduced by nonvegetated wetlands, such as beaches and mudflats by causing waves to spread out as they pass over the flat (Theberge and Boesch, 1978). Vegetated wetlands can reduce shoreline erosion by several mechanisms. The complex root system binds and stabilizes the sediment; as a wave propagates through vegetation additional frictional drag reduces wave energy and current velocity (Dean, 1979). Wetland vegetation also increases deposition of sediment which helps build the shoreline channelward of the uplands. Wetlands reduce the final impact on the upland, thereby reducing erosion of upland areas (Figure 33).

As wave action and current speed are reduced by the wetland, sediments in the water settle to the bottom, resulting in improved water quality and the

Socio-Economic Values

- **Shoreline erosion control**
- **Flood protection**
- **Groundwater recharge and discharge**
- **Natural products (timber, fisheries, furbearers)**
- **Recreation (boating, fishing, hunting)**

Table 8.

Figure 33. *Newly restored vegetated wetland.*

build-up of the marsh surface (Figure 34). Knutson et al., (1982) found that more than 50% of the energy associated with waves passing through a fringe marsh was dissipated within the first eight feet of the marsh. A planted salt marsh fringe may be an effective, inexpensive, and ecologically-preferred alternative to a bulkhead or a revetment (Hardaway et al., 1984).

Figure 34. *Vegetated wetland buffer.*

Bulrushes and reed grass have been reported as the most successful herbaceous vegetation in freshwater wetlands in erosion abatement (Seibert, 1968; Kadlec and Wentz, 1974). Forested wetlands or buffer areas are also useful in minimizing erosion. Trees stabilize banks of streams and rivers with their deep penetrating roots (Siebert, 1968; Virginia State Water Control Board, 1979a). Shoreline erosion control with vegetation has its limitations depending on many factors such as: potential wave energies, current velocities, flood magnitude, vegetation type, soil type, and slope.

Flood Storage

Wetlands adjacent to watercourses slow surface water flow and may temporarily store flood waters (Figure 35). Wetlands are able to store or remove water through several mechanisms, which include: maximum water storage resulting from soil properties specific to wetlands, plant uptake and evapotranspiration, and open water surface evaporation (Carter et al., 1979). The predominantly organic soils of wetlands have better water retention capabilities than mineral soils (Novitzki, 1979). Plant evapotranspiration is the loss of water vapor by plant parts. Flood storage may be reduced when soils are already saturated or in winter when plant uptake is lower (Carter et al., 1979). The increased friction caused by contact with wetland vegetation and roughness of the ground reduce flood current velocities. These processes desynchronize peak flows by temporarily slowing and storing water, which results in a non-simultaneous, gradual release of peak waters, minimizing flow downstream (Zacherle, 1984). This effect is particularly evident in riverine systems.

Figure 35. *Wetlands flanking river channel.*

Estuarine wetlands adjacent to tidal rivers provide a temporary storage of flood water, but their storage effect may be either increased or reduced by the tidal stage during flooding (Carter et al., 1979). Boon (1975) demonstrated that the configuration of meandering marsh creeks and broad tidal flats can cause diversion and retention of peak tidal current flows. The ability of wetland vegetation to slow flood waters depends on the type and density of vegetation and the depth of the water (Carter et al., 1979).

Flood control has become increasingly important in urban areas where the rate and volume of stormwater runoff have increased with nonporous surfaces, such as roads, parking lots, and buildings. The U.S. Army Corps of Engineers found that protection of natural wetland systems along the Charles River basin in Massachusetts was the most cost-effective solution to controlling flood waters (U.S.

Army Corps, 1972; Carter et al., 1979). Mangrove swamps are so effective at reducing flood levels and buffering storm water damage that the Federal Flood Insurance program requires coastal communities to prohibit mangrove destruction if they wish to remain eligible for insurance (Tiner, 1984). Flood flows in watersheds with wetlands may be 80 percent lower than in basins without wetlands (Novitzki, 1979). Mitsch et al., (1979) observed floodwaters being slowly returned to the river from a swamp months after maximum runoff occurred. This action results in reduced flood water heights because water levels have subsided in the river channel as these floodwaters are slowly released (Figure 36).

