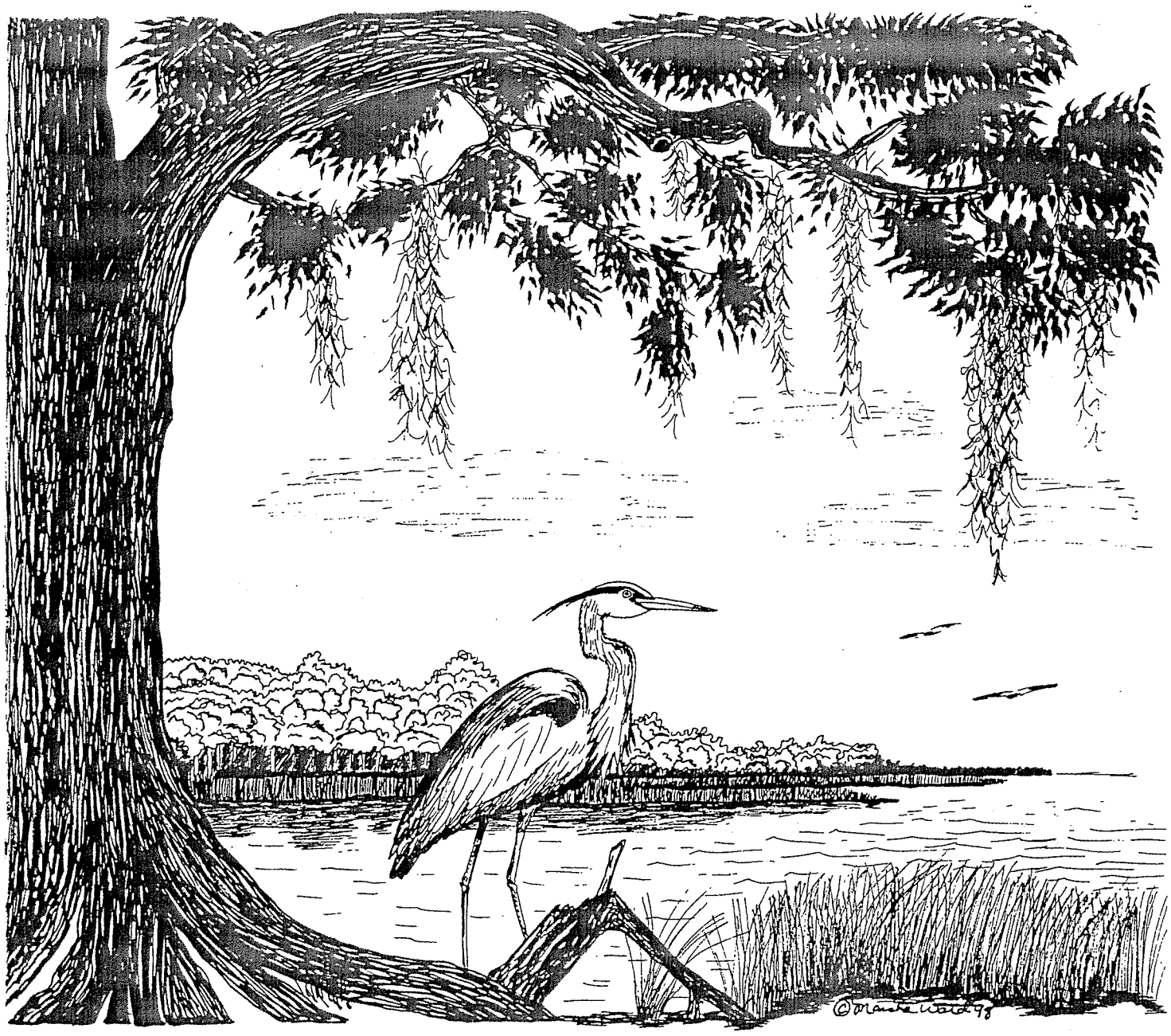
GEORGIA'S WETLAND TREASURES



GEORGIA
Coastal Resources Division

Sponsored by:
Georgia Department of Natural Resources
Coastal Resources Division
and
The U.S. Environmental Protection Agency

EPA United States Environmental Protection Agency

Written by Margaret Olsen, Oceanography Teacher, Woodward Academy, College Park, Ga.
Illustrated by Marsha Ward

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Georgia Department of Natural Resources - Coastal Resources Division

The Coastal Resources Division (CRD) has primary responsibility for managing Georgia's marshes, beaches, and marine fishery resources. Based in Brunswick, CRD administers Georgia's Coastal Management Program; permitting programs under the Coastal Marshlands Protection Act and Shore Protection Act; issues revocable licenses for use of state-owned water bottoms; monitors coastal water quality; and manages shellfish harvest areas. CRD conducts research; management and development activities associated with recreational and commercial fishery resources; represents Georgia on regional marine fishery boards and commissions; and builds boat ramps, artificial reefs, and fishing piers.

Mission Statement

The mission of the Department of Natural Resources is to sustain, to enhance, to protect, and to conserve Georgia's natural, historic, and cultural resources for present and future generations.

EPA's Mission

The mission of the U.S. Environmental Protection Agency is to protect human health and to safeguard the natural environment - air, water, and land - upon which life depends.

EPA's purpose is to ensure that:

- All Americans are protected from significant risks to human health and to the environment where they live, learn, and work.
- National efforts to reduce environmental risk are based on the best available scientific information.
- Federal laws protecting human health and the environment are enforced fairly and effectively.
- Environmental protection is an integral consideration in U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agriculture, industry, and international trade, and these factors are similarly considered in establishing environmental policy.
- All parts of society-communities, individuals, business, state and local governments, tribal governments-have access to accurate information sufficient to effectively participate in managing human health and environmental risks.
- Environmental protection contributes to making our communities and ecosystems diverse, sustainable, and economically productive.
- The United States plays a leadership role in working with other nations to protect the global environment.

EPA United States Environmental Protection Agency

Acknowledgments

I would like to give a very special and heartfelt thanks to all those who played important roles in helping to bring this project about.

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To all those whom I have not mentioned who gave their support, encouragement, and advice.

Dedication

I dedicate this guide to all the students and teachers of Georgia with the following quote from my very dear friend **Georgia Graves** of Coastal Encounters Nature Center, Saint Simons Island, Georgia.

"Understanding and appreciating Southeast Georgia's beautiful and fragile ecosystems as they relate to our students and the global environment is crucial to the future and longevity of these magnificent places. Teach them how the marsh, or any wetland, protects us and benefits us, but that it can only do this if, in return, we give it the respect, care, and appreciation it deserves. We may be the complex, high level thinkers with the ability to reason, but never underestimate those wild critters' ability to adapt and survive in a lifestyle that we may only observe and understand, yet never match. If our students leave a wetland or our classrooms taking with them a new respect for these ecosystems, and with the understanding that one person's actions will affect life on earth for generations to come, then we have done our job."

It is my hope that this guide will enable teachers all over the state of Georgia and beyond to inspire their students by providing them a better understanding of the importance of preserving the wonderful but fragile wetland habits of our state.

Table of Contents

Section IV: How To

Section V: Marinating Your Vocabulary

Section VI: Appendix

Fact Sheets

What Is A Wetland?

A **Wetland**, simply put, is a wet area where land and water mix in unique and complex ways to create extraordinarily diverse types of habitats. Wetlands are areas of transition located between dry land (terrestrial) habitats and deep water or aquatic habitats where the water table is at or near the land's surface. Most wetlands have three characteristics in common; their hydrology, their substrate or hydric soils, and their hydrophyte vegetation.

Hydrology of a wetland: Water is the lifeblood of a wetland and is the primary factor controlling the soil structure as well as the types of plants and animals that live there. The water level fluctuates, but the top twelve inches (one foot) of soil must be saturated with water for extended periods of time (at least 15 days) during the growing season. The actual surface can appear dry or it may be covered with shallow standing water with a maximum depth of no more than seven feet. The two main sources of water for wetlands is surface water and ground water. Surface water comes from streams, rivers, lakes, ponds and the ocean. Ground water is found in pores or cracks in sand, gravel, and rock beneath the earth's surface. The ultimate source of all water is rain or snow. The amount of water required for a wetland to form is the amount necessary to sustain wetland plants and does not always have to be visible.

Wetland substrate: Wetlands have **hydric soils** which are different physically and chemically from dry land soils. In hydric soils the spaces between the soil grains are filled with water. They are anaerobic (having little or no oxygen). They are usually dark brown to black in color and may be composed of mineral or organic matter, and they usually have a rotten egg or sulfur smell.

Wetland Vegetation: Wetland plants are known as **hydrophytes,** which are plants that have special adaptations that enable them to live in areas frequently saturated by water or that can tolerate varying degrees of inundation or flooding by water.

In general there are two broad categories of wetlands - Coastal and Inland. **Coastal wetlands** make up about 5% of all wetlands and are found along all the coastlines of the United States. Coastal wetlands are closely linked with estuaries, where freshwater mixes with saltwater. **Inland wetlands** occur throughout our nation's interior along lakes, streams, rivers, ponds, and along the upper edges of coastal marshes. Inland wetlands make up the majority, about 95%, of all wetlands.

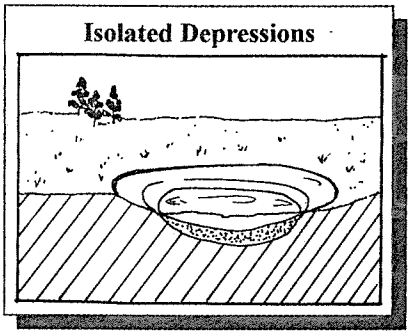
Wetlands exist along a continuum between open and closed systems. In open wetland systems there is a significant flow of materials and energy into and out of the system, and materials that are dissolved or suspended in water are exchanged with the surrounding environments. The majority of Georgia's wetlands are open systems such as coastal marshes and river and stream corridors. These open wetland systems are often affected by land use within their watershed. In closed wetland systems, there is very little exchange of minerals with the surrounding environments because the only water that enters a closed system is rainwater or groundwater and most of the nutrients are simply recycled within the system. Any contamination of groundwater

or changes in groundwater levels due to watershed land disturbing activities may seriously affect the closed system wetland's hydrology by drying it up or flooding it.

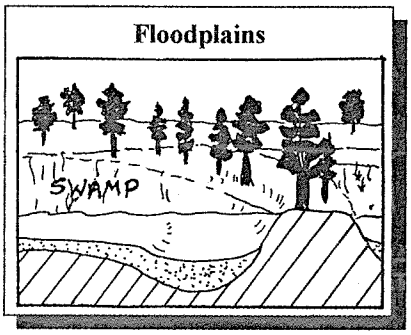
Scientists have divided wetlands into five major types: **Marine**, **Estuarine**, **Lacustrine**, **Riverine**, and **Palustrine** where each type is characterized by its type of vegetation, pattern of flooding, water chemistry, and soil. Marine and estuarine wetlands are saltwater, while the other three types are freshwater wetlands. Ninety percent of the Nation's wetlands are freshwater.

About 95% of Georgia's wetlands are Palustrine and therefore freshwater. Four percent of Georgia's wetlands are Estuarine and Marine habitats with the remaining 1% being Lacustrine and Riverine wetlands.

How Do Wetlands Form?

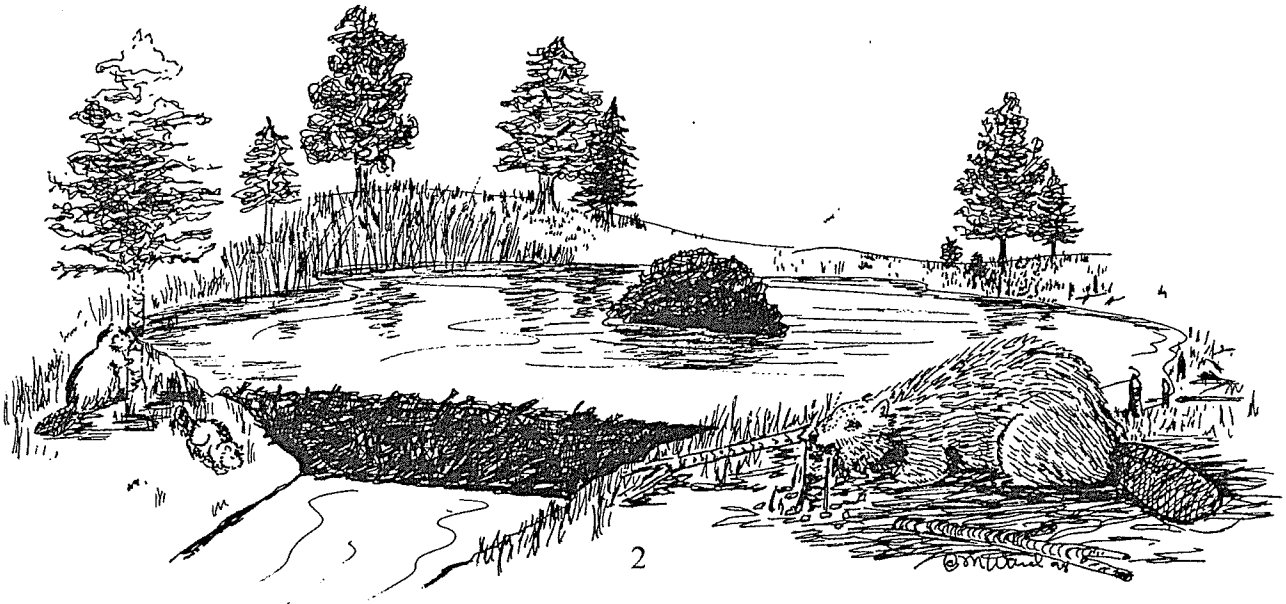


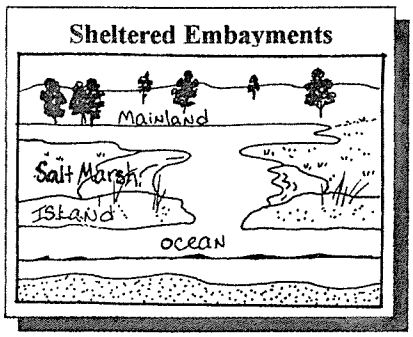
In the Northern States many wetlands formed as a result of the melting of glaciers between 10,000 and 12,000 years ago. Glaciers scraped out depressions that filled with water as the glaciers melted and became wetlands.



In all parts of the country where there are major rivers, floodplains develop as a part of the river's natural evolution. These floodplains are low-lying flat regions along the banks of rivers. It is in these floodplains that rivers "store" excess water during floods. Many types of wetlands such as marshes, floodplain forests, bottomland forests, and swamps can develop on these floodplains.

Beavers may cause wetlands to form by building dams near streams or rivers. These dams block the flow of water, flood the nearby areas, and create wet sites where wetlands can form.

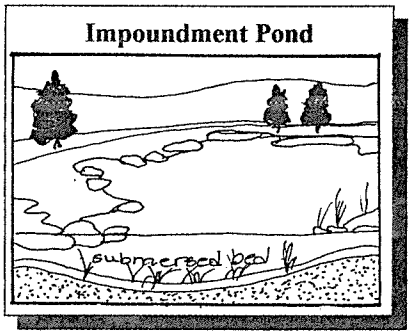




Near the coast, wetlands will form in any low-lying area where groundwater is at or near the surface. They may even form on the landward side of dunes on barrier islands. In some areas where limestone is the bedrock, the underlying rock gradually dissolves and sinkholes or limesinks form that gradually fill with water. These sinkholes or limesinks may also become wetlands.

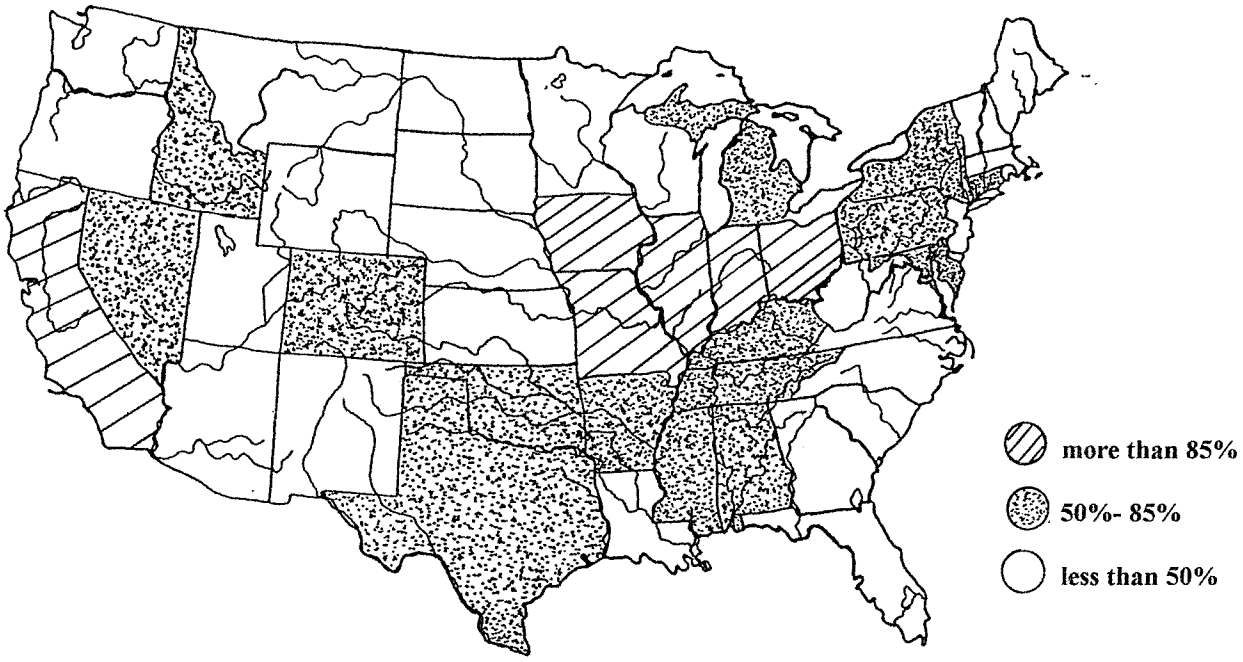
Earthquakes can also create low-lying areas that can become wetlands. This is especially true along the west coast of the United States.

Humans have also created wetlands. Humans have built dams for flood control and the production of hydro-electric power, reservoirs for drinking water, impoundment and farm ponds for irrigation and animals, and abandoned mining pits and quarries that fill with water. Any wet area will gradually fill in due to natural succession, and, as they do, wetlands can form.



States with notable wetland loss, 1780's to mid-1980's

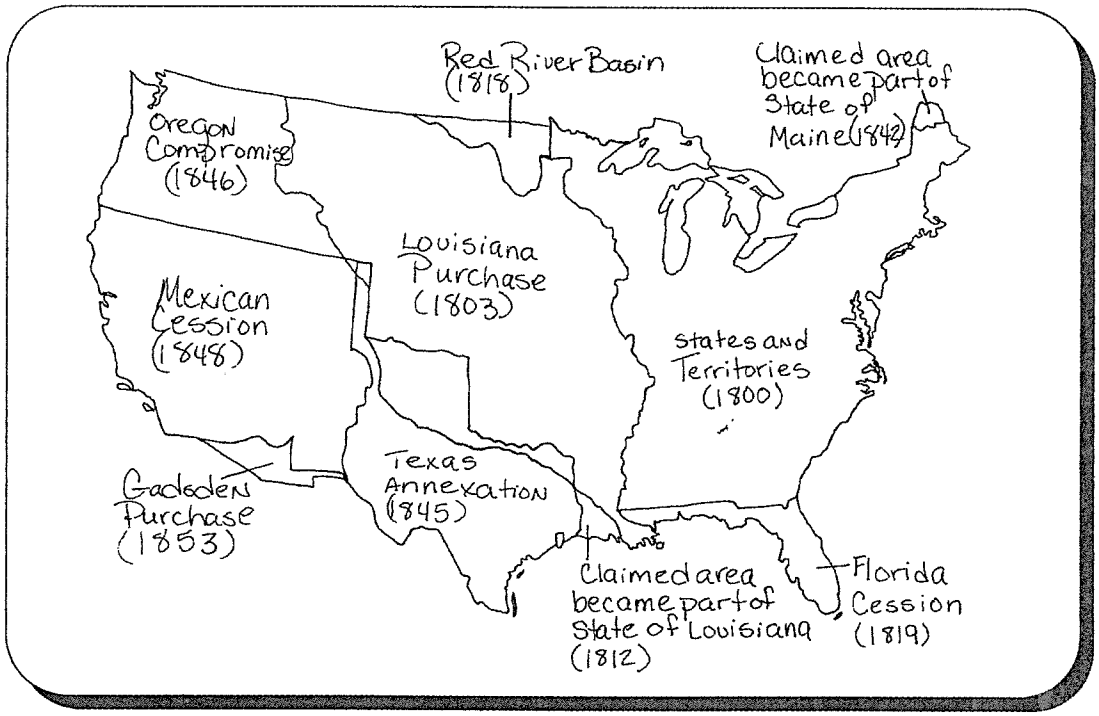
(Source: Modified from Dahl, 1990)



Percent of Wetland loss, 1780's to mid 1900's

Major United States land acquisitions between 1800 and 1860

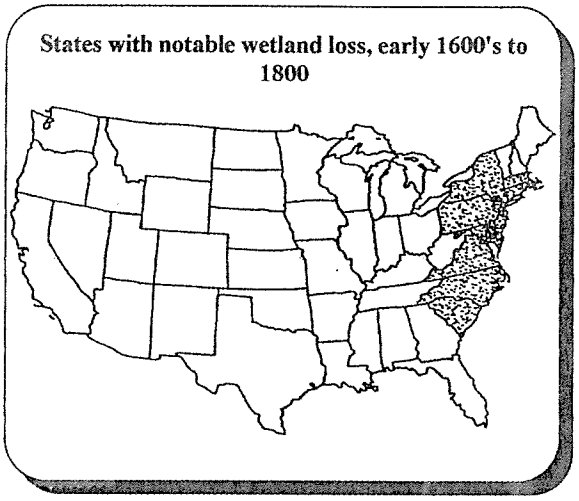
(Source: U.S. Geological Survey, 1970)

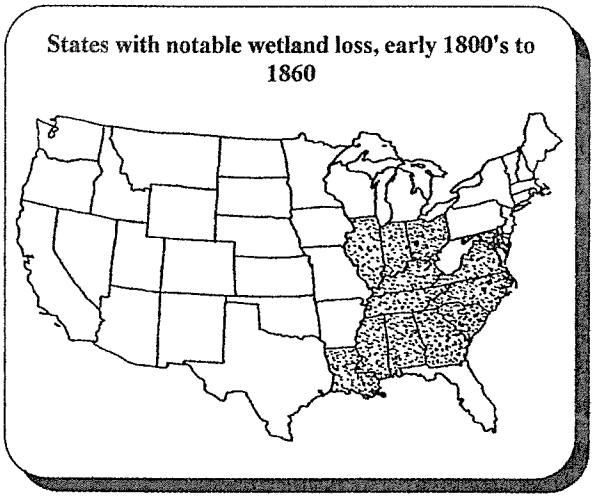


History of Wetlands and Wetland Trends

When America was settled by the Europeans in the early 1600's there were over 221 million acres of wetlands in what is now known as the lower 48 states. Today, less than half (only 46%), approximately 100 million acres of wetlands remain. The destruction and drainage of wetlands began with the permanent settlement of Colonial America.

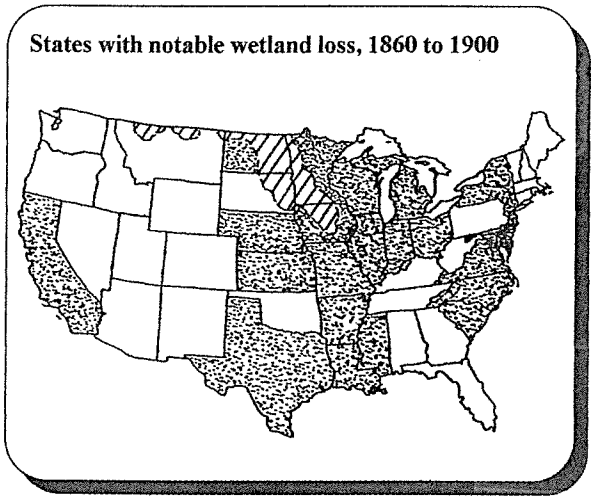
During the 1700's, wetlands were thought of as swampy lands that bred diseases, restricted overland travel, impeded the production of food and fiber, and generally not useful for frontier survival. Settlers, mercantile interests, and governments agreed that wetlands presented a hindrance to development and they should be eliminated so that the land could be used for profitable purposes. During the middle to late 1700's, as population grew and farming became a profitable business, many coastal wetlands were drained and converted to farmland. Widespread wetland drainage was most prevalent in the southern colonies. By the 1780's, the colonists had settled along the fertile river valleys as far south as Georgia.

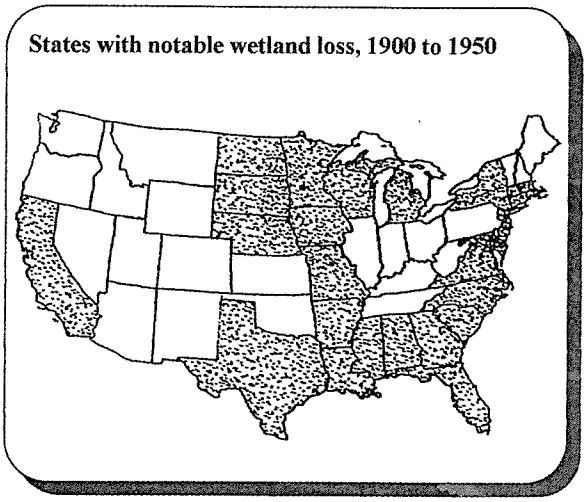




Between 1800 and 1860, the land area of the United States greatly increased through the various land acquisitions such as the Louisiana Purchase in 1803, the ceding of Florida and eastern Louisiana from Spain in 1819, the annexation of Texas in 1845, the acquisition of lands in the northwest through the Oregon Compromise in 1856, and the ceding of lands in the southwest from Mexico in 1848. The population of the country increased also and land speculation became rampant. This land boom, combined with technological advances such as the opening of the Panama Canal, steam-powered dredges and new agricultural tools such as plows, rakes, cultivators, and reapers, resulted in wide-scale conversion of wetlands into farmland. Cotton and tobacco farming led to the drainage of thousands of acres of wetlands in the South. In 1849, 1850, and 1860, the Federal Government passed the Swamp Land Acts which gave 15 states the right to drain and reclaim all swamp lands for settlement and development.

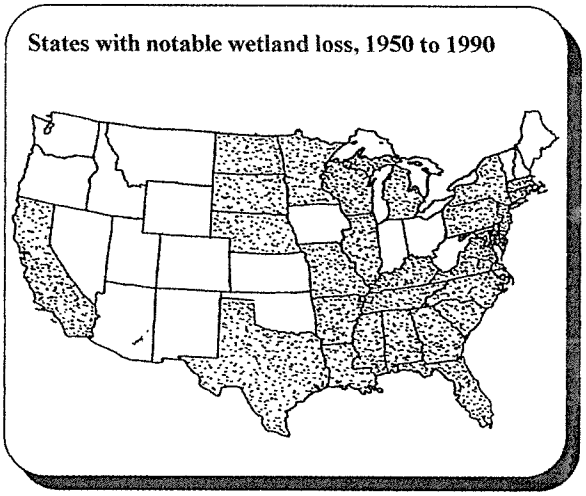
After the Civil War (1865), railroad systems were built to open up the western territories to development and settlement. The wood needed for railroad ties and fuel for the engines came from wetland forests. These railroads made more and more land accessible to settlement, and more and more wetlands were diked and drained.





The first half of the twentieth century was a time of ambitious engineering and drainage operations in the United States. The rapidly growing population after the two World Wars lead to industrial growth and urban and agricultural expansion projects that drained both large and small wetlands. In the early 1900's attempts were even made to drain Georgia's Okefenokee Swamp. In the 1930's the U. S. Government provided free engineering services to farmers to drain wetlands. The Sugar Act of 1934 led to even more wetland drainage for the planting of sugarcane. The first legislative act by the government to acquire and restore wetlands, which was very unusual for the times, was the Migratory Bird Hunting Stamp Act that passed Congress in 1934. By the 1960's, the Federal Government encouraged land drainage and wetland destruction through a variety of legislation such as the Watershed Protection and Flood Prevention Act of 1954. Between the mid-1950's to the mid-1970's, over 550,000 acres of wetlands were drained each year. Over half of these acres were drained for agricultural purposes.

By the mid-1970's over 52.2 million acres of wetlands were lost in the ten Southeast states and another 2.3 million acres were lost by the mid-1980's. By the mid-1980's, 47% of all remaining wetlands (nearly 1/2 of the freshwater wetlands and over 3/4 of the estuarine wetlands) were located in the Southeastern states.



Public awareness of and education about wetlands began in the early 1950's, and by 1970 the values of wetlands as important environmental ecosystems became apparent. Federal policies such as the Fish & Wildlife Coordination Act in 1967; the Land & Water Conservation Fund Act in 1968; the National Environmental Policy Act in 1969; the 1972 Clean Water Act (and its amendments, Floodplain Management Executive Order 11988, and Protection of Wetlands Executive Order 11990 in 1977); the "Swampbuster" in 1985 which significantly reduced the rate of wetlands conversion to agricultural uses; and the Emergency Wetland Resources Act of 1986 began to curtail wetland

Estimates of Wetland Loss Rate between 1780 and 1991

Time Period	Total Acres Lost	Loss Rate in Acres/Year
1780's-1950's	106,000,000	624,000
1950's-1970's	9,100,000	458,000
1970's-1980's	2,600,000	290,000
1987 - 1991	432,000	180,000

losses. Between the mid-1970's and the mid-1980's, wetland losses were about 290,000 acres per year which is about one-half of the losses that occurred each year between 1950 and 1960.

From about 1987 to the present, Federal efforts to restore wetlands have increased. The federal government began several non-regulatory programs designed to restore wetlands. Wetland restoration is defined as the re-establishment of wetland hydrology and wetland vegetation to lands which had previously been drained. In 1986, the U.S. and Canada signed the North American Waterfowl Management Plan and the Partners For Wildlife Program to protect wetlands through partnerships. In his 1989 State of the Union address, President George Bush pledged that his administration would attempt to achieve "no net loss" of wetlands. The phrase "no net loss" became an environmental buzzword for environmental protection.

In 1989, The North American Wetland Conservation Act was established to encourage partnerships between public agencies and other interests to protect, restore, and enhance wetlands. In 1991, the Coastal Wetlands Planning, Protection, and Restoration Act was passed to define coastal wetland restoration projects. In 1992, the Wetland Reserve Program was passed allowing the federal government to purchase easements for wetland protection from landowners in nine states. Between 1993 and 1995, through the Wetland Reserve Programs and other Federally funded programs it is estimated that over 570,000 acres per year were reclaimed and restored to wetlands. In 1995 alone, The Partners For Wildlife Program restored 48,000 acres; The North American Waterfowl Management Plan restored 42,000 acres; and, The Wetland Reserve Program enrolled 118,000 acres.

Although current data shows that wetlands are being restored all across the country by numerous federal, state and local government programs, as well as non-profit programs, our Nation is still losing between 140,000 and 200,000 acres of wetlands a year. Virtually all of the reduction in wetland losses have come in the agricultural sector, and most current wetland losses come from urban and industrial development. Our Nation is making strides towards "no net loss" of wetlands, but we need to continue to support and pass laws for the protection of wetlands especially in the areas of ground-water withdrawals, partial drainage, pollution, and urban encroachment.

Section 404 of the Clean Water Act establishes the major federal program that regulates activities in wetlands. Under this law, the discharge of dredged or fill material into waters of the United States (including wetlands) requires a permit from the Army Corp. of Engineers. Failure to obtain a permit or to comply with the terms of a permit can result in civil and/or criminal penalties.

Where Does Georgia Stand?

Georgia has faired much better than other states as to wetland loss. From the 1780's to the 1980's, Georgia lost an estimated 23% of its wetlands. This is the lowest percentage of wetland loss in the Southeastern states. Today, Georgia ranks third, following Florida and Louisiana, in total wetland area. Georgia has 7.7 million acres of wetlands which cover 20% of the State. Approximately 90% of Georgia's wetland acreage is in the Coastal Plain, with 7.3 million acres of Palustrine wetlands (mainly forested, scrub-shrub, and emergent wetlands) and 3,768,582 acres of Coastal wetlands. Georgia also ranks fifth in the Nation in wetland conservation. Only Alaska, New Hampshire, Hawaii, and Maine have protected more of their original wetlands than Georgia.

In recent years, federal, private, and state organizations have cooperated in different but complementary approaches to ensure the protection of Georgia's remaining wetlands. Some of these activities include aggressive acquisition of significant wetlands, public education, land use planning, economic incentives for protection of wetlands, regulation of activities in wetlands, and wetland restoration. The most active of many government agencies and private organizations that participate in wetland conservation in Georgia are listed in the table to the right. Since 1987, Georgia has acquired more than 150,000 wetland acres through these programs and a special Preservation 2000 acquisition effort. See the table to the right for recent land acquisitions. An Aquatic Education Program has begun and includes education and training for teachers, adults and youths. Grant-in-aid funds are available for research on Georgia's endangered animal and plant species. Some of the State laws that provide protection for wetlands are as follows:

- **Coastal Marshland Protection Act**
- **Shore Protection Act**
- **401 Water Quality Certification**
- **Water Quality Control Act**
- **Ground Water Use Act** (1972)
- **Safe Drinking Water Act** (1977)
- **Erosion and Sediment Control Act** (1975)
- **Metropolitan Rivers Protection Act** (1973)

Agency or Organization	MAN	REG	R&C	LAN	R&D	D&I
Federal						
Department of Agriculture						
Consolidated Farm Service Agency		x				
Forest Service	x		x	x	x	x
Natural Resources Conservation Service		x	x		x	x
Department of Commerce						
National Oceanic & Atmospheric Admin.	x	x			x	
Department of Defense						
Army Corps of Engineers	x	x	x		x	x
Military Reservations	x					
Department of the Interior						
Fish and Wildlife	x		x	x	x	x
Geological Survey					x	
National Biological Service					x	
National Parks Service and Historic Div.	x			x		
Environmental Protection Agency		x			x	x
State						
Department of Community Affairs		x				
Department of Natural Resources						
Coastal Resources Division	x	x	x		x	x
Environmental Protection Division		x	x			
Game and Fish Division	x		x	x	x	x
Parks, Recreation, and Historic Sites Div.	x			x		
Department of Transportation			x			
Georgia Forestry Commission	x				x	
Regional, County, and Local						
Regional Development Centers		x				
Some county and city governments	x	x	x			
Private Organizations						
The Nature Conservancy of Georgia	x			x	x	x
Georgia Wildlife Federation				x		
Trust for Public Lands				x		

MAN: management, REG: regulation, R&C: restoration and creation, LAN: land acquisition, R&D: research and data collection, D&I: delineation and inventory. Those agencies marked with a X participate in the activity.

LAND ACQUIRED BY THE STATE WITH SIGNIFICANT WETLAND ACREAGE PROGRAM EXPANSION FOR 1987-1989

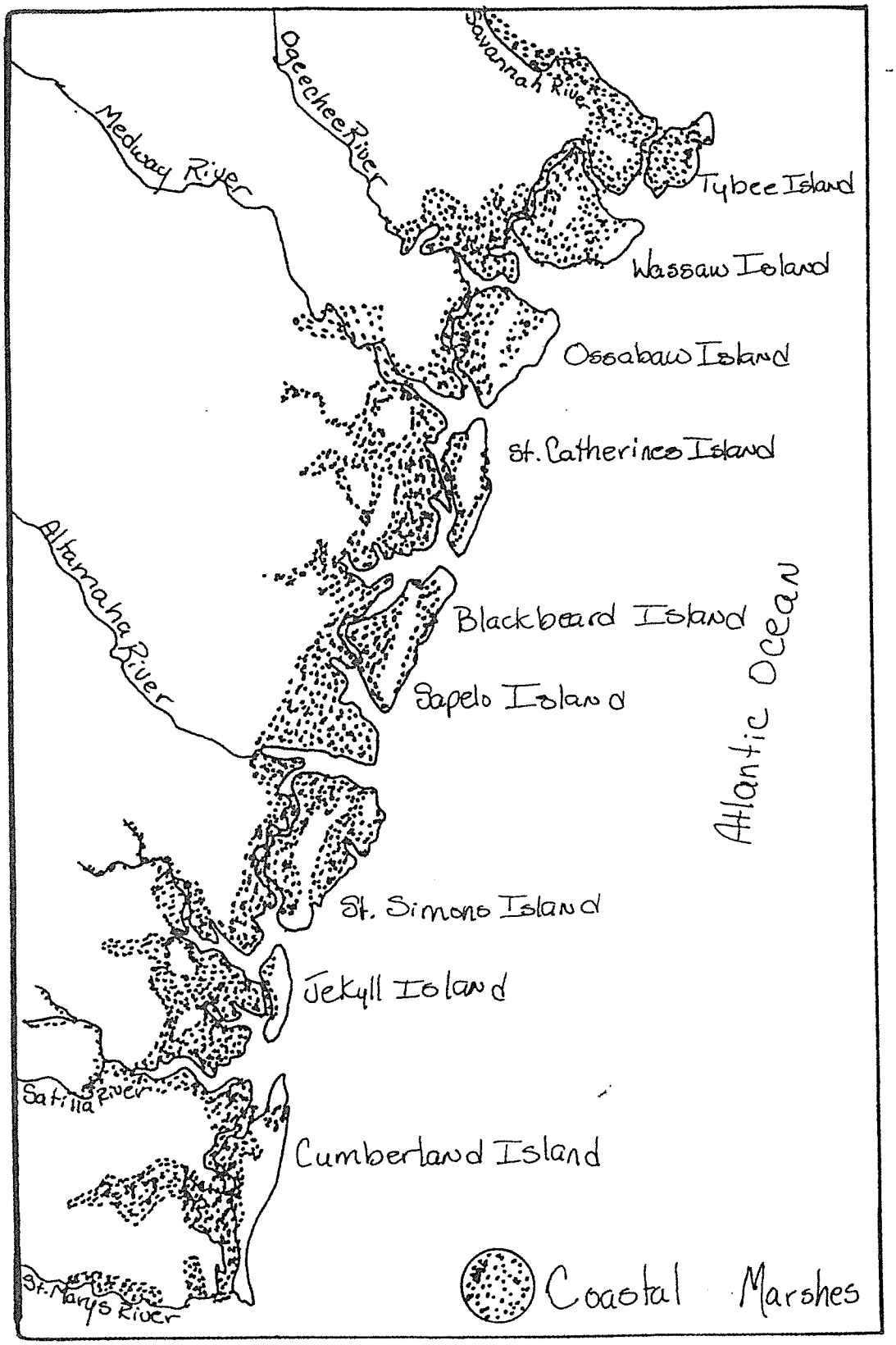
Site Name	Type of Area	County(s)	Acreage
Beaverdam	WMA	Laurens	326
Big Hammock	WMA	Tattnall	5,566
Bullard Creek	WMA	Jeff Davis, Appling	8,442
Dodge County	PFA	Dodge	444
Grand Bay	WMA	Lowdes	1,865
Hannahatchee	WMA	Stewart	258
Horse Creek	WMA	Telfair	3,787
Big Lazer Creek	WMA/PFA	Talbot	2,233
Paradise	PFA	Berrien	1,060
Yuchi	PFA	Burke	7,360
		Subtotal	**31,341**

LAND ACQUIRED BY PRESERVATION 2,000 FROM 1990-1995

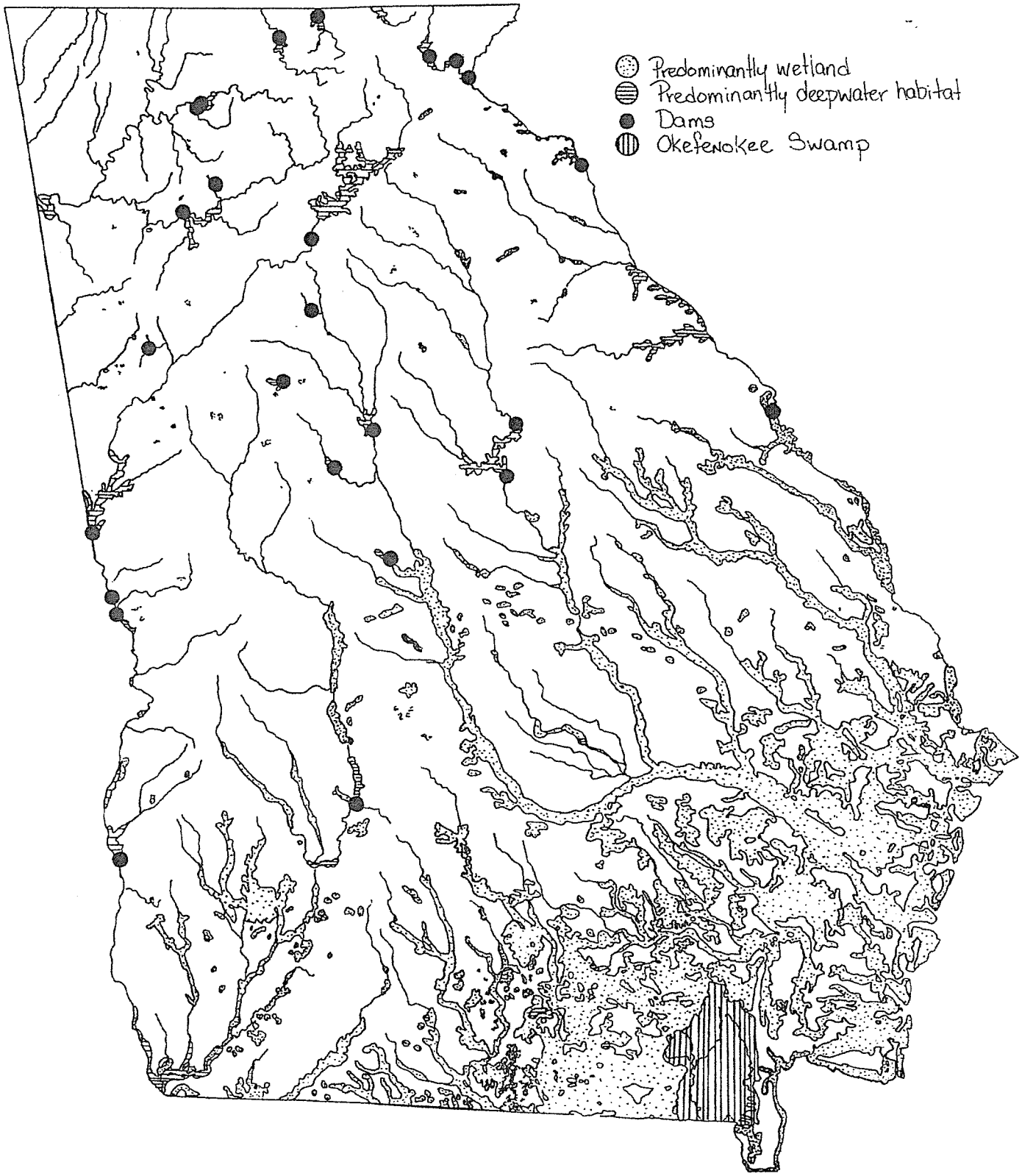
Siste Name	Type of Area	County(s)	Acreage
Mayhaw	WMA	Miller	4,681
Ocmulgee	WMA	Pulaski	5,836
Tuckahoe	WMA	Screven	10,950
Little Tybee/Cabbage Islands	NA	Chatham	7,721
Buffalo Swamp	WMA	McIntosh	5,939
Charlie Elliott	WMA/PFA	Jasper, Newton	6,039
Flint River	WMA	Dooley	2,358
Lighthouse Tract-Sapelo Island	NERR	McIntosh	206
Dawson Forest	WMA	Dawson	2,710
Doerun Bog	NA	Colquitt	650
Grand Bay	WMA	Lowdens	429
Paradise	PFA	Berrien	181
Montezuma Bluffs	NA	Macon	499
Griffin's Ridge	WMA	Long	5,615
Little Wahoo Island	NA	McIntosh	1,012
Oaky Woods	WMA	Houston	107
Smithgall-Dukes Creek	NA	White	5,604
Echoeconnee Creek	CA	Bibb	159
Ohoopee Dunes	NA	Emanuel	1,808
Jericho River	NA	Liberty	776
Meriwether County	WMA	Meriwether	3,654
Troup Lake	WMA	Laurens	3,509
		Subtotal	**70,443**
Grand Total			**101,784**

Key: **CA:** Conservation Area **PFA:** Public Fishing Area
NA: Natural Area **WMA:** Wildlife Managemant Area
NERR: National Estuarine Research Reserve

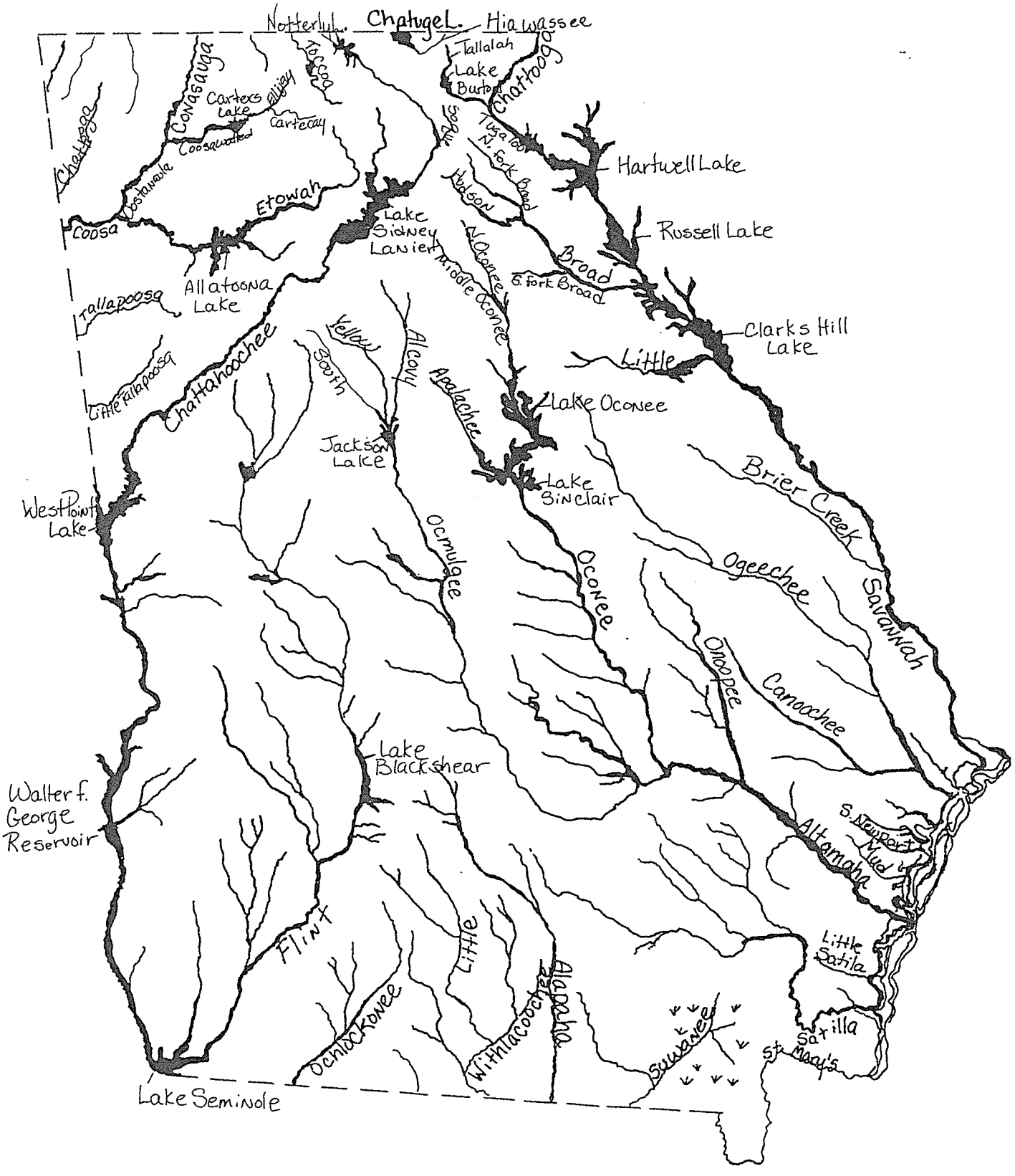
COASTAL WETLANDS IN GEORGIA



GEORGIA'S WETLAND HABITATS



GEORGIA'S LAKES AND RIVERS



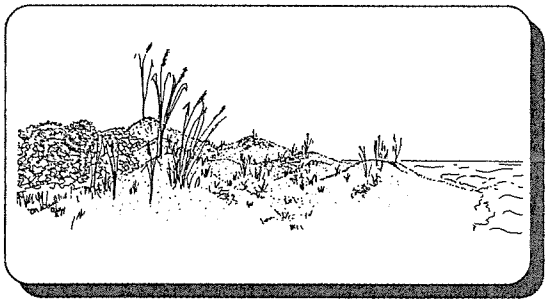
Types of Wetlands

Georgia has more than 7.7 million acres of wetlands distributed very unevenly over the state. About 90% of all of Georgia's wetland acreage lies in the Coastal Plain province of South Georgia. The rest occurs in the Appalachian Plateau, Ridge and Valley, Blue Ridge and Piedmont provinces of North Georgia. Four percent (4%) of Georgia's wetlands are Estuarine and Marine habitats or salt water wetlands. Ninety-five percent (95%) are freshwater Palustrine wetlands and the remaining 1% are freshwater Lacustrine and Riverine wetlands. One of the most well known of Georgia's wetlands is the Okefenokee Swamp. The Okefenokee Swamp is located in southeastern Georgia and northeastern Florida and is one of the largest freshwater wetlands in the United States. It is a combination of six different wetland types such as pond cypress forest, emergent marshes, aquatic beds, broad-leaved evergreen forest, broad-leaved shrub wetland, mixed cypress forest, and black gum forest. In all, Georgia boasts over 60 different wetland types. The major categories and some examples are discussed below.

I. Coastal Wetlands

All coastal wetlands are saltwater wetlands and are found along every coast in the United States and around the world. Coastal wetlands make up five percent (5%) of all our Nation's wetlands. Many coastal wetlands are located near large cities and are therefore very vulnerable to the pressures of development. The two types of coastal wetlands are Marine and Estuarine wetlands.

Coastal Marine Wetlands are areas directly along the coast. They are alternately exposed and flooded by tides and exposed to the high energy of waves and currents. The salinity of the water in marine coastal wetlands is greater than 30 ppt (parts per thousand). Examples of marine coastal wetlands include shorelines, beaches, bars, tidal or mud flats, saltmarsh, and mangrove swamps (not found in Georgia).



The organisms characteristic of **shorelines, beaches, and bars** must be adapted to the harsh conditions that exist there. They must be able to withstand the crashing waves and periods of inundation by sea water at high tide. They must be able to survive the hot, beating sun and wind during low tide, and the freezing cold of winter. Many organisms like the ghost shrimp, polychaete worms, coquina clams, mole crabs, isopods, amphipods and sand dollars burrow into the sand. They are either filter feeders and use their antennae to extract food from the water or scavenge the algae and detritus from between the sand grains. Gastropods like the oyster drill, moon snail, and whelks actively prey on other animals. At low tide, a large variety of shorebirds, raccoons, insects and ghost crabs visit the beach to feed. Algae is the only characteristic plant of the beach. Algae lives between the grains of sand and occasionally adds a green, gold, pink or purple tint to the

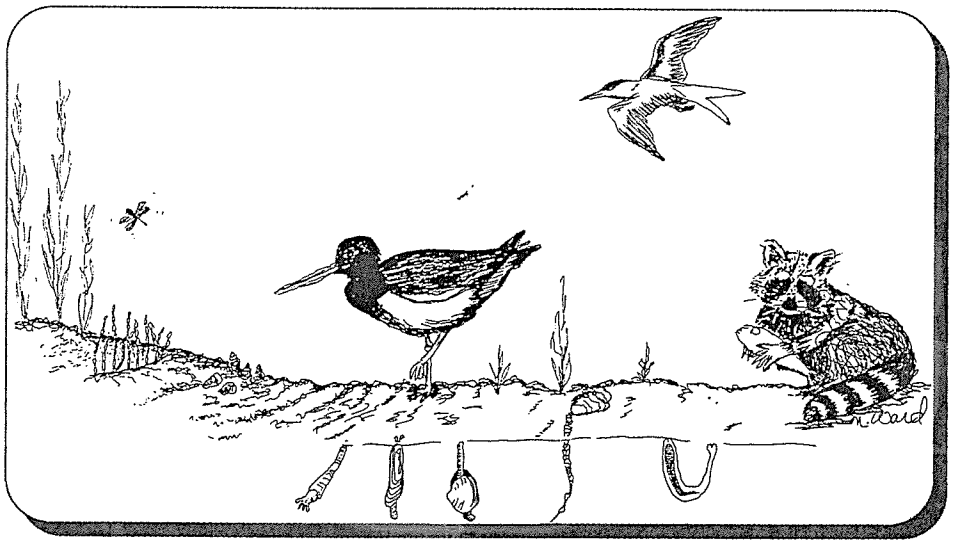
sand. Other plants like *Ulva* (sea lettuce) and *sargassum* (a brown algae or seaweed) do not grow on the beach but are often washed up onto the beach where they decay and become part of the detrital food chain.

Intertidal mud flats are located along the edges of the salt marsh. This harsh habitat is covered by water at flood (high) tide and exposed to the scorching sun at ebb (low) tide. It consists of a soggy substrate (soil) made up of clay and silt that is deposited during slack tide. Slack tide is the brief period between flood tide and ebb tide during which the water is not flowing in or out but is still. Only the upper layers of this muddy substrate contain oxygen. The deeper layers contain decaying organic matter that gives off a hydrogen sulfide gas that causes a rotten egg smell.

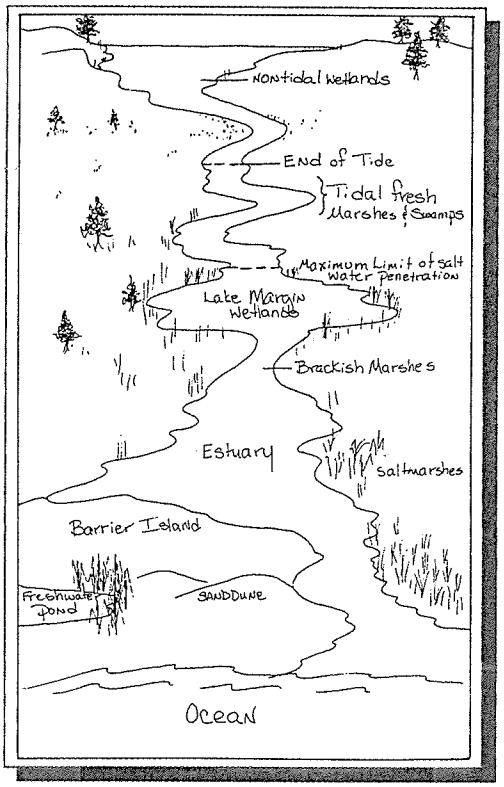
Only a few plants and animals live in the tidal flats, but those that do are an important food source for larger animals. Phytoplankton and algae grow on the surface of the mud (giving it a greenish tint) and attached to hard surfaces such as old shells or logs. Insects breed in small pools and the larvae feed on algae and zooplankton. Buried animals such as cockles, whelks, amphipods, lugworms, and fiddler crabs eat microorganisms that are trapped in the mud. When the tide comes in, phytoplankton, algae and zooplankton serve as the food source for filter feeders (oysters, clams, mussels, barnacles), and several types of worms including the parchment tube worm. Shrimp and crabs scavenge the bottom for food, while flounder await a meal of shrimp. Also at high tide, organisms that always live in the water come in to feed. Blue crabs and several species of hermit crabs scavenge for food while fish such as the mummichug, silversides, spot, and croker feed on insect larvae, zooplankton and small fish.

When the tide goes out, the muddy substrate is exposed and fiddler crabs come out of their burrows and sift through the mud for food while periwinkle snails eat algae off the surface of the mud. Mud snails scavenge the surface, eating both living and dead organisms. Wading and shore birds like egrets, clapper rails, gulls and sandpipers come in to eat the snails, worms, fiddler crabs or any other floating or crawling animals. Oyster catchers feed off the oysters, mussels, and clams. Raccoons also venture onto the mud flat to feed on whatever they can find.

The animals that live in or on the mud flats are important food sources for larger animals, and any disturbance of this harsh but fragile habitat could have grave consequences for the food chain.



Coastal Estuarine Wetlands are located in sheltered coastal areas where fresh and salt water mix. They are exposed to low wave energy and are flooded periodically by the tides. Due to evaporation and mixing of fresh and salt water, the salinity of estuarine wetlands ranges between 0.5 ppt and 30 ppt. The plants and animals that live in coastal estuarine wetlands must have special adaptations to enable them to survive the harsh and ever changing levels of water and extremes in water temperature. Examples of coastal estuarine wetlands include estuarine creeks (tidal creeks); sounds and tidal pools with sandy or mud bottoms; subtidal/intertidal oyster reefs; intertidal sandy or mud creek banks; bars and flats where vegetation covers less than 30% of the area; salt marshes; brackish marsh; sandflats (also known as saltflats or salt ponds or salt pans); and, mangrove swamps (not found in Georgia).



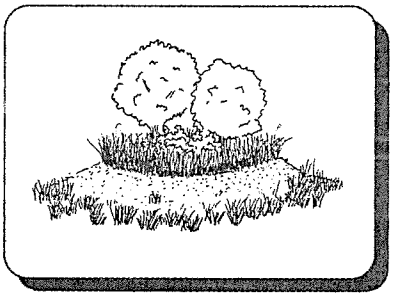
Salt Marshes occur almost continuously along the east coast and are areas that are periodically flooded by salt water due to the tidal cycles. Georgia's coastal marshes cover a four to six mile border between the barrier islands and the mainland. Third in acreage only to Florida and Louisiana, Georgia's more than 475,000 acres of salt marsh make up more than 30% of all the salt marshes along the Atlantic coast and produce more food and energy than any other estuarine zone on the entire eastern seaboard. The food energy stored in smooth cordgrass *(Spartina alterniflora)*, the major producer of the marsh, produces 17.8 tons of biomass per acre annually making it second only to sugar cane in productivity. (One acre of corn only produces 5.7 tons of biomass annually.)

Twice a day tides flood the marshes, nearly covering the grasses. Tidal creeks carry water, dissolved chemicals such as nitrogen and phosphorus (natural fertilizers), and nutrients stirred up from the bottom to all parts of the marsh. This provides food not only for the plants but for invertebrates as well and brings in fish to feed and breed. The ebbing waters of low tide transport a murky soup of dissolved nutrients, marsh grass, detritus and small animals (dead and alive) back out to the estuary where they become food for other marine organisms.

The harsh conditions facing organisms living in a salt marsh require special adaptations to the rapid changes in salinity, temperature, and frequent changes in water-level. The substrate (soil) of the marsh is fine-packed mud and silt which is oxygen poor. Here, anaerobic (without oxygen) bacteria decay organic matter and release hydrogen sulfide, methane, and iron compounds.

Only specially adapted salt-tolerant plants, **halophytes**, live in the salt marsh. Diatoms and other phytoplankton live and grow on the surface of the marsh mud. The dominant plant, smooth cordgrass, *Spartina alterniflora*, covers 73% of the marsh. In Georgia, in its detrital form, *Spartina* makes up more than 85% of the primary producers in a marsh food web. The cell membrane of the root epidermal cells inhibits the entry of salt. Root hairs and cortex cells concentrate the salt and draw the water into the roots where it is then pumped to the rest of the plant. The stems of the *Spartina* are hollow and carry oxygen down to the roots. The leaves produce epidermal glands that excrete excess salt. Although *Spartina* produces over half of the food in the marsh food web, only a few animals (insects and periwinkle snails) eat it directly. It is only after it dies, decays and turns into detritus, a process taking about a year, that it becomes the major food source for marine life.

Plants in the salt marsh are found in distinct zones depending on the soil type, salinity, temperature and tidal fluctuations. *Spartina* grows from one foot to ten feet high in the low marsh nearest the waters of the sound and tidal creeks where it is almost covered at high tide. In slightly higher marsh terrain that is flooded only about one hour a day the dominant pants include spike grass or salt grass, sea oxeye daisy, and sea lavender. In the high marsh where there is more sand mixed with the mud and where it is only covered by a few inches of water at high tide, the *Spartina* only grows from three inches to about a foot. *Spartina patens* (salt meadow cordgrass or salt meadow hay) grows in the high marsh and along the marsh borders where the soil is more sandy and there is less water. Black needle rush also grows abundantly in the high marsh. **Sandflats** (Salt pans or salt ponds) and **hammocks** are interesting features of the high marsh. Saltflats, bare sandy spots, mark the highest tide level and form when very high tides cover the area with thin sheets of water. The sun evaporates the water, leaving the salt behind. The salt content of a salt pan is too great for plants to grow. Glasswort and saltwort are common in salt pans as well as the high marsh. Hammocks are small tree islands that form within the expanses of the marsh. They form where sediments have accumulated forming a higher area where the water seldom reaches and the soil has become richer. These hammocks are filled with bayberry (wax myrtle), yaupon holly, red cedar, palmettos, prickly pear, yucca, and various vines.



Brackish Marshes form upstream from salt marshes where there is a significant amount of freshwater to dilute the saltwater. Brackish marshes vary in salinity from moderately high or 18 ppt to essentially fresh at 0.5 ppt. The plants of brackish marshes range from those characteristic of the high borders of salt marshes (listed above) to less salt tolerant plants such as big cordgrass (*Spartina Cynosuroides*), switchgrass or panic grass, sawgrass, common reed, salt marsh bulrush, spike rushes, and knotgrasses.

Mangrove Swamps though not present in Georgia are as important to the marine ecology of South Florida and other tropical regions as salt marshes are to Georgia. The

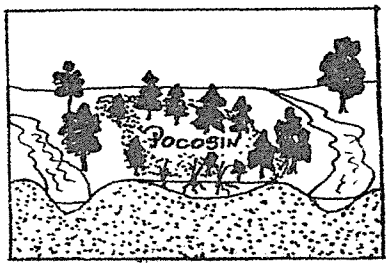
three main types of mangroves are red mangrove, white mangrove, and black mangrove. Among the many interesting adaptations of the mangroves is their ability to either extrude or exclude salt.

II. Inland Wetlands

Inland wetlands make up the majority (about 95%) of wetlands in the United States. They occur throughout the interior of every state and are commonly found along the banks of rivers, streams, lakes, ponds, and isolated water filled depressions. The three major types of the freshwater wetlands include **Lacustrine**, **Riverine**, and **Palustrine** wetlands. The vast majority of Georgia's wetlands (95%) are Palustrine wetlands.

Palustrine Wetlands are nontidal freshwater wetlands and make up the vast majority of Georgia's freshwater wetlands. Palustrine wetlands are dominated by trees, shrubs, or persistent emergent plants. The salinity of the water is less than 0.5 ppt. Also included in Palustrine wetlands are areas with less than 20 acres where the water is less than 6.6 feet deep. The five types of Palustrine wetlands include such areas as floodplain/bottomland hardwood swamps, forested wetlands, non-alluvial forested wetlands, shrub/scrub areas, emergent ponds and bogs, and aquatic beds.

Floodplain/bottomland hardwood wetlands and swamps are dominated by woody trees and shrubs. The trees are usually more than 20 feet high. Many of these swamps occur in isolated depressions along the borders of ponds, rivers and streams, old river scares or oxbows. These floodplain or bottomland hardwood swamps may be flooded periodically or permanently by freshwater with less than 0.5 ppt of ocean derived salts.
Floodplain and bottomland hardwood wetlands are dominated by oaks. Other common trees include the green ash, sweet gum, Ironwood, Cypress, and water tupelo.
Forested Wetlands are bottomland areas that experience lesser degrees of flooding than the floodplain/bottomland hardwood wetlands. The predominant trees include willows, maples, overcup oak, and water hickory.
Non-alluvial Forested Wetlands cover large areas and include pine dominated pocosins, savannas, wet pine flatwoods, hydric hammocks, bayheads, Atlantic white cedar swamps, pin oak flats, and cypress or gum ponds.



Pocosins are similar to bogs in that they are nutrient-poor acidic wetlands. The word "pocosin" comes from an Algonquin Indian phrase meaning "swamp on a hill". The dominant tree in a pocosin is the pine tree.
Bayheads or bay swamps are wet-floored evergreen forests dominated by bay trees and sphagnum moss. They are located mostly along the Coastal Plain in flat shallow areas. They contain peaty soil and though constantly wet are seldom flooded.
Atlantic white cedar swamps contain mostly Atlantic white cedar, while **pin oak flats** contain mostly pin oak tree.
Cypress and gum ponds occur throughout the Coastal Plain. These are important in treating run-off wastes, storing water and serving as nesting and refuge areas for waterfowl. Many reptiles, amphibians, marsh rabbits, deer, wading birds and their

predators are dependent on these freshwater ponds. The dominant trees are cypress and gum trees.

Palustrine shrub and scrub swamps are freshwater areas with a salinity less than 0.5 ppt and dominated by woody plants less than 20 feet tall. They include areas that have previously been cleared, burned or otherwise impacted by man but are still wet and are experiencing regrowth. Shrub-dominated bogs, river bars, the backwaters of ponds and reservoirs, beaver ponds, sand and gravel pits and mountain bogs are all considered Palustrine shrub/scrub areas. Common plants in these areas include hollies, bays, fetterbushes, buckwheat tree, titi, button bush, willows or alders, and rhododendron .

Palustrine emergents include such areas as freshwater ponds and bogs, wet prairies, wet meadows and pitcher plant and herb bogs.

Freshwater ponds and bogs are dominated by rooted erect soft-stemmed plants such as cattails, arrowhead, and pickerelweed. **Wet meadows** are dominated by grasses or sedges such as woolgrass, loosestrife, sensitive fern and soft rush. Water is generally not visible on the surface but saturates the soil to a depth of six inches or less.

Pitcher plant and herb bogs are found in low-lying areas in pine uplands where the water table is near the surface and the ground is kept moist by seepage. Common plants are orchids, meadow beauties, goldenrod, sphagnum moss, three to six species of pitcher plants and sundews. Because of habitat destruction these areas are becoming very rare in Georgia.

Palustrine aquatic beds include shallow freshwater wetlands containing less than 0.5 ppt salt and include areas dominated by floating or submergent plants, areas with rooted vascular plants, and upland shallow bogs and seeps. Common plants of these areas are duckweed, mosquito fern, spatterdock, water-lilies, pondweeds, and hornworts.

Lacustrine Wetlands include nontidal and tidal freshwater wetlands that border lakes and reservoirs, including the shallow, near-shore areas without plants. They are situated in a topographic depression or a dammed river channel. They are permanently flooded with freshwater deeper than 6.6 feet and are usually larger than 20 acres. The salinity in Lacustrine wetlands is less than 0.5 ppt. When vegetation is present, it is predominately non-persistent emergent plants and/or submersed floating plants. Some common examples of Lacustrine wetlands include impoundment or natural lakes formed by dams; natural stream levees; river meanders or beaver dams; Carolina Bay/Okefenokee (broad, acidic, peat-bottom lake); limesinks formed from solution of limestone rocks; sagponds common in the Cumberland Plateau/Ridge and Valley areas; and barrier island lakes (nontidal, freshwater lakes on barrier islands). Although only one percent (1%) of Georgia's freshwater wetlands are Lacustrine, they are extremely important to the ecological welfare of their surrounding environments.

Impoundment ponds are often built by farmers for their livestock and for irrigation.

Carolina Bays are oval wetlands that formed about 250,000 years ago. They are usually oriented in a northeast to southwest direction and have raised sandy rims on their south and east edges. They are found mostly in sandy areas in the Southeastern portion of the Coastal Plain. Carolina Bays have **tannic water** that is acidic and brown and their trees grow slowly. They serve as reservoirs and keep the water table recharged, and they also absorb much of the waste that they receive. They are a significant source of habitat for

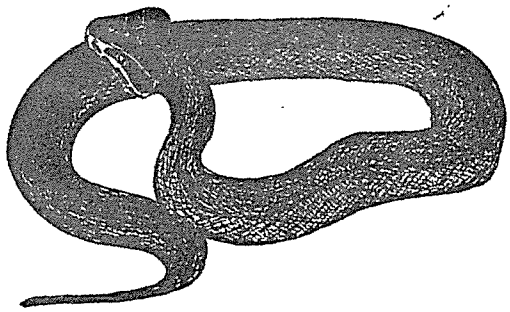
amphibians and provide homes for the endangered sandhill cranes, wintering grounds for ducks, and nesting sites for a wide variety of birds and mammals. They also provide watering places for deer, reptiles, and birds such as herons, egrets, and woodstorks. They provide the only breeding grounds for many frogs, toads and salamanders. Fish commonly found in Carolina Bays include redfin and chain pickerel, lake chub sucker, large mouth black bass, warmouth, blue-spotted sunfish and yellow perch.

Limesinks or sinkholes occur in regions where the underlying bedrock is limestone . Acidic groundwater dissolves the limestone creating an underground cavern. The ground above these underground caverns cave in or sink forming a depression that then fills with water. These limesinks come in many sizes and shapes and the water level in them varies from dry to permanently flooded. They serve to recharge major aquifers and they also support many different species of animals and plants.

Sagponds are modified limesink ponds and serve as reservoirs for underwater aquifers.

Barrier Island Lakes are found on most of Georgia's barrier islands including Wassaw, Ossabaw, Sapelo, St. Simons, Jekyll, and Cumberland Islands. They serve as an important source of freshwater for many migratory birds as well as the animals of the islands.

Riverine Wetlands are nontidal and tidal freshwater wetlands and deepwater habitats contained within a channel of moving water and are found along rivers and streams. When vegetation is present, it is predominately non-persistent emergent plants and/or submersed floating plants. Riverine wetlands are permanently flooded open freshwater with a salinity less than 0.5 ppt. Common examples of Riverine wetlands include **mountain streams, brown water streams, blackwater streams, tidal streams, mountain, Piedmont and Coastal Plain springs.** All of these occur along the headwaters of major rivers and are vital wetlands. Their vegetation slows and filters runoff. These streams and springs are the first line of defense in treating wastes, nitrates, weedsprays, and pesticides that are run-off pollution from the agricultural areas that surround them. They also recharge water tables and help store flood waters. Some of the common plants found along Georgia's blackwater streams include black gum, sweet bay, swamp red bay, loblolly bay, tulip poplar, sweet gum, red maple, slash and loblolly pines, cypress and water oak. Common shrubs include vibernum, black titi, azalea, alder, and button bushes. The relatively clear waters of the blackwater streams support various populations of fish like bluegill, spotted sucker, redfin pickerel, warmouth, largemouth bass, pirate perch, and channel catfish. Cottonmouths, turtles, alligators, and migrating waterfowl also make these areas home.



Cottonmouth

The Altamaha River

The Altamaha River, often called "Georgia's Mightiest River", is truly one of Georgia's greatest natural resources. The Altamaha begins near Hazlehurst where the Oconee and Ocmulgee rivers join. It flows 137 miles through some of the South's last remaining hardwood bottomlands, cypress swamps, historic rice fields and tidal marshes to the coast near Darien, where it fans out in a wide delta.

Some Altamaha Facts

- The Altamaha is the second largest river basin on the Atlantic Seaboard and drains more than 14,000 square miles (one quarter of Georgia's land surface) including half of Atlanta and all of Macon.

- The Altamaha River floodplain is 89 miles long with an estimated 170,000 acres of contiguous bottomland and swamp forest.

- It pumps an average of 100,000 gallons of fresh water into the Atlantic every second which is one-sixth of the freshwater input to the South Atlantic continental shelf.

- The natural beauty of the Altamaha is relatively undisturbed. Their are no dams on the river and it is crossed only five times by roads and only twice by rail lines.

- More than 130 rare or endangered animals and plants inhabit the Altamaha River corridor including seven species of pearly mussels and the Radford's dicerandra which are found nowhere else in the world.

- The only known Georgia population of the Florida corkwood thrives in the Altamaha basin.

- The Altamaha River corridor provides an important stop for migratory birds.

- The Altamaha is bordered by 10 Georgia counties: Appling, Glynn, Jeff Davis, Long, McIntosh, Montgomery, Tattnall, Toombs, Wayne, and Wheeler. Many of the over 181,000 residents of these counties are employed in the agricultural, commercial fishing, forestry, and tourism industries - all of which depend on a healthy river ecosystem.

- From the late 1700's through the 1800's, swamps near the lower Altamaha River were cleared to make way for vast rice, cotton, and sugar cane plantations, and in the 1800's and early 1900's it was a major artery to the Georgia coast for commercial shipping.

- In the early 1800's, large-scale timbering became a booming industry along the Altamaha River and continued through the turn of the century until accessible supplies of cypress and longleaf yellow pine trees were depleted.

Land of The Trembling Earth

The Okefenokee Swamp, of southeast Georgia, is a rare ecosystem of global importance. There is no place on Earth exactly like this wilderness area. A Presidential Proclamation on March 30, 1937, protected the Okefenokee as a National Wildlife Refuge and ended a history of hunting, trapping, attempted drainage, and successful logging. The swamp has been recovering nicely ever since.

This "swamp" we see today is actually a conglomerate of ponds, streams, marshes, bogs, islands, cypress and gum swamps. To understand why these habitats exist we have to look back in time. The Okefenokee is a biologically young ecosystem, but its geologic core dates back to more ancient times.

During the Pleistocene, when sea level was higher than the swamp's present 120 foot elevation, the sand floor of the Okefenokee basin was deposited on the ancient sea bottom. This basin is bounded on the east by Trail Ridge, which is the highest identified Pleistocene barrier island shore line.

Fluctuating sea level left this basin high and dry. And, about 17,000 years ago the sea reached its low stand of a minus 300 to 400 feet. It has been rising ever since. As the level of the oceans increased so did the rains and ground water. In the last 7,000 or so years the Okefenokee has become wet enough for peat (partly decayed plant material) to begin forming. First in the seasonal streams and ponds, it soon formed sheets that filled the entire basin and acted like a giant sponge holding water during the dry periods. In some places the peat is over 15 feet thick. Studies indicate that the average peat accumulation is about one centimeter in 20 years.

Submitted by John "Crawfish" Crawford, MAREX, Skidaway Island

The present plant succession of the swamp goes something like this. Fire burns down through the peat during droughts forming depressions that create ponds when the rains fill the swamp again. Aquatic plants grow well in these shallow ponds and over time peat forms in the bottom. The lack of oxygen in the lower levels of peat allow anaerobic bacteria to live. The gases they give off as waste products (methane and hydrogen sulfide) give buoyancy to thick layers of the peat and it floats to the surface. Here it is colonized by grasses and sedges and becomes known as a "blowup". Later, swamp shrubs succeed and it is called a "battery". These floating islands eventually grow cypress and gum trees and are called "houses". The name Okefenokee owes its origin to a Native American word describing this "land of the trembling earth". Eventually, the pond becomes a marsh (called a "prairie"). The marsh becomes a shrub bog which becomes a swamp forest. Fire renews the cycle and is necessary to create ponds and prairies. Presently, about 30% of the swamp is prairie which is some of the swamps most productive habitat.

Eventually, the entire swamp may develop into a swamp forest. But, presently the varied habitats give homes to many species of plants and animals. There are over 620 species of vascular plants, some quite rare. 235 species of birds have been identified there. Recorded, also, are 50 species of mammals, 39 species of fish, 37 species of amphibians, 15 species of turtles, 11 lizards, 37 snakes and of course, the American Alligator.

The Okefenokee Swamp is vast, wild and protected ..... today. Recent plans to mine Trail Ridge have met with wide spread opposition and seem to have been dropped. But, no place is safe unless we continue to value and learn from it and be willing to expend the efforts protecting it requires. Lets hope the "Land of the Trembling Earth" is around for our children's, children's, children to experience and enjoy.

Submitted by John "Crawfish" Crawford, MAREX, Skidaway Island

Wetland Functions and Values

In the past, wetlands have received a "bad rap". Many people thought of them as buggy, mosquito-infested, mucky, worthless, mysterious, and even dangerous wastelands. Because many individuals and government agencies alike thought that draining and filling wetlands would improve their value, people have drained, filled, abused, and built on over one half of our nation's wetlands.

It has only been in the last twenty or so years that we have realized just what wetlands are and that they are important ecosystems and resources. Some of the ecological and economic benefits of wetlands were stated in the following environmental message given in 1977 by President Carter to our nation.

> **The nation's coastal and inland wetlands are vital natural resources of critical importance to the people of this country. Wetlands are areas of great natural productivity, hydrological utility, and environmental diversity, providing natural flood control, improved water quality, recharge of aquifers, flow stabilization of streams and rivers, and habitat for fish and wildlife resources. Wetlands contribute to the production of agricultural products and timber and provide recreational, scientific, and esthetic resources of national interest.**

Although only about 5% of the nation's total land area is wetlands, almost 35% of the nation's rare or endangered plants and animals are found there and over 900 species of vertebrates (in the United States) spend at least part of their life in wetland habitats.

The three basic types of wetland values include environmental quality values, fish and wildlife values, and socioeconomic values.

Environmental Quality Values

Water Quality and Purification: Wetlands help maintain and improve surface and groundwater quality by acting as natural filters. Rainwater that runs off buildings and streets in agricultural, industrial and residential areas pick up nutrients, sediments, phosphates, heavy metals, pesticides, and other wastes (including bacteria and viruses). If this rainwater flows through a wetland before it reaches streams, rivers, or the ocean, some of these pollutants can be filtered and absorbed by the wetland plants and soils. Unfortunately, as with any filter, there is a limit to the amount of pollutants that wetlands can handle before becoming damaged or overloaded. Only through conservation and careful management of point and nonpoint source pollutants can we insure that our wetlands will work properly.

Oxygen Production: 75% to 80% of all the oxygen on earth is produced by microscopic plants called ***phytoplankton***. These tiny plants live in or near the surface of wetland waters.

Sediment Traps: As water passes through a wetland, 80% to 90% of the suspended soil particles (sediments) settle out and become attached to the stems and roots of wetland plants. As sediment traps, wetlands help to provide cleaner environments for aquatic plants and animals. They also help to reduce the amount of pollutants that enter our water ways and the amount of sediments that have to be dredged and removed from our ports, shipping channels and reservoirs.

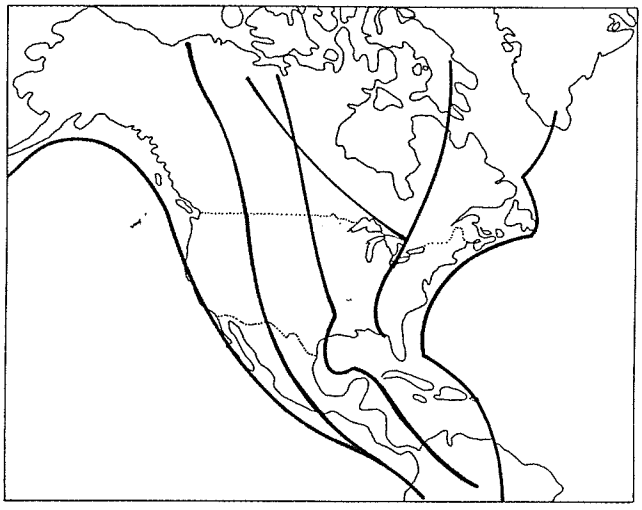
Nutrient Removal and Recycling: Elements such as nitrogen and phosphorus are important parts of the life processes of animals and plants and are called ***nutrients***. All plants and animals need some nutrients but too many can cause serious problems. Too many nutrients in the water can cause ***eutrophication*** or extremely rapid growth of algae called ***algal blooms*** that can cover the entire surface of the water. When this happens the oxygen supply is cut off to other aquatic life and they die. All human wastes contain nitrogen and phosphorus and when sewage is dumped into our waterways there is always a threat of algal blooms. Wetlands are capable of removing 85% to 90% of the nitrogen and phosphorus from run off water as it flows through them. Microorganisms and wetland plants absorb some nutrients, store some in the soil, convert others into usable products, and release some as nitrogen gas.

Chemical and Organic Waste Processing: Certain wetland plants can change the chemical make up of certain viruses, coliform bacteria, and suspended solids in waste water into substances that are not harmful. Georgia is one of the few states that has recognized the value of wetlands in water purification and are using wetlands in isolated areas to help remove household and sewage wastes from water. If a dollar value could be put on the water treatment services provided by wetlands, they would be valued at $50,000 per acre.

Climatic and Atmospheric Functions: Wetlands are a major source of water to the atmosphere and can play a role in local and regional droughts. They also tend to moderate local temperatures. Temperatures in areas with wetlands are warmer in the winter than areas where wetlands are absent.

Fish and Wildlife Values

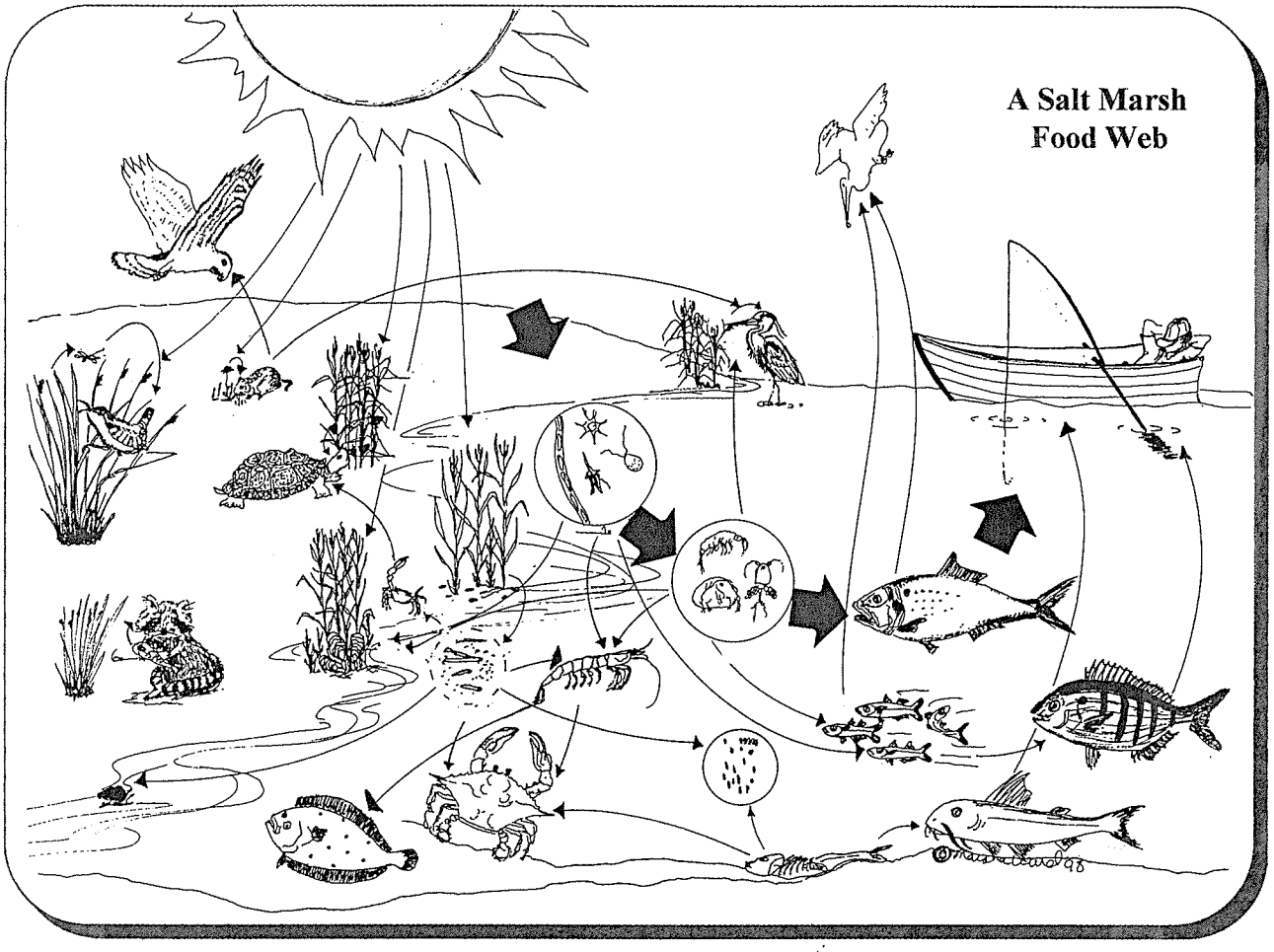
Habitat: Wetlands provide essential habitats and shelter for a great variety of animal species including amphibians, birds, fish, insects, mammals, and reptiles. The thick vegetation in a wetland provide some animals cover and protection from predators. Eighty percent of waterfowl use wetlands as feeding, breeding and nesting grounds. Over half of the nation's migratory birds either spend the winter in the wetlands of the South or rest in our wetlands during their long migrations. Almost all of the nation's recreationally and commercially important freshwater fish and about two-thirds of saltwater shellfish and fish species rely on wetlands and coastal marshes for spawning



Routes commonly used by migratory birds.

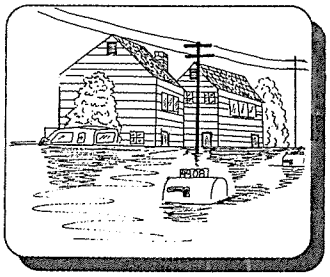
wetlands and coastal marshes for spawning and nursery grounds. Relatively few animals (alligators, muskrat, marsh rabbit, and wood ducks) live year round in wetlands. Many are ***obligate*** species and require a wetland habitat to complete only part of their life cycle. Other animals, such as deer, just visit wetlands occasionally for food, water, or shelter. Over one third of the nation's threatened and endangered species (both plant and animal) live in wetland areas.

Food Webs: Wetlands are phenomenally productive ecosystems. When the plants of wetlands die, they are decomposed by bacteria and fungi into ***detritus.*** These nutrient rich plant fragments provide the basis of food chains for thousands of small fresh and saltwater animals. These animals are then eaten by larger animals such as fish, raccoons, otters, ducks, herons, other shorebirds, and humans.



Socioeconomic Values

Flood Control: Wetlands that are located near lakes, rivers, streams and the ocean protect the surrounding land from damage from floods by acting as a "sponge" and temporarily storing flood waters. They then slowly release these waters back into the system. The trees, grasses, and other wetland vegetation slow down the flow of the flood water and spread it out over a larger



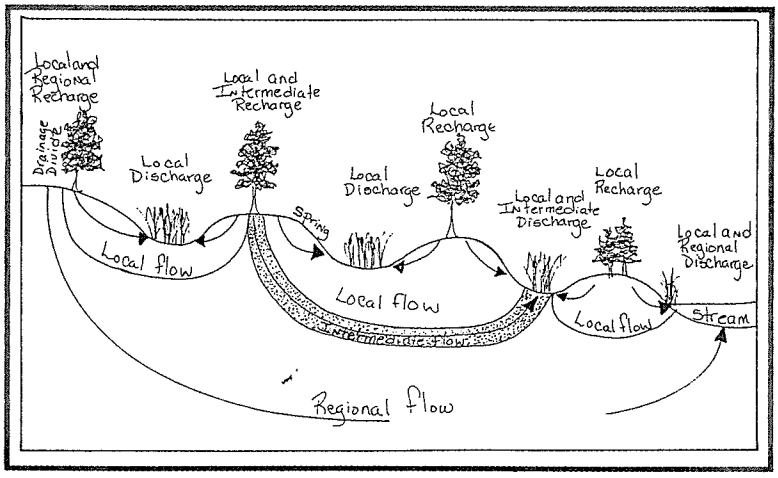
area. This allows time for the water to percolate through the soil rather than continue movement downstream. This reduces the effect of floods on properties downstream. In areas where wetlands have been destroyed for agriculture and urban development, the flood waters have nowhere to seep into the soil and valuable property and often lives are lost.

In July of 1994, Georgia experienced its worst flooding in over 500 years due to Tropical Storm Alberto. An estimated 1700 roads and 600 bridges were damaged. Over 40,000 people were evacuated from their homes; 12,000 homes and businesses were destroyed, and 30 people lost their lives. About one third of Georgia suffered flood and rain damage and fifty-five counties were declared as disaster areas and thousands of acres of farmland and crops were destroyed. The damage and loss of life would have been much less if wetlands along Georgia's major rivers had not been destroyed.

Protection from Wave Damage: The vast expanses of marshes between Georgia's barrier islands and the mainland slow the action of storm waves and currents and therefore reduce the damage to the mainland during severe storms and hurricanes.

Erosion Control: During a storm, the effects of rushing water, waves, and currents can be devastating. Fast moving water wash immense amounts of soil and sand particles into lakes, rivers, streams, and the ocean. These unusually high amounts of sediments are considered both chemical and physical pollution because they contain bacteria and other harmful substances. The plants in the wetlands and marshes slow these storm and flood waters and allow some of the sediments to settle out before they reach major waterways or the ocean. They also hold the soil with their roots and help to absorb impacts from wave action.

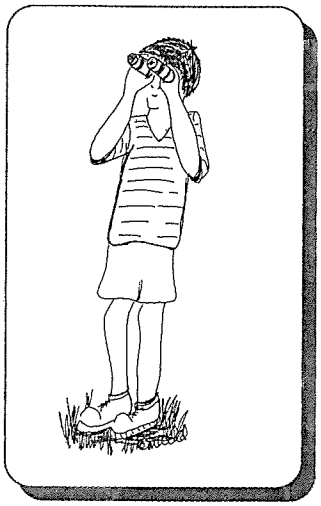
Salt Water Intrusion Control: The movement of fresh water through wetlands produces groundwater pressure that prevents saltwater from penetrating public freshwater supplies.