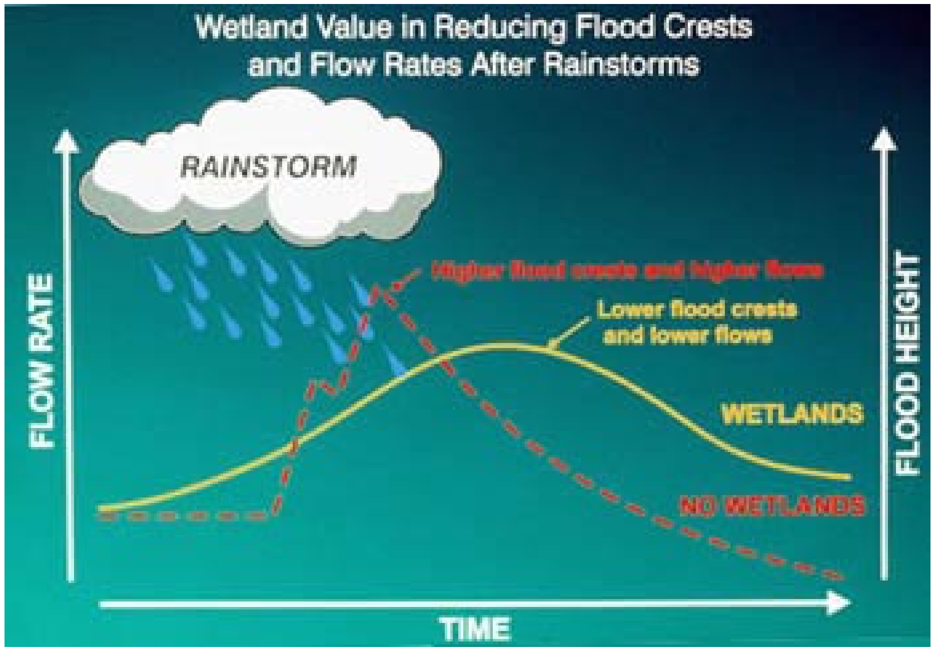


Figure 36.

Groundwater Discharge and Recharge

Some wetlands have been shown to be sites for groundwater recharge while most have been identified as areas of groundwater discharge. Groundwater recharge is the movement of water into a potential drinking water supply or aquifer. Wetlands located at sites of groundwater discharge occur where the groundwater table meets the surface of the land and discharges as springs or seeps. Most wetlands are discharge areas and may be used to supply drinking water. At least 60 municipalities in Massachusetts have public wells in or near wetlands (Motts and Heeley, 1973). In riverine wetlands, groundwater aquifers are recharged during floodplain inundation (Ward, 1989). Recharge potential varies according to wetland type, geographic location, season, soil type, water table location and precipitation (Tiner, 1984). Most estuarine intertidal wetlands are discharge rather than recharge areas (Carter et al., 1979). May (1989) observed that the freshwater wetlands on Hilton Head Island, South Carolina are important recharge reservoirs for the aquifer that supplies potable water. Wetlands have the potential to impact the quantity and quality of potable water supplies as recharge or discharge areas.

Economic and Recreational Values

The economic benefits of wetlands are realized in natural products, shoreline erosion control, stormwater treatment, flood protection, water supply, livestock grazing, and recreation. Natural products include timber, fish, shellfish, waterfowl,

Figure 37. *Recreational fishing.*

Figure 38. *Recreational boating.*

Figure 39. *Wildlife habitat.*

Figure 40. *Wetland flora.*

Figure 41. *Pound net.*

furbearers, peat, and wild rice. Wetland grasses are also used for livestock grazing or are harvested for hay. Recreational activities in wetlands include boating, swimming, fishing, hunting, and nature study (Figures 37, 38, 39, 40). All of these activities and products derived from wetlands bring direct and indirect economic benefits to the adjacent communities.

Economic benefits from hunting and fishing are significant. Commercially important species such as striped bass, menhaden, bluefish, flounder, spot, blue crabs, oysters, and clams are partially dependent

Figure 42. *Shellfish harvest.*

Figure 43. *Pound net being fished.*

on coastal wetlands during some part of their life history (Figures 41, 42, 43). In 1980 furs from muskrats yielded approximately $74 million; in 1980 5.3 million people spent $638 million on hunting waterfowl and other migratory birds; and in 1975 sport fishermen spent $13.1 billion to catch wetland dependent fishes in the U.S. (Burke et al., 1988). In 1980, 47 percent of Americans spent $10 billion observing and photographing waterfowl and other wetland birds (Burke et al., 1988) (Table 9, Figure 44).