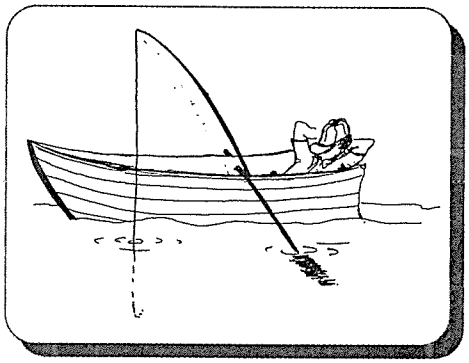


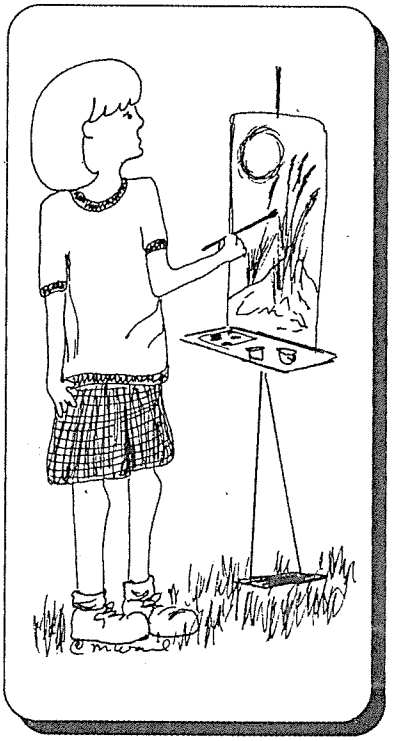
Ground Water Discharge and Recharge: Some wetlands store water and allow it to slowly percolate into the underlying aquifer and recharge groundwater supplies. Others will slowly discharge groundwater into lakes, rivers and streams which helps to maintain water levels during dry seasons.

Timber and Other Natural Products: Georgia's wetlands produce a wealth of natural products. Although the types of products vary between salt marshes and freshwater wetlands, most wetlands, simply by being wetlands, will produce from $10,000 to $50,000 worth of

products per acre. The majority of the trees for Georgia's $12 billion dollars a year timber, pulpwood, and paper industry comes from wetlands. Most of the Georgia's fishing and shellfish (shrimp, crab, etc.) industries harvest wetland dependent species. The most valuable fishery in the United States is the southern shrimp industry. Commercial fisheries contribute over $23 million dollars to Georgia's economy. The annual shrimp catch for Georgia alone is over $20 million dollars. The seafood processing industry is another vital component to the economy of coastal Georgia. One acre of river swamp produces as much as 1,300 pounds of fish each year. The furs and skins of alligators, beaver, mink, and muskrat is over a billion dollar industry nationally.

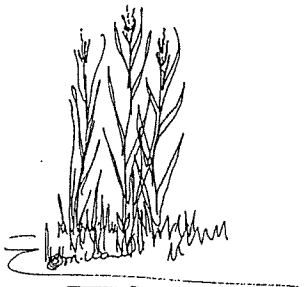






Recreation and Aesthetics: Wetlands offer unspoiled, open spaces for the aesthetic enjoyment of nature as well as activities such as birdwatching, boating, canoeing, fishing, hiking, hunting, painting, photography, and swimming. Birdwatchers and photographers spend over $50 million annually on their hobby. Approximately 1 in 10 Georgians fish, and 1 in 20 hunts. These hunters and fishermen spend $900 million each year for licenses, transportation, lodging, etc.. Of the top 25 national wildlife refuges most visited, 19 are wetland areas. Georgia's Okefenokee Swamp is one of the largest and best preserved freshwater wetlands in the United States and is ranked in the top 20 in visitation. Georgia's coastal marshes support a tourist industry of over a billion dollars a year.

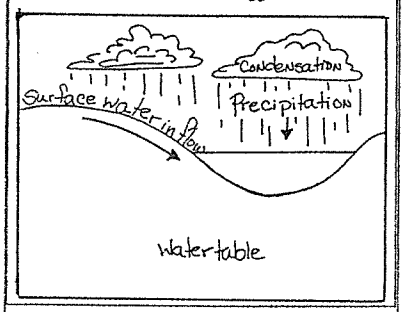
Education and Scientific Research: The natural beauty and diversity of wetlands provide an excellent setting for scientific research and living laboratories that can be used to study art, biology, ecology, geology, history, language arts, and photography.



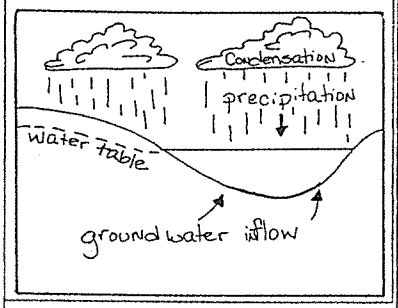
Wetland Hydrology

Where does the water in a wetland come from?

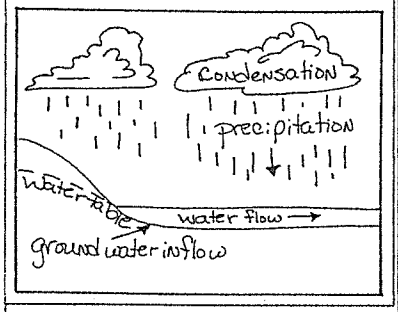
Direct precipitation and surface water runoff



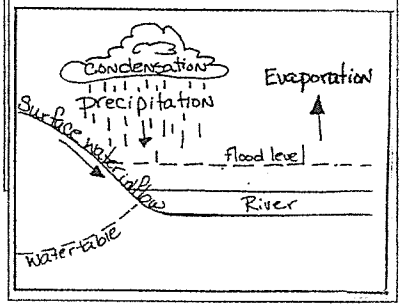
Direct precipitation. and groundwater inflow



Inflow from seeps



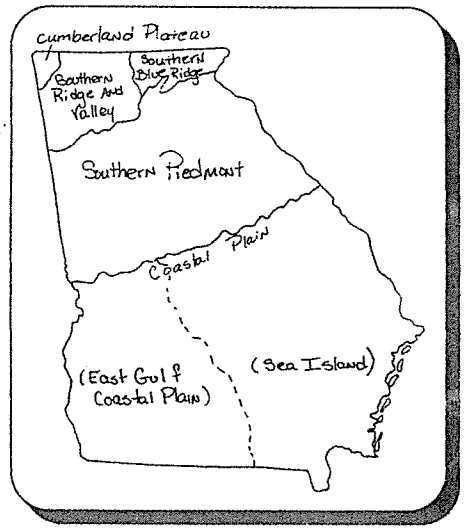
Flooding



The distribution and circulation of water or **hydrology** of a wetland determines its water depth, flow patterns, and the frequency and duration of flooding or saturation. The major factors that influence wetland hydrology are topography, nearness to other bodies of water, and depth of the water table.

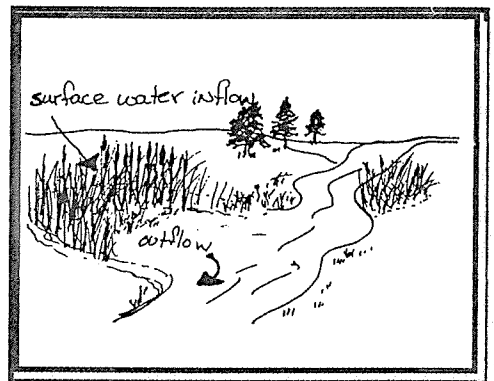
The amount of water present and the duration and frequency of flooding or saturation varies from one wetland type to another. Some wetlands are ephermeral or seasonal and contain water for only a few weeks during the spring. Wetlands that are located where groundwater is at or near the surface of the soil or near large bodies of water may remain wet year round. This variability in wetland hydrology is the main reason that so many different types of wetlands develop. Water can enter a wetland in several different ways, called **hydrologic pathways**. These hydrologic pathways include: (1) direct precipitation; (2) surface water runoff from rivers and streams; (3) underground water sources such as groundwater or springs or seeps; (4) flood waters from upstream and adjacent surface water bodies such as rivers, ponds and lakes; (5) tidal flow and storm surges in coastal areas.

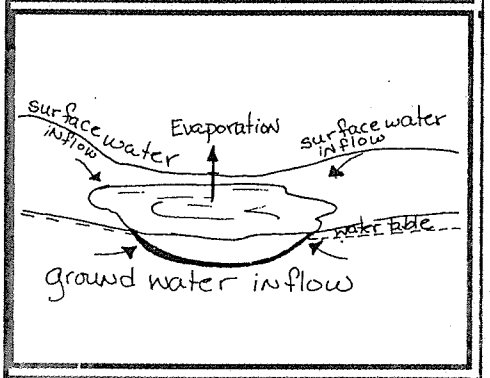
The amount of water and the rate at which it flows through a wetland determines the type of soil and vegetation found in a wetland which in turn influences the diversity of wildlife. These two factors also influence the availability and cycling of nutrients within the wetland which determines the wetland's productivity. The hydrology of a wetland also determines what functions it will perform. In general, wetlands that are created by flooding or flowing conditions like those along rivers and tidal marshes can support more plant types and animal life than those with stagnant waters like bogs because there is a greater exchange of nutrients from the surrounding environments.

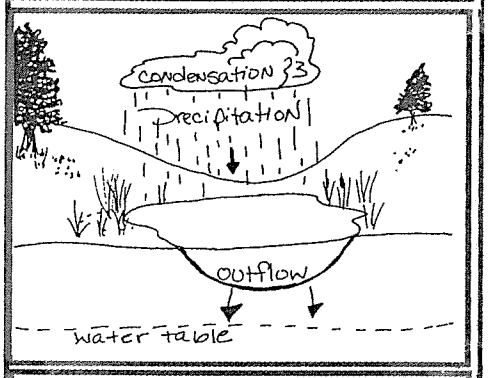


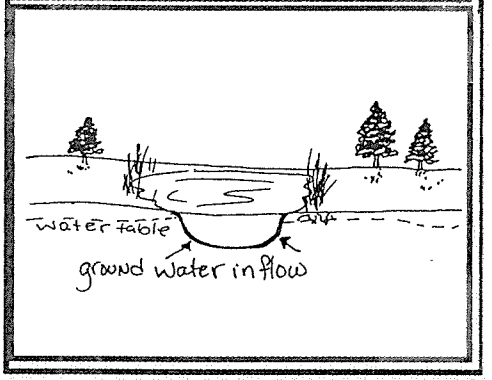
Due to Georgia's high rainfall statewide (over 50 inches per year) and it's varied topography (with the mountains of the Cumberland Plateau, Ridge and Valley, and Blue Ridge, the gently rolling hills of the Piedmont, and low-lying areas of the Coastal Plain), Georgia has over 60 different types of wetlands. The vast majority of Georgia's wetlands, approximately 90%, are located in coastal areas.

Water Quality in Wetlands









The water chemistry in wetlands is dependent on the following factors:

- The geologic setting of the area.
- Water balance or how much water comes in, how much goes out, and how much is stored.
- The quality of the water coming into the wetland.
- The types of soils and vegetation.
- Human activity in or near the wetland.

The water in wetlands rarely comes from a single source and therefore the water chemistry of a wetland is usually a combination of the chemistry of the water from various sources. Wetlands will probably receive their chemistry from one or more of the following:

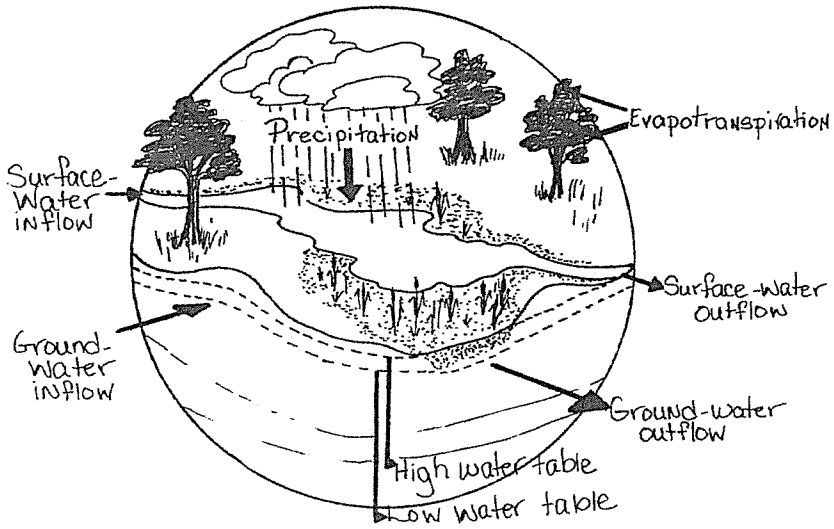
- Wetlands that are dominated by surface water inflow and outflow have water chemistry similar to that of the lakes and rivers from which the water comes.
- Wetlands that receive water from surface water or ground water inflow, but have little outflow will have high concentrations of chemicals and will most likely contain brackish or saline water. This is because they lose most of their water through evaporation and the salt concentration in the water increases because salts do not evaporate. The salts in this case come from natural elements dissolved in the water and probably not from the ocean.
- Wetlands that receive most of their water from rainfall and lose water by surface water outflow or seepage into the ground water have lower concentrations of chemicals.
- Wetlands that receive their water mainly from groundwater discharge have water chemistries that are similar to ground water.

The type of plants present in a wetland are indicators of the water chemistry of that particular wetland. The abundance of plants and species diversity in a wetland is determined by the amount of salt in the water in coastal wetlands and the pH and mineral content of the water in freshwater wetlands.

Wetlands will naturally filter out the pollutants that are in the water. It is important to remember, however, that there is a limit to how much a wetland can filter.

The Water Cycle is the Vital Link between Wetlands and Watersheds

The circulation and distribution of water is the driving force behind the formation of wetlands. Through the water cycle, or **hydrologic cycle**, water continuously circulates from the atmosphere to the earth and back. The major components of the water cycle are precipitation (rain or snow), surface-water flow, ground-water flow, and transpiration, evaporation, and condensation. Precipitation falls to the ground because of gravity and moves toward the lowest point in the landscape. Water may flow over the surface to streams and rivers or it may percolate through the soil and eventually become part of an underground water supply such as an aquifer or a surface water supply such as a river. When the sun heats the surface of the earth, water molecules evaporate from the land as well as from lakes, rivers, and oceans. This water vapor then returns to the atmosphere. Plants also give off water through transpiration. These processes are often grouped together and called evapotranspiration. As water vapor rises, it cools and condenses into liquid water particles that collect around dust particles in the atmosphere and forms clouds. When these clouds become saturated, water falls as rain or snow. Eighty-seven percent (87%) of all precipitation falls into the ocean. The other thirteen percent (13%) enters various watersheds.



A watershed, the total drainage basin of an area is defined by the topography or shape of the land governing the path that runoff follows as it moves from higher to lower elevations. The watershed includes not only the streams and rivers that flow directly into the ocean, but also wetlands and dry land areas over which the runoff flows. Watersheds are like a large bowl. All of the water that falls into that bowl eventually ends up at the bottom of the bowl or in the ocean. Wetlands act like a sponge and help to regulate the amount of water moving through a watershed by holding water during wet periods and slowly releasing water during dry periods. Wetlands, whether isolated or part of an expansive system, are hydrologically important resources within the watershed. Everyone of us lives within a watershed, and every watershed eventually drains into the ocean. Through the water cycle (evaporation, transpiration, condensation, and precipitation), our homes and businesses are all connected to local watersheds. The water in these small local watersheds eventually reaches the ocean. Therefore, we all have an effect on our region's water quality and thus on the quality of the water that reaches our oceans.

Wetland Soils

Wetland soils are called **hydric soils** and are different from upland soils because they develop under anaerobic (without oxygen or with low oxygen) conditions because the soil in usually saturated with water. The air or pore spaces between the soil particles are filled with water and cannot hold much if any oxygen. Only water loving or hydrophytic plants can grow in these anaerobic conditions. The prolonged presence of water and lack of oxygen cause chemical reactions to take place in the soil that affect the color, texture and organic content.

The shape of the landscape creates unique drainage conditions which influence the formation and characteristics of the wetland soils. Soils are classified according to the rate at which they drain water. Most upland soils are usually well drained while wetland soils are either poorly drained or very poorly drained. Water flows so slowly through the poorly drained wetland soils that the surface of the soil is periodically saturated or may remain wet for long periods. This poor drainage is the result of seepage, nearly continuous rainfall, or a combination of the two. In the very poorly drained soils of wetlands, water moves so slowly that it remains at or on the surface of the soil.

Hydric soils are classified as either organic or mineral soils based on their composition. Organic wetland soils contain more than ten percent (10%) of partially decayed plant and animal matter. This organic matter creates a thick dark brown or black layer within 1.5 feet (0.46 meters) of the soil surface. Mineral wetland soils contain little or no organic material and more sand, silt and clay and are generally lighter in color than organic soils. Wetland scientists use color charts to classify soils based on their color, lightness or darkness, and the degree that colors are mixed.

Organic soils:

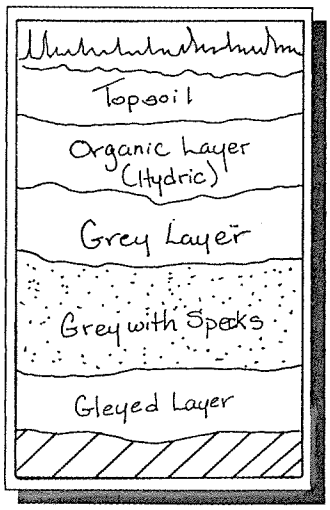
The water-logged and oxygen-poor conditions in wetlands inhibit the growth of microorganisms that decompose organic materials such as leaves, roots, and stems. Over time, organic material tends to accumulate and form a dark brown or black layer of peat or muck. Organic wetland soils are classified as either muck or peat by the amount of plant materials that are identifiable in the soil. In soils classified as **muck** most of the plant material is decomposed and is no longer identifiable. Very few plant fibers can be detected by rubbing the soil between your fingers. **Peat** contains more than 2/3 its original organic matter and most plant fibers are still identifiable when rubbed between fingers.

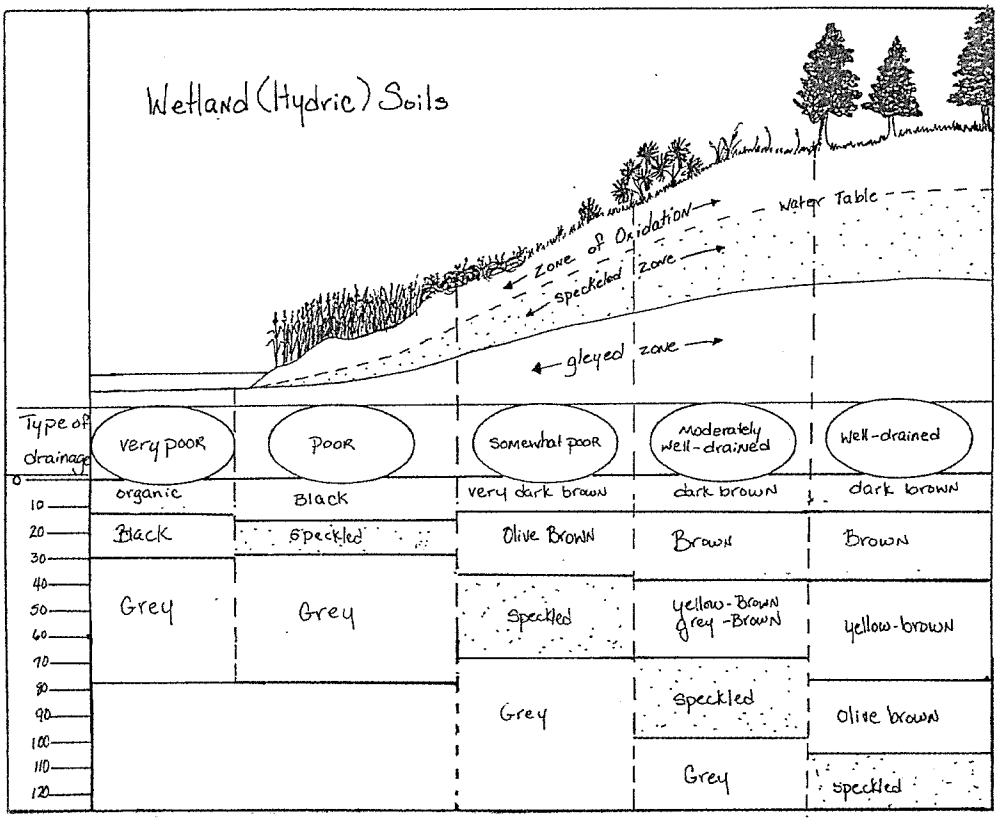
The amount of organic matter affects both the chemical and physical properties of soils. Organic matter acts like a sponge and absorbs large amounts of water that otherwise might run off the land. Organic soils also slow the flow of floodwater and protect the mineral soil layer beneath it from the erosive force of rain.

Mineral soils:

Mineral soils contain very little organic matter and are made up of mostly inorganic matter such as sand, silt, and clay. They are usually found deeper under the surface and are either gleyed

(pronounced "glade") or mottled. Gleyed soils form when iron deposits in the soil are converted from an oxidized state to a reduced state due to low oxygen conditions and extended periods of saturation. This process gives gleyed soils a gray, bluish gray, or greenish gray color. Mottled soils form where mineral soils are alternately wet and dry allowing oxygen to mix with iron and oxidation or rust occurs. This creates splotches of orange, yellow, or reddish-brown mixed in with the usual gray mineral soil.





Biological Processes in hydric soils:

The surface of the soil is oxygenated supporting such organisms as aerobic bacteria, algae, fungi, and protozoa. The depth of this oxygenated zone is dependent upon several factors including how often and how deeply the soil is stirred up by waves or macro-organisms. Below the oxygenated zone anaerobic bacteria are present. In this oxygen-depleted environment, the anaerobic bacteria use nitrogen, manganese, iron, and sulfur in a manner analogous to the way humans (and other aerobic organisms) use oxygen to obtain energy. Each of these reactions are performed by different anaerobic bacteria and produce compounds such as nitrogen gas, carbon dioxide, methane, and hydrogen sulfide (which gives the soil a "rotten egg" smell).

Wetlands as Ecosystems

All wetlands are natural ecosystems. An **ecosystem** is defined as any grouping of animals, plants, and microbes that interact with each other and their environment in such a way as to perpetuate the group more or less indefinitely. The animals, plants and microbes are the living organisms of an ecosystem and make up the **biotic community**. The environment of an ecosystem is made up of the non-living factors (**abiotic factors**) and includes chemical and physical factors such as the amount of water or moisture, temperature, salinity, and soil type. These abiotic factors both support and limit the biotic community within the ecosystem.

There are three major categories of living organisms in the biotic community and each has a special job to do. They are the **producers, consumers, and decomposers** and/or **detritus feeders.**

The producers are green plants and photosynthetic or chemosynthetic bacteria. These producers manufacture food for the ecosystem. They do this through the process of photosynthesis during which carbon dioxide and water are chemically combined by the presence of light energy from the sun and chlorophyll into glucose (food). As a by product of this process, oxygen is produced and released into the air. Since plants produce their own food as well, they are **autotrophs**. All other organisms in an ecosystem are **heterotrophs** and depend on others for food. All heterotrophs are either consumers, detritus feeders, or decomposers.

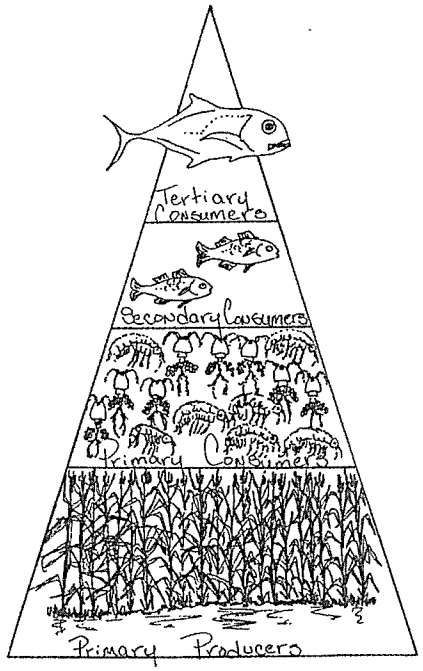
Consumers that feed on plants are the **primary consumers** and are called **herbivores**. Some consumers can eat both plants and animals and are known as **omnivores**. **Secondary consumers** feed on plant eating animals. **Tertiary consumers** eat secondary consumers and so on. **Parasites** are also considered consumers because they feed on other plants and animals. Detritus feeders and decomposers are consumers that feed on and decompose dead plant and animal matter. These are nature's recyclers and are very important to the ecosystem as they return nutrients to the soil.

Autotrophs (Conduct photosynthesis and make their own food)	**Heterotrophs** (Feed on others)	
Producers	**Consumers**	**Detritus feeders and decomposers**
Photosynthetic green plants that use chlorophyll to absorb light energy from the sun.	Primary consumers (herbivores) are animals that feed only on plants.	Decomposers like fungi and bacteria cause rotting.
Photosynthetic bacteria use purple pigments to absorb light energy from the sun .	Omnivores are animals that eat both plants and animals.	Primary detritus feeders feed directly on detritus.
Chemosyntheitc Bacteria use chemicals such as hydrogen sulfide to produce food.	Secondary consumers are animals that feed on primary consumers.	Secondary and higher order detritus feeders eat primary detritus feeders.
	Tertiary consumers and higher order consumers feed on other carnivores.	
	Parasites are plants or animals that have symbiotic relationship with another plant or animal and feed on that plant or animal for a period of time.	

The food energy produced by the producers is cycled through the ecosystem through **food chains** and complex **food webs** through a series of energy levels or feeding levels called **trophic levels**. Producers make up the first or bottom level. Primary consumers make up the second level and secondary consumers make up the third level and so on. The largest amount of available food or biomass is in the first trophic level and the available amount decreases drastically in each higher level. Less than 10% of the amount of food that is available in level one is available to level two. Less than 10% of what is available to level two is available to level three. This is called the 10% rule and continues all the way up the food pyramid. Because the amount of available energy or food available in each successive level is less, each successive level can support fewer and fewer organisms. The number of organisms in the top level is directly related to the number of levels and determines the number of top level consumers. Any wetland ecosystem can only support a limited number of organisms and still function properly.

Energy is never lost, It is simply not available to the next energy level. Some has gone into the production of new cells and tissues and some is used in respiration and leaves the system as heat.

Wetland Food Pyramid

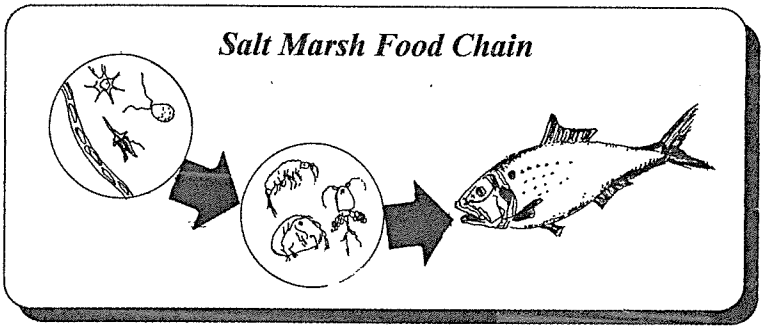


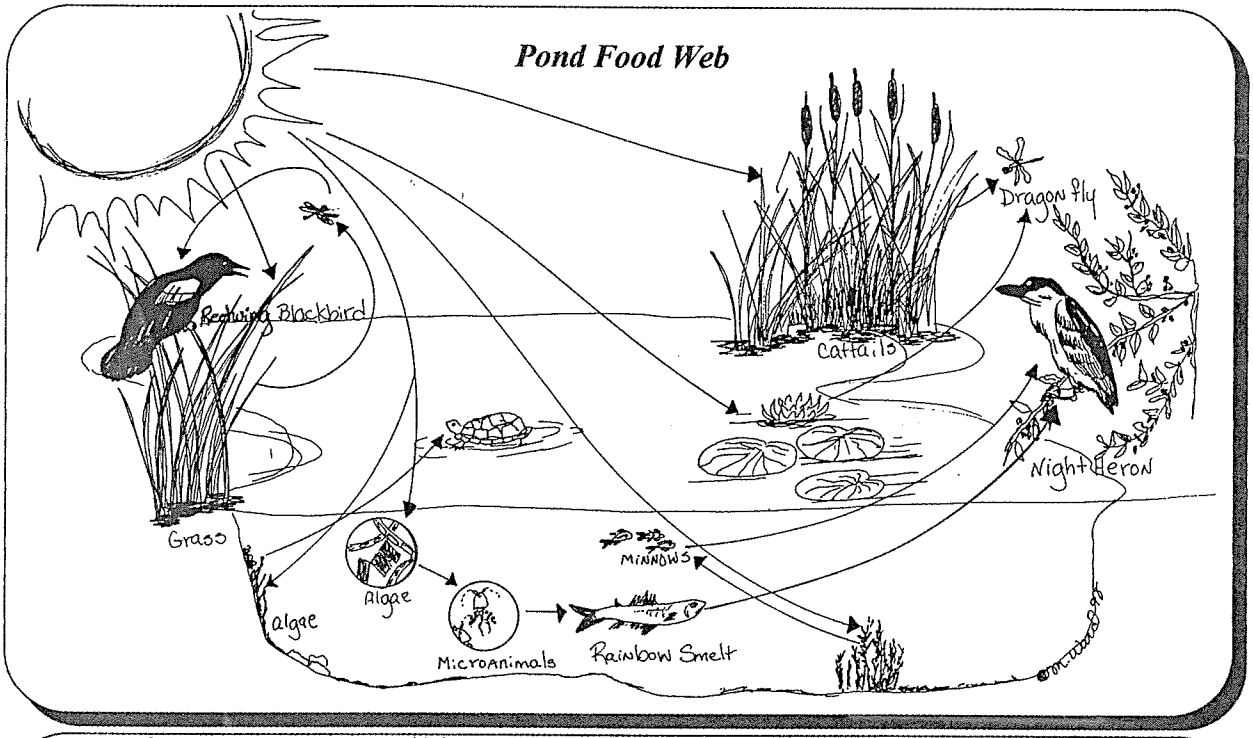
All food chains, webs and trophic levels in wetlands start with the plants or producers and they must have suitable environmental conditions to support that growth. There are two major energy flow patterns within a wetland; the grazing food chain and the detrital food chain. The grazing food chain involves direct consumption of green plants. The detrital food chain is one in which organisms eat detritus or dead, decomposed plants and organic debris.

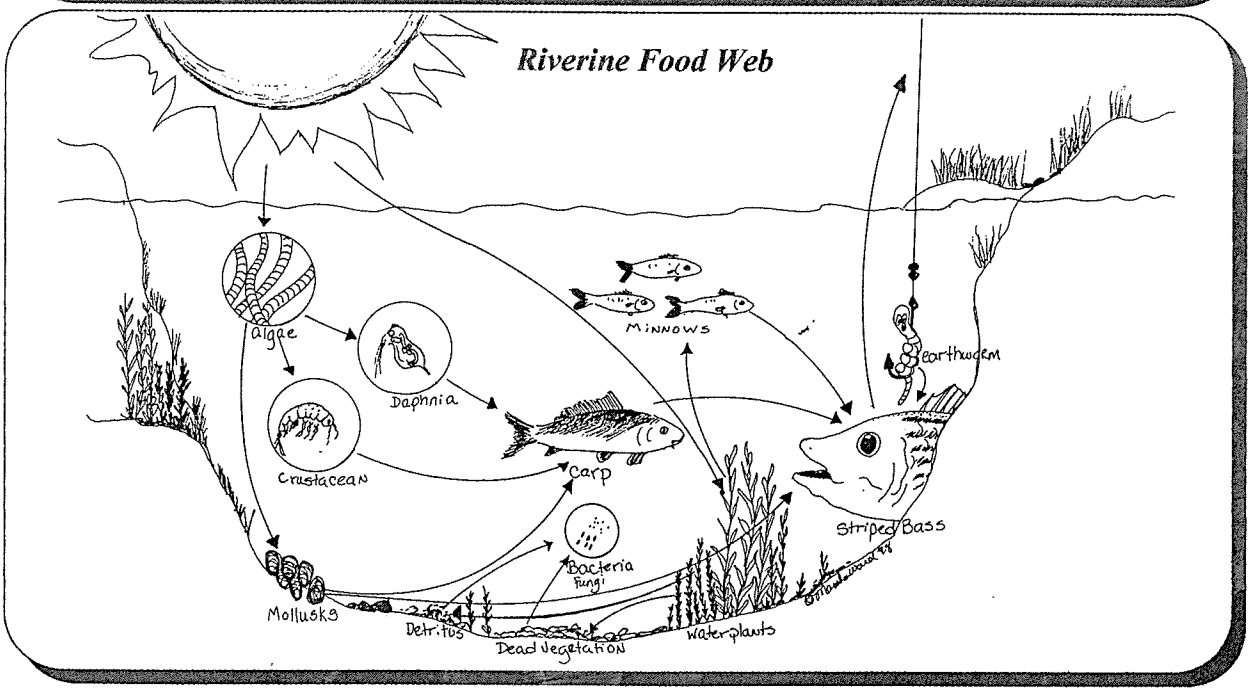
In lakes and pond wetlands, the basis of the food chain is submerged plants and floating algae (phytoplankton). Zooplankton (tiny animals) eat the algae; aquatic insects eat the zooplankton; small fish eat the zooplankton, which are eaten by larger fish and then may be eaten by man. In streams, decomposed leaves and other organic material (detritus) or algal mats on rocks are the producers and are eaten by caddisflies and stoneflies which are eaten by small fish which are eaten by larger fish. In Riverine bottomland hardwood swamps, leaves are broken down by bacteria and fungi into detritus which is eaten by worms and insects which in turn are eaten by birds. In a salt or brackish marsh, detritus may be eaten by a larval crab (zoea) which may be eaten by a fish larvae which may be eaten by a larger fish, and so on.

Any alteration of a wetland by humans can disrupt the natural cycling of food energy through the wetland. When humans destroy wetlands to build homes, factories, shopping centers, etc. they are not only destroying habitats but the plants that produce the food for many food webs. Some wetland animals are finicky eaters and eat only one or very few types of organisms. Therefore, if one food source disappears, the animal that eats it might also die.

Examples of Wetland Food Chains and Food Webs





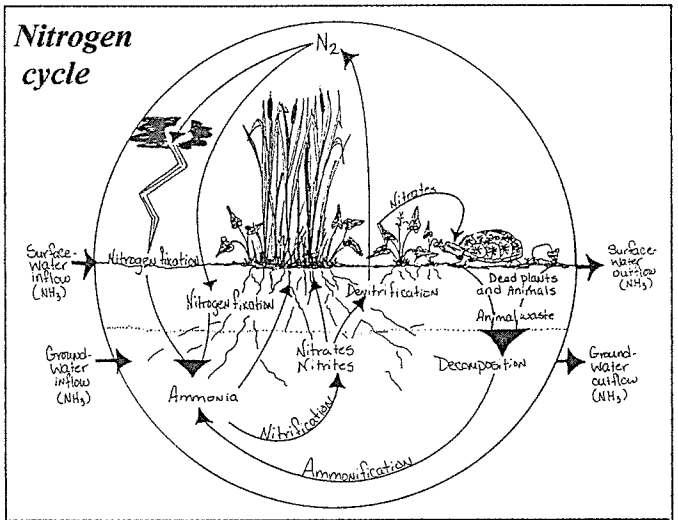


Nutrient Cycling in a Wetland

Although there is a constant flow of energy through a wetland, very few wetland aquatic plants are eaten directly by grazers (**hervbivores**). When wetland plants die or loose their leaves, they fall into the water and decomposers such as bacteria, fungi, worms, and some aquatic insects break this plant material down into tiny particles of organic matter called **detritus**. This detritus is then eaten by small aquatic invertebrates which are then eaten by larger animals; or it is washed out to sea by the tides and becomes available to fish, shellfish and other marine invertebrates. These animals use some of the energy from the detritus for growth, but some is released as mineral nutrients and organic compounds such as nitrogen and phosphorus (the animal's wastes) that dissolve in the water. This creates a natural fertilizer for the wetland plants. Wetlands do not need artificial fertilizers like argicultural crops do. They recycle their own over and over again in this cycle of eating and excretion.

Both nitrogen and phosphorus are necessary nutrients for the proper function of certain life processes, but they can be toxic (deadly) in large amounts. Nitrogen is essential to the formation of proteins, and phosphorus is necessary for energy reactions, the formation of cell membranes, and nucleic acids.

Each different types of wetland decompose organic matter at different rates, thus creating natural fertilizers at different rates. So, some types of wetlands are more productive than others. Bogs are the least productive of the wetlands because organic matter is decomposed very slowly. Bottomland hardwood swamps and salt and brackish marshes are much more productive since they produce tremendous amounts of detritus and in turn can support a great abundance of life. Worldwide, the coastal wetlands are second only to sugar cane in productivity. This high biological productivity of wetlands is due to their ability to capture large amounts of the sun's energy, convert and store it as chemical energy, and their ability to efficiently recycle all natural elements.



1. Bacteria change gaseous nitrogen to ammonia. 2. Bacteria change ammonia to nitrate. 3. Plant roots absorb ammonia and/or nitrate formed in step 1 and 2 and incorporate nitrogen into plant proteins and nucleic acids.
4. Nitrogen compounds of decaying plants are broken down by bacteria and release ammonia that can be recycled through steps 1 & 2. 5. Bacteria change nitrate to gaseous nitrogen.

THE NITROGEN CYCLE

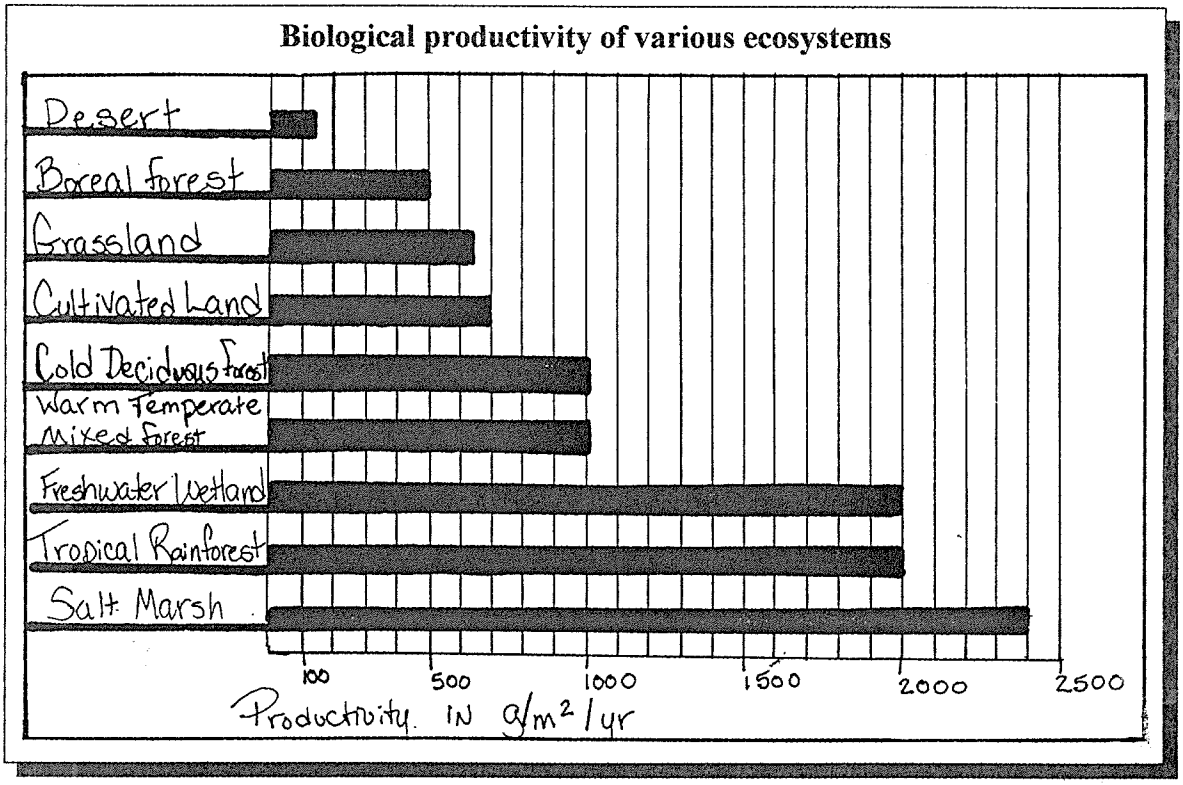
One important nutrient that is cycled in the wetlands is nitrogen. Nitrogen enters the system as ammonia(NH_3 & NH_4) from the wastes of animals. Ammonia is posionous to most organisms when it is present in large amounts. Nitrifying bacteria (*Nitrosomonas and Nitrobacter*) and other organisms in the water oxidize the nitrogen in ammonia first to nitrite (NO_2) which is less toxic and then to nitrate (NO_3). Nitrogen in the form of nitrate is soluable in water and is removed from the water by phytoplankton and is converted into proteins and nitrogen gas. As long as these nitrifying bacteria can continue their activities, the free amonia in the wetland environment is held in check.

Wetland Productivity

Biological productivity is the number of animals and plants that occur because of the interaction of organisms within the wetland ecosystems. Wetlands are the second most biologically productive ecosystem in the world. No agricultural crop other than sugar cane is more biologically productive than wetland plants.

This high biological productivity in wetlands is due to the abundance of water, the wetland's ability to capture and store large amounts of the energy from the sun and to recycle nutrients. Some of the energy produced through photosynthesis is used in the life process of the organisms like respiration, digestion, etc. The energy that is stored in the bodies of the plants within a wetland is the wetland's net productivity.

Factors contributing to the high productivity in wetlands include: 1. The efficient functioning of the various wetland food chains and webs. 2. The periodic rise and fall or cycling in and out of wetland water levels that bring in the necessary nutrients and replenish the oxygen supply. Some wetlands are more productive than others. Wetlands where the plants are periodically flooded, like saltmarshes, are much more productive than bog areas where the water is mostly stagnant.

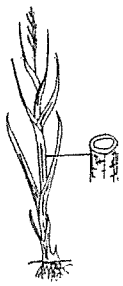


Adaptations of Wetland Plants

Wetland plants are water loving plants called hydrophytes. Hydrophytes are herbaceous or non-woody plants, shrubs, and trees. These plants have developed special adaptations that enable them to withstand the stressful conditions that are characteristic of wetlands such as fluctuations in water levels, periodic or permanent inundation or saturation with water, and little oxygen.

The following are some of the ways that hydrophytes have adapted to the wet, anaerobic conditions of wetlands:

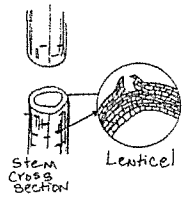
1. Many wetland plants have special air or pore spaces in their roots and stems called **aerenchyma** through which oxygen can enter the pant and be transported to its roots. Some have air spaces on their stems and leaves that allow the exchange of oxygen and carbon dioxide.



2. Some plants like *Spartina alterniflora* have hollow stems that transport oxygen to the roots.

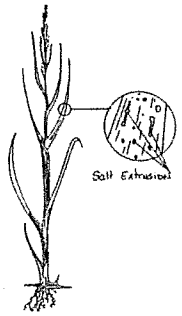
3. Some, especially woody plants, pump oxygen from their leaves to their roots. This enables the root cells to respire (breathe) and carry on the necessary nutrient exchange reactions with the soil. This process often results in rust-colored root channels in the upper layers of the soil called oxydized rhizosphores.

4. Many wetland trees develop shallow root systems, swollen trunk, or roots that grow above the soil surface. Cypress Knees are an example of this. Other trees, during flooding, produce new air-filled roots to replace those killed by the flood. Also during flooding, some trees grow openings in their bark called **lenticels** that allow oxygen to enter. Some trees are even capable of switching to anaerobic respiration.



5. Hydrophytic plants that grow in brackish and salt water have adaptations that tolerate saline conditions are called **halophytes**. Halophytes that require saltwater for growth are known as **obligate halophytes**. Only a few halophytes such as glassworts and saltwort are obligate halophytes. Most halophytes are **facultative halophytes** and do not require salt water but can tolerate it and grow well there because there is less competition from other wetland plants. Some of the special adaptations of saltwater wetland plants are as follows:

   - Some have developed ways to reduce salt intake by the roots called salt water exclusion.
   - Some take the salt in but have salt-secreting glands to get rid of the salt. This process is called saltwater extrusion.
   - Some have developed salt concentrating glands like fleshy leaves. They collect salt in these special leaves and then shed them.
   - Some plants have developed succulent leaves that store water and help to keep the level of salt concentrations at acceptable levels.
   - Some plants have saltwater-proofed their leaves with a waxy covering.



- Some have adapted by reducing their leaf surfaces to minimize exposure to salt and evapotranspiration.
- Some can isolate the salt in certain internal organs.

Hydrophytes are generally grouped into the following four categories:

- **Obligate wetland** plants are found only in wetlands (99% of the time).
- **Faculative wetland** plants are plants that occur 67% in wetlands.
- **Faculative** plants occur both in wetlands and uplands (34% in wetlands).
- **Obligate upland** plants occur only in dry upland areas. (These are not wetland plants)

Types of Wetland Plants

Phytoplankton is microscopic algae and chlorophyll containing bacteria that live on or near the surface of the water. It is phytoplankton that produces the majority of the world's oxygen and are the basis for any aquatic food chain. If nutrient levels in the water are low, phytoplankton grows at a normal rate and the water remains clear and sunlight can penetrate the water and support submergent plant growth. If there are too many nutrients in the water, algal blooms can form covering the surface with a green film that cuts off sunlight to the submergent plants.

Herbaceous plants are non-woody plants and can be categorized by their location in the water:

Emergent plants are erect plants that are rooted in the sediment, but their flowers, fruit, leaves, and stems are above the water. Some common freshwater emergent plants are arrowhead, cattail, giant reed, rushes, and wool grass. Common saltwater emergents include *Spartina*, and black-needle rush.

Floating plants my be either free-floating or rooted in the soil. Their leaves, flowers, and fruit float just above the surface of the water. Some common floating plants include duckweed and the water lily

Submergent plants grow completely under the water's surface. Submergent plants need water that is clear enough for light to penetrate for photosynthesis. [The euphotic zone is the depth to which light for photosynthesis can reach.]Eelgrass, wild celery and coontail are common submergent plants.

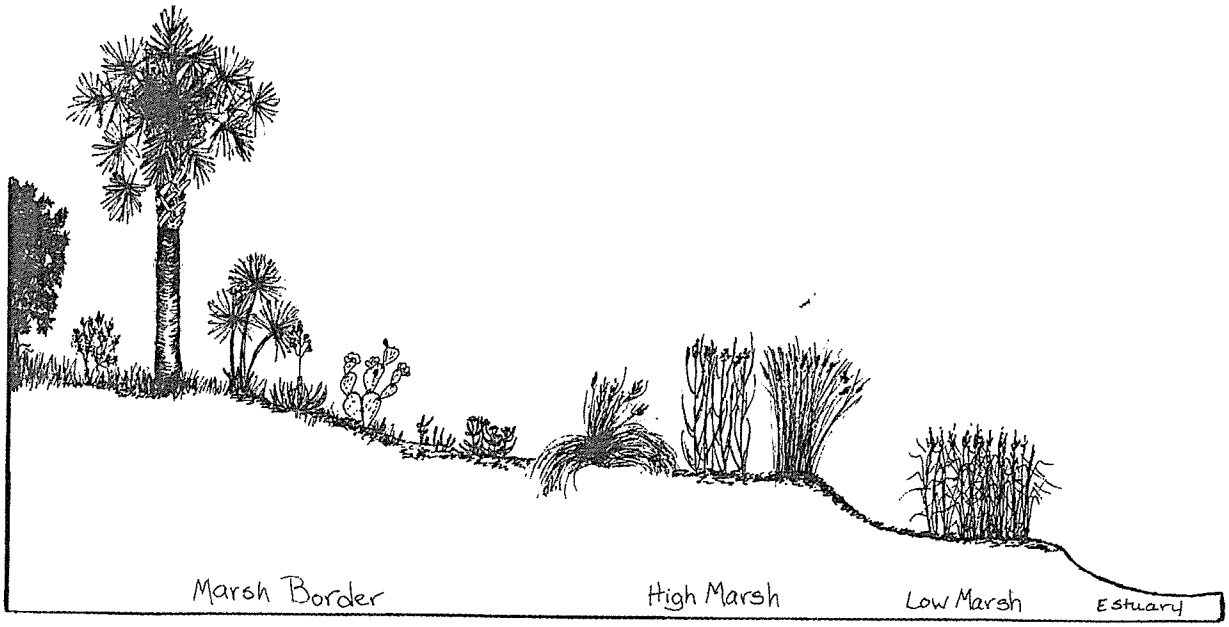
Shrubs are low, woody plants that are less than 20 feet high and have permanent stems instead of a single trunk. Tree saplings or young trees are also considered shrubs.

Trees are woody perennial plants that have one main stem or trunk that develops many branches. Most trees are over 20 feet tall. Many wetland trees have unusual adaptations for coping with low oxygen levels.

Vines are woody or herbaceous plants that climb or twine around the stems of other plants.

Some Common Plants of Coastal Salt Marshes

Common Name	Scientific Name	Position in Marsh
Smooth Cordgrass	*Spartina alterniflora*	low marsh
Salt Marsh Hay	*Spartina patens*	high marsh & marsh border
Black Needle Rush	*Juncus roemerianus*	high marsh & marsh border
Salt Grass	*Distichlis spicata*	high marsh & marsh border
Sea Oxeye Daisy	*Borrichia frutesens*	high marsh & marsh border
Glasswort	*Salicornia europpaca*	high marsh
Saltwort	*Batis maritima*	high marsh
Bayberry (Wax Myrtle)	*Myrica cerifera*	marsh border and hammocks
Yaupon Holly	*Ilex vomitoria*	marsh border and hammocks
Red Cedar	*Juniperus virginiana*	marsh border and hammocks
Cabbage Palmetto	*Sabal palmetto*	marsh border and hammocks
Saw Palmetto	*Serenoa repens*	marsh border and hammocks
Prickly Pear	*Opuntia compressa*	marsh border and hammocks
Spanish Bayonet orYucca	*Yucca aloifolia,Y.gloriosa, Y. filamentosa*	marsh border and hammocks
Various vines Catbrier Muscadine Grape Virginia Creeper Pepper-vine Morning Glory	 *Smilax sp.* *Vitis rotundifolia* *Parthenocissus quinquefolia* *Ampelopsis arborea* *Impomoea stolonifera*	hammocks

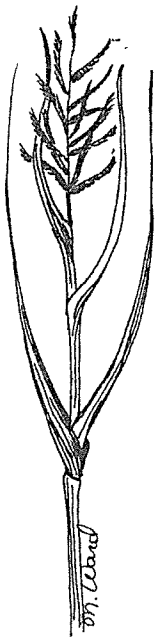


See Wetland Plant Identification Guides

Some Common Plants of Brackish Marshes

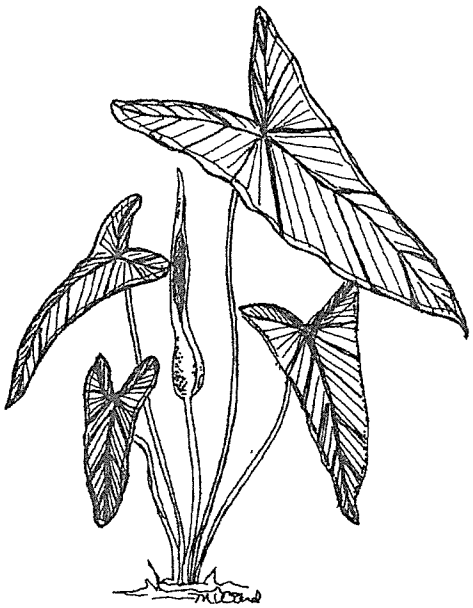
Note: Brackish marshes often contain the same plants listed as salt marsh plants in addition to those listed below.

Common Name	Scientific Name
Big Cordgrass	*Spartina cynosuroides*
Switchgrass or Panic grass	*Panicum virgatum*
Sawgrass	*Cladium jamaicense*
Common Reed	*Phragmites australis*
Salt Marsh Bulrush	*Scirpus robustus*
Spike Rushes	*Eleocharis parvula, E. cellulosa and E. tuberculosa*
Knotgrasses	*Paspalum distichum and P. vaginatum*



Big Cordgrass

Some Common Plants of Freshwater Marshes



Arrow Arum

Common Name	Scientific Name
Soft-stem Bulrush	*Scirpus validus*
Bristlebract Sedge	*Carex tubuloides*
Fox Sedge	*Carex vulpinoikea*
Soft Rush	*Juncus effusus*
Broad-leaved Cattail	*Typha latifolia*
Narrow-leaved Cattail	*Typha angustifolia*
Bulltongue Arrowhead	*Sagittaria lancifolia*
Big-leaved Arrowhead	*Sagittaria latifolia*
Arrow Arum	*Peltandra virginica*
Burreeds	*Sparganium eurycarpum*
Wild Rice	*Zizania aquatica*
Water Millet	*Echinochloa Walteri*
Marsh Purslane	*Ludwigia palustris*

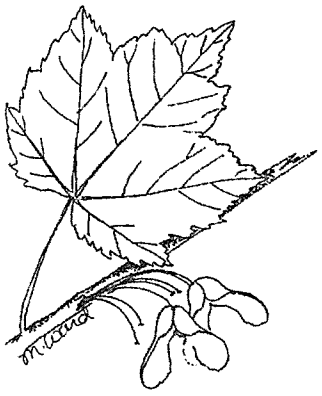
Some Common Plants of Wet Meadows

Common Name	Scientific Name
Woolgrass	*Scirpus cyperinus*
Purple Loosetrife	*Lythrum salicaria*
Soft rush	*Juncus effusus*
Sensitive Fern	*Onoclea sensibilis*
Small White Aster	*Aster vimineus*
Newyork Ironwood	*Veronia noveboracensis*
Southern Blue Flag	*Iris virginica*

Small White Aster

Some Common Plants of Forested Wetlands

Common Name	Scientific Name	Common Name	Scientific Name
Red Maple	*Acer rubrum*	Swamp magnolia	*Magnolia virginiana*
Black Willow	*Salix nigra*	Spice bush	*Lindera benzoin*
Green Ash	*Frazinus pennsylvanica*	Swamp azalea	*Rhododendron viscosum*
Loblolly Pine	*Pinus taeda*	Highbush blueberry	*Vaccinium corymbosum*
Eastern Red Cedar	*Juniperus virginiana*	Cinnamon fern	*Osmunda cinnamomea*
Atlantic White Cedar	*Chamaecyparis thyoides*	Royal fern	*Osmunda regalis*
Overcup Oak	*Quercus lyrata*	Slender spikegrass	*Chasmanthium lazum*
Water Hickory	*Carya aquatica*	Virginia creeper	*Parthenocissus quinquefolia*
Silky Dogwood	*Cornus amomum*		



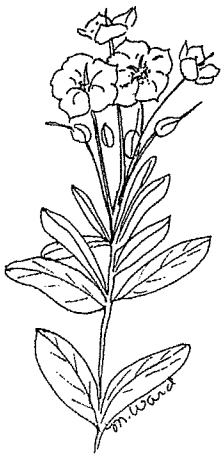
Red Maple

Swamp magnolia

Some Common Bog Plants

Northern Pitcher

Common Name	Scientific Name
Sphagnum Moss	*Sphagnum spp.*
Hooded Pitcher Plant	*Sarracenia minor*
Northern Pitcher	*Sarraceria purpurea*
Round-leaved Sundew	*Drosera rotundifolia*
Highbush Blueberry	*Vaccinium corymbosum*
Leatherleaf	*Chamaedaphne calyculata*
Swamp Azalea	*Rhododendron viscosum*
Bog Laurel	*Kalmia polifolia*

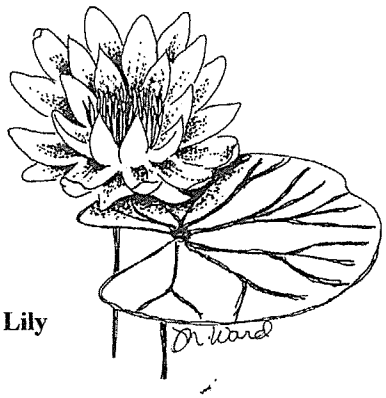


Bog Laurel

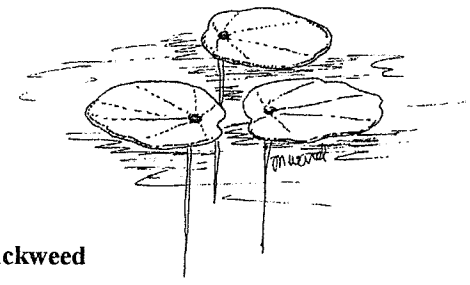
Swamp Azalea

Some Common Plants of Shallow Freshwater Ponds and Seeps

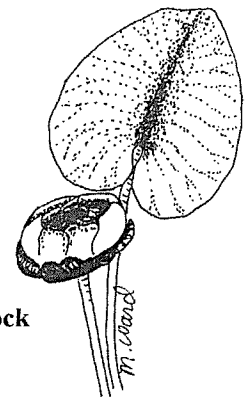
Common Name	Scientific Name
Duckweed	*Lemna spp.*
Mosquito fern	*Azolla caroliniana*
Spatterdock	*Nuphar spp.*
Water-lilies	*Nymphaea spp.*
Pondweeds	*Potamogeton spp.*
Hornworts	*Ceratophhyllum*



Water Lily



Duckweed

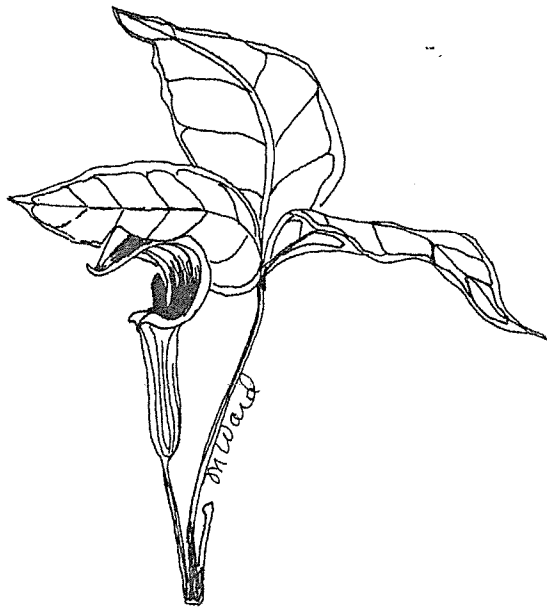


Spatterdock

See Wetland Plant Identification Guides

Some Common Plants of Shrub/Scrub Swamps

Common Name	Scientific Name
Swamp Willow	*Salix caroliniana*
American Holly	*Ilex opaca*
Yaupon Holly	*Illex vomitoria*
Buttonbush	*Cephalantus occidentalis*
Silky Dogwood	*Cornus amomum*
Sweet Pepperbush	*Clethra alnifolia*
Speckled Alder	*Alnus rugosa*
Swamp Rose	*Rosa palustris*
Skunk Cabbage	*Symplocarpus*
Marsh Marigold	*Caltha palustris*
Jewelweed	*Impatiens capensis*
Marsh Fern	*Thelypteris thelypteroides*
Sensitive Fern	*Onoclea sensibilis*
Loosestrife	*Lysimachia quadrifolia*
Jack-in-the-pulpit	*Arisaema triphyllum*



Jack-in-the-pulpit

Some Common Trees of the Swamp

Ironwood

Common Name	Scientific Name
Water Oak	*Quercus nigra*
Laural Oak	*Quercus laurifolia*
Willow Oak	*Quercus phellos*
Green Ash	*Fraxinus pennsylvanica*
Sweet Gum	*Liquidambar styraciflua*
Bald Cypress	*Taxodium distichum*
Ironwood	*Carpinus caroliniana*
Water Tupelo	*Nyssa aquatica*

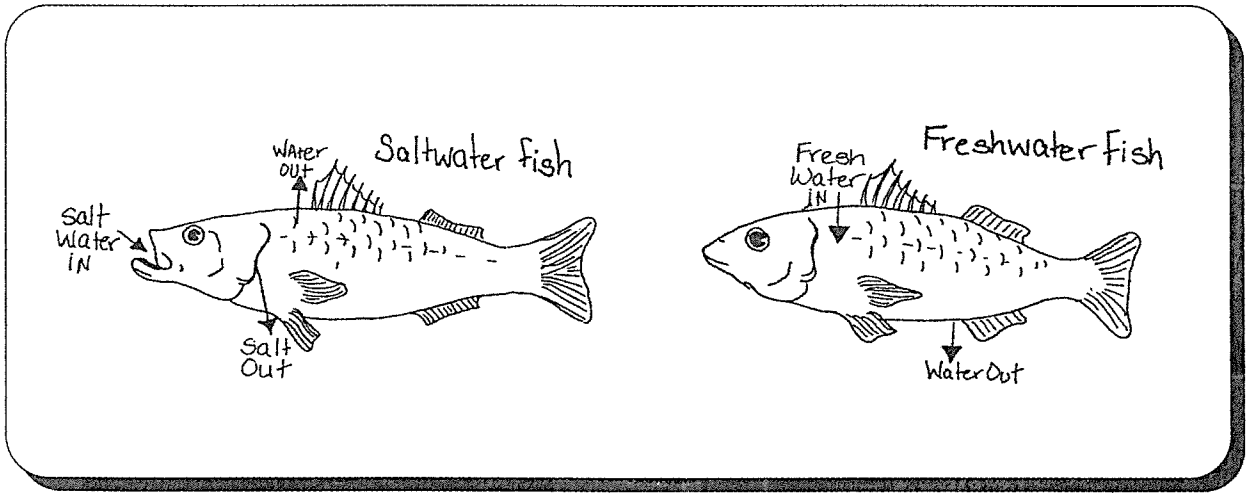
Adaptations of Wetland Animals

The adaptations of animals for life in the wetlands is as varied as the number of species that live there. Through natural selection (survival of the fittest), animals develop special genes and traits that help them survive in the water environment of wetlands. These specially adaptive genes are passed on to their young and again to their young and so on. Some animals become so well adapted to wetland life that they never leave and cannot survive anywhere else. Many of our endangered species (about 30%) are dependent on wetlands for survival.

Some animals spend their entire life in water. Others are aquatic only in some of their life stages. Some animals only visit wetlands to feed and raise their young. Animals are more mobile than plants and protists, and their adaptations to wetland conditions are more complex. Animals have developed biochemical, physiological and behavioral strategies for coping with the obstacles of living in wetlands. Some of these include strategies for coping with low oxygen levels; for maintaining osmotic balance; for successful reproductive strategies; for dispersal and migration, and, responses to environmental changes. Other adaptations include camouflage and various body structures that enable them to live in a wetland environment.

Adaptations to low oxygen levels: Many wetland species have gills that are used to bring oxygen into and carbon dioxide out of the body. They have powerful hearts or super-efficient circulatory systems and make efficient use of oxygen-binding compounds. Some species can slow down body processes and reduce the need for oxygen during periods of low oxygen. For example, fiddler crabs remain inactive in their burrow during high tide and consume little oxygen.

Adaptations for maintaining osmotic balance: During osmosis, water passes from areas of high concentrations to low concentrations of materials. Some animals have external impervious shells or skin that help regulate their internal environment. Fish in saltwater wetlands drink a lot of water to keep from drying out. Water continually flows out of a saltwater fish's body due to the natural tendency of water to flow towards saltier water. Therefore, saltwater fish continually drink water and hardly ever urinate. Any extra salt that they drink in is excreted through their gills. Fish living in freshwater wetlands have more salt inside their bodies than outside, and fresh



water continually moves into their body through osmosis. Freshwater fish never drink water and urinate often to keep the water balance inside their bodies so they do not swell up like a balloon.

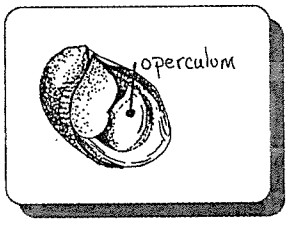
Adaptations for successful reproduction strategies: Some animals have adapted their life cycles so that they can take advantage of conditions favorable to reproduction. The eggs of some wetland animals can remain dormant until conditions are favorable for their development. Some animals have adapted their life cycles so that their eggs will hatch at times when the conditions they need for survival, such as temperature and the availability of food, are favorable. Frogs lay eggs in jelly-like masses that float among the stems and leaves in the shallow water of wetlands. Some wetland animals reproduce asexually and take advantage of favorable environmental conditions to quickly reproduce.

Adaptive methods of dispersal and migration: Many wetland animals move regularly in response to environmental conditions. Insects fly to new homes. Frogs hop from pond to pond. Fish travel in ocean and stream currents. Birds migrate to different areas; South in the winter and North in the summer. Organisms that are immobile use animal hosts, currents, or winds to disperse themselves.

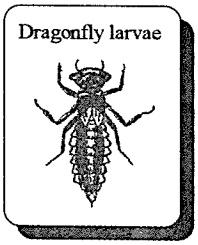
Adaptive responses to environmental change: Many wetland amphibians and reptiles hibernate or burrow in the winter when temperatures are cold and food is less abundant. Even some fish like bass and catfish will bury themselves in the muddy bottom under dead leaves in shallow water for winter. Cold blooded reptiles are often seen basking in the sun to warm up their body temperatures. Some wetland animals can slow their metabolism during periods of drought. This process is known as aestivation. Other animals have adapted their life styles to adjust to the daily changes and fluctuations in their environment. Fiddler crabs burrow during high tide, barnacles and oysters close their shells during low tide, and periwinkle snails climb the stems of Spartina when the tide comes in.

Camouflage and body structures: Many wetland animals have excellent camouflage and their color or shape helps them to blend in with their environment. The webbed feet of beavers, ducks, and muskrats help them to swim. The long toes of wading birds enable them to walk on soft ground. Birds have water proof feathers. Wetland mammals have thick layers of fat and dense fur for insulation and special oil glands to waterproof their fur. Birds use their songs to mark their territory, and the dull color of the female helps her blend in with the environment.

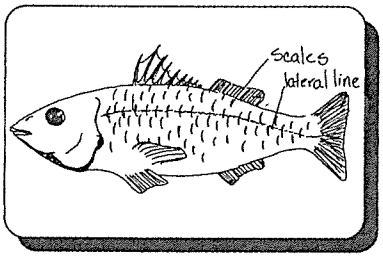
The following are examples of some of the ways that animals have adapted to living in and around wetlands:



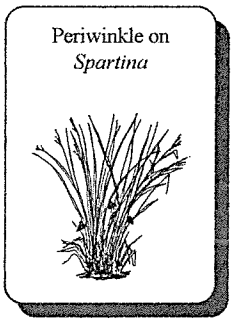
1. Crustaceans, like shrimp, crayfish, crabs, etc., have an exoskeleton for protection, muscle attachment, and to prevent them from drying out.
2. Snails (both fresh and salt) have an operculum, or "trap door", that protects them from drying out by closing when they are out of the water.
3. The greendarter dragonfly larvae has a scoop that it can extend to capture food.
4. True bugs and flies have mouthparts adapted for piercing and sucking.



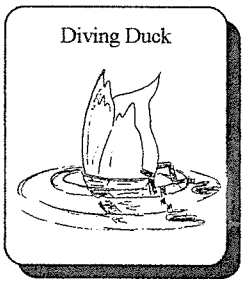
5. Some stream caddisflies build nets that they use to capture food drifting in the water.
6. Clams have a shell for protection and two openings called siphons for taking in water (for food and oxygen) and for the elimination of wastes.



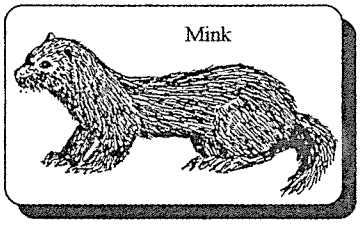
7. Fish have streamlined bodies covered with scales. Their bodies are covered with a mucus to protect them from disease. Their countershading (dark on top and light on the bottom) helps them to blend in with their environment. The lateral line which is a line of special scales down the side of their bodies help them to sense movement in the water. The placement and number of fins determines how they swim and maneuver and their mouth position determines what they eat.
8. Most amphibians must live in damp areas because their bodies must stay moist, and they lay their eggs in water.
9. The hind legs of frogs and toads are adapted for hopping or jumping as well as swimming.
10. Reptiles are protected from drying out and from predators by scales or horny plates. Their eggs have a hard outer shell.
11. Turtles have sharp bony jaw (no teeth) for crushing their prey. Their feet are webbed for swimming. While underwater, they can breathe through openings in their skin called "cloaca". The cloaca is a lining of sensitive tissue that acts like a gill and filters oxygen out of the muddy water.
12. Alligators have eyes on the top of their heads so they can keep their bodies submerged and still see above the water. They also dig deep holes called care dens or "gator wallows" where they raise their young. These also serve as a source of freshwater during periods of drought.



13. The periwinkle snail climbs up and down the stems of Spartina twice a day to escape the rising water of high tides.
14. Fiddler crabs burrow into the mud and plug up their holes when the tide comes in.
15. Some small fish and other marine life forms burrow beneath the mud.
16. Frogs breathe through their skin.
17. Salamanders lay their eggs on the bottom of ponds and hang them under logs and roots in the water. Some have no gills but breathe through their skin.



18. Diving ducks have heavy bones and webbed feet set back on their bodies. They can empty their air sacs and push all the air from their feathers so they can sink.
19. Beavers have a layer over their eyes for seeing under water. They also have waterproof fur, webbed feet, and valved nostrils. Their lips close behind their teeth so they can eat without drowning. They also have a grasping toe similar to a thumb for grasping and holding food.
20. The River Otter has a sleek shape, webbed feet, and muscles that flex up and down for speed while swimming.
21. The mink has a long thin body and webbed feet. It releases musk like a skunk.

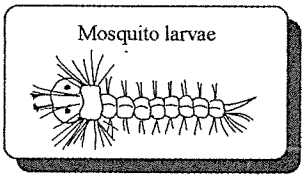


22. The green frog has long kicking legs and webbed feet. It lays its eggs in a jelly-covered mass that floats among the plant stems of shallow

marshes and ponds. The green frog also has eyes on the top of its head so it can see while keeping the rest of its body under water.

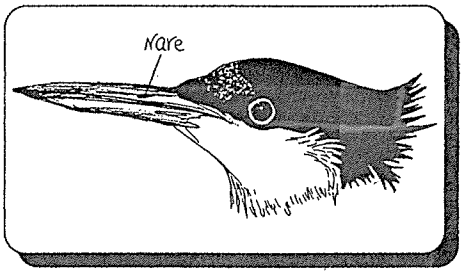
23. The spiny softshell turtle has a long neck so it can keep its nostrils above water while it lays on the bottom in shallow water.
24. The opossum has an opposable thumb for clasping branches, and a tail that can curl around branches.
25. Fawns of the white-tailed deer are odorless and have speckled coats that blend in with the sunspecks on the forest floor.
26. Wood ducks have narrow wings that allow them to maneuver at high speeds and claws on their webbed feet that allow them to perch on branches.
27. Tree Frogs have enlarged, sticky toe pads that glue them to leaves. The tips of their toes are jointed to hook around twigs. Their bodies are flattened for better weight distribution and their skin is the color of leaves and bark.
28. The marsh rice rat has water repellent fur, can swim under water and reproduce rapidly.
29. The swamp rabbit can float in the water with its nose just above the water, and it also can swim.
30. The five-lined skink can break its tail off.
31. The Diamondback Terrapin has strong jaws for grinding up snails and clams.

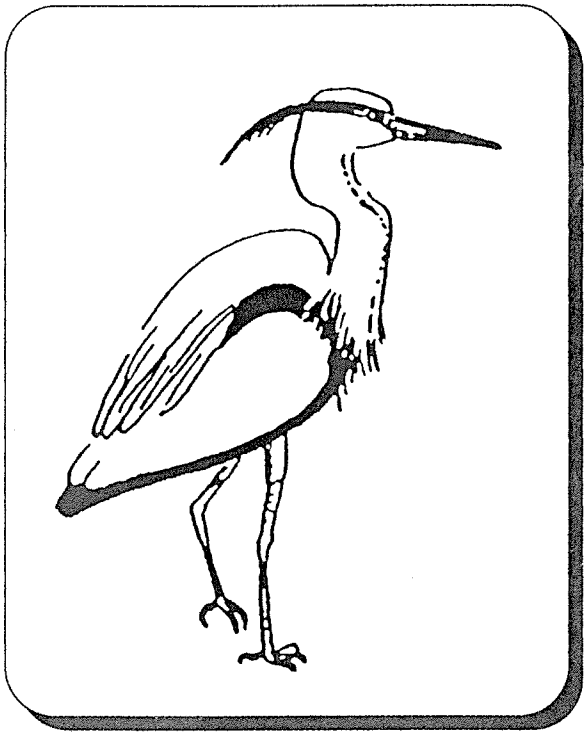
32. Raccoons have good night vision and hand-like paws.
33. Kingfishers have oversized heads and necks to absorb the shock of plunging into the water after fish. They also have spearlike bills to grip slippery prey.
34. Hawks have tufts of feathers around their faces that direct sound to their ears. Their eyes have special visual receptor cells that make their eyesight five times better than humans.
35. Barred owls have large wing spans and their feathers have frayed edges for silent flight. They have huge eyeballs and oversized pupils that enable them to see well at night. Their eyes are close together and on the front of their face which gives them three dimensional and binocular vision. They also have large ear openings on the side of their heads for better hearing.
36. Water spiders keep afloat with oarlike legs.
37. Mosquito larvae can pierce the air pores of plants to obtain oxygen. They also lay about 300 cone-shaped eggs that they stick together in an unsinkable raft. Each egg has an opening in the bottom so the larvae can hatch straight into the water.



38. The shell of the nine-banded armadillo is made of shell-like plates and thick hide. It can arch its back and jump straight into the air when alarmed. Armadillo are not the pests we think them to be. In fact, when an armadillo dies the entire ecosystem suffers. Many animals use their burrows for homes. They help in controlling insects and can lap up 60 to 70 insects with one swipe of their tongue. They are the only N. American mammals other than humans that can contract leprosy and are currently being used in research.

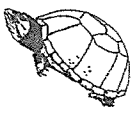
39. The various colorations of birds provide them with camouflage. Birds also have nares which are special nasal glands for excreting excess salt. Sometimes when we see birds shaking their heads, they are getting rid or this excreted salt.





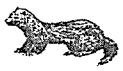
40. Egrets and herons have long flexible necks and strong, sharp beaks for spearing fish and frogs. Their long, thin legs, and their long, skinny, slightly webbed toes enable them to walk easily through the water and mud flats. They can also stand very still for long periods of time waiting on their prey.
41. Some water beetles and bugs carry air bubbles with them for air.
42. The fishing spider dangles the tip of one leg in the water to attract small fish.
43. Some wetland insects have special appendages that allow them to walk on the surface film of the water.

Some Common Animals of Wetland Habitats

Type of Animal	Common Name	Bogs	Cypress Swamps	Shrub Swamps	Bottomland Hardwood Swamp	Rivers & Streams	Lakes & Ponds	Fresh H_2O Marsh	Salt Marsh
Amphibians	Bullfrog		X		X	X	X		
	Carpenter Frog	X					X		
	Dwarf Salamander						X		
	Dwarf Siren				X				
	Eastern Newt						X		
	Greater Siren				X				
	Green Frog		X	X			X		
	Lesser Siren		X	X	X				
	Mud Salamander		X	X	X	X			
	River Frog		X	X	X	X			
	Southern Cricket Frog		X	X		X	X	X	
	Spring Pepper		X	X	X			X	
	Tiger Salamander					X	X		
	Two-lined Salamander		X	X	X	X			
Reptiles	American Alligator		X		X				
	Black Swamp Snake		X	X	X				
	Brown Water Snake		X	X	X	X			
	Brown Snake	X		X				X	
	Cottonmouth		X	X	X	X	X		
	Eastern Mud Turtle					X			
	Eastern Ribbon Snake	X						X	
	Glossy Crayfish Snake		X	X	X	X	X		
	Green Water Snake		X	X	X			X	
	Mud Snake		X	X	X				
	Mud Turtle					X			
	Pine Woods Snake							X	
	Redbelly Snake	X							
	Slider		X	X	X	X	X		
	Snapping Turtle		X				X		
	Southern Water Snake		X	X	X		X		
	Spiny Softshell Turtle					X	X		
	Stinkpot Turtle					X	X		
	Timber Rattle Snake		X	X	X				

See Identification Guides for pictures of some of these animals

Some Common Animals of Wetland Habitats

Type of Animal	Common Name	Bogs	Cypress Swamps	Shrub Swamps	Bottomland Hardwood Swamp	Rivers & Streams	Lakes & Ponds	Fresh H_2O Marsh	Salt Marsh
Mammals	Marsh Rat								X
	Mink				X				X
	Muskrat								X
	Beaver				X	X	X		
	River Otter				X	X	X		
	Bobcat		X	X	X				
	Cotton Mouse		X	X	X				
	Golden Mouse		X	X	X				
	Raccoon		X	X	X				
	White-tailed Deer	X	X	X	X				
Birds	American Bittern							X	
	American Coot						X	X	X
	American Wigeon							X	
	Bald Eagle				X	X	X	X	X
	Barred Owl		X	X	X				X
	Belted Kingfisher					X	X	X	X
	Bufflehead	X					X		X
	Black-crowned Night Herron		X	X	X	X		X	X
	Canada Goose					X	X	X	X
	Clapper Rail								X
	Common Goldeneye							X	
	Common Loon					X	X		X
	Common Moorhen							X	
	Common Tern						X		X
	Double-crested Cormorant			X	X	X	X		X
	Eastern Phoebe					X			
	Great Blue Heron		X			X	X	X	X
	Great Egret							X	X
	Green-backed Heron		X			X	X	X	X
	Green Winged Teal						X	X	X
	Herring Gull					X	X		X
	Hooded Merganser				X	X	X		X

See Identification Guides for pictures of some of these animals

Some Common Animals of Wetland Habitats

Type of Animal	Common Name	Bogs	Cypress Swamps	Shrub Swamps	Bottomland Hardwood Swamp	Rivers & Streams	Lakes & Ponds	Fresh H_2O Marsh	Salt Marsh
Birds (Cont.)	Laughing Gull								X
	Least Sandpiper						X		
	Lesser Scaup				X	X		X	X
	Limpkin	X					X	X	X
	Little Blue Heron	X	X	X				X	X
	Mallard					X	X	X	
	Marsh Wren						X	X	
	Northern Pintail						X	X	
	Northern Shoveler						X	X	
	Pied-billed Grebe						X		
	Purple Gallinule						X	X	
	Osprey			X	X	X		X	
	Pileated Woodpecker	X						X	
	Ring-billed Gull				X	X		X	
	Ring-neck Duck				X	X		X	
	Prothonotary Warbler		X	X					
	Red-bellied Woodpecker	X	X	X					
	Red-shouldered Hawk	X	X					X	
	Red-winged Blackbird			X			X	X	
	Redhead Duck						X	X	
	Rudy Duck						X		
	Snowy Egret						X	X	
	Swamp Sparrow		X				X		
	White Ibis							X	
	Wild Turkey			X					
	Wood Duck	X	X	X				X	
	Wood Stork	X						X	
	Yellow-crowned Night Heron	X	X	X				X	

See Identification Guides for pictures of some of these animals

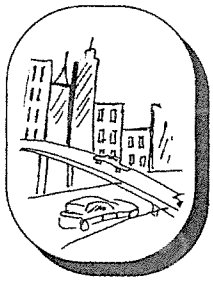
Major Threats to Wetlands

Nature poses some natural threats to wetlands such as soil erosion, droughts, hurricanes and other storms, sea level rise, and wildlife over population and use. But these threats are minimal compared to the threats created by man. The major threat to coastal wetland loss in Georgia is the result of unrestrained and unplanned economic development.

Natural Threats to Wetlands
soil erosion
droughts
hurricanes and other storms
sea level rise
subsidence
wildlife over population and use

Major Wetland Threats by Humans
Urbanization and development
Hydrologic alteration
Marinas and Boats
Industry and industrial development
Agriculture
Timber Harvesting
Mining
Atmospheric deposition

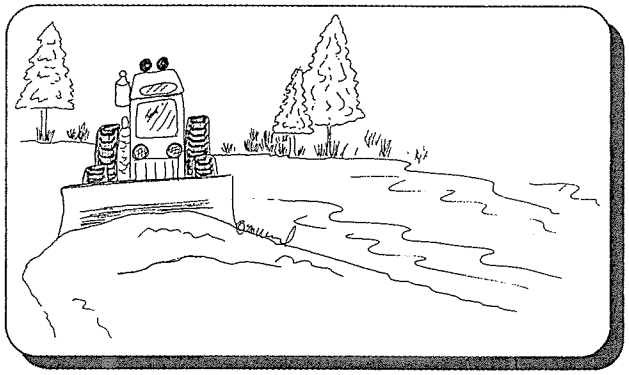
Urbanization and development: Urbanization and development is the major cause of wetland losses in the United States and in Georgia. Wetlands have been filled and dredged to make way for airports, commercial buildings, highways, houses, ports, and waste disposal sites. This loss of wetlands has led to changes in water quality, quantity and flow rates; increases in non-point source pollutants; and changes in species composition. The major nonpoint source pollutants associated with urbanization include sediment, nutrients, road salts, heavy metals, petroleum products, and organic chemicals.



Surfaces such as buildings, roads, and parking lots are impervious and do not allow water to percolate into the soil. Rainwater runs off of these surfaces and may cause flooding and carries sediments, organic matter, pet wastes, pesticides, fertilizers, heavy metals oil, road salts, and trash into streams and rivers.

Leachate from solid waste landfills are toxic to plants and animals and often reach our groundwater supplies which eventually flow into wetlands.

Mosquito control efforts in urbanized and resort communities has resulted in wetland loss through drainage, channelization, and use of toxic pesticides.



Hydrologic alteration: Man has caused wetland loss and degradation through hydrologic alteration by drainage, dredging, stream channelization, ditching, levees, deposition of fill material, stream diversion, ground water removal, and impoundment.

Sources of Non-point Source Pollution

Bacteria and viruses are found in rainwater runoff from streets and agricultural lands as well as sewage and septic tank effluents.

Heavy metals such as arsenic, cadmium, chromium, copper, lead, mercury, and zinc come form industrial emissions, incinerators, exhaust from cars and other vehicles, and landfills. They may enter the wetlands through rain water or they may be leached directly into the groundwater. Heavy metals may cause cancers, deformities and death to aquatic organisms.

Nutrients are important to all animals and plants. But too many nutrients like nitrogen and phosphorus in the water may cause algal blooms that block sunlight and pollute the water.

Organic chemicals like industrial and household cleaners, pesticides, and solvents are carried by rain water from commercial areas and farms to major water systems.

Petroleum products like gasoline, grease, and oil are carried by runoff water from commercial areas, parking lots, and streets to our water supplies.

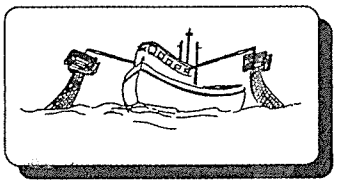
Sediments such as clay, sand, silt, plant material, and microscopic plankton become suspended in moving water and cause the water to become turbid or cloudy. Excessive turbidity blocks the sunlight from aquatic

Any alteration that reduces or increases the amount of water in a wetland can change the soil chemistry and the plant and animal communities. Removal of water and other resources from under wetlands, channelization, and drainage of wetlands for development can cause subsidence. Land subsidence may lead to sea level rise or saltwater intrusion. Any modification of wetland habitats will threaten the billion dollar fishing and trapping industries as well as cause destruction of valuable coastal properties. Habitat fragmentation which often results from wetlands being drained and altered will most likely lead to changes in the types of plant and animal species present in the wetland.

Various water diversion structures, such as channels, ditches, and levees have been built to modify wetlands in an attempt to control flood waters, drain land, control mosquitoes, harvest timber, for industrial practices, irrigation, navigation, and transportation. These practices increase the speed at which water moves into and through wetlands resulting in increased sedimentation rates. This sediment can smother aquatic vegetation, shellfish beds and tidal flats, and increase the turbidity of the water.

The building of impoundment lakes and ponds alter the wetlands' natural hydrology and decreases water circulation. This leads to increased water temperatures, lower oxygen supplies, and changes the salinity and pH of the water. Impoundments also prevent the outflow of nutrients and increase sedimentation which reduces the water storage capacity, smothers vegetation, and reduces the distance that light can penetrate. These affect the entire ecosystem's diversity and productivity. Toxic chemicals often cling to sediments and may accumulate in the lake waters. Impoundment of coastal wetlands reduces the exchange of tidal water in the salt marshes and may prevent fish from entering the marsh for part of their life cycle.

Marinas and Boats: The construction of marina and the dredging activities necessary to keep channels navigable contribute sediments into the waters next to wetlands. Wetlands can also be adversely affected by intense boating activity which increases turbidity and adds various pollutants and wastes that may lead to eutrophication.



Industry and Industrial development: The adverse effects of industry on wetlands may include reduction of wetland acreage, alteration of wetland hydrology due to industrial water intake and discharge, water temperature increased, point and nonpoint source pollution, pH changes in the water and atmospheric deposition. Some of the hydrocarbon discharges from industries that enter wetlands are toxic compounds and can cause abnormalities in fish. Oysters, crabs, and other shellfish absorbed these into their bodies, and although not toxic to the shellfish, these chemicals can be passed up the food chain.

Some of the worst Superfund sites are abandoned industrial waste sites. A Superfund site contains toxic, radioactive, or acidic compounds with high concentrations of metals. These contaminants can be extremely destructive to life in a wetland and they are very expensive to clean-up. Some radioactive wastes remain in the wetland soils for thousands of years.

Agriculture: Agriculture has resulted in major freshwater and marine wetland loss through harvesting food, fiber, or timber products; minor drainage; drainage ditches; construction and maintenance of farm or forest roads; maintenance of dams, dikes, and levees; direct and aerial application of pesticides; and ground water withdrawals. These activities can change the hydrology, water quality, and composition of wetland species. Runoff from agricultural operations can lead to eutrophication.

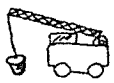
Runoff from irrigation ditching and urea and manure from farm animals contain dangerous chemicals that can accumulate in fish and other aquatic organisms. The economic losses attributed to the reduced quality and quantity of water and habitat from overgrazing of riparian wetlands is estimated at more than $200 million a year.

Timber Harvest: If careful harvesting procedures are used and because timber is only harvested every 20 to 50 years, the drainage, clearing, haul road construction, rutting, and ditching of forested wetlands may only cause temporary damage to wetlands. The adverse effects of timber harvesting can include a rise in the water table due to a decrease in transpiration; soil disturbance and compaction by heavy equipment; sedimentation and erosion from logging decks, skid trails, roads, and ditches; and drainage and altered hydrology from ditching, draining, and road construction.

Mining: Mining operations usually require clearing and draining wetlands. Roads have to be built to the mine site. Hydrologic alterations of wetlands by mining operations may include the introduction of high metal concentrations, and/or decreased pH. Acid drainage from active and abandoned mines can cause extensive ecological damage to wetlands.

Atmospheric Deposition: Nitrous oxides, sulfurous oxides, heavy metals, volatilized pesticides, hydrocarbons, radionuclides, and other organic and inorganic compounds are released into the atmosphere through agricultural and industrial activities, and from vehicles. These compounds can enter wetlands through atmospheric deposition and can adversely affect aquatic organisms and the terrestrial organisms that feed on them.






Pollution In Wetlands

For thousands of years, humans have lived along our Nation's wetlands and these areas have always been a convenient place to dispose of wastes. For many years, pollution was not a great problem because the water could dilute and wash away most of the wastes that were dumped into it. With the dramatic increase in human population along our coast and waterways , the quantity and quality of pollution has exceeded our natural ecosystem's ability to store and dispose of them.

Pollution, by definition, is the addition of substances into the environment that harm living things and damage water quality. The substances that have a harmful effect are **pollutants**. Pollution not only threatens the well-being of other living things but also endangers human health as well. Sources of pollution that can be traced to an identifiable single source are called **point source pollution** and include pollution from industrial sites, sewage treatment plants, hydroelectric plants, and factories. Although point source pollution can be devastating, it is usually localized and can be located and cleaned up fairly quickly. **Nonpoint source pollution,** or "people pollution," is another story. Nonpoint source pollution is the Nation's leading source of surface and groundwater pollution and cannot be traced to a specific point, but comes from many individual places.

The primary contributors to nonpoint source pollution include urban runoff, agriculture, silviculture (the care and cultivation of forest trees), stormwater, livestock wastes, and raw domestic wastes. It may also include such substances as sediment, bacteria, oil and oil-related chemicals, pesticides, heavy metals, and other toxic substances. Nonpoint source pollution increases during periods of heavy rainfall by washing sediment, chemicals and other pollutants from fields, towns and cities into wetland areas.

Wetlands can help prevent nonpoint source pollution from degrading our water quality. Wetland plants help to reduce the effects of nonpoint pollution by slowing the flow of runoff and filtering and storing pollutants.

YOU CAN HELP REDUCE NONPOINT SOURCE POLLUTION

- Be aware that many chemicals commonly used around your home are toxic. Use less toxic or non-toxic substitutes wherever possible.
- More is not better! Buy chemicals only in the amount you expect to use, and apply them as directed.
- Do not pour unwanted household chemicals down the drain. Take them to hazardous waste collection centers.
- Never pour unwanted chemicals on the ground, as they may contaminate our groundwater.
- Use low-phosphate or phosphate-free detergents.
- Cultivate plants that discourage pests. Reduce the use of pesticides and herbicides.
- Inspect your septic system annually.
- Clean up after your pets. Their wastes contain harmful pathogens that can contaminate groundwater.
- Tune up your car regularly and take used automotive fluids to collection centers.
- Avoid or reduce the use of garbage disposals; they add unnecessary solids to sewage systems.