Dominant Commercial and Recreational Wetland-Associated Fish and Shellfish

Common Name	Scientific Name	Commercial Harvest metric tons*
Anadromous		
Shad and Alewife	***Alosa* sp.**	**27,700**
Striped Bass	***Morone saxatilis***	**5,000**
Saltwater		
Menhaden	***Brevoortia* sp.**	**889,000**
Blue Crab	***Callinectes sapidus***	**63,900**
Oyster	***Crassostrea* sp.**	**24,000**
Mullet	***Mugil* sp.**	**15,400**
Sea Trout	***Cynoscion* sp.**	**11,300**
Atlantic Croaker	***Micropogonias undulatus***	**9,500**
Hard Clam	***Mercenaria* sp.**	**6,800**
Fluke	***Paralichthys* sp.**	**4,500**
Soft Clam	***Mya arenaria***	**4,500**
Bluefish	***Pomatomus saltatrix***	**--**
Drum	***Pogonias cromis, Sciaenops ocellata***	**--**
Spot	***Leiostomus xanthurus***	**--**

***Source: After Peters, Ahrenholz, and Rice, 1979, p. 609**

Table 9.

The ability of wetlands to control flood waters reduces property damage from flooding, and reduces costs for flood control structures. Property damage from floods for 1975 in the U.S. was estimated to be $3.4 billion (U.S. Water Resources Council, 1978). Wetlands provide perpetual values, whereas economic benefits from wetland destruction are finite (Mitsch and Gosselink, 1986).

Figure 44. *Recreational hunting blind.*

Wetland Losses

Human threats to wetlands include drainage, dredging, filling, construction of shoreline structures, groundwater withdrawal, and impoundments. Between 1956 and 1977, coastal and inland vegetated wetland loss in Virginia was approximately 63,000 acres (Tiner, 1987). Direct conversion of wetlands to cropland was the major cause of inland wetland loss (Figure 45). Wetland losses in the coastal area were dominated by urban development which accounted for 43 percent, and coastal waters (from impoundments) accounted for 36 percent (Tiner, 1987) (Figure 46).

Coastal wetlands are often lost where shoreline erosion control structures are built. The natural inland migration of wetlands is slowed or stopped where bulkheads or riprap are placed along shorelines for erosion control. As sea level rises wetlands in front of hardened shorelines will eventually be

Figure 45. *Direct conversion of wetlands to croplands in Virginia was the major cause of inland wetland loss, while other development (mainly channelization projects) and lake and pond construction were also major loss factors (Tiner, 1987).*

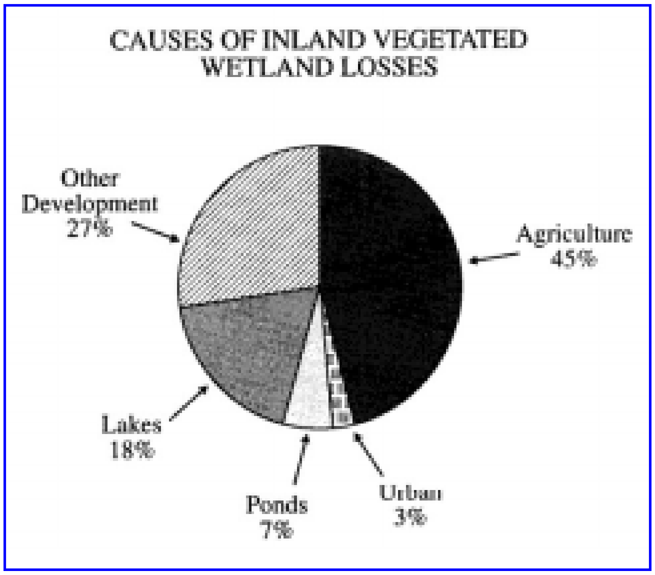
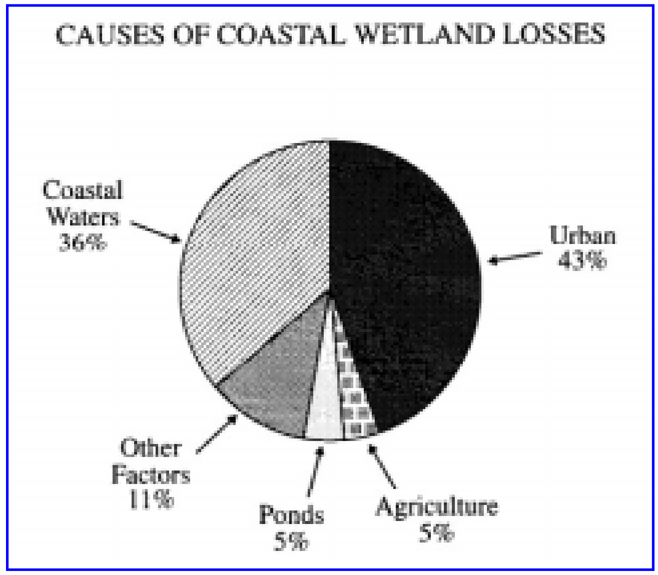