POINT SOURCE VS NONPOINT SOURCE POLLUTION

DIRECTIONS:

Label each drawing below as point source (P) or nonpoint source (N) pollution.

What Can You Do To Protect The Wetlands?

The fact that Georgia has made great strides in wetland protection is evident in the fact that Georgia is fifth in the nation in wetland conservation and third in the Southeast in wetland acreage. But, despite the efforts of individuals such as yourself, government agencies, and private conservation organizations, wetlands are still disappearing and degrading at an alarming rate. Wetlands provide thousands of jobs and puts millions of dollars into our local economy each year. Each of us, in one way or another, depend on and enjoy wetlands. It is the responsibility of each of us to take positive steps to protect wetlands to ensure that the values they provide will be our preserved for future generations.

What we all should do:

- First and foremost, we should all educate ourselves about the importance and value of wetlands and share our knowledge with others. Only through education will we be able to make the proper decisions and vote properly on legislation concerning wetlands.
- Stay abreast of wetland issues in your community and attend permit and important land use hearings.
- Get involved in federal and state permitting processes. State and Federal agencies publish regulation guidelines and public input is an integral part of their policy making.
- Write to your Mayor, Governor, and Congressmen asking for their support in the preservation of our wetlands. Every letter counts. Elected officials assume that for every letter they receive there are 100 other citizens that feel the same way. Letters should be positive and informative. You should state your concern, give at least three facts to support your concern, and give possible solutions.
- Participate in the Section 404 permit review process by reading and commenting on permit applications.
- Establish a local "wetlands watch" program and monitor development activities in wetlands in your neighborhood and report any violations.
- Support legislation that supports effective wetland conservation .
- Participate on watershed planning committees or in programs intended to protect the entire watershed.
- Join public and private conservation organizations.
- Ask for local and statewide education programs to make students and all citizens aware of wetlands' values.
- Encourage the building of boardwalks over fragile dunes and other wetland areas.
- Promote and support wetland nature centers and sanctuaries.

As a landowner, you can:

- Create and maintain vegetative buffer zones between lakes, creeks, streams, rivers, and marshes and the surrounding landscape.
- Rather than draining or filling wetlands, seek compatible uses that involve minimal alternation, such as waterfowl production, fur harvest, hay or forage, wild rice production, hunting and trapping leases, and selective timber harvest.

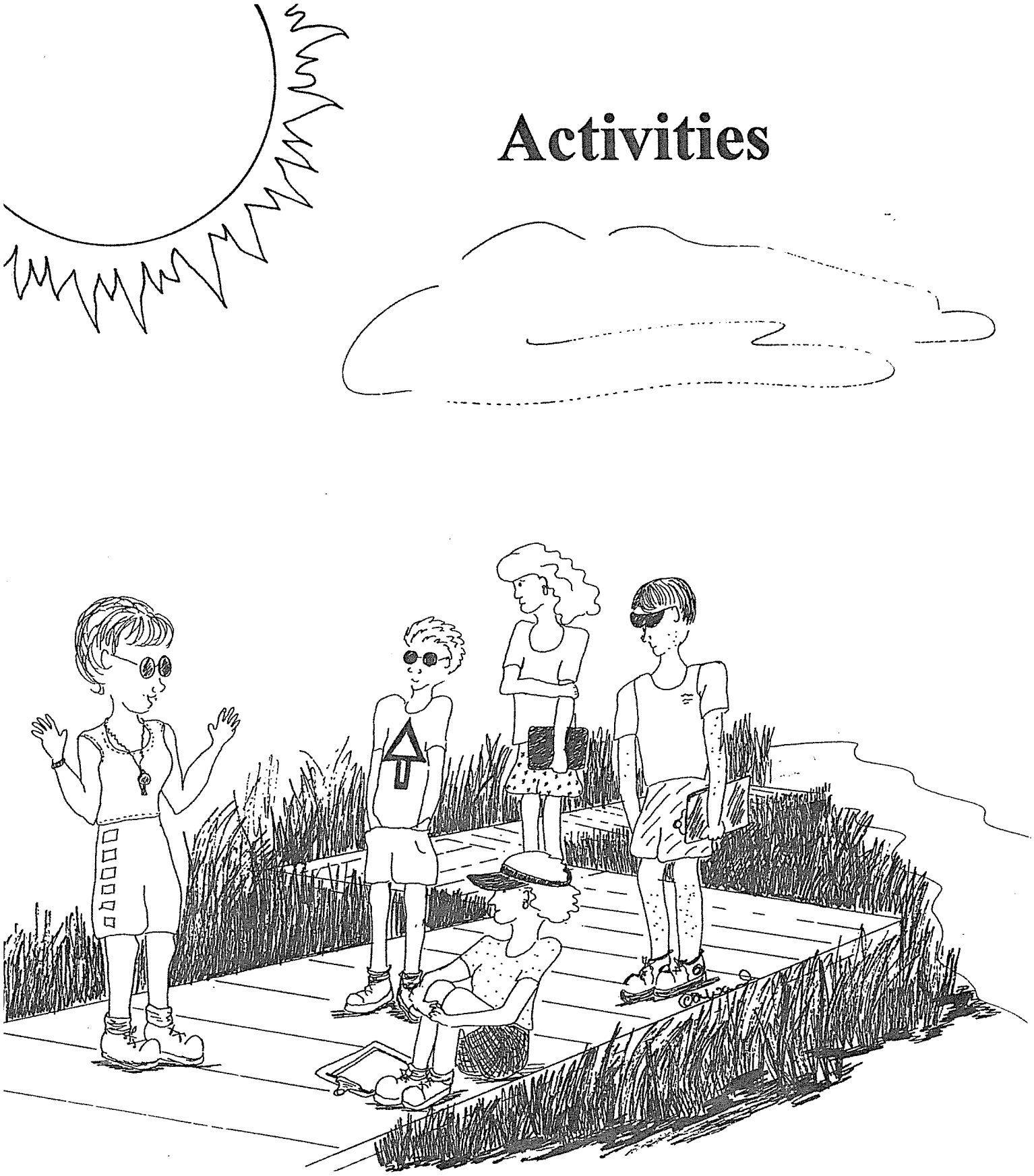
- Avoid wetland areas when undertaking construction projects.
- Donate wetlands, or funds for purchasing wetlands, to private or public conservation agencies.
- Maintain wetlands and adjacent buffer strips as open spaces.
- Construct ponds in uplands rather than in wetlands.
- Support wetland conservation initiatives by public agencies and private organizations.
- Participate in the Clean Water Act Section 404 program by reviewing public notices.

As a student, you can:

- Start a wetland education and stewardship program in your school.
- Write letters about wetlands and their values and submit them to local newspapers.
- Construct "Wetland Crossing" signs to increase public awareness of wetlands in your community
- Create public awareness fact sheets about wetlands and distribute them around your school and neighborhood.
- Start a "Wetland Watch" patrol in your school.
- Participate in or organize a beach and/or wetland clean-up.
- Encourage your parents and friends to help reduce nonpoint source pollution by using alternatives to pesticides and fertilizers, composting solid wastes, drive less and keep cars tuned properly, recycle used automotive fluids.

- Plant bare areas around your school and home with vegetation.
- Pick up after pets and dispose of wastes in the toilet.
- Wash dishes in a dishpan rather than running water or a dishwasher.
- Wash cars on the grass and use non-phosphate detergents or at commercial car washes that recycle water.
- Take showers instead of baths.
- Don't litter.
- Recycle.
- Start an "Adopt-A-Wetland" program in your school.

Activities



BUILD A WETLAND MODEL

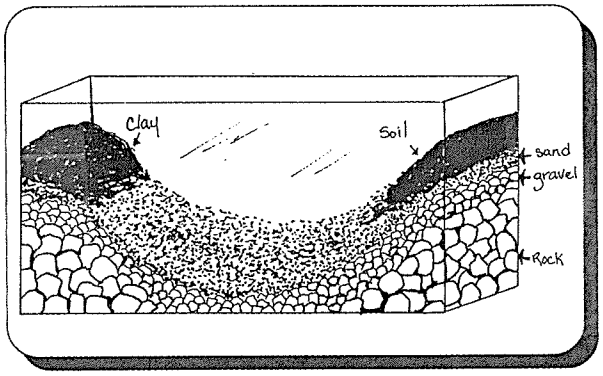
PURPOSE: To investigate wetland functions within a watershed.

MATERIALS:

small aquarium or plastic container
several rocks (the size of oranges)
cotton swabs (painted brown)
What Is A Wetland? Fact Sheet
paper towels
food coloring
pine needles
dried flower heads
plastic flowers
small sponges
spray bottle
gravel
soil
sand
water
pie pan

BACKGROUND INFORMATION: When it rains, water flows over the earth's surface. Some of the water will stay on the surface (**surface water**) and form lakes, ponds, rivers, streams, or the ocean. Where it can, the water will percolate into or sink into the earth and become **groundwater**. Groundwater accumulates in the air spaces (**intersticles**) between grains of sand, gravel, and even rock forming a body of water called an **aquifer**. Wetlands control the flow of water over the earth's surface by holding large quantities of water, thus helping to prevent flooding. They slow the flow of water which helps to prevent erosion and, they act as filters by trapping sediments that would otherwise flow directly into our water systems.

PROCEDURE:



To create your wetland model:

1. Place rock in two hills on either side of the container.
2. Spread the gravel over the rocks in a layer about two inches thick and slope them downhill toward the middle of the container.
3. Spread a two inch layer of sand over the gravel. This layer should also slope toward the center. (You should have a large bowl shaped structure).
4. On the right side of the container make a hill out of soil. Pack this soil hill down fairly tightly.
5. On the left side of the container make a smaller hill out of clay. (Both the clay hill and soil hill should slope over the sand a couple of inches (see diagram).

Part I:

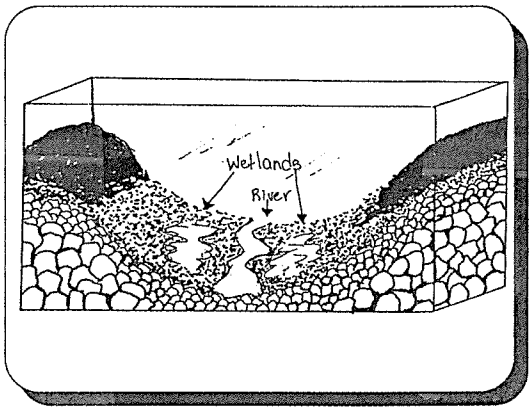
1. Fill the spray bottle with water and spray water over your model. Observe where water sinks into the ground and where it runs off or where it stays on the surface.
2. Continue spraying (you may have to refill the spray bottle several times). Notice where the water accumulates.
3. Continue to spray the surface. Explain what is happening in your observations.
4. Continue this process until a river forms in your model.

Part II:

1. Now make a wetland in your model. Place small sponges and or pieces of tightly rolled paper towels in the lowest part of your model near the river. Put wetland plants on two of the

pieces of sponge or paper towel (cotton swabs, pine needles, flower heads).

2. Continue spraying water into your model until the ground is really wet and water is flowing down toward your wetland.
3. Take the sponges and/or paper towel pieces out and squeeze them out into the pie pan. Record your observations.



Part III:

1. Place the wetland material back into your model (you may need new cotton swabs).
2. Repeat steps 2 and 3 of part II using some muddy water. Record your observations.

Note: You may want to use some paper towels and remove some of the water from your river before you begin part III.

OBSERVATIONS:

Part I:

1. Describe what happens to the water as you spray your model.
   Where does the water flow over the surface?
   Where does it accumulate on the surface?
   Where does it sink into the ground?

2. Describe what happens as you continue to spray water into your model.

3. Does a river form? If so, where does it form?

Part II:

1. Describe what happens to the water after you added the wetland.

2. How much water collected in the wetland material?

Part III:

1. Describe what happens to the water in the river after you sprayed the muddy water.

   Explain why this happened.

CONCLUSIONS: Explain what wetlands are, how they help in preventing floods, and how they act as natural filters.

EXTENSIONS: Repeat the processes above, but change it to demonstrate how human impacts alter wetlands (remove some of the wetlands). Locate some industrial areas near you that were built where wetlands once were. Explain what effects this industrialization has had on the water quality of the area.

CREATE A BOG ECOSYSTEM/HABITAT IN YOUR SCHOOL YARD

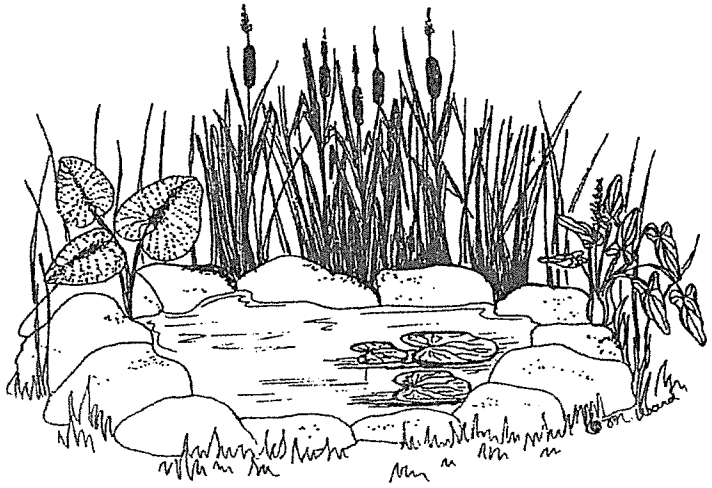
PURPOSE:

1. To provide schools and individuals with ready access to a bog ecosystem for observation and other ecological studies.
2. To introduce students and others to the components and dynamics of a bog ecosystem.
3. To enhance property, increase biodiversity and preserve indigenous bog species

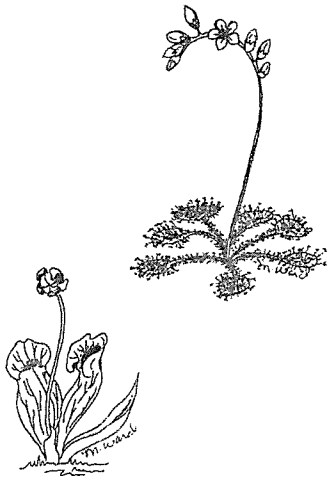
BACKGROUND INFORMATION:

What is a bog? The term 'bog' probably originates from the Irish-Gaelic bogach, or the Scots-Gaelic boglach, both of which mean 'soft'. A bog is currently defined as "wet, spongy ground, especially poorly-drained acid-rich areas rich in plant residues, surrounding a body of open water, and having a characteristic flora (as of sedges, heaths, and sphagnum)". Bogs are most often associated with northern climates, especially within taiga forests. Some ecologists now think that peat bogs and similar moss communities are the final climax stages of terrestrial succession in northern latitudes, supplanting coniferous forests after a few hundred years. In limnic succession, or eutrophication, the bog stage is considered the final wetland community prior to the wet meadow stage and subsequent terrestrial succession. Bogs can also be found within most temperate biomes, including grasslands, deciduous broadleaf forests and southern pine forests.

Organisms found within bog ecosystems vary with the climatic zone in which they are found. However, in general, they are dominated by mosses, especially in the Genus *Sphagnum*. Other hydrophytic plants inhabiting these communities include ferns, horsetails, sedges, grasses, flowering annuals and perennials and others. The most interesting bog plants are the carnivorous plants. The southeastern US boasts species of these unusual plants, including several threatened and endangered species. Included are the famous Venus' flytrap, native to the coastal plain of North Carolina, sundews, and several species of pitcher plants in the Genus *Sarracenia*. Several animals are found in and around bogs, most notably the endangered bog turtle *Clemmys muhlernbergi*. Spotted turtles, cricket and chorus frogs, newts and salamanders all can be found in and around bogs.



MATERIALS:



Digging tools - shovels, mattock, etc.
Pre-formed commercial liner or black, plastic sheeting
sand
peat moss
bog plants - sundew, Venus' flytrap, pitcher plants, Sphagnum, etc.
bog animals - cricket frogs, newts, etc.
ornamental and functional extras - rocks, logs, leaf litter, etc.

DIRECTIONS:

1. The first step always involves locating a site appropriate for establishing a bog. Choose a low-lying area that receives natural rain runoff. The area should be in full sun at least 4 hours, with partial sun the rest of the day. Too much sun can dry out the bog quickly, while too little will not allow for good plant growth.

2. Mark off the area with twine or spray paint. If you decide on a pre-formed pond liner, measure and map its outer dimensions. If you use a sheet-type liner, you can have any shape or size you desire.

3. Dig out the pond to a depth of at least 18". [NOTE: Most directions for constructing a pond call for providing 'shelves' on which to place plants or other decorations. This is not necessary for a bog.]

4. Place the pre-formed liner or sheet-type liner in the excavation. [NOTE: For the sheet-type liners, a thickness of at least 21 mm is optimum. Seven sheets of 3 mm plastic should prove adequate.] You may wish to fill the area with water to check for leaks.

5. Fill the bottom 12" with sand. Fill in the rest of the area with a 3:1 mix of peat moss to sand. Completely saturate the 'bog' with water. If desired, decorate the surrounding area with stones, wood pieces and other natural items.

6. Once the bog is saturated, you may plant desired bog flora as suggested above or discovered in your own research. **DO NOT COLLECT ENDANGERED OR PROTECTED PLANTS OR ANIMALS WITHOUT PERMITS.** A local nursery or botanical garden can assist you in selecting appropriate plants.

7. For the first couple of years, you may have to experiment with different species to discover those that are best suited for your area. If you choose to introduce animals to your habitat, make sure they are protected from overeager observers, predators and escape.

EXTENSION: With a little work and data collection, this could be turned into a fun and interesting science fair project.

This activity was submitted by Dan Coleman

WETLANDS: NATURE'S SPONGE

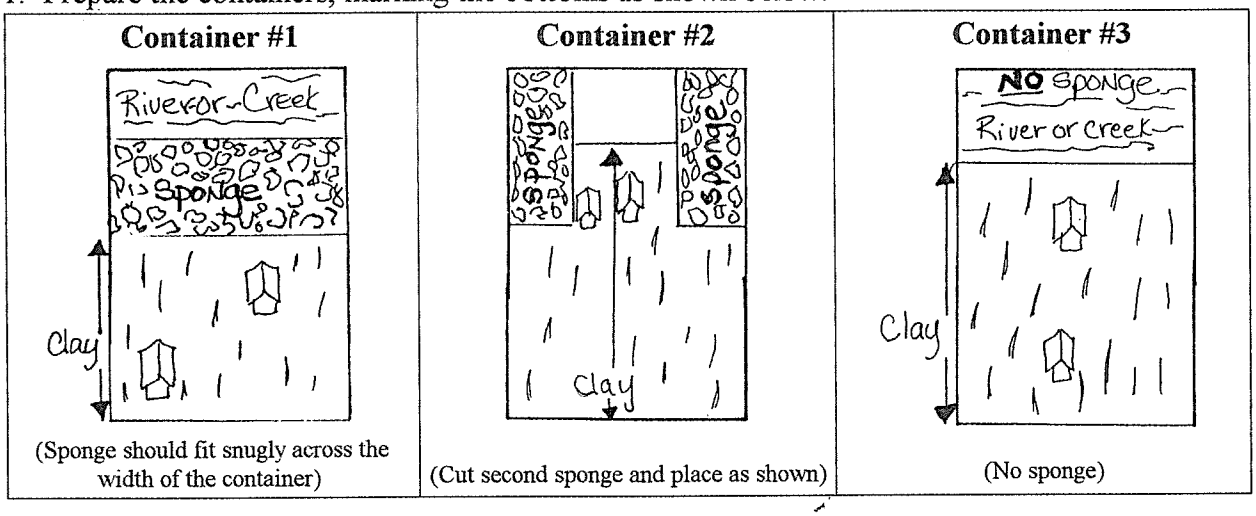
PURPOSE: To recognize the importance of wetlands as a protection against flooding.

MATERIALS:
3 rectangular baking or plastic containers (9" X 12")
1 large sponge (should fit snugly in the width of the container)
1 small kitchen sponge
modeling clay
twigs and leaves (to represent trees and foliage)
paper or cardboard
markers
water
4 paper or plastic cups
* a second large sponge will be needed for the extension activity

BACKGROUND INFORMATION: Wetlands act as a natural sponge, absorbing water from spring tides or excessive rains. This water is later slowly released back into the environment. When wetlands are destroyed or damaged, many low-lying and upland areas are subject to damage by flood waters. Currently, new wetlands are being created to replace those lost to development through a policy called mitigation.

PROCEDURE:

1. Prepare the containers, marking the bottoms as shown below.



2. Spread the clay with the lowest area near the line drawn in the container and make it thicker towards the back of the container (this is the land). The land area should form a slant with the thickest part at the back of the container.
3. Add twigs and leaves for foliage.
4. Use paper or cardboard to construct "homes" (representing development) and place these in various locations on the clay.
5. Place the sponges where shown in the drawings above.

This activity was submitted by Georgia Graves, Coastal Encounters Nature Center

6. Fill three of the cups with the same amount of water.
7. Slowly pour one cup of water over the sponge in container one. (This represents an unaltered wetland and all or most of the water should be absorbed by the sponge).
8. Slowly pour another cup of water onto the sponges in container two. (This represents a wetland that has been altered. Some of the water will be absorbed, but some will flood onto the uplands).
9. Slowly pour the third cup of water into the river/creek area of the third container. (This represents an area where the wetland has been totally destroyed and development goes all the way to the edge of the water).

OBSERVATIONS:

1. Describe what happens to the water as it is added to each container. Explain why.

Container #1	Container #2	Container #3
Description:	Description:	Description:
Why did this happen?	Why did this happen?	Why did this happen?

CONCLUSION: Explain the importance of wetlands as a natural buffer against flooding.

EXTENSIONS: Mitigate one of the altered wetland models (container 2 or 3). Add the same amount of water as you did in the original experiment. Describe the benefits of mitigation.

This activity was submitted by Georgia Graves, Coastal Encounters Nature Center

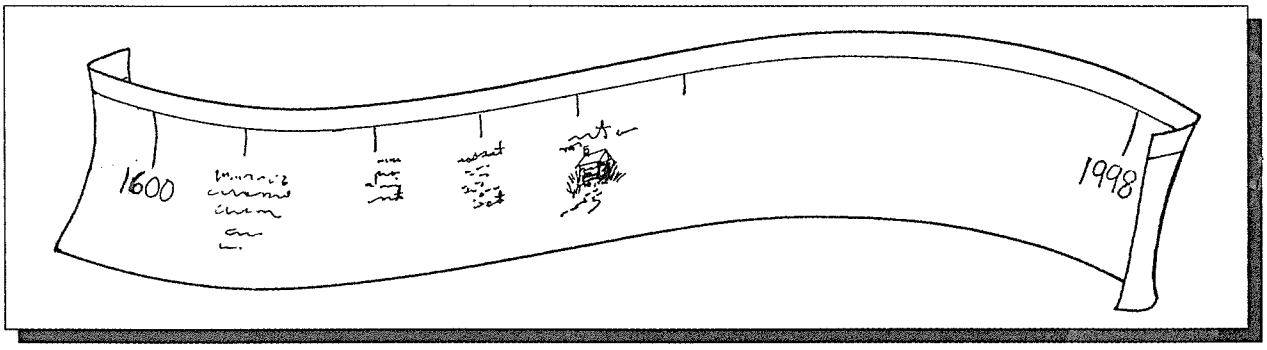
TIMELINE OF THE HISTORY OF MAJOR WETLAND REGULATIONS IN THE UNITED STATES AND GEORGIA

OBJECTIVE: To investigate the major laws and regulations affecting wetlands.

MATERIALS:
History of Wetlands and Wetland Trends fact sheet
Where Does Georgia Stand fact sheet
adding machine tape
yard stick (meter stick)
markers

PROCEDURE:

1. Read the "History of Wetlands and Wetland Trends" and "Where Does Georgia Stand" fact sheets and prepare a list of dates and events/regulations affecting wetlands. (You may use the chart provided in this activity or prepare your own). Your information should begin with the early 1600's and end with 1998. For the most recent information on wetland laws, call the Ga. DNR Coastal Resources Division at 912-264-7218.
2. Organize your information by dates in ascending order from 1600 to 1998.
3. Decide how much space you will need for each event/regulation and measure that length of adding machine tape.
4. Along the top of this length of adding machine tape draw a straight line. At the left end of the tape draw a vertical line about an inch long and label this line 1960's. At the right end of the tape draw a vertical line about an inch long and label it 1998.



5. Fill in the space between 1960 and 1998 with the rest of the information from your list.
6. Research each event/regulation and place that information in the proper location on your timeline. For more information contact the EPA Wetlands Hotline at 1-800-832-7828 or research the following web sites:
   http://www.epa.gov/Region4Wet/wetlands.html
   http://www.epa.gov/OWOW/wetlands/res.html
   http://www.epa.gov/OWOW/wetlands/contents.html
   http://water.usgs.gov/public/nwsum/WSP2425
   http://www.nwi.fws.gov/

Chart of Wetland Events/Regulations

Date	Event/Regulation	Effect on Wetlands
1600's	America settled by Europeans	over 221 mil. acres of wetlands
early 1700's	wetlands considered hinderance	cleared for homes and travel
Middle 1700's	land needed for farms	wetlands were drained

In the margin to the left of each date place a - sign beside the events that had a negative impact on our Nation's (or Georgia's) wetlands and a + sign by those which had a positive impact.

CONCLUSIONS: Discuss how the attitudes of citizens and governments have changed in regard to the value of wetlands.

WHERE HAVE ALL THE WETLANDS GONE?

PURPOSE: To investigate the percentage of the lower 48 States showing wetland loss between the 1860's and 1990.

MATERIALS: Fact Sheet: History of Wetlands and Wetland Trends
Maps of Wetland Loss in the Lower 48 States

PROCEDURE:

1. For each map, count the number of states with wetland loss and place this information in your data table.
2. Calculate the % of wetland loss for each map by dividing the answer to question #1 by 48 (carry the answer out to two decimal places) then multiplying that answer by 100.
   Example: 9 states divided by 48 = .1875, .1875 X 100 = 18.75%
3. Prepare a graph of the information in your data table.

OBSERVATIONS:

Data Table:

Map	# of States with wetland loss	% of states with wetland loss
1600's - 1800's		
1800-1860		
1860-1900		
1900-1950		
1950-1990		

1. During which time period was there the greatest % of wetland loss in the lower 48 States?

2. Use the information provided in the fact sheet: ***History of Wetlands and Wetland Trends*** and suggest the major cause(s) for wetland loss during each time period represented by the maps.

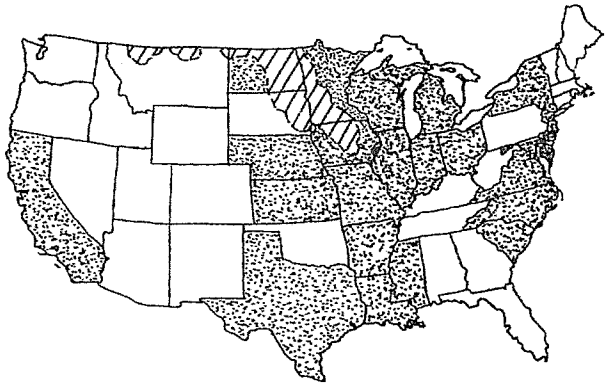
Graph of Wetland Loss Information

CONCLUSION: Discuss the amount of wetland loss in the lower 48 States between the 1860's and 1990.

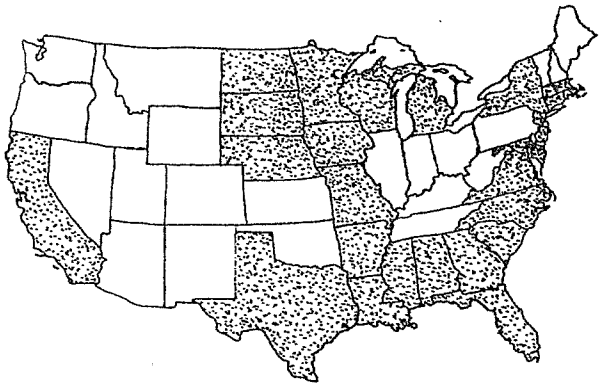
MAPS OF WETLAND LOSS IN THE LOWER 48 STATES

Wetland loss from 1600's to 1800's

Wetland loss from 1800 to 1860

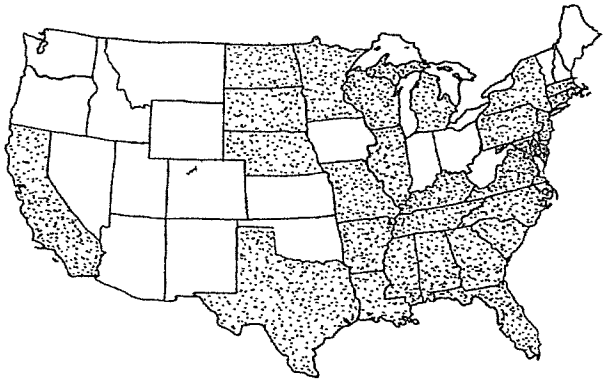


Wetland loss from 1860 to 1900



Wetland loss from 1900 to 1950

These maps were adapted from: National Water Summary on Wetland Resources - United States Geological Survey, Water-Supply Paper 2425



Wetland loss from 1950-1990

"GOING, GOING --- HEY WAIT A MINUTE"
A Wetland Tug of War

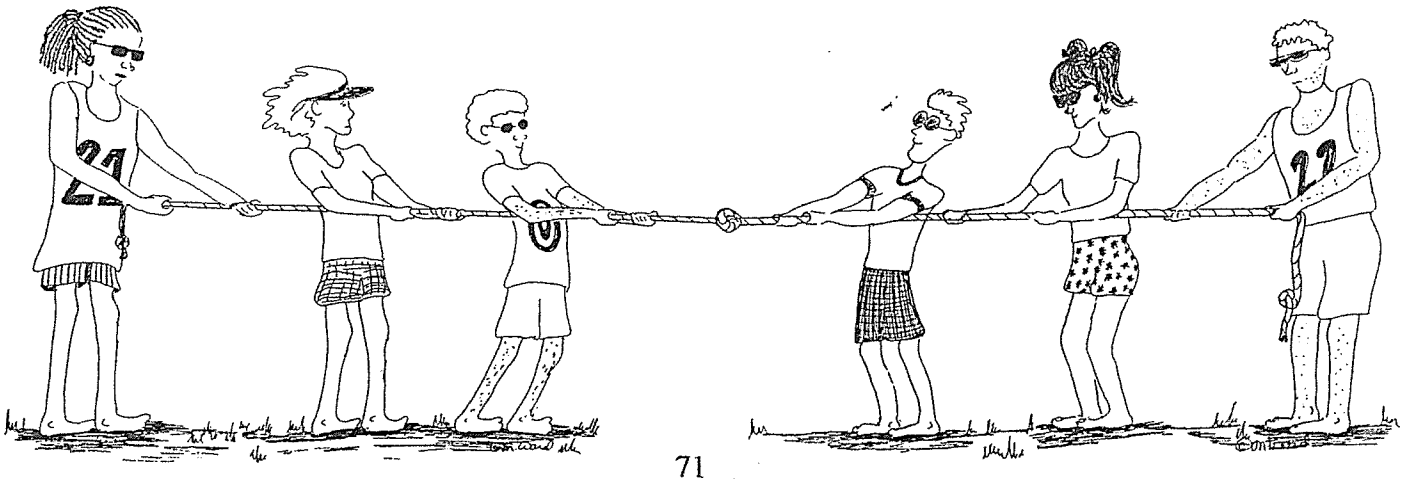
OBJECTIVE: To simulate the effect of human activities on wetlands.

MATERIALS: large area (playing field or gymnasium)
rope (long enough for all students to hold on to with a couple of feet left over)
duct tape

PROCEDURE:

1. Divide the class into two groups or have them choose sides. Group one will represent the wetlands and group two will represent human activities.
2. Mark the center of the playing field and the center of the rope with duct tape.
3. Lay the center of the rope along the center of the playing field.
4. Have group one (the wetlands) line up along the left side on the rope and group two (human activities) line up along the right side of the rope. Tell them to arrange themselves anyway they want to, but they are not to touch the rope until they have heard all instructions.
5. Give the following instructions:

    a. This is not so much a test of strength as endurance, so each of you is to pull at a steady rate. Not too forceful or too weakly, just apply a steady pressure or pull.
    b. Each time I make a statement, one person will leave his/her position at the front of the line (nearest the center of the rope). That person will go to the end of the other side's rope and take that position. The other members of that side of the rope must move forward to give that person room.
    c. Now, tell the students to pick up the rope (being sure to leave some space at each end), and on your signal practice pulling with a steady pressure on the rope. This is to represent humans and wetlands living or working together in harmony, and although there is pressure a balance is maintained. Give a signal for the students to start pulling. Once you are satisfied that they are pulling with the correct amount of pressure, tell them that they are to continue pulling with the same pressure no matter what happens. (Tell them that the center of the rope will probably go back and forth across the center of the playing field several times).



d. When you feel that they are ready to begin, tell them that they will now begin the wetland tug of war. Read the following statements (you may change these or add to them as you see fit).

1) It is the year 1600 and Native Americans live in harmony with the wetlands. Nobody has to move. Continue pulling with a steady pressure.
2) It is the year 1705 and many acres of wetlands are cleared to make way for homes, roads, and land to grow crops. One wetland member leave your position and go to the other side. (The wetland member at the front of the wetland side leaves his/her position and goes to the back of the human activities side). Continue to pull with the steady pressure.
3) It is the mid-1700's and wetlands are drained to make way for homes and farmland. One wetland member leave your position and go to the other side.
4) The Federal Government passes the Swamp Land Act and gives 15 states the right to drain swamp land for settlement and development. One wetland member go to the other side.
5) Wood is needed to fuel the railroads, and wetland forests are cut down to supply this fuel. One wetland member go to the other side.
6) An attempt is made to drain the Okefenokee Swamp in 1900's. One wetland member go to the other side. Pull only with the steady pressure.
7) In the 1930's the U. S. Government provides free engineering services to farmers to drain wetlands. One wetland member go to the other side.
8) The Sugar Act of 1934 is passed and more wetlands are drained for the planting of sugarcane. One wetland member go to the other side.
9) The Migratory Bird Hunting Stamp Act passes Congress in 1934 and some wetlands are restored. One human activities member go to the other side.
10) Educational programs begin to educate the public on the values of wetlands as important environmental ecosystems. One human activities member go to the other side.
11) The Clean Water Act passes Congress in 1972 reducing the rate of wetland conversion for agricultural use. One human activities member go to the other side.
12) The Emergency Wetland Resources Act of 1986 slows wetland loss. One human activities member go to the other side.
13) A major shopping center is built and several hundred acres of wetlands is lost. One wetland member go to the other side.
14) In the 1980's the Federal Government begins non-regulatory programs to restore wetlands. One human activities member go to the other side.
15) President Bush promises "no net loss" of wetlands in 1989. One human activities member go to the other side.
16) In 1989, the North American Wetland Conservation Act is established to encourage partnerships between public agencies and other interests to protect, restore, and enhance wetlands. One human activities member go to the other side. Remember to apply only a steady pressure.
17) Many people are moving to coastal regions and wetlands are filled to make way for houses. One wetland member go to the other side.

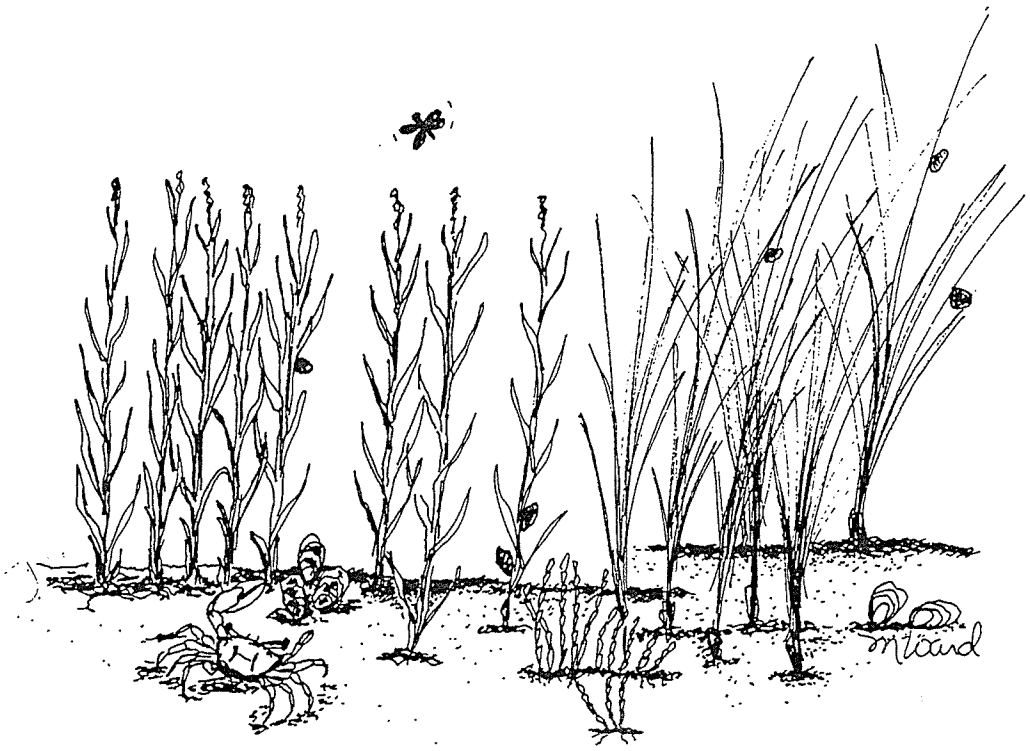
18) A pipe breaks at a local industry, leaking toxic materials into the surrounding wetlands. One wetland member go to the other side.
19) The wetland Reserve Program restores 118,000 acres of wetlands. One human activities member go to the other side.
20) Environmental agencies begin educational programs on the importance of wetlands. One human activities member go to the other side.

You may want to add additional statements here!

Now, tell the students that they will have 30 seconds (or a time limit of your choice) from your signal to complete this tug of war. On your signal, they can pull as hard as they can. The winner will be the side that can pull the most members of the opposing side across the center line.

Follow up:

Have the students discuss their feelings at the beginning, middle, and end of the tug of war. Discuss the future of our wetlands. What can they do to help preserve wetlands?



THE WETLANDS ABC GAME

PURPOSE: A game to pass the time and challenge the mind. Any number can play.

PROCEDURE:

1. Divide the class into teams and have the teams compete against each other for total points. Have each team decide on a name and put the names on the board.

Team A	Team B
3	3
5	3

For two teams

or

Herons	Spartina	Fiddler Crabs
5	3	5
5	5	3

For three teams

1. Players work through the alphabet beginning with A and alternating teams (team A begins with A, team B begins with B, then team A uses C, etc.).
2. Each player will say the letter, then give any name beginning with that letter.
3. The player will then give a "wetlands term" followed by a definition or a feature beginning with the same letter of the name stated in procedure #2.
4. Bonus points will be given for examples or locations.

SCORING:

3 points for the term and definition or feature.
2 bonus points for an example and/or specific location

Example #1: B -- My name is Bunny.
B -- Stands for bog which is wet, spongy ground surrounding an open body of water. A Venus' Fly Trap is a carnivorous plant that can be found in the bogs of Georgia's Coastal Plain.
Scoring for Example #1: 3 points + 2 bonus points = 5 points

Example #2: L -- My name is Leigh.
L -- Stands for leaves which are found on wetland plants.
Scoring for Example #2: 3 points

Example #3: M -- My name is Margaret.
M -- Stands for Marsh which is like a sponge.
Scoring for Example #3: 3 points

This activity was submitted by Leigh Scott and Bunny Clayton

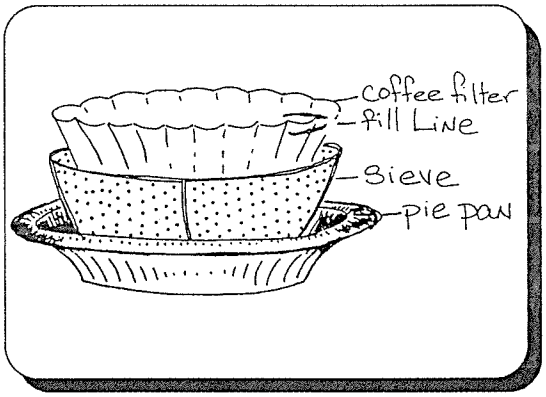
WHICH SOIL HOLDS MORE WATER?

PURPOSE: To investigate the water storage capacity of various soils.

MATERIALS: Soil samples: gravel, peat moss, potting soil, and sand
large coffee filters (or cheesecloth)
4 sieves
4 measuring cups or 8 oz. soup cans
4 pie pans
scales

BACKGROUND INFORMATION: One of the important functions of wetlands is the ability to absorb large quantities of water and thus help in the prevention of floods. The water storing ability of wetlands is due in part to the organic matter that is present in the wetland soils.

PROCEDURE:



1. Place a large coffee filter into each of the four sieves.
2. Fill each sieve with a different type of soil. Make sure that you fill the sieves to the same level with each soil type.
3. Place each sieve in a pie pan and weigh each. Record the weight of each in your observations.
4. Pour 8 ounces of water into each sieve. Allow the water to soak through each soil for about 5 minutes.
5. Remove each sieve from the pie pans and pour the water off. Place the pie pans back under the sieves and weigh each sieve again. Record each weight in your observations.
6. Use the following formula and information to calculate the percent of water absorbed by each soil. Record your answers in your observations.

A /D x 100 = % of water absorbed.

D = dry weight, W = wet weight
A = W - D (subtract dry weight from wet weight to get A)

OBSERVATIONS:

Soil	Dry weight (D)	Wet weight (W)	W - D = A	% water absorbed (A/D x 100)
Gravel				
Peat moss				
Potting soil				
Sand				

Answer the following:

1. Which soil material absorbed the most water?
   What reason or reasons can you give for this?

2. What factor(s) determine how much water a soil can hold?

3. Which of these types of soil would you classify as a wetland soil?
   Explain your answer.

4. Which of these types of soil would help in the prevention of floods?
   Explain your answer.

5. What would happen to an area where the wetland soil was removed, filled by a soil with less water holding capacity, or covered with asphalt?

6. Explain any personal experiences that you have had with flooding.

   What do you think caused this flooding?

CONCLUSIONS:

Explain how the ability of wetland soils to absorb large quantities of water can help in the prevention of floods.

IDENTIFYING WETLAND SOILS

OBJECTIVE: To investigate the physical differences between wetland and upland soils.

MATERIALS:

Wetland Soils fact sheet
scissors or single edged razor blades
cardboard pieces
glue
some type of stiff paper (cardstock, posterboard, or file folders)
Crayola Crayons (gray, white, olive green, peach, goldenrod, brown, tan, bittersweet, black, sepia, raw sienna, Indian red, sea green, forest green, pine green, sky blue, and cornflower)
shovel
yard stick
pencils
discovery scopes (hand lenses or dissecting microscopes)
copies of "Color Me Wet" and "Key to Soil Texture by Feel"
soil samples from various wetland and upland locations (only if you cannot go to a wetland)
copies of "Soil Data Chart" for each set of soil samples

PROCEDURE:

Part I: Make your own soil color chart. You will use this chart to identify your soil samples.

1. Carefully read the information the "Color Me Wet" sheet.
2. Use the Crayola Crayon colors listed in the materials to color the squares on the wetland soils color chart. It is important to color lightly where indicated and firmly on all others.
3. Glue the chart onto a piece of stiff paper (If you can Xerox this page on cardstock, you can skip this step).
4. Cut out the black circles. If you are using a single edge razor blade, place a piece of cardboard under your chart before cutting and be very careful.

Prior to beginning part II:

1. Collect several soil samples from various wetland and upland locations. To collect soil samples: At each location, dig a hole about two feet deep and collect samples about the size of a golf ball from the walls of the hole. The samples should be collected from various depths beginning at a depth of about two inches. (Mark your samples with the depth from which they were collected = sample #1, 2 inches; sample #1, 4 inches, etc.).
2. Each student should read the "Wetland Soils" fact sheet.

Part II:

1. Fill in a soil data chart for each set of soil samples.
2. Use the "Key to Soil Texture" by Feel to identify the type of each soil.

OBSERVATIONS: Answer the following questions after completing part II.

1. List the soil characteristics that you observed.

2. Was the soil the same at all depths?
   Explain any differences.

3. Did you find anything that was not natural in your samples?

   If so, explain.

4. Which of your soil samples were wetland soils?
   What makes you think so?

5. Which of your soil samples were upland soils?
   What makes you think so?

CONCLUSION: Describe the characteristics of wetland soils and explain how you can distinguish wetland soils from upland soils.

Soils Data Chart

(one for each set of soil samples)

Record the words or phrases that apply to each soil sample in the chart below.

Texture/moisture: Rub the soil between your fingers. Choose words that describe how it feels.

- dry, moist, wet, very wet, or drippy
- falls apart, sticks together, sticky (sticks to fingers)
- feels like clay (easily molded into shapes)
- slippery, oozes (exudes between fingers when you squeeze it)

Soil particles: Draw the size and shape of the particles. What is the sample made of?

- sand (feels gritty)
- minerals (tiny bits of rock)
- clay
- silt (like flour or powder, slippery when wet)
- pebbles
- organic matter (bits of leaves,

Color: Use your color chart.

Other features or creatures: What does the soil smell like? List or describe any rocks, dead plants, or other nonliving materials in the soil. List or describe any living things such as worms, roots, or insects. Do you see any roots with "rusty" red or orange soil around them?

Depth From Soil Surface	Texture/Moisture (describe how it feels)	Soil Particles (describe or identify them)	Color # (use color chart)	Other Features or Creatures

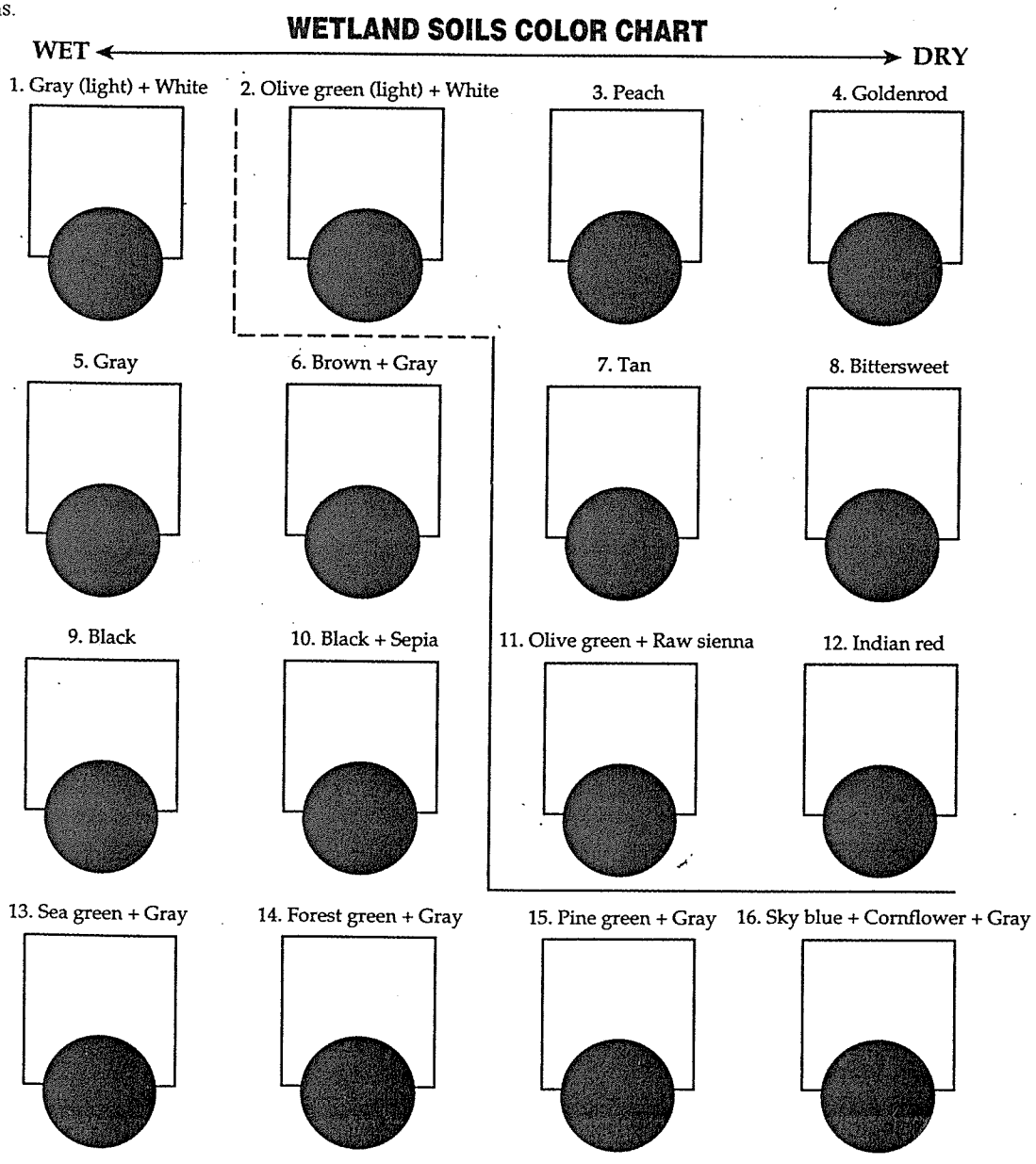
This activity was adapted with permission from WOW!: The Wonders Of Wetlands, 1995. Published by Environmental Concern, Inc., St. Michaels, MD, (410) 745-9620, and The Watercourse, Bozeman, MT, (506) 994-1917.

Color Me Wet!

Use Crayola Crayons to color in the squares on the chart below. It is very important to use the right colors! Press firmly when coloring, unless the name says "light." Cut out the whole chart and paste it to a piece of posterboard or half of a manila folder. Carefully cut out the black circles, through all thicknesses. (You could Xerox this onto cardstock also).

Use this color chart when studying soil in the field. Wetland scientists use similar but much more complicated color charts to identify wetland soils. Hold the chart in one hand; in the other hand hold a sample of soil behind the chart so that it is visible through one of the holes. Your soil sample may contain bits of rock, organic material, and mineral concentrations. You must key out only the dominant soil color and ignore all other materials. Move the sample around until you find one or two colors that nearly match or approximate the dominant color.

Numbers 1, 5, 6, 9, 10, 13, 14, 15, 16, and sometimes 2 are probably wetland soils; the others are probably not wetland soils. Any soil with a basic (matrix) color that is a shade of dark brown, black, or gray may be a wetland soil. You will probably see other colors and materials within the matrix soil color. These colorful streaks may be the result of certain minerals. They appear as shades of red, orange, and yellow (associated with iron in the soil), or black (associated with manganese, not to be confused with dark organic material). These areas are good indicators of seasonal wetlands and other wetlands that are not always wet. Do not use these color mottles to key out the soil, but recognize that they are an additional indicator of werland conditions.



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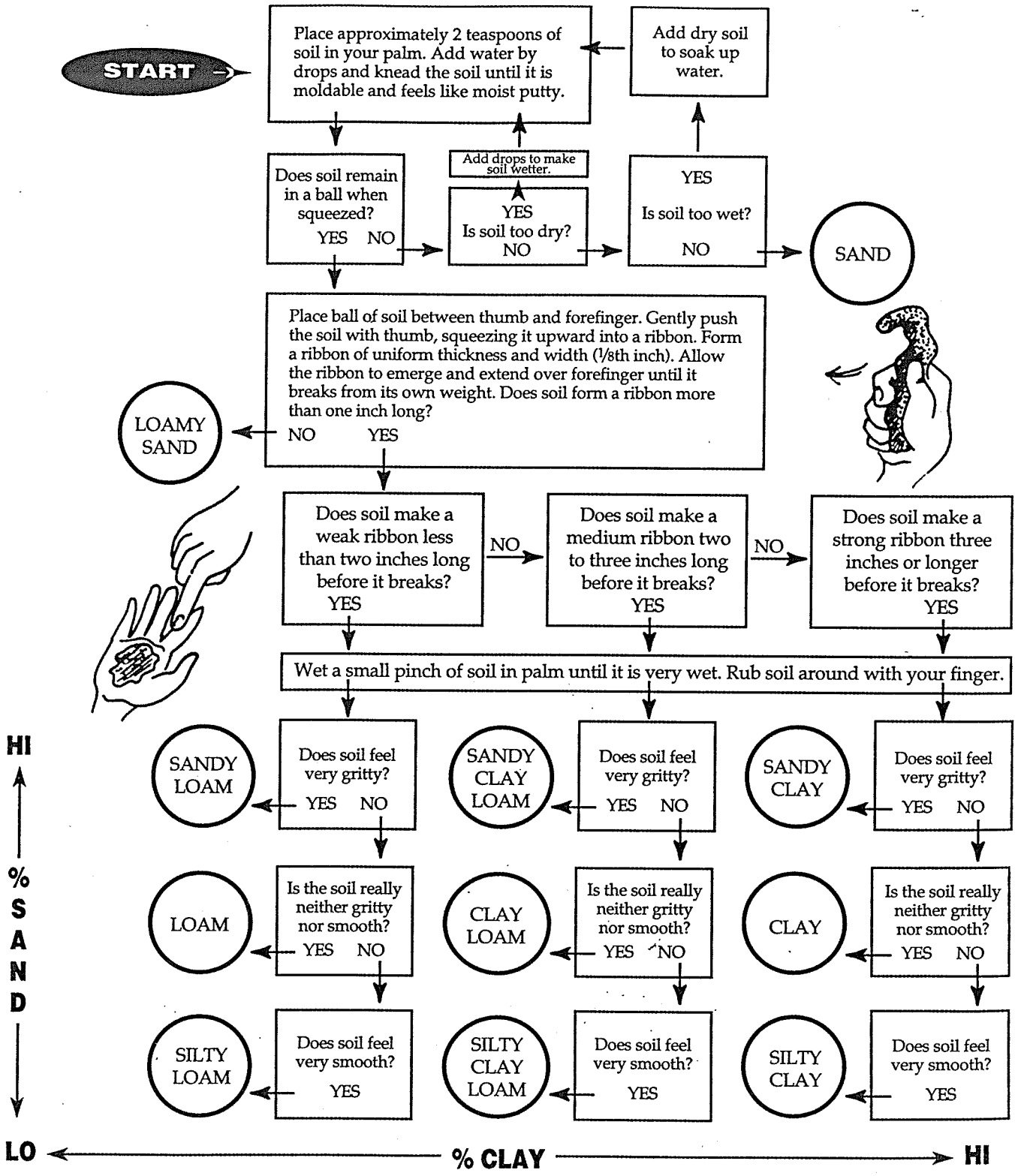
Key To Soil Texture by Feel

Begin at the place marked "Start" and follow the flow chart by answering the questions until you identify the soil sample.



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pH CHANGES ALONG A WETLAND

PURPOSE: To Investigate how pH changes along a wetland.

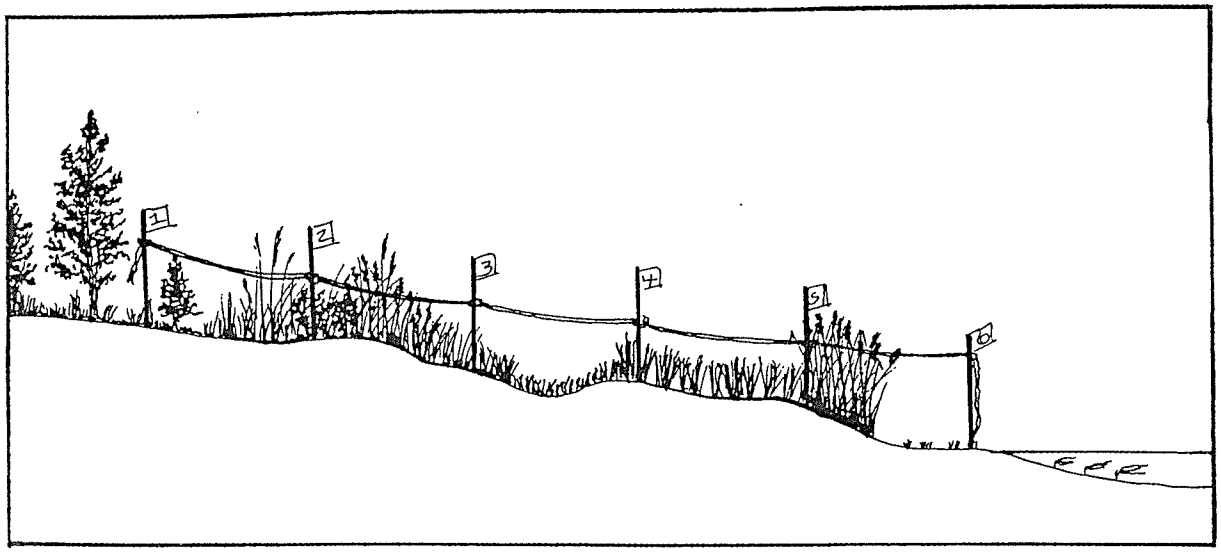
MATERIALS:

5-10 beakers or jars	ruler or meter stick
50-100 feet of chord	jars to collect water/soil samples
5 to 10 stakes or poles	
pH electrodes, hydrion paper or universal indicator	

PROCEDURE:

Note: If the marsh is muddy, the students will need boots and old clothes.

1. Select a marsh to study.
2. Using the stakes or poles and chord, mark off a line cutting across the length of the wetland from the high and dry area to the water's edge or edge of the tidal creek.
3. Divide this line into 5 to 10 collection stations. The number will depend on the size of the marsh.



4. Collect water/soil samples from each collection station.
5. Measure the pH of the water/soil sample using electrodes or a pH test kit. (Hydrion paper or universal indicator paper also work well). Record this information on a chart in your observations. (If the soil is dry, mix it with some distilled water.)
6. List the types of plants and count the numbers of each that are growing at each station.
7. Measure the height of the different plants at each station.
8. Describe any animals or signs of animals around each station.
9. Collect a small sample of soil from each station.

Ideas for this activity were submitted by James Jackson

OBSERVATIONS:

Data Chart:

Station #	pH	Types of Plants & No./ Height of Each	Animals or Signs of Animals
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

1. At which location was the pH the lowest? _____ Is this area considered high marsh, middle marsh, or low marsh (low marsh is the closest to the water)?

2. At which location was the pH the greatest? _____ Is this area high, middle, or low marsh?

3. On a separate sheet of paper, graph the pH of your marsh. Use this graph to do a cross-section drawing of the wetland showing the pH at each station (you may use the drawing on the previous page)..

4. At which station was there the greatest variety of plant types? _____ At which station was there the least variety of plants? _____ Explain why you think this is so.

   Was there any difference in the heights of the plants at each station? _____ Explain your answer.

5. Was there any difference in the types of animals or evidences of animals that you observed around each station?

6. How is the soil alike or different at each station? Explain your answer..

CONCLUSIONS: Discuss how the pH changes across a wetland. Explain any correlation between pH and soil, water, plant life and animal life.

Extension: Try this at different times of the year or compare fresh and salt water marshes.

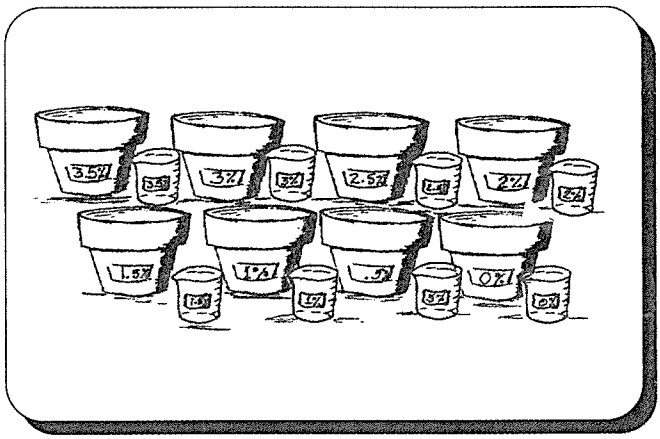
Ideas for this activity were submitted by James Jackson

THE EFFECT OF SALINITY ON PLANT GROWTH

PURPOSE: To investigate the effect of different salinity levels on plant growth.

MATERIALS:

8 containers for growing seeds	8 beakers or containers for water solutions
potting soil	scale
radish seeds	water
salt	ruler



PROCEDURE:

1. Prepare 8 different solutions of water containing 0%, .5%, 1%, 1.5%, 2%, 2.5%, 3%, and 3.5% salinity. 0% solution = tap water, .5% solution = .5 grams of salt to 100 ml of water, 1% solution = 1 gram salt to 100 ml of water, 1.5% solution = 1.5 grams of salt to 100 ml of water, etc. Note: sea water has a salinity of 3.5%.
2. Label each container 0%, .5%, 1%. and so on.
3. Plant radish seeds in each of the eight growing containers. Label each container 0%, .5%, 1%, 1.5%, 2%, 2.5% and so on.
4. Water each growing container with the appropriate water.
5. Set up a watering schedule: every other day, three times a week, etc. Be consistent with the amount of water added each watering period
6. Set the growing containers in an area where they can receive sunlight and observe over a two-three week period.
7. On the chart indicate when the seeds sprouted, how many sprouted each day, written description and drawing of the plants each day, height of plants each day, etc. At the end of the growing period, prepare a line graph showing the growth rate of each container of plants. Use a different colored pencil for each % salinity.

OBSERVATIONS:

1. How many days did it take the plants to sprout in each container?

2. Did the salinity of the water affect the growth of the plants in height? Explain your answer..

3. Did the salinity of the water affect the plants in any other way besides height? Explain your answer. (Describe the appearance or viability of the plants in each container).

This activity was submitted by James Jackson

Data Chart:

	Date	# of Sprouts	Height	Drawing	Description
0.0% Salinity					
0.5% Salinity					
1.0% Salinity					
1.5% Salinity					
2.0% Salinity					
2.5% Salinity					
3.0% Salinity					
3.5% Salinity					

CONCLUSION: Explain the effect of salinity on plant growth.

Extensions: Try different types of seeds and compare the results. You may also want to try this using plants that are already growing. Locate areas in your county or neighborhood that have experienced flooding. What effect did the flooding have on the local plants?

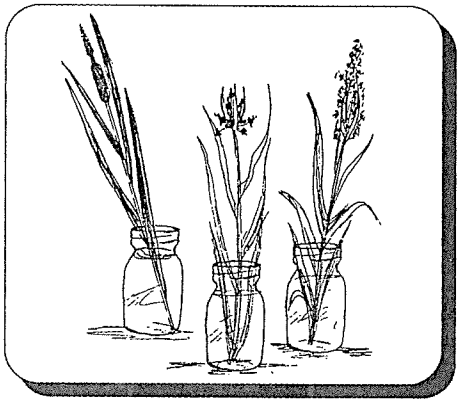
This activity was submitted by James Jackson

WETLAND PLANTS FILTER POLLUTION

PURPOSE: To Investigate how wetland plants can filter pollutants out of water.

MATERIALS: Several of the following plants:
If available, use wetland plants such as cattails, sedges, various grasses
If wetland plants are not available, use celery stalks with leaves, daffodils, carnations, and daisies (or any non-woody plant that is available)
Clear glass jars or plastic cups (one for each type of plant)
Food coloring
Scissors
Water
Dissection microscope, discovery scope, or magnifying glass
Colored pencils (same colors as food coloring)

PROCEDURE:



1. Cut off about one inch from the end of the stem from each plant.
2. Observe a cross-section of each stem with a dissection microscope, discovery scope, or magnifying glass. Record your observations and draw what you see in the table in your observations.
3. Prepare a jar or cup of colored water for each of your plants.
4. Place each plant into a jar or cup of colored water.
5. Set these aside and observe each day for a period of three days.
6. Each day cut a small cross-section from the stem of each plant about an inch up from the bottom and record your observations. Use colored pencils to indicate the degree of coloration.

OBSERVATIONS:

	original cross-sect. drawing	original cross-sect. description	day 1 cross-sect. drawing	day 1 cross-sect. description	day 2 cross-sect. drawing	day 2 cross-sect. description	day 3 cross-sect. drawing	day 3 cross-sect. description
Plant #1								
Plant #2								
Plant #3								

Answer the following questions:

1. If you used celery, daffodils, carnations, or daisies, what did these represent from a wetland?

2. What did the food coloring represent?

3. Did the amount of "pollutants" in each plant appear to increase over the course of this experiment or did it appear to stay pretty much the same? Explain your answer.

4. How long did it take the food coloring to reach the top of the leaves or flowers of each plant?

5. Did the concentration of food coloring appear to be more, less, or the same each day? List as many sources of non-point source pollution for wetlands as you can think of.

6. Assuming that the plants used in this experiment represent wetland plants, why do you think that each wetland plant can continue to absorb pollutants. Is there a limit to the amount of pollution each wetland plant can absorb?

7. What do you think happens to the pollutants that wetland plants absorb when the plant dies? Explain your answer.

CONCLUSION: Explain the importance of, and limits of wetland plants as filters of pollutants.

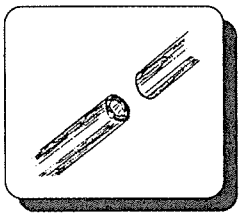
WETLAND Vs LAND PLANTS

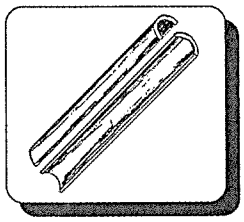
PURPOSE: To investigate how wetland plants are adapted to transfer oxygen to their roots.

Note To Teacher: *Bullrush is a sedge and can be identified by its triangular stem. When collecting specimens, remember the important role that wetland plants play and take only a few! Many grocery stores or florist shops will donate flowers they can no longer sell.*

MATERIALS:

stems from the following wetland and land plants:
water-lily (freshwater)
bullrush (freshwater)
Spartina alterniflora (saltwater)
daisy
carnation (or any two non-woody land plants (except grass)
scissors
dissecting microscope, discovery scope or magnifying glass
clear plastic cup or glass
water





PROCEDURE:

1. Lay each stem in front of you and observe each. Describe each stem in your observations.
2. Cut off a small (one inch) section of each stem and observe this cross-section under the dissecting scope, discovery scope, or magnifying glass.
3. Cut this small piece of the stem lengthwise. Describe and draw what you see in each stem.
4. Fill the glass 3/4 full of water.
5. Place each stem, one at the time, in the cup of water. Blow into the stem. Describe what happens (for each stem) in your observations.

OBSERVATIONS:

1. Description of each stem:

	Plant Name	Fresh or Saltwater Plant?	Description
Stem 1			
Stem 2			
Stem 3			
Stem 4			
Stem 5			

2. Explain how each stem is alike.

3. Explain how each stem is different.

4. The difference(s) you observe are adaptations. Why do you think the wetland plants need this adaptation?

5. Fill in the data table:

Stem #	Cross-section description	Cross-section drawing	Lengthwise description	Lengthwise drawing
Stem 1				
Stem 2				
Stem 3				
Stem 4				
Stem 5				

6. Describe what happened when you blew into each stem:
Stem 1:
Stem 2:
Stem 3:
Stem 4:
Stem 5:

CONCLUSION: Based on your observations and your reading of the fact sheets, explain how wetland plants are adapted to transfer oxygen to their roots.

ENERGY FLOW in a WETLAND FOOD CHAIN

OBJECTIVES:

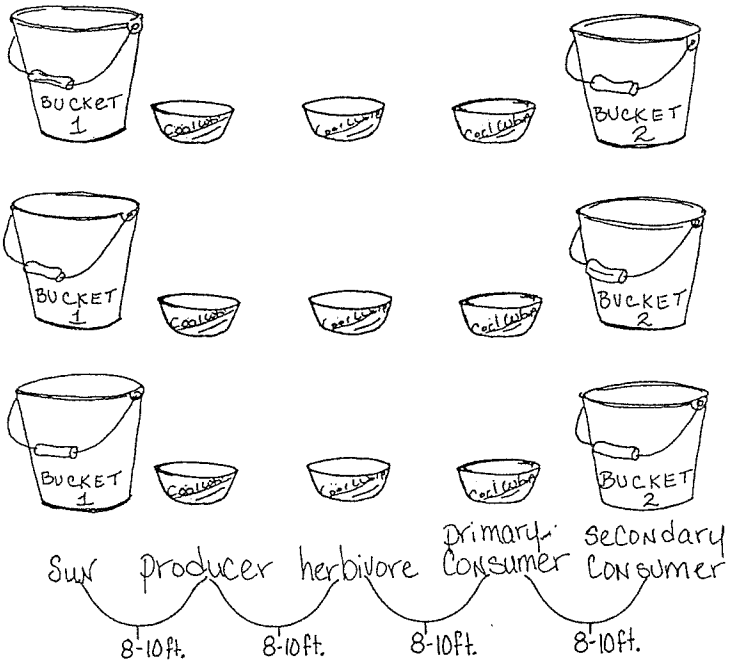
1. To investigate the energy flow in a wetland food chain.
2. To investigate how energy is transformed and not lost.
3. To investigate how organisms use the energy they obtain.
4. To investigate how the energy organisms use comes from the sun.
5. To investigate the importance of producers in a food chain.

MATERIALS:

6 buckets (approximately 5 gallons)
12 cool whip containers (the same size)
ice pick or small nail
large area outside (at least 50 feet in length)
water
"Wetlands as Ecosystems" fact sheet

PROCEDURE:

1. Use the ice pick or nail to poke small holes in the cool whip containers. These holes allow water to drain out, representing the energy that is used in moving to the next level of the food chain.
2. Arrange the buckets and cool whip containers like the diagram below. This is a "wet" activity and should be done outside. There will be one extra cool whip container for each group.



3. Fill only the first bucket from each group (the sun bucket) with water and record the volume of water in your data table. The first bucket represents the sun and the water in this bucket represents the energy from the sun that reaches the earth.

This activity was submitted by Deborah Moroney, MAREX, Skidaway

4. Each of the cool whip containers and the last bucket represent organisms in a wetland food chain. Name an appropriate organism for each link in your food chain and record this information in question 1 of your observations. An example is as follows:

algae	--->	amphipod	--->	small fish	--->	big fish
producer		primary consumer		secondary consumer		tertiary consumer

5. Select your three teams. Teams should consist of 5 students each. The remainder of the students should observe along the sidelines. Each team should line up in single file behind their first bucket (the bucket filled with water).
6. Give the first student in each team the extra cool whip container. When given a signal by your teacher, this student fills the cool whip container with water from the bucket and as quickly as possible moves to the next cool whip container.
7. Pour the water from the first cool whip container into the second container. Pick up the second container and as quickly as possible move to the next container. Leave the empty container where you picked up the second one. Repeat this process with each of the cool whip containers.
8. When you reach the last bucket, quickly pour what little water is left into the bucket and quickly carry the empty container back to the next student in line. (If your container has no water left in it, go to the bucket and pretend to pour the water in before returning to your group).
9. Continue this procedure with each student until the first bucket is empty.
10. Measure the volume of the water that was transferred to the last bucket and record this information in your data table.

OBSERVATIONS:

Data Table:

	Volume of H_2O in Bucket 1	**Volume of H_2O in Bucket 2**
Team 1		
Team 2		
Team 3		

1. Name the organisms in a wetland food chain:

_____	---->	_____	---->	_____	---->	_____
producer		primary consumer		secondary consumer		tertiary consumer

2. How much water was there in the first bucket? _____ How much water was transferred to the last bucket? _____ Based on these results, what fraction or percent of the sun's energy was transferred to the fish? _____
3. In a natural food chain, with the same number of organisms, do you think more or less energy gets transferred to the fish than what we obtained in this activity? _____ What would we need to change in this activity in order to represent the fact that in nature less energy gets transferred to the fish?

This activity was submitted by Deborah Moroney, MAREX, Skidaway

If we start with 5 gallons of water and we want to imitate what happens in nature, how much water would be transferred to the last bucket?

4. What are some forms of energy?
   In what form does the sun's energy reach the earth?

5. Does all of the sun's energy that reaches the earth get used by plants? _____
   What happens to the rest of it?

6. How do organisms use the energy they consume?
   Do all organisms use the same amount of energy?
   How would we represent using varying amounts of energy in this activity?

7. Since the amount of water in the last bucket was less than what was in the first bucket, not all of the sun's energy that reaches the earth is transferred to the big fish. What happened to the rest of the sun's energy?

   Is the energy lost or is it transformed?
   Into what forms does the sun's energy transfer into?

8. If energy is not lost and nothing eats the big fish, what happens to the energy stored in the big fish?

9. Do consumers obtain more energy from eating plants or animals?
   How could this activity be changed to answer this question?

10. Why are producers important?

11. Name some other wetland food chains.

CONCLUSIONS: Explain how energy from the sun flows through a wetland food chain. Describe how organisms use this energy and the fact that energy is transformed and not lost. Explain the importance of producers in the wetland food chain.

Extensions: Repeat this activity using fewer containers to represent two or three organisms in the food chain. (In this activity there were 4 organisms in the food chain)

This activity was submitted by Deborah Moroney, MAREX, Skidaway

OSMOTIC PRESSURES ON ORGANISMS IN AQUATIC ENVIRONMENTS

PURPOSE: To investigate the water stresses experienced by organisms exposed to varying types of aquatic environments.

MATERIALS:
Adaptations of Wetland Animals Fact Sheet
2.5 cm dialysis tubing
200 ml graduated cylinder
6 plastic cups or beakers
distilled water
balance (any type of scale)
paper towels
sucrose solutions (.2 M, .4 M, .6 M, .8 M, 1.0 M)
grocery store sucrose works fine (see recipe in appendix)

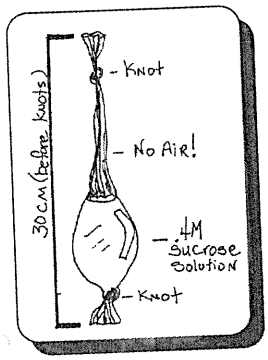
BACKGROUND INFORMATION:

The ability of both freshwater and saltwater organisms to maintain a proper water balance within their bodies is called osmoregulation. Osmoregulation is related to the process of osmosis. Osmosis is the movement of water molecules from an area of high concentration to an area of low concentration through a semipermeable membrane.

PROCEDURE:

For each group of students:

1. Cut six 30 cm long strips of 2.5 cm dialysis tubing and **soak in water overnight.**
2. Tie a knot in one end of each of the dialysis strips and fill each tube with .4M sucrose solution.
3. Next, tie a knot in the other end of each tube. Before tying the knot, squeeze out as much air as possible. Be sure to leave some space between the knot and the solution. Each of these sucrose filled tubes represent an organism.
4. Rinse and carefully blot the **outside** of each tube.
5. Weigh each tube (organism) and record this initial mass in your data table.



6. Fill the six plastic cups (or beakers) with approximately 200 ml of the following solutions
   (a) distilled water
   (b) .2 M sucrose
   (c) .4 M sucrose
   (d) .6M sucrose
   (e) .8 M sucrose
   (f) 1.0 M sucrose

(These cups represent aquatic environments with varying solute concentrations analogous to conditions in fresh water, estuarine, and marine habitats.)

This activity was submitted by Cheryl Gibson, Woodward Academy

7. Submerge each tube into one of the six solutions and allow to stand for 30 minutes.
8. During the standing time the students should read the Background Information and the Adaptations of Wetland Animals Fact Sheet.
9. At the end of the standing time, remove each tube (organism) and blot carefully.
10. Immediately weigh each tube to determine its final mass. Record the final mass of each tube organism in your data table. Be sure to record + and - signs to indicate mass gain or loss.

OBSERVATIONS:

Data Table:

	Distilled water	.2 M Sucrose	.4 M Sucrose	.6 M Sucrose	.8 M Sucrose	1.0 M Sucrose
Initial Mass						
Final Mass						
Mass Gain (+) or Loss (-)						

Answer the following questions:

1. Which organism(s) experienced a net osmosis which caused them to gain water from their surroundings?

   Explain why this was so.

2. Which organism(s) experienced a net osmosis which caused them to lose water to their surroundings?

   Explain why this was so.

3. List any organism(s) that neither lost nor gained water to or from its surroundings?

   Explain your answer.

This activity was submitted by Cheryl Gibson, Woodward Academy

4. Which situation(s) most closely resembles the osmotic conditions experienced by a freshwater wetland organism?

   Explain your answer.

5. Which situation(s) most closely resembles the osmotic conditions experienced by an estuarine organism?

   Explain your answer.

6. Which situation(s) most closely resembles the osmotic conditions experienced by an organism in the salt marsh?

   Explain your answer.

7. Which situation(s) most closely resembles the osmotic conditions experienced by an intertidal organism at low tide during a heavy rain?

   Explain your answer.

8. Which situation(s) most closely resembles the osmotic conditions experienced by an intertidal organism in a tide pool on a hot, sunny day?

   Explain your answer.

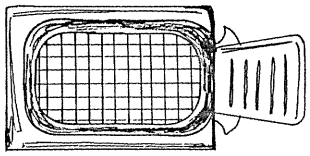
CONCLUSION: Explain what osmosis is and suggest what might cause changes in the osmotic balance of wetland aquatic organisms. How are wetland organisms adapted for maintaining osmotic balance?

This activity was submitted by Cheryl Gibson, Woodward Academy

USING MILLIPORE SAMPLERS TO TEST FOR BACTERIA IN WETLAND WATERS

PURPOSE: To investigate the presence of bacteria in wetland waters.

MATERIALS:
sterile glass jars for collecting water samples
water from wetland areas
Millipore samplers (see note below)
waterproof marker
incubator (or some means of maintaining a constant temperature)
colony count comparison chart or microscope



Note: Millipore samplers provide a means for simple, fast, and inexpensive microbiological analyses of environmental waters. Three types of samplers are available; Coli-Count Sampler, Yeast and Mold Sampler, and Total Count /MHPC Sampler. For this activity, I recommend using the Coli-Count (blue) and/or the Total Count Sampler (white). Millipore samplers are available from Carolina Biological Supply Company. See appendix for the address and phone number.

BACKGROUND INFORMATION: The following background information has been modified from the Field Testing Manual for Water Quality, Fisheries Education Unit #18 Produced by The Education Division Department of Marine Resources, State House Station #21, Augusta, Maine, 1989.

There are four different types of bacteria:

1. Saprophytic bacteria are "decomposers" in nature because they feed on dead organic matter. The decomposition process requires large volumes of oxygen and frees nutrient material.
2. Commensal bacteria obtain their food from a living animal but in the process provide a service to the organism. The bacteria found in the intestines of animals that aid in digestion are commensal.
3. Parasitic bacteria are usually pathogenic as they live off another organism and reduce the health of that organism. These bacteria get into water through animal waste and are dangerous to the health of others.
4. Autotrophic bacteria make their own food from simpler inorganic substances. Some of these bacteria contain chlorophyll and carry out photosynthesis. Others of these bacteria utilize sulfur and iron in an anaerobic environment to produce food.

Pathogenic bacteria in water are usually low in concentrations, difficult to test for and dangerous. However, tests for commensal coliform bacteria are relatively easy to conduct, and since they also come from animal waste they can be used as an indicator of potential pathogens.

Coliform bacteria are found in the intestines of both warm and cold blooded animals. Fecal coliform bacteria by themselves are not pathogenic (they do not cause disease). However, people infected with disease can pass them off along with the fecal coliform and these can cause severe illnesses. All these bacteria can enter the water body through runoff from land or from sewage. Therefore, a positive test for coliform bacteria requires a second test for fecal coliform to determine if it came from warm or cold blooded animals.

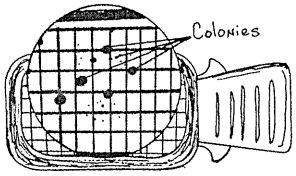
The idea for this activity was submitted by James Jackson. Input was also given by Cheryl Gibson.

PROCEDURE:

1. Collect water samples from various wetland areas. The samples should be collected in sterile glass jars. You can sterilize your collecting jars or containers by placing them in a pressure cooker at 15 pounds of pressure for 15 minutes. Samples should always be taken below the surface of the water and in the current if there is one.
2. Remove the Sampler from its plastic bag and write on the case with the waterproof marker the date, type, location of the sample.
3. Pour the water sample to be tested into the Sampler case. Fill to the upper graduation (18 mL).
4. Insert the Sampler paddle firmly and quickly into the case containing the water sample. Shake several times, then hold the case still for 30 seconds.
5. After 30 seconds, remove the paddle and, with a firm snap of the wrist, shake off the excess liquid. Firmly, reinsert the paddle into the case.
6. Incubate the Sampler gridded side down. If you are using the Coli-Count Sampler, incubate at 35°C for 22-24 hours. If you are using the Total Count Sampler, incubate at 25°C-35°C for 48-72 hours.
7. After incubation, use the colony count comparison chart or a microscope and count the bacterial colonies.
8. To count the bacterial colonies: The colonies that grow on the surface of the Sampler during incubation are counted as individual organisms. You can make a rapid estimate of your counts by comparing the test colonies to those illustrated on the comparison chart. (In recording your count when using the Coli-Count Sampler, count only the blue colonies. Coliform and fecal coliforms are always reported as the number per 100 mL sample. Your sample is for 1 mL, so multiply the number of colonies by 100).

OBSERVATIONS:

Data Table:



Date	Type of Wetland	Location of Wetland	# of Bacterial Colonies

1. Which location(s) or wetland(s) had the bacterial colonies present?

2. What do you think might be the source of the bacteria (be sure you have read the background information)?

[Be sure to report any high concentrations of bacteria to the water authority]

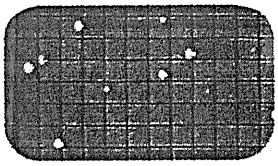
CONCLUSION: Explain how bacteria can get into wetland waters.

The idea for this activity was submitted by James Jackson. Input was also given by Cheryl Gibson.

COLONY COUNT COMPARISON CHART

Directions: To obtain approximate count, align Sampler with the photo showing the same density of colonies.

FOR SMALL COLONIES



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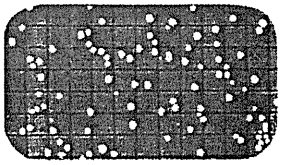

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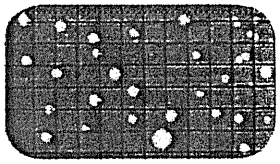

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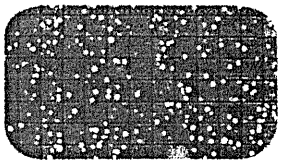

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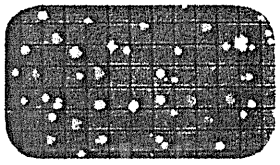

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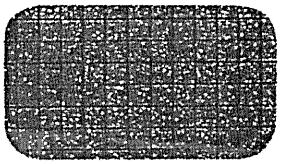
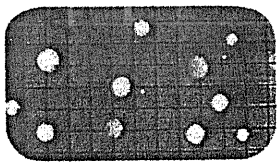


TNTC*
Too numerous
to count

FOR LARGE COLONIES



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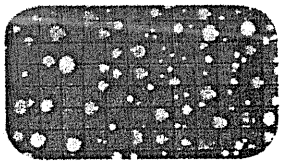

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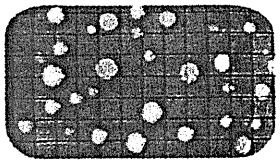

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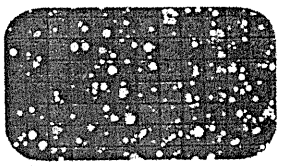

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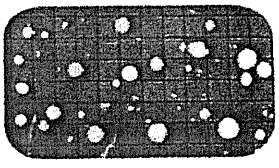

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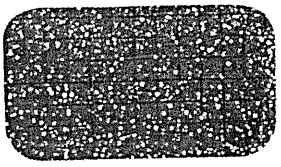


TNTC*
Too numerous
to count

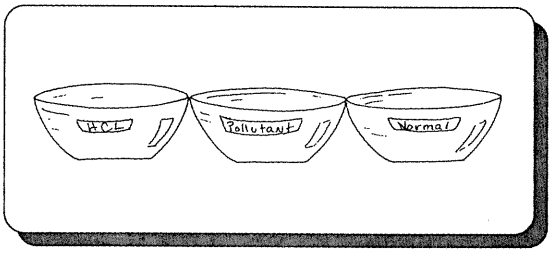
The idea for this activity was submitted by James Jackson. Input was also given by Cheryl Gibson.

POLLUTION IN THE WETLANDS

PURPOSE: To investigate the effects of pollution on animals that live in the wetlands.

MATERIALS:
salt
distilled water
brine shrimp eggs (available from science supply companies)
3 small glass bowls
stirring rod (spoon)
hydrochloric acid (HCl can be obtained from local high school)
dish detergent
large beaker
Microscope

PROCEDURE:



1. In a large beaker mix 18 ml of salt in 300 ml of distilled water to make a 6% solution of sodium chloride (6 ml of salt to 100 ml of distilled water = 6% solution).
2. Label each of the three bowls as follows: HCl, Pollutant, and Normal
3. Pour 100 ml of this solution into each of the three glass bowls.
4. Put a drop of brine shrimp eggs into each bowl of water.
5. Add one drop of HCl to the bowl labeled "HCl". Add one drop of the dish detergent to the bowl labeled "Pollutant". The bowl labeled "Normal" is your control.
6. Observe each bowl under the microscope and record your observations.
7. Put the three bowls away in a safe place.
8. After 24 hours, observe each bowl under the microscope. Record your observations.

OBSERVATIONS:

	Bowl with HCl	**Bowl with Pollutant**	**Control**
Original observation			
After 24 hours			
After 48 hours			

Answer the following:

1. Describe what happened in each of the three bowls after 24 hours.

2. Describe what happened in each of the three bowls after 48 hours.

3. How quickly are the brine shrimp affected by pollutants and acid?

4. Coastal estuaries are wetlands that serve as nursery grounds for most of the animals that live in the ocean. How concerned should you be about pollution in wetlands? Explain your answer.

5. How would or could larger animals like birds, mink, otters, humans, etc. be affected by pollution in the wetlands?

CONCLUSION: Explain why it is important that we keep our wetlands free of pollution. Explain how pollution in the wetlands could have a far reaching effect on other organisms that are dependent on wetlands for their survival.

COASTAL BIRDS AS INDICATORS OF POLLUTION

PURPOSE:

1. To recognize that birds act as indicators of pollution because of their sensitivity to environmental change.
2. To identify reasons why people should monitor toxic substances and pesticides used in their homes.
3. To investigate how hazardous marine debris can be to waterfowl.

MATERIALS: plastic sweater boxes (enough for each group of students)
water
gummy fish (goldfish crackers or "Snorklers" will also do)
rigid drinking straws (one for each student)
watch with second hand or stopwatch
small rubber bands (one for each student)

Note: The rubber bands should be a size that will fit snugly over the thumb and little finger when stretched over the back side of the hand.

BACKGROUND INFORMATION:

Coastal estuaries perform many functions. Among these functions is the fact that they provide essential habitat for about 75 percent of all the waterfowl that migrate across the United States. Although migratory birds cannot call the brackish water habitat their permanent home, it provides nourishment for their continued existence. So in addition, estuaries support large populations of shorebirds, colonial nesting seabirds, and many other forms of food for these feathered beauties.

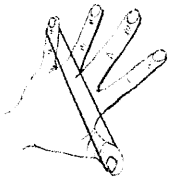
Southern estuaries supply about half of all the fish and shellfish produced in the United States. Most of these species of fish, shrimp, oysters, and other shellfish spend part or all of their lives in these brackish environments. Many marine species use estuaries as nurseries, and they depend on the different levels of salt concentrations to guide them to and from the nursery areas. It is no "small" wonder that water birds hang-out in this fertile area.

Freshwater inflow is a critical element in the health existence of estuaries. Freshwater inflows bring the essential nutrients that are the first level (microscopic phytoplankton) of the estuarine food chain. Too many nutrients can be harmful. Nutrients are found in fertilizers, detergents, sewage, and other substances. They are carried by rivers, streams, and rainwater into the estuaries. These toxic substances and pesticides can pose immediate death, or can accumulate in animal tissues to harm the food chain, including water birds. Some of these toxic nutrients can place future generations at risk.

This activity was submitted by Rodie Higginbotham

PROCEDURE: For Teachers Only

1. Tell the students to fill the plastic container about half full of water. Explain to the students that this water-filled container represents the estuary.
2. Tell the students that they are to pretend that they are Great Blue Herons. Explain that Blue Herons are wading birds and do not swim.
3. Give each student a straw and explain that the straw represents the Blue Heron's beak. Explain that in order to feed, they must spear their food. It has been recorded that Great Blues can thrust their beak into the water so fast that it will blur a photograph taken at 1/1000 second shutter speed.
4. Tell the students that since they are Blue Herons, they will not be able to use their hands. They should hold their hands behind their back while they are "fishing". Explain that they will need to figure out how to use the straw as a beak to catch their fish.
5. Explain to the students that the Blue Heron is a solitary hunter, so only one of them can feed at the time. Tell the students that they will each have 30 seconds in which to catch as many fish as possible. The fish in this case are represented by the Gummy fish or goldfish crackers, etc.
6. One student in each group is to act as the timer while the others take turns "fishing". The timer can fish after all others in their group have had a turn.
7. Each group should place their "estuary" (the water-filled container) in the center of their table.
   Blue Herons are wading birds and wade in the shallow edges of the estuary, so they should stand around the table and be ready for their turn.
8. The timer will indicate when each "heron" should start feeding. Each student has 30 seconds in which to feed (they have caught a fish when they are able to get it out of the water and onto the table surrounding the plastic container). Each student in each group should have a turn - including the timer.
9. Tell the students that they should continue taking turns feeding until time is called (you decide on the time) or until at least one member of each group has caught three fish.
10. After time is called, have the students divide into three separate groups; those who caught three fish, two fish, and zero or one fish.
11. Give the students that caught three fish a short eulogy. Tell them that you are sorry that they died, but that the fish they ate had too many toxins in them. Tell them that they died quickly.
12. Tell the group that caught two fish that toxic substances accumulated in their tissues so that their eggs will not hatch; therefore, their future generations are at risk.
13. Probably no further explanation will be necessary, but you can continue on and tell the group that caught only one fish that they will probably be all right because they did not eat enough of the contaminated fish to hurt them. Tell the students that caught no fish that they will be OK this time, but they will need to eat in order to survive.
14. Allow a minute for what you have told the students to sink in.
15. Give each student a small rubber band. They should lay the palm of their left hand flat on the table and hold up their thumb and little finger. They should stretch the rubber band over these two fingers. Next, they should place their other hand behind their back. Tell the students that this represents a marine or wetland animal that has become entangled in fishing line or a six-pack plastic ring . Now, tell the students to try to remove the rubber band.