Figure 46. *Urban development in Virginia had the biggest impact on coastal wetlands. Loss of coastal wetlands to estuarine waters through impoundments, derdging projects, and sea level rise was also significant (Tiner, 1987).*



drowned because their natural inland migration has been stopped by the structure. Wave reflection from shoreline defense structures may accelerate erosion on adjacent or channelward wetlands unless there is a sediment source that can keep pace with the rise in sea level. Natural events that may cause wetland loss include rising sea level, natural succession, the hydrologic cycle, sedimentation, erosion, beaver dam construction, and fire (Tiner, 1984).

As wetlands are lost so are their associated benefits. The short term economic gains acquired through wetlands destruction are relatively easy to measure and therefore have received a great deal of emphasis in the past. However, the long term economic and environmental costs of wetland destruction may well outweigh the short term gains.

Regulation of Wetlands

In 1972 Virginia enacted a law with the intent to protect tidal wetlands while accommodating necessary economic development. The Virginia Marine Resources Commission (VMRC) was given the responsibility of lead state agency. Under the Act's local option alternative most localities have adopted the model ordinance and administer their programs through local wetlands boards and ordinances. Federal wetland regulation under the Clean Water Act is administered by the U.S. Army Corps of Engineers (COE) and overseen by the U.S. Environmental Protection Agency (EPA). The federal jurisdiction covers both tidal and nontidal wetlands. The Corps and the VMRC have developed a joint permit application that is used by the local, state, and the federal regulatory authorities to streamline the permit process. The VMRC has available a set of Wetland Guidelines which describe tidal wetland types, their values, and methods of coastal construction that minimize wetland impacts. These guidelines can be used to assist applicants when filling out the joint permit application. Other state and federal agencies that may comment on wetland applications during the joint permit review include: the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Environmental Protection Agency, Council on the

Environment, the State Department of Health, State Water Control Board, Shoreline Erosion Advisory Service, and Game and Inland Fisheries.

Presently Virginia does not have a state nontidal regulatory program. The Commonwealth's Chesapeake Bay Preservation Act includes nontidal wetlands that are connected by surface flow and are contiguous to tidal wetlands or tributary streams as part of Resource Protection Areas. These areas and an upland buffer bordering the wetland will be subject to land disturbance restrictions. The land management practices are implemented by local governments. The intent of the Act is to protect water quality in the Chesapeake Bay, through managing lands that have the potential to impact water quality in the Bay and its tributaries.

Concerned citizens can assist in wetland protection through various activities including: attending Wetlands Board public hearings, locating and monitoring wetlands in their area, supporting wetland legislation, informing neighbors and developers of the values of wetlands, and encouraging them to minimize their impact on wetlands. It is important for citizens to consider that any substances such as fertilizers, auto fluids, and pesticides that are distributed or disposed of within the Bay watershed (Figure 2) may potentially impact the waters of the Chesapeake Bay and drinking water supplies.

Economic development and wetland protection are not mutually exclusive. Many commercial activities and economic growth depend on the productivity and aesthetic values of the Chesapeake Bay. Without wetlands and their attendant values, expensive alternative methods would be required to prevent flooding, control erosion, improve water quality, and provide fish and wildlife habitat and recreational opportunities. Our wetlands resource, if properly managed, will provide these services far into the future. We risk much more than just the wetlands if we allow their loss in favor of short term economic gain.

"In the beginning, wetlands were considered valueless. Only when most of the native waterfowl vanished was it determined that wetlands might ensure the survival of many endangered plants and animals. Only after billions of dollars were spent on structural flood control that resulted in further flooding were wetlands recognized for reducing flood peaks. Only after additional billions were spent to purify streams was it realized wetlands naturally filter pollutants for free." (Illinois Institute of Natural Resources.)

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