This activity was submitted by Rodie Higginbotham

After completing the activity, answer the following questions:

1. How did it feel to be the ones to catch the most fish?

2. How did it feel when you realized that by catching the most fish, you would die?

3. Since birds are unable to distinguish between contaminated and non-contaminated fish, how can this situation be prevented from happening?

4. What types of contaminants do you think can cause this type of problem with birds?

   Where do these types of contaminants come from?

5. Is there anything that you, personally, can do to help prevent this situation from occurring?

   Explain your answer.

6. The Brown Pelican and Bald Eagle became endangered because of DDT that got into the water from runoff from agricultural farm land. After it was discovered that DDT was responsible, laws were passed to prevent its use. Do you think this was a good idea?

   Has it worked? (You may have to do some research or ask you teacher about this).

7. Were you able to remove the rubber band from the back side of your hand?
   If so, was it easy or difficult?

   If not, why do you think you were unable to remove it?

8. Do you feel that this activity accurately represents a problem that is occurring along our coastal waters and in our wetlands.
   Explain your answer.

   Is there a solution to this problem? Explain your answer.

9. How do you think that birds act as indicators of pollution?

CONCLUSIONS:

In a paragraph, explain how birds act as indicators of pollution. Give reasons why you and others should monitor toxic substances and pesticides that are used in your homes. Discuss how such things as fishing line, plastic rings, etc. can be a danger to marine and wetland animals.

This activity was submitted by Rodie Higginbotham

ACID POLLUTION Vs WETLAND PLANT GROWTH

PURPOSE: To investigate how acid pollution can affect the growth of duckweed.

MATERIALS:

- duckweed plants
- 4 large coolwhip or butter containers
- measuring cup or graduated cylinder
- bucket
- baking soda
- masking tape
- waterproof marker
- tweezers
- spoon or stirrer
- apple juice
- lemon juice
- tomato juice
- clear marsh water (fresh)
- pH paper

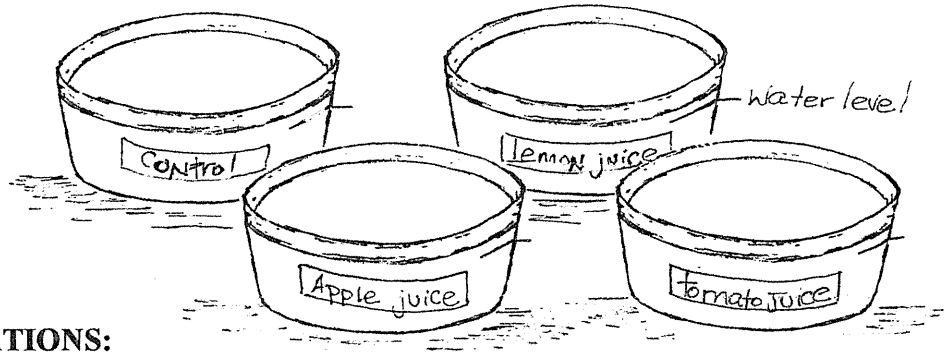
BACKGROUND INFORMATION: Duckweed is a very common plant that grows on the surface of the still water of freshwater ponds or marshes. It is one of the smallest flowering plants in the world and one of the fastest spreading plants in a wetland. These tiny plants not only reproduce by seed but send out shoots that break off and grow into additional plants. The duckweed absorbs all the nutrients it needs from the water on which it grows. Duckweed serves as a food source for waterfowl and insects. Some wetland plants and animals are very sensitive to rising acid levels. Acid pollution may be caused by emissions from automobiles and other machinery, burning coal for the production of electricity, and smoke emissions from some factories. Some marshes have limestone rock below their mud. Limestone is alkaline and it helps reduce the effects of acid pollution. The pH of a liquid indicates the relative number of hydrogen and hydroxide ions in acids and bases. On the pH scale, a measure of 7 is neutral, below 7 is acidic and above 7 is basic.

PROCEDURE:

**** ***This should be done prior to conducting this activity:*** Find a freshwater marsh or pond that has duckweed and use a bucket to collect the duckweed and some clear marsh or pond water.

1. Pour one cup (250 ml) of marsh or pond water into each of the four coolwhip containersor butter tubs.
2. Use masking tape and a waterproof marker to label each container as follows: control, apple juice, lemon juice, tomato juice.
3. Add 1/2 cup (125 ml) of each juice to the container marked for that juice and mix well. Add 1/2 cup (125 ml) of marsh water to the container labeled control. (You have the same amount of liquid in each container).
4. On the outside of each container, mark the water level. You will need to add more water to each container as the water evaporates (including your control).
5. Use the pH test paper to check the pH of the water in each container.
6. Use tweezers to place 12 duckweed plants in each of the four containers.
7. Place the four containers in an area where they will receive plenty of sunlight.
8. Observe the duckweed plants every two days for a period of 8 days. Count the number of plants in each container and record the information in your data table.

9. After 12 days, add one teaspoon (5 ml) of baking soda to the apple, lemon, and tomato juice containers. Observe every 2 days for a period of 8 days. Record your observations.
10. If you have a refrigerator available, place the containers in it for a couple of weeks, then record the number of plants in each. (This would represent fall/winter growing conditions)



OBSERVATIONS:

Data Table:

Container	Original pH	Original # plants	# plants Day 2	# plants Day 4	# plants Day 6	# plants Day 8	pH after bak. soda	# plants Day 10	# plants Day 12	# plants Day 1 4	# plants Day 16
Control											
Apple juice											
Lemon juice											
Tomato juice											

Prepare a bar graph representing the plant growth information from the table above.

Answer the following questions:

1. What did the juice in the containers represent?
2. In which container were there more plants after the first 8 days?
3. Rank the containers according to the number of plants after 8 days, from the highest to the lowest number.

4. Which juice do you think contained the most acid?
   Explain your answer.

5. Which juice contained the least acid?
   Explain your answer

6. What effect did the amount of acid in each container have on the growth of the duckweed plants?

7. Baking soda is alkaline. What effect did the baking soda have on the growth of the duckweed?

   Did the baking soda totally eliminate the acid in each container?

   What would the baking soda represent in nature?

8. List as many sources of acid as you can think of that may have an effect on the waters in wetlands.

9. Explain what happened to the rate of growth of the duckweed plants after they were placed in the refrigerator. (That is, if you did this part).

CONCLUSIONS: Discuss the effects of acid pollution on the growth of duckweed. Relate this to the effect of acid pollution on all wetland plants.

WETLAND WHEELS FOR FRESHWATER WETLAND HABITATS

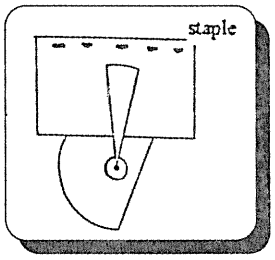
OBJECTIVE: To recognize and classify invertebrates common to freshwater wetlands.

MATERIALS:
Copies of all parts of the three freshwater wetland wheels
cardstock or some kind of stiff paper
scissors
glue stick
stapler
straight pin or nail
3 round head paper fasteners
transparent contact paper or laminating paper (& machine)
metal key ring or cord

BACKGROUND INFORMATION: See "Where do you look to find freshwater animals?"

PROCEDURE:

1. Photocopy materials for wetland wheels 1, 2, and 3. If possible, photocopy them onto cardstock. If cardstock is not available, make regular copies (these will have to be glued onto manila folders). You may want to use a different color for each wheel.
2. Cut out the wheel cover front, wheel cover back, outer wheel, and inner wheel for each wheel to be constructed.
3. Laminate all pieces or cover with transparent contact paper.
4. Staple the wheel covers, front to back, along the top. Make sure to match the dark center circles.
5. Use a straight pin or nail to poke a hole through the small dark center circle (do not use a hole punch, the hole will be too big).
6. Place the inner wheel on top of the outer wheel and insert them into the wheel cover. Match up the center circles. Use the straight pin, nail, or point of scissors and carefully poke a hole through all thicknesses.
7. Secure all four pieces together with a round head paper fastener.
8. Make a hole (you can use a hole punch for this one) in the upper left hand corner of your wheel.
9. Repeat steps 2 - 8 for each wheel.
10. Use a hole punch and make a hole in the upper left corner of each wheel cover. Connect all three wheels with a key ring or piece of chord.
11. Take your wheels with you when you visit a wetland.



OBSERVATIONS: Record all the invertebrates you find in each wetland you visit.

CONCLUSIONS: Discuss the diversity of invertebrate animals that you find in the wetlands.

The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Where Do You Look to Find Freshwater Animals?

Looking across a lake, stream, or river, we may first think of visible residents, like waterbirds, or of edible ones, like fish. Some of us may even think of turtles, snakes, beavers, and otters. But much closer at hand, and easier to hold in the hand, is a vast community teeming with fascinating and bizarre creatures. I refer to freshwater invertebrate animals.

Fully half of all animal phyla - about 16 - can be found in freshwater habitats. A few - rotifers, gastrotrichs, nematodes (roundworms), and waterbears - require a microscope to see. The rest - sponges, hydras/jellyfish, flatworms, gordian (horsehair) worms, ribbon worms, moss animals, molluscs, annelids, and arthropods (as well as small vertebrates) - are all common, visible, and easy to collect in the southeastern USA.

A successful search for these creepy-crawlies requires a little, but not much, preparation. The intrepid searcher needs to obtain some small, clear containers (plastic jars or bottles, pudding cups). Because some of these creatures are small, a hand magnifying lens is very useful, and a flashlight, for shady areas. Hand-held aquarium nets will catch larger animals, and fine-mesh (infusoria) nets or "professional" collecting nets will capture more and smaller animals. Plastic water droppers, forceps (tweezers) for handling, and shallow, white porcelain pans for viewing dark animals can also be helpful.

It is easy to collect specimens along the margins of lakes and ponds, and throughout streams and wetlands (bogs, marshes). All taxonomic groups can be found in the shallow waters of ponds. Many are freeswimming in clam waters. Many crustaceans have anti-predator swimming patterns, and will evade nets with an opening less than 30 cm. Both in ponds and in streams, animals can be found associated with rooted and floating plants and algae, in packs of dead leaves, and on sticks, logs, stumps, and rocks. Every surface is important. Collect samples of gravel, sand, and mud to sift for burrowing types.

In streams, there are two major habitat types: riffles and pools. Riffles include rocky areas where water flows rapidly with cascades (i.e., rapids, waterfalls); even woody obstructions could be perceived as riffles by aquatic animals. Pools are areas of slow flow, especially at turns, or corners of streams. Large rivers also have regions of linear flow.

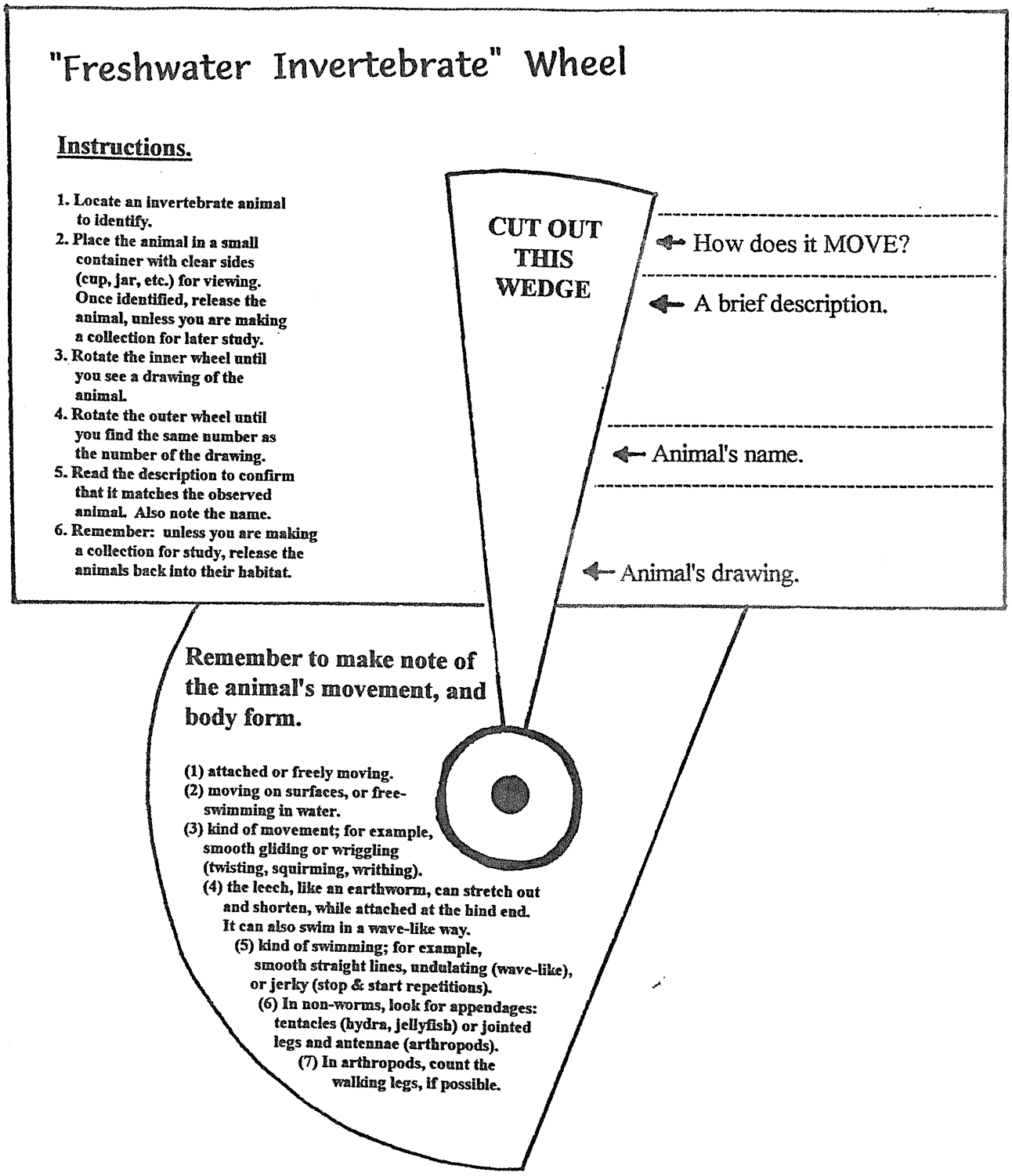
Along the margins of both flowing and standing waters, vegetation may grow below the waterline (submerged), up from under water (emergent), and floating on the water. Also, dead trees and rocks may be partially submerged and on shore. Waterside soils may be saturated, and indeed, alternate between being submerged and exposed, depending on recent rainfall and runoff.

So, ultimately, one can look for small, freshwater animals in any habitat with fresh water.
Examine the water column, using a net. Examine all plants: submerged, emergent, floating, and waterside. Observe other structures, such as deadwood, leafpacks, rocks, and sediments. Some animals specialize in living on the surface film, such as whirligig beetles. In other words, look everywhere, closely.

Another frequently overlooked aspect of collecting is the importance of STANDING STILL AND BEING QUIET, for up to five minutes at a spot. Many small animals have a "stop and freeze" response to large moving objects (like people) and noises (like talking). So, if you act like you're in town, you may miss the smaller wildlife. Practice patience; its fun.

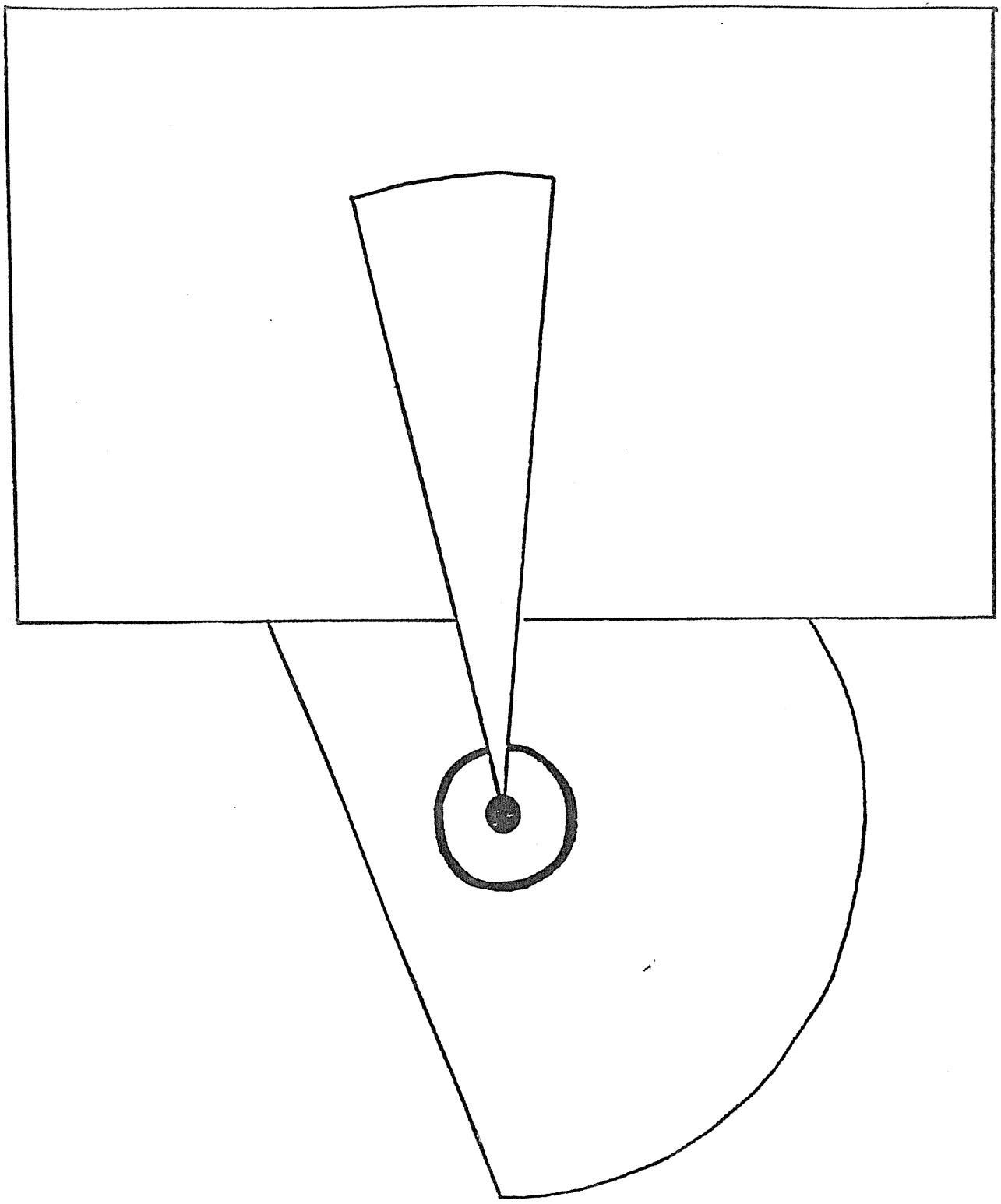
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Invertebrate Wheel : Wheel Cover - Front



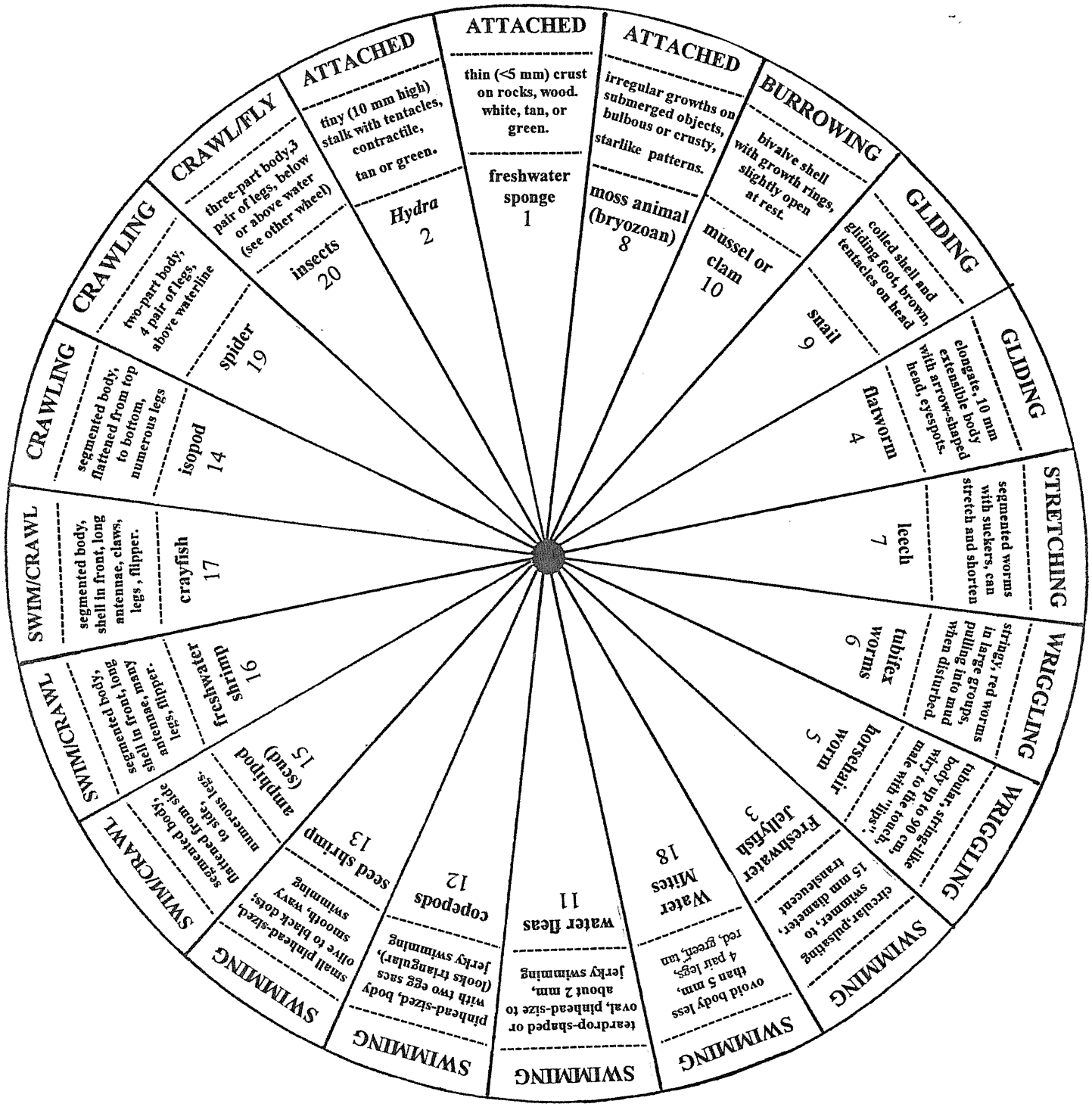
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Invertebrate Wheel: Wheel Cover - Back



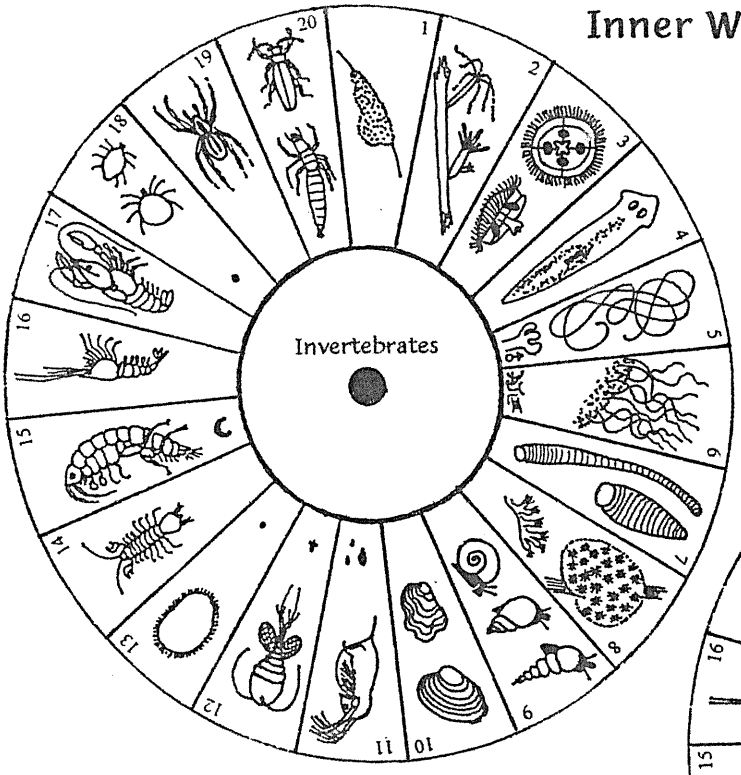
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Invertebrate Wheel : Outer wheel

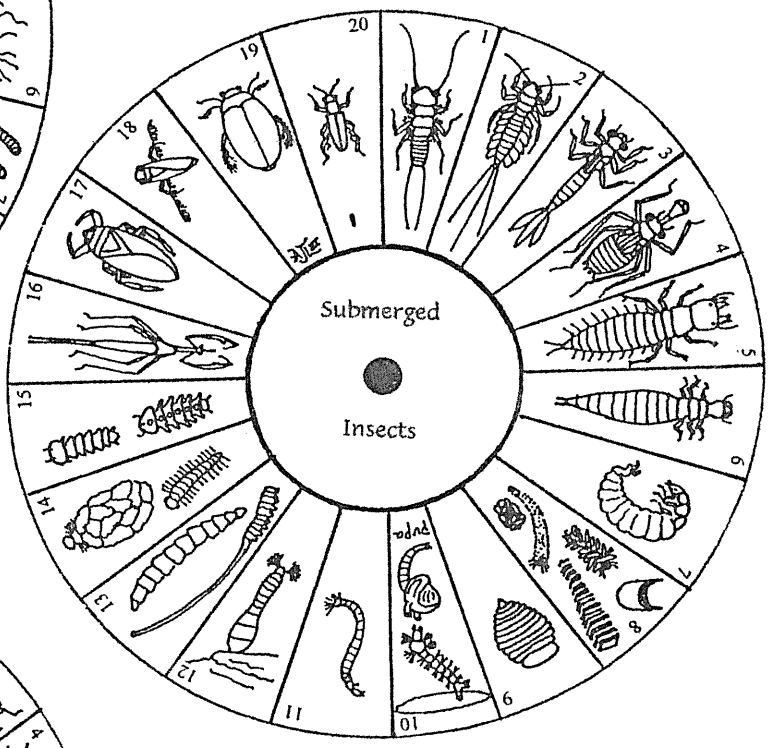


The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Inner Wheels



Invertebrates

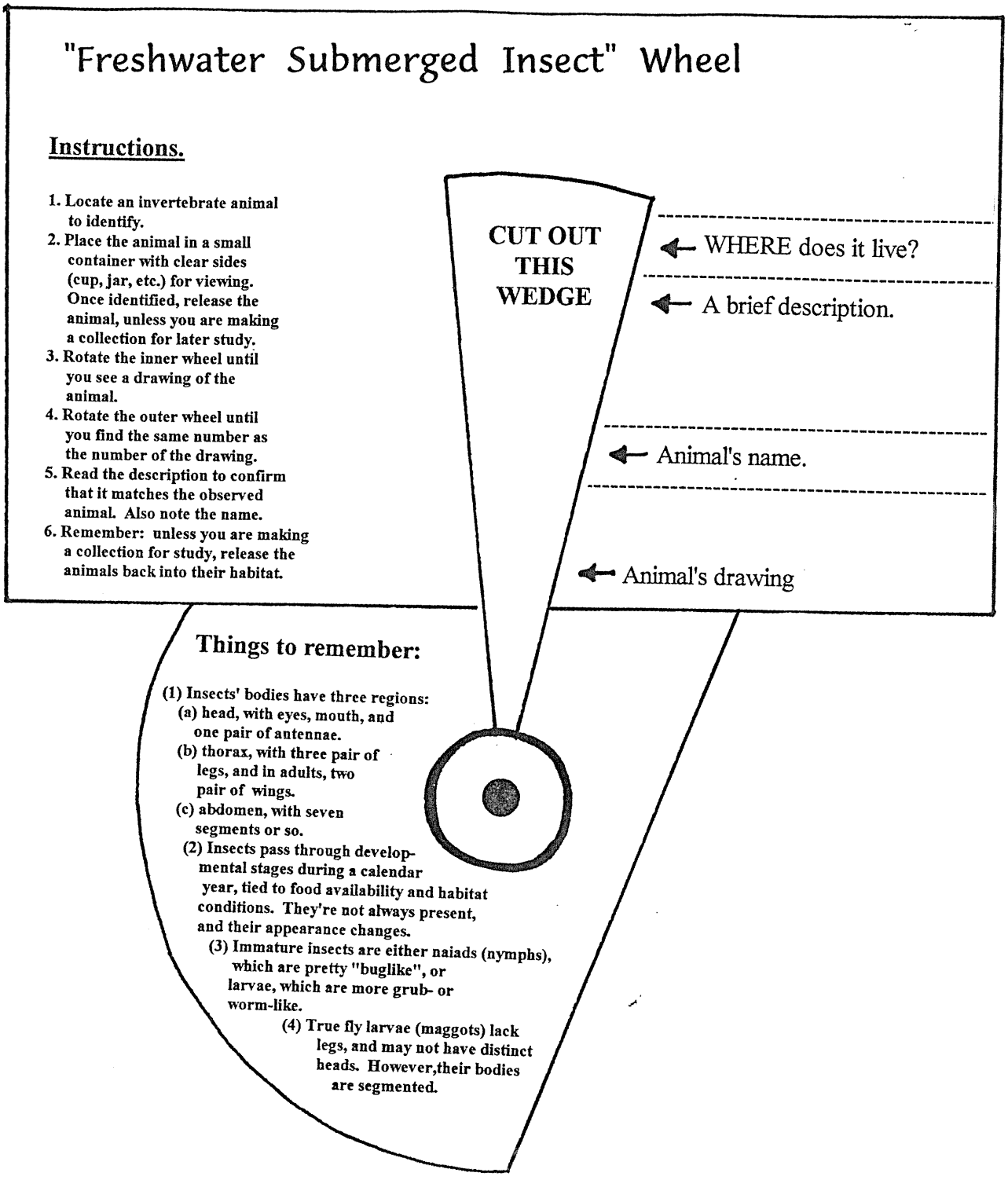


Submerged Insects

Above Water

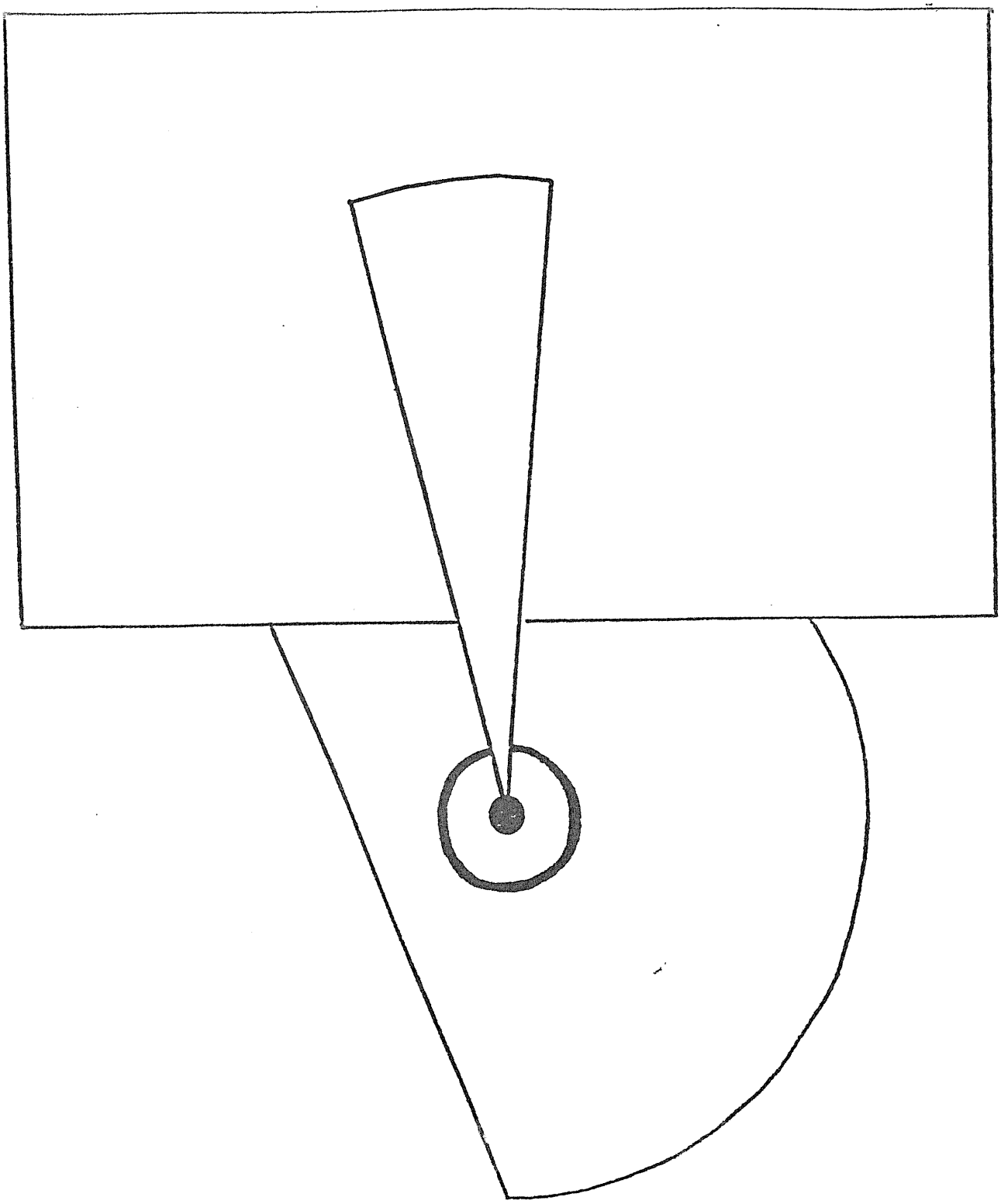
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Submerged Insect Wheel : Wheel Cover - Front



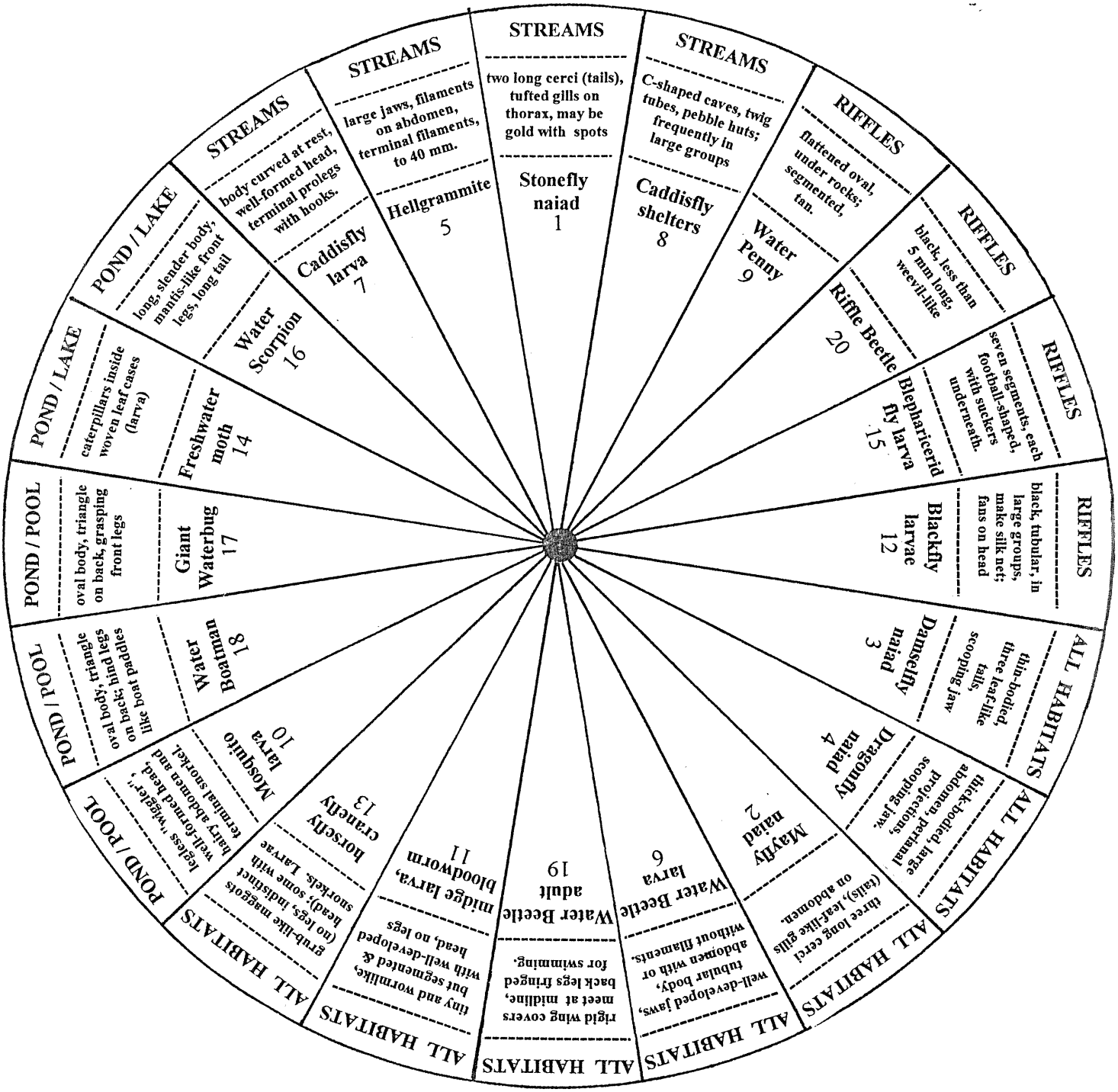
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Submerged Insect Wheel : Wheel Cover - **Back**



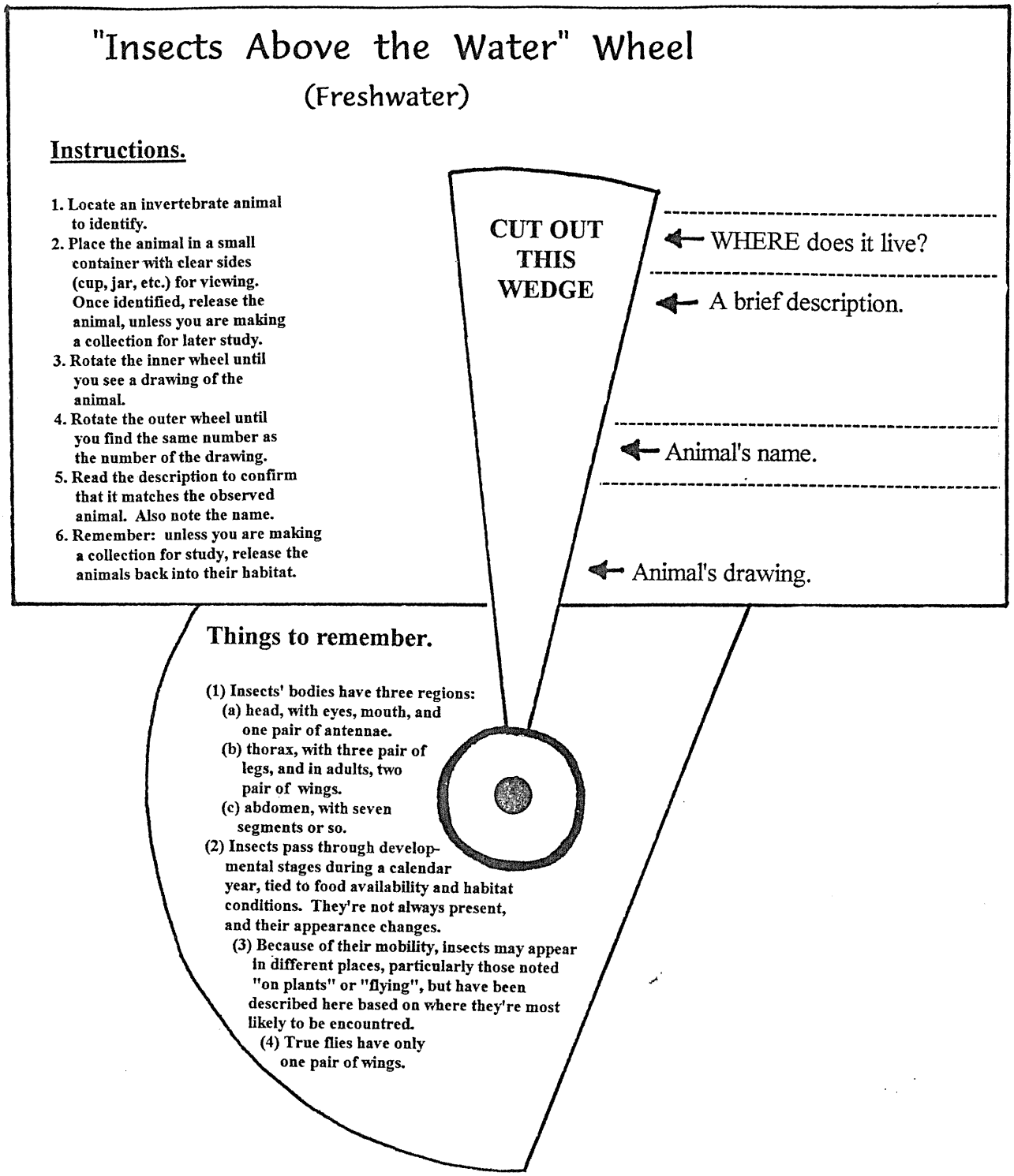
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Submerged Insect Wheel : Outer Wheel



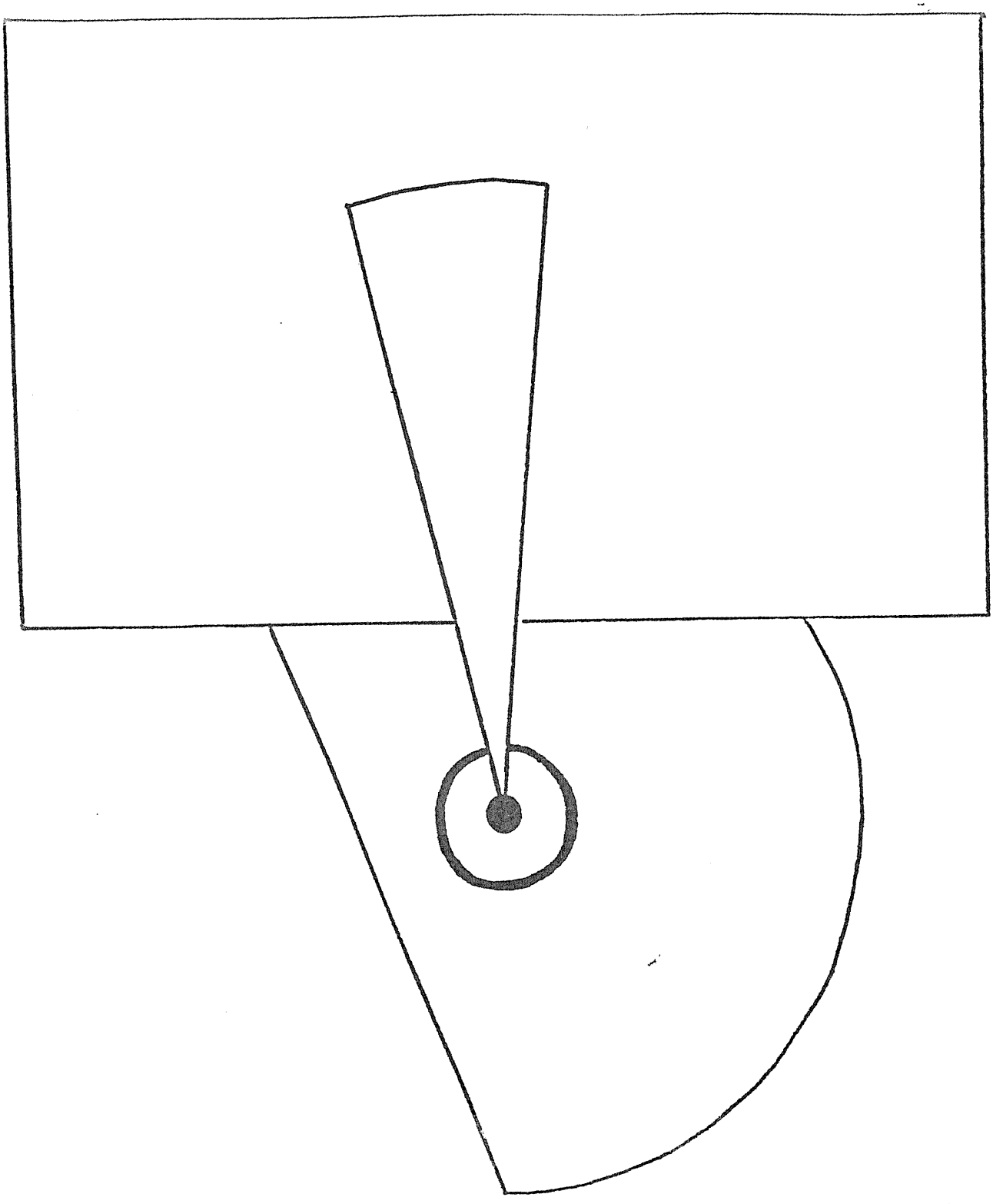
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Insects Above the Water Wheel: Wheel Cover - Front



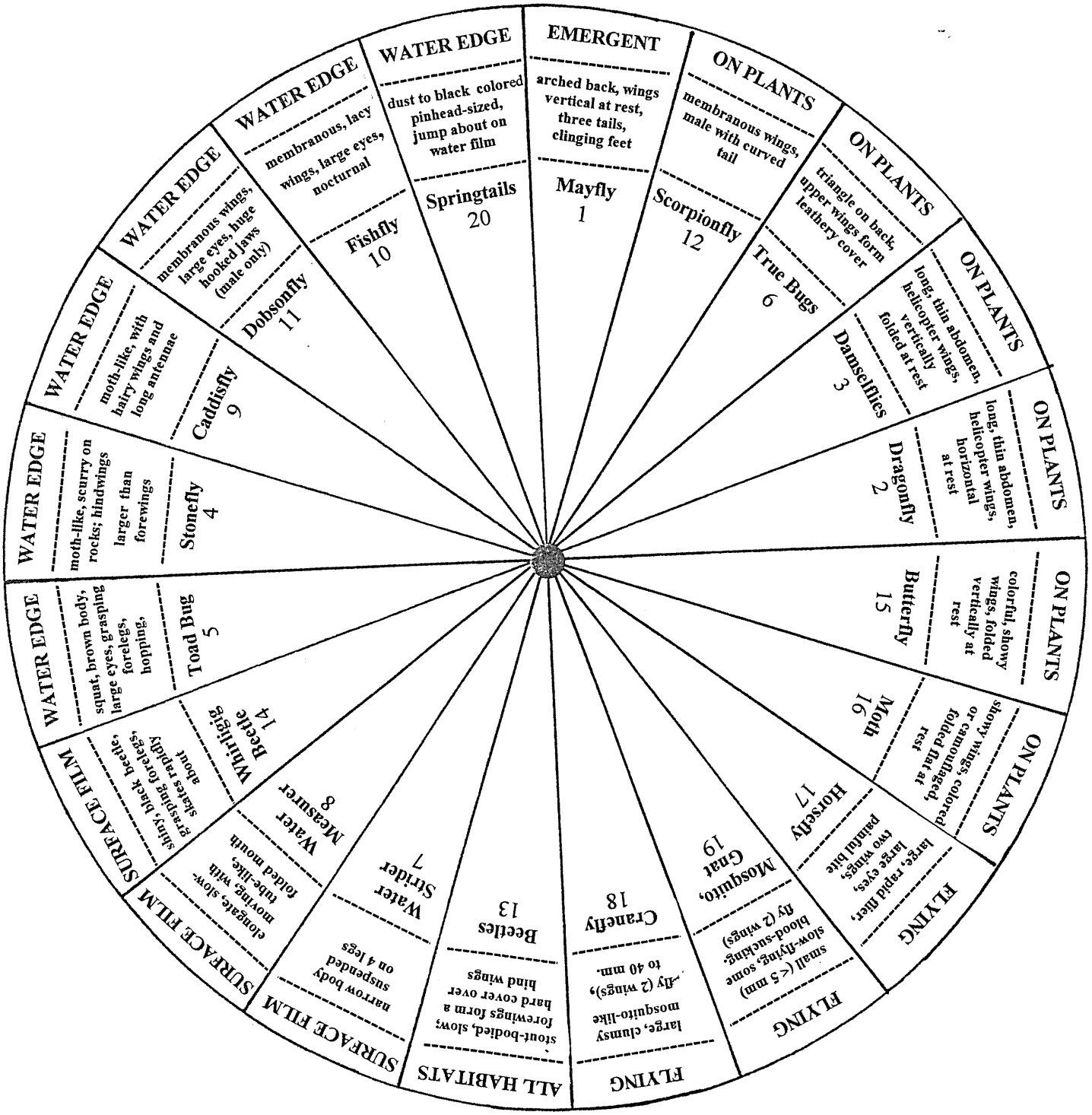
The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Insects Above the Water Wheel: Wheel Cover - Back



The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Freshwater Insects Above the Water Wheel: Outer Wheel



The artwork and information for this activity was submitted by Andrew Lampkin, Woodward Academy.

Teacher's page

The Adventure of Billy The Bass

OBJECTIVES:

1. To illustrate the effects of point source and non point source pollution.
2. To investigate the problems of cleaning-up pollution in the wetlands.

Teacher demonstration.

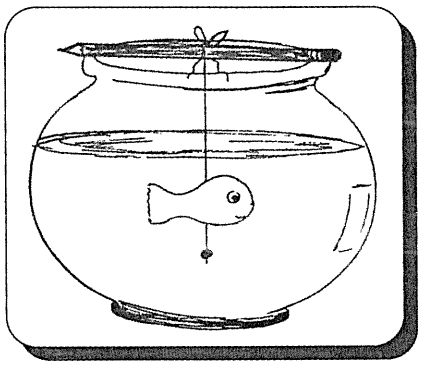
MATERIALS:

large fish bowl or gallon jar	salt
pancake syrup	string
cold tap water	pencil
hot tap water	red and green food coloring
white or light colored sponge	soil
plant fertilizer (powdered)	hole punch
colored paper	liquid detergent
6 small paper cups	fishing weight

Prior to doing this activity, you may want the students to read the fact sheet on Pollution in the Wetlands.

PROCEDURE:

1. Prepare these ahead of time: Number the cups 1 - 6. Place soil in cup # 1, fertilizer in cup #2, syrup in cup #3, salt in cup #4, colored paper dots in cup #5, and hot water and detergent in cup #6. Number the red food coloring #7, and the green food coloring #8.
2. Fill the large fish bowl 3/4 full of cold tap water.
3. Cut a fish shape out of the sponge and using the string, attach a weight to the bottom of the fish. Attach another piece of string to the top of the fish and tie that to a pencil. This sponge fish is "Billy" the bass and it should be submerged a few inches below the surface of the water.



4. Ask for eight student volunteers and give each one of them one of the numbered cups or containers of food coloring. (#1-#8 of procedure #1).
5. Tell these students, that as you read Billy's story, they are to add the contents of their cup (or a few drops of food coloring) into the fish bowl.
6. Introduce all the students to Billy the Bass and ask them to describe his appearance in the proper place on their data sheet. Also tell the students that they are to record one adjective in the proper place on their data sheet every time you say, "How Does Billy Feel"?
7. At the end of the demonstration, lift Billy out of the fish bowl and discuss how his appearance and the appearance of the water has changed. (You may want to list all or at least part of the objectives they used to describe how Billy felt on the board.)
8. Divide the students into groups for the student activity. Give each group of students a set of materials listed on their activity sheet and tell them that they are to devise a way to clean up the water in which Billy lives. First they should predict which of the items you give them will work best.

The Adventure of Billy the Bass

Imagine a clean river as it twists and turns through a protected wilderness area. Billy, a Largemouth Bass, has lived in pretty much the same part of this beautiful river since he was born. In the place labeled *protected part of river* on your data sheet, describe how you think Billy Feels. Now that Billy is almost grown, he decided to strike out on an adventure and to explore the area downstream.

It isn't long before Billy swims into farm country. A farmer is plowing a field right up to the river bank and it starts to rain. Some of the soil from the farmer's land erodes into the river. (Have the student with cup # 1 pour the soil into the fish bowl). HOW DOES BILLY FEEL? (Students write down one adjective to describe how Billy feels every time this question is asked).

Billy swims on and before long the river flows past a suburban housing development. The houses in this development are built very close to the river bank. Some fertilizer from the farms upstream and the lawns of the housing development washed into the river awhile back. (Have the student with cup # 2 pour the fertilizer into the fish bowl). The fertilizer made the phytoplankton grow very fast until they cut off sunlight to the submerged plants in the river. The submerged plants died and are starting to decay. Their decomposition is using up some of Billy's oxygen. HOW DOES BILLY FEEL?

Billy decides that he does not like it here so he swims on. He swims under a highway bridge. Some of the cars traveling on the bridge are leaking oil onto the highway and the rain is washing this oil into the river. (Have the student with cup # 3 pour the syrup or motor oil into the fish bowl). HOW DOES BILLY FEEL?

During a recent cold spell, ice formed on the bridge. County trucks spread salt on the bridge to melt the ice and prevent accidents. The rain is now washing that salt into the river. (Have the student with cup # 4 pour the salt into the fish bowl). HOW DOES BILLY FEEL?

Billy swims past a roadside park. Some picnickers did not throw their trash into the garbage can and the wind blows it into the river. (Have the student with cup #5 pour the colored paper dots into the fish bowl). HOW DOES BILLY FEEL NOW?

Next, Billy swims past several factories. Although there are regulations that limit the amount of pollution the factories are allowed to dump into the river, the factory owners do not always abide by these laws. (Have the student with cup #6 pour the hot soapy water into the fish bowl). HOW DOES BILLY FEEL NOW?

Billy swims past a sewage treatment plant that is located near the river. One of the plant's pipes has broken and raw sewage is pouring into the river. (Have the student with the red food coloring squirt several drops into the fish bowl). HOW DOES BILLY FEEL NOW?

Billy is really beginning to feel kind of bad now, but he keeps on swimming. The river flows past an abandoned hazardous waste dump that is located on the river bank. There are rusty barrels of

toxic chemicals everywhere. Several of the barrels are leaking and the rain is washing these toxins into the river. (Have the student with the green food coloring squirt several drops into the fish bowl). HOW DOES BILLY FEEL?

Billy is really feeling bad now and would like to return to his beautiful, clean portion of this river, but he does not think he can swim back through the water he has just traveled through. **To the students say:** It is now your job to clean up the pollution from the river so that Billy can go home.

Before dividing the students into groups to work on their clean-up strategies discuss point source and non point source pollution (see fact sheet). Have the students list the types of pollution that Billy encountered and tell what type of pollution each was (point source or non point source).

The Adventure of Billy The Bass

OBJECTIVES:

1. To understand the effects of point source and non point source pollution.
2. To investigate the problems of cleaning-up pollution.

Part I: As your teacher demonstrates the adventures of Billy the Bass, fill in the data table below with a single adjective to describe how Billy feels.

Billy's Location	Adjective describing how Billy feels	Type of pollution (point source or non-point source)
Protected part of river		
Farm country		
Housing development		
Oil entering from bridge		
Salt entering from bridge		
Roadside park		
Factories		
Sewage treatment plant		
Hazardous waste dump		

Part II:

Your job or the job of your group is to clean up the pollution from this river so that Billy the Bass can return to his home. Before beginning this activity, discuss with your teacher the major sources of pollution in the wetlands. Obtain the materials listed below.

MATERIALS:

Container or glass of polluted water from Billy's river
Netting (bags that onions or oranges come in will work)
Pieces of cloth (cheese cloth)
Paper cup to place pollutants in after they are recovered
Wire screen
Pieces of sponge
Dish detergent
Paper towels
Eyedropper
Plastic spoon

PROCEDURE:

1. Discuss with your group how you will clean up the river (make a plan of attack).
2. Predict which item or items that you have available will be the best for cleaning up this river. Place you answer in the prediction blank in your data chart.
3. Using the materials you are provided, do your best to clean-up the pollution in Billy's river.
4. Record in your data table how effective each item is in cleaning up the pollution.

OBSERVATIONS:

Data Table:

Prediction	Name of clean-up item	How effective was it in cleaning up the pollution?

1. Were you able to completely clean the river of pollution?
   If not, what did you have problems removing?

   Why do you think you had problems

2. Define point source pollution and list some sources not described in Billy's adventure.

3. Define nonpoint source pollution and list some sources not described in Billy's adventure.

4. List some ways that you personally can help to prevent pollution in our wetlands.

CONCLUSION: Explain the effects of pollution in the wetlands and suggest solutions to the pollution problem in our wetlands.

HOW TO DRESS AN ALLIGATOR

PURPOSE: Students will be able to name and describe the functions of the various adaptations of an alligator.

MATERIALS: A student volunteer
The props listed in the chart below

PROP	ADAPTATION	FUNCTION
Poncho	Water-proof skin	Protection from the water
Paddle	Tail	Provides power for swimming
Goggles	Nictitating membrane	Protects the eyes during attacks
Nose Plugs	Nostrils (closed)	Keep water out of the nose
Snorkel	Nostril (open)	Allow animals to breathe while the rest of the body is underwater
Tongs	Teeth	Used to capture and hold prey
Flippers & Hand Paddles	Webbed Feet	Support on sandy or muddy bottom
Breast Plate	Scutes	Protection of the animal's back

PROCEDURE:

1. Ask for a volunteer with a good sense of humor.

2. Explain that the volunteer will pose as an alligator. Various objects will represent the adaptations of the alligator, or the physical structures and functions that enable the alligator to survive in its environment.

3. Place the items (props) listed in the chart on the "volunteer alligator" (one at the time) and ask for suggestions about the meaning of the prop and the usefulness of the adaptation it represents.

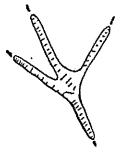
4. After the "volunteer alligator" has been dressed, remove each item (one at the time) and ask the students to name the adaptation that each item represents.

EXTENSIONS:

1. Have the students research alligators. Their research should include such items as scientific classification, description of the animal, habitat and range, diet, reproduction, and how man has affected alligators.

Adapted with permission from Denise Ponce, the Aquarium of the Americas.

TRACKING WETLAND WILDLIFE



OBJECTIVE: To investigate the evidence left behind by wetland animals.

MATERIALS:

plaster of Paris	hair spray	camera (optional)
spoon	notebook/pencil	cardboard coke flat
water	trowel, knife or stick	salt
ruler	old toothbrush	stapler or tape

mixing container (plastic bowl or tin can)

several cardboard strips (1 inch wide and lengths from 15 to 24 inches)

BACKGROUND INFORMATION:

Animals living in or visiting wetland environments often leave tracks, trails, and other evidence of their presence even though they may be absent when the area is viewed. Other pertinent signs include scat (fecal remains or droppings), food litter, gnawings, scratchings, rubbings, nests and burrows. This indirect evidence is important because the correlation of these track, trails, burrows and other signs of the organisms that made them allow the natural scientist to interpret or infer a great deal about the area being studied. Although the organisms may not be present, careful observation of what they leave behind gives evidence to what the animals were doing, where they went or how large they were. Geologically they enable interpretation of what otherwise would be strange markings in the ancient geologic record.

Once you become aware of the tracks and other evidences an animal leaves behind, you will be surprised at how many animals may visit a seemingly barren area. Whether walking, running, crawling, or hopping, animals leave a story of their activities in the tracks they leave behind by their claws, feet and tails. When you learn to "read " tracks and trails, you may want to become a "track detective" and figure out track riddles as you walk along a wetland.

PROCEDURE:

1. As you walk through wetlands, watch for any sign of an animal. When you find one, record its location, describe its overall pattern, and the direction it is heading. Measure the length and width of the track and the distance between the tracks (stride) if more than one is available. Look for signs of tail or wing marks and record these. If you have a camera, take a picture. Remember to place a ruler or some other marker beside the track to indicate its size.

[Record your observations on charts like the one to the right]

Date _____ Type of wetland habitat _____

Direction heading _____ Length _____ Width _____

Stride _____ Drawing:

Description of overall pattern:

Other marks or evidence present:

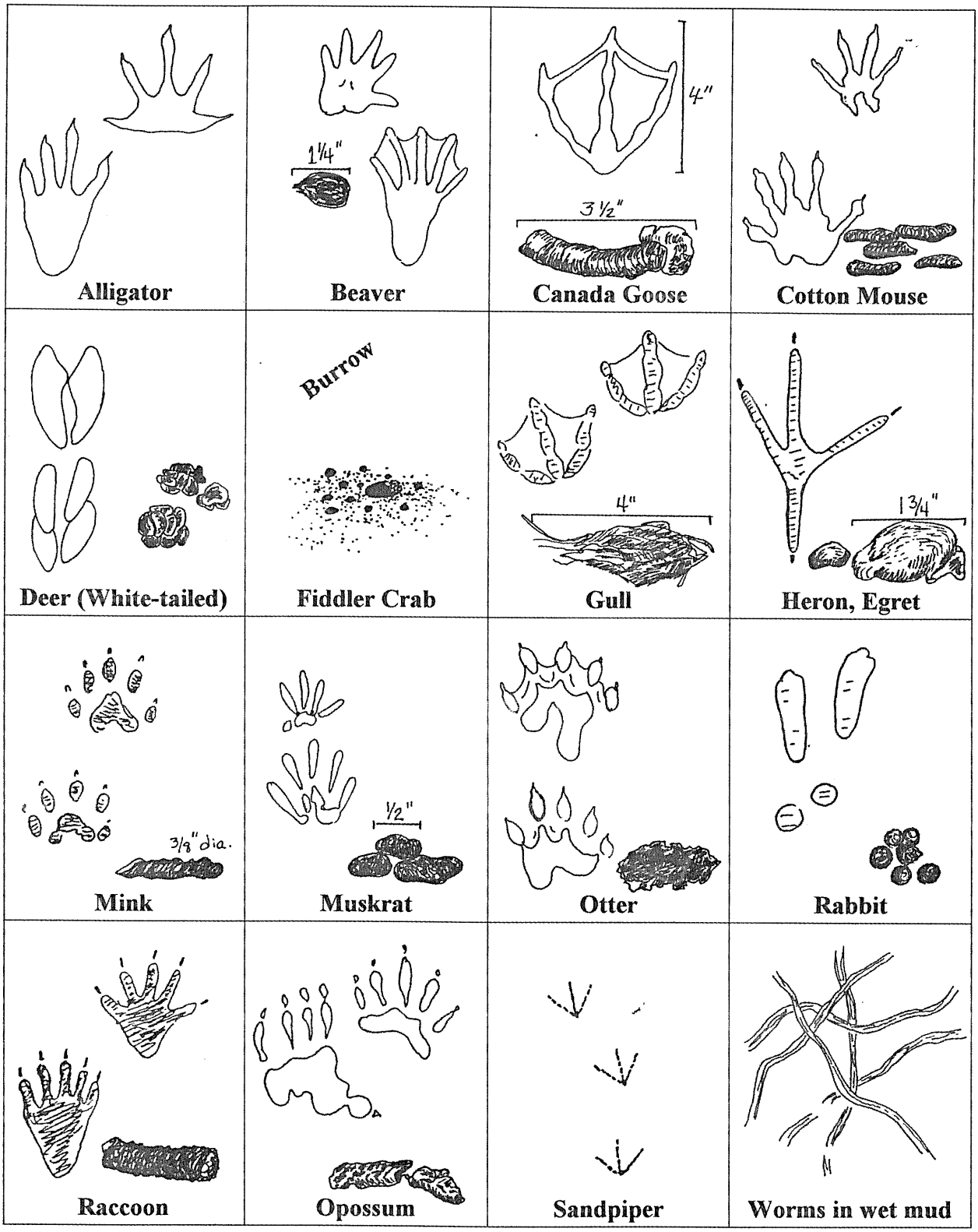
2. Make a plaster cast of the track:
    A. Make a cardboard ring out of one of the strips and put it around the track. Allow about one inch overlap and staple or tape the two edges together. Press the ring firmly into the mud or sand.
    B. Mix plaster of Paris and water in your mixing container following the directions on the package until it is the consistency of a thick pancake batter. Add a pinch of salt to the dry plaster before adding water to make it harden faster. For easier mixing, add plaster to the water instead of water to the plaster.
    C. Tap the bottom of the mixing container several times to remove any air bubbles.
    D. Pour the mixture into the track until it almost fills the cardboard ring.
    E. Smooth the surface of the plaster with your ruler or finger and let it set until the plaster hardens. The time required for the plaster to harden will vary from about 10 minutes on a dry sandy beach to 30 minutes or longer in a damp marsh.
    F. While the plaster is drying, attempt to follow the trail of the animal but be sure not to damage any fragile wetland plants.
    G. When the plaster hardens, remove the cardboard ring and lift the cast up.
    H. Clean off the dirt or sand by washing it or gently brushing it with an old toothbrush.
    I. Scratch the date and location on the back of your plaster print.
    J. Place the cast in a cardboard coke flat for transportation back to the classroom or home.
3. Look around for other evidence of animals. Record and describe what you find. If you find scat, examine it to see if you can tell what the animal had eaten.

OBSERVATIONS: Using your cast and the information you recorded when you found the print answer the following questions.

1. What do you think the animal that made the track was doing? Give evidence to support your answer.
2. Was the animal hopping, running, walking or just standing? Give evidence to support your answer.
3. Was the animal feeding? Give evidence to support your answer. (Consider where the track was and any surrounding evidence such as beak marks or food remains)
4. Could the animal have been hiding from a predator? Give evidence to support your answer.
5. If you followed a trail of tracks, where was the animal going or where did it appear to be going? Give evidence to support your answer.
6. Why do you think the animal was where it was when it made the track? Support your answer.
7. Using reference books in the library or from your teacher, try to find out what kind of animal made the track.

CONCLUSION: Explain how, even though an animal cannot be seen, observing the tracks and other evidences left behind by animals can give scientists a better understanding of an area and what goes on there.

TRACKS AND SCAT OF SOME COMMON FRESHWATER OR COASTAL WETLAND ANIMALS



MARSHVIEW INHERITS HERON'S NEST PLANTATION

OBJECTIVE: Students will conduct a mock town hall meeting during which they will improve their analyzing, communicating, decision making, problem solving, and valuing skills.

BACKGROUND INFORMATION:

Heron's Nest Plantation is a 3,000 acre tract of land located on a tidal river near the town of Marshview. In the early 1800's, Heron's Nest was a profitable plantation on which rice, Sea Island Cotton, and sugar cane were grown . During the early 1900's, the plantation served the community as a dairy farm. For the last 60 years or so, the fields (except for about 40 acres around the plantation house) have been allowed to return to their natural state. The owner of Heron's Nest recently passed away and left the land, the plantation house, the barns, and all the out buildings to the town of Marshview.

The town now must decide what to do with the land. About 1,700 acres are marshland; 500 acres are forested with a good number of old live oak trees; 600 acres are a mixture of shrubs and grasses containing a few cedar hammocks; and the remaining 200 acres (including the 40 acres around the plantation house) are fairly clear fields. There are five small ponds scattered across the property as well. There are several dirt roads on the property, with one leading to a deep water dock that is in exceptionally good shape for its age.

Since inheriting the land, there has been quite a bit of controversy as to what would be the best use of the land. The town has decided to hold a town hall meeting and has encouraged all the citizens of Marshview to attend and give their input. The town also realizes that there are numerous laws regulating the use of wetland areas and have invited representatives from several government agencies to also attend the meeting.

INSTRUCTIONS FOR THE TEACHER:

(This activity should be conducted only after the students have studied the importance of wetlands).

1. Photocopy and give each student a copy of all roles.
2. Explain to the students that they will be taking part in a simulation game depicting a town hall meeting. Read the background information to the students (or have them read it). Explain that they will be meeting to discuss what the town of Marshview will do with the Heron's Nest Plantation property.
3. Stress to the students that they will be playing a role (acting) where they present or argue a point of view that may or may not be their own. Regardless of how they personally feel, they must portray the role they are assigned or choose.
4. Assign one student the role of town Mayor. It is the Mayor's job to conduct the meeting. He must remain non-biased and cannot express his own views. His responsibility is to make sure that the meeting runs smoothly and that everyone has an opportunity to express their views.

5. Assign one student the job of recorder. This student should write the important point or points presented by each participant on the board or on butcher paper placed strategically around the room. (You might want to have more than one student act as the recorder).
6. Five students will serve as City Council members. Explain to these students that they will sit in front of the room and listen as each special interest group explains their views. After hearing from each participant, they will meet and make recommendations as to what should be done with the land. They are to keep in mind that they are elected officials and if they want to be re-elected, they must satisfy as many citizens as possible. They should read all the roles and be prepared to ask questions of all the participants. They should also remember that they do not have to come to a final decision after this meeting. They can set up committees to do additional investigation and schedule an another meeting or meetings to present those findings.
7. Assign or allow the other students to choose from the following roles: historian, educator, local citizen #1, local citizen #2, banker, developer #1, developer #2, environmentalist, high school student, retired person, biologist, city merchant, local shrimper, hunter/fisherman, representative from the Environmental Protection Agency (EPA), representative from the Department of Environmental Quality (DEQ), representative from the Department of Natural Resources (DNR), representative from the U.S. Fish and Wildlife Service.
   Explain to these students that they should study their roles and be prepared to take part in the town hall meeting where they will present the position of the interest group that they represent. They may use the roles as printed but encourage them to add additional information that they learned from their study of wetlands. The students should also read the roles of the other participants in order to ask questions of the other participants. They should also be prepared to answer questions from the other participants and the City Council members.
8. Your role as the teacher is to mediate if necessary and to make sure that the students stay on task. You may want to play "the devil's advocate" and ask pertinent questions if the students do not do so.
9. Once everyone has presented their role, the City Council and the Mayor should gather to discuss their recommendations.
10. While the Mayor and City Council members are meeting, discuss questions 1, 2, 3, and 6 of the follow-up discussion questions below.

FOLLOW-UP DISCUSSION:

1. Have the students discuss how they felt about their role. Did they change their views after listening to the other participants? Is so, what made them change their minds?
2. What were the basic disagreements among the different interest groups?
3. List any areas of agreement and common interest.
4. Discuss the decision(s) of the City Council. Was the decision fair to all the interest groups? If not, what was sacrificed? By whom?
5. Did all groups sacrifice the same thing? Different things of equal or similar importance?
6. Discuss the difficulties of meeting the needs of all interest groups.
7. Suggest to the students that they attend a real town hall meeting and compare it to the one they enacted in the classroom.

ROLES FOR THE MARSHVIEW TOWN HALL MEETING

City Mayor: It is the Mayor's job to conduct the town hall meeting. You must remain non-biased and cannot express your own views. It is your responsibility to make sure that the meeting runs smoothly and that everyone has an opportunity to express their views. You need to find out from your teacher exactly how much time you will have for the town hall meeting and plan accordingly. You will open the meeting and introduce each of the participants. You will need to explain the rules of the meeting. Tell the participants how much time they will have to present their views. Tell them how they will be recognized (by raising their hands, etc.) Also, give the order of the presentations for the meeting. After the meeting is over, you will lead the City Council members in their discussion and you will present their decisions to the citizens of Marshview.

Recorder: Prior to the town hall meeting, you should write the name of each participant on a piece of butcher paper, poster paper, or on the board. During the town hall meeting, your job is to listen to what each participant says and write down the important points of each presentation. If these are written on butcher paper or poster paper, post them around the room (during the meeting) for everyone to see. You need to write fast and accurately. You will probably need assistance to place the sheets of paper around the room in a timely manner.

City Council Members: Your job is to sit in front of the room and listen as each special interest group explains their views. You should read all the other roles and be prepared to ask questions of each group representative about how what they want could best be accomplished. After hearing from each participant, all five of the city council members will meet with the Mayor and attempt to come to a decision(s) that will satisfy as many of the interest groups as possible. Your decision can be final or it can be a recommendation that can be voted on by the citizens of Marshview. You may also decide to form one or more committees to do more in-depth research. If you choose to set up the committees, you will need to schedule another town hall meeting to discuss their findings. Remember that as a city council member, you are an elected official and it is your duty to attempt to meet the desires of as many citizens as possible.

Historian: I represent the Coastal Georgia Historical Society. Heron's Nest Plantation is a truly wonderful representation of a coastal plantation. We would really like to encourage the citizens of Marshview to consider restoring the plantation house and the outbuildings as a museum. With its history, I am sure that it would qualify to be on the National Historical Register and qualify for funding to assist in the restoration. This may not bring in as much money to the city as some of you might like, but it would preserve an important part of our heritage.

Educator: I just want to say that we have a wonderful opportunity here to turn the Heron's Nest Plantation into an extended classroom for the students of Marshview. Before he died, Mr. Kingfisher allowed me to take my biology students there on field trips. What an incredible classroom it makes. We were able to do dock and plankton studies, marsh studies, and plant and insect collections. The fields, shrub, and forest areas are an excellent example of natural succession. It is truly a "living laboratory". If the city council would turn it into an extended classroom, all subject areas could benefit. Not only is it is a great place to study science, but history, language arts, and art as well. Personally, I feel that students learn best by experiencing things first hand. Please, whatever you decide to do with the property, make sure that our students are allowed to continue to use it.

Local Citizen #1: I think that we should use the land to build a shopping center with a decent grocery store, a Wal Mart or K-Mart, and a movie theater. Now, we have to drive 20 or so miles just to go shopping. A shopping center would bring a lot of money into the city and provide jobs for a lot of our citizens. When I moved out here I expected the city to grow and more businesses to come. But they did not, and I am stuck here because my husband loves the peace and quiet. Now, with all this land, we have the opportunity to bring in some of the modern conveniences.

Local citizen #2: My family and I moved to Marshview because it is so peaceful and quiet and away from the hustle and bustle of a larger city. Our children are safe here away from drugs and crime. They can even play in the street because the traffic is so light. I love looking up and seeing all kinds of birds flying over on their way to the ponds on Heron's Nest Plantation, and listening to the sounds of nature. I do not think we should do anything with the land.

ROLES FOR THE MARSHVIEW TOWN HALL MEETING

Banker: As the local banker, I am definitely in favor of bringing in new businesses or building homes on the property, provided of course, that the loans for whatever is done goes through my bank. We are sitting on a gold mine here and we really need to get the ball rolling and bring some real money into this town.

Developer #1: I'm with you, Mr. Banker. I think this property would be perfect for a housing development. We could have condos and really nice houses, and if we could fill in some of the marsh, we could add swimming pools, tennis courts, and maybe even a golf course. We would be able to attract people with real money to build here and then maybe we would attract the other businesses that Local citizen #1 was talking about. But we really need to put first things first. I am ready to get started just as soon as the city will sell me the land.

Developer #2: I would also like to see some development on the Heron's Nest property; however, I have a different vision for the property than the other developer. Last weekend I visited a friend who is building some houses on Dewees Island in South Carolina. Everything there is built out of natural products, and they are only able to impact a 20 foot area around whatever they are building. No large trees can be cut, and the houses have to be designed to fit the property. Only native plants can be planted outside. They have no paved roads and drive golf carts instead of cars. The property and houses on Dewees are extremely expensive, but I think something less expensive would really go over well here. We could put in some small two and three bedroom cottages that blend in with the natural surroundings. We would leave all the marsh area and most of the forest untouched so that it could still be used by students and other nature lovers. I think it would be an exciting project that might even be used as a model for other areas.

Environmentalist: Personally, I think that Heron's Nest Plantation would make an ideal environmental education facility. The natural surroundings are perfect and there is definitely enough land. If making a profit is what concerns most citizens, we could advertise and bring in school groups from all over the country. We would need a sizable staff so it would provide jobs. It just seems a real shame for such a perfect natural area to be spoiled by building on it. The people of this country need to understand how important the marshes and natural ecosystems are and this would be an excellent place to teach about them.

High school student: I am one of the students that got to go to Mr. Kingfisher's land on a biology field trip and I can truthfully say that I learned more on that field trip than any another time in all my years in high school. But, I will be graduating in the Spring and would really like to be able to find a job here in Marshview. I could go to Savannah, Brunswick, or Jacksonville, but I love the laid back atmosphere here in Marshview. I hope that you can come to some kind of compromise that will preserve the integrity of the marsh land yet still offer job opportunities for those like me.

Retired person: I came here to put in my two cents for a nice retirement home on the Heron's Nest property, but after listening to that developer feller, I have another idea. I like the idea of small cottages, as long as it is something someone like me could afford. I also like the idea of keeping it natural with no paved roads and all. I have a couple of grandchildren and we love to go to the marsh and fish and watch the birds. I wouldn't even mind having that education center as long as they kept things quiet and peaceful. But, please, no shopping centers or big fancy houses. Those would take away from the homeiness of Marshview.

Biologist: When I heard about this town hall meeting, I went out to Heron's Nest to look around. What I found was incredible. The area is just teaming with life of all kinds. In just the few hours that I was there, I saw 20 types of birds, raccoons, opossum, mink, rabbits, and deer. There is even a beaver family living in one of the back ponds. The plant life there is also remarkable. This property has been virtually left alone for a long time and supports a tremendous number of ecosystems. I understand that many of the citizens of Marshview would like to turn this property into a profitable venture, but with proper and careful planning, the diversity of life there can be preserved also.

City merchant: If more people were to move here to Marshview it certainly would help my business and the other businesses in town. Has anyone thought about turning the old plantation house into a bed and breakfast? That would bring people in. I'll bet that the barn and outbuildings could be fixed up for that environmental education center at the same time. I agree with those who don't want the town to grow too much because I like the peace and quiet of Marshview myself. But a little progress never hurt anybody.

ROLES FOR THE MARSHVIEW TOWN HALL MEETING

Local shrimper: I know most of you are wondering why I am here. I am a shrimper and shrimp are in the ocean, so why should I be concerned with what goes on on a tidal river. Well, whatever goes into the water of the river here in Marshview goes into the ocean. I do most of my shrimping (I catch crabs and fish also) in the estuaries where the water from this river goes into the ocean. What I worry about is the effect that the runoff from any construction that may be done will have on the water quality. If the water is muddied it smothers the shrimp and crabs and there goes my livelihood. So what ever you do, please be aware that it might affect other people like me.
Hunter/fisherman: With all the wildlife that the biologist says is here, this property could be turned into a hunter's and fisherman's paradise. If the plantation house was turned into a B & B, it would give the men somewhere to stay, or some of the land could be made into a campsite for those who like to rough it. The dock that is there is supposed to be in pretty good shape, and it would be a great base for taking out deep sea fishing parties. We would surely bring in a good revenue from hunting and fishing licenses, equipment, and supplies. I think this place has great potential and I'm just itching to get things started.
Representative from the Department of Environmental Quality (DEQ): First of all, let me thank you for inviting me and the other agency representatives here tonight. It shows us that the town of Marshview is concerned with the proper way of doing things. Representatives of the DEQ will gladly work with you to make suggestions on the best ways to prevent any sedimentation and pollution of the river. We can also advise you on the best methods of environmentally safe waste management.
Representative from the Environmental Protection Agency (EPA): Good evening everyone. I have been listening to all of the suggestions that have been made here tonight and agree that Marshview has some exciting times ahead. For those of you who are unfamiliar with the role of the EPA, it is to ensure that there is minimal impact on the environment. Representatives of our agency will be on hand to work with you to ensure that whatever project you undertake is planned and managed well with respect to the environment.
Representative from the Department of Natural Resources (DNR): I, too, would like to congratulate the citizens of Marshview on their foresight in inviting the government agencies to your first discussion session. We at the DNR will have to approve any construction that might affect the wetland areas and will issue the necessary permits. As you are all aware, there are several federal and state laws that will limit what you can do with this property. We will gladly give any advise and suggestions on the best way to go about whatever you decide to do. We look forward to working with you.
Representative from the U.S. Fish and Wildlife Service: I would like to expand on what the biologist told you about the wildlife at Heron's Nest Plantation. There are several other valuable wildlife species using the area for nesting and feeding. We have noticed a small rookery of great blue herons, egrets, and a few woodstorks. We have also seen two osprey nests and a bald eagle nest on the property. Some other important species include the box and spotted turtle and the spotted salamander. We are concerned about protecting the existing habitats and minimizing any sedimentation of the river. We need to protect what is left of the wetlands in this area. Our wetlands serve as nurseries for many of our aquatic animals as well as nesting and breeding grounds for migratory birds. As long as you make every effort to minimize any disturbance to the wetlands, I am sure that we will be able to work well together.

YOU AND ME AND WETLANDS MAKE THREE

SCENARIO:

It is the year 2050 and due to the fact that new technology has made timber production no longer profitable, a major timber firm has decided to sell much of its land. The company you work for has bought a 2,000 acre tract of this land. This tract of land is located along the Altamaha River near Cox, Georgia. The timber was cut about eight years ago and it was never replanted. Near the river there is a freshwater marsh and a narrow band of floodplain/bottomland hardwoods. Located in the center of the property is a small bald cypress swamp. There are also several locations where wet meadows and bogs have developed. There have been two nesting pairs of Bald Eagles sighted on the property and an Egret/Heron Rookery is located near a freshwater pond.

The owners of your company would like to develop this land in order to make a profit on their investment, but they are also very concerned about the preservation of and health of the environment. They eventually plan to live on the property and enjoy nature. You have been asked to draw up plans for the land's development. You have been told that in no way is the environment to be impacted by the development you propose. You may build houses, apartments, shopping centers, a nature center, some type of tourist attraction, a combination of any or all of these, or something completely different. Your plan must account for all the necessities of life such as transportation, waste management, water, electricity, telephone, television, etc. Your development is not to have any paved roads or septic tanks. Basically all utilities must be above ground and not harmful to the environment. Cars as we know them today are non-existant. Remember that this is 50 years from now and there should be a tremendous amount of new technology available.

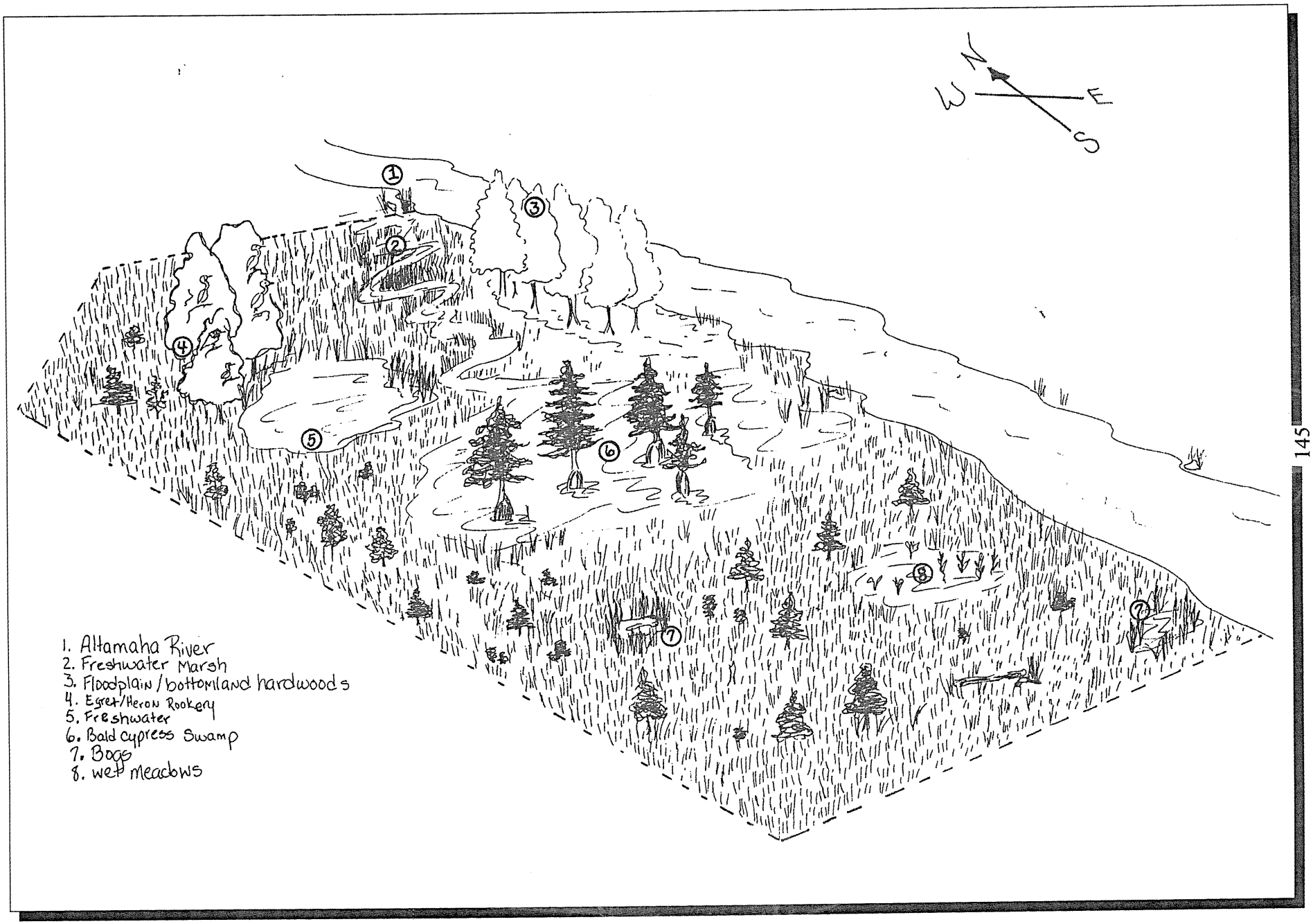
You should plan this development to take place over a 15 year period. At the end of this 15 year period, all construction should be complete and your company should be showing a profit. You are to present your plan for development to the board of directors and it should include: Your immediate plans, your plans for five years from now, ten years from now, and the final completed plan for 15 years from now.

You are to submit a written plan for the development as well as four drawings of you plans; one each for your immediate, five, ten, and fifteen year plans. These drawings should show where everything is to be located and how the land is to be used.. You may use the chart on the following page or prepare posters that show this information for your presentation.

PROPOSAL FOR YOU AND ME AND WETLANDS MAKE THREE

	Immediate Plan	5 Year Plan	10 Year Plan	Completed Plan
Transportation				
Waste Management				
Water				
Electricity				
Telephones				
Entertainment				
Other				
Plans to prevent impacts on the environment				

2,000 Acre Tract of Land For You and Me and Wetlands Make Three



1. Altamaha River
2. Freshwater Marsh
3. Floodplain / bottomland hardwoods
4. Egret/Heron Rookery
5. Freshwater
6. Bald cypress Swamp
7. Bogs
8. wet meadows

WHO AM I - A WETLAND HABITAT CONCENTRATION GAME

PURPOSE: To reinforce the students understanding of wetlands.

MATERIALS:

32 Index cards
glue or tape
scissors
ruler
laminating materials and machine (optional)
1 copy of each card front (A-P and 1-16)
4 copies of the card backs

DIRECTIONS:

1. Cut each index card to the size of a playing card = 3 1/2 inches by 2 1/4 inches.
2. Cut out all the card fronts (A-P and 1-16) and glue each onto an index card.
3. Cut out 32 card backs and glue them to the back of each card.
4. If a laminating machine is available, laminate all the cards.

HOW TO PLAY THE GAME:

1. This game may be play by one student or by two students competing against each other.
2. Cards A - P are the names of wetland habitats. Cards 1 - 16 are the definitions.
3. The object of the game is to match each wetland habitat with its definition.
4. Shuffle the cards.
5. Lay the cards on a table with the back side up. (You may want to have four rows of eight or eight rows of four).
6. Turn two cards over. If you think you have matched a wetland habitat with its definition, remove the two cards from the table. If they are not a match, turn the cards back over to their original position.
7. Continue turning cards over, two at the time, until you think you have matched up all the habitats with their definitions.
8. Check the answer key to see if you have matched the habitats correctly.
9. If two students are playing against each other, the winner is the one with the most correct matches.

ANSWER KEY:

A-11, B-2, C-12, D-16, E-10, F-5, G-6, H-13, I-1, J-9, K-15, L-4, M-8, N-14, O-3, P-7.

Who Am I Cards (front #1)

A Coastal Marine Wetlands	B Shorelines, Beaches, and Bars	C Intertidal Mud Flats	D Lacustrine Wetlands
E Coastal Estuarine Wetlands	F Salt Marshes	G Brackish Marshes	H Floodplain Hardwood Swamps

Who Am I Cards (front #2)

I Riverine Wetlands	J Palustrine Wetlands	K Carolina Bays	L Limesinks
M Pocosins	N Wet Meadows	O Bogs	P Cypress Swamps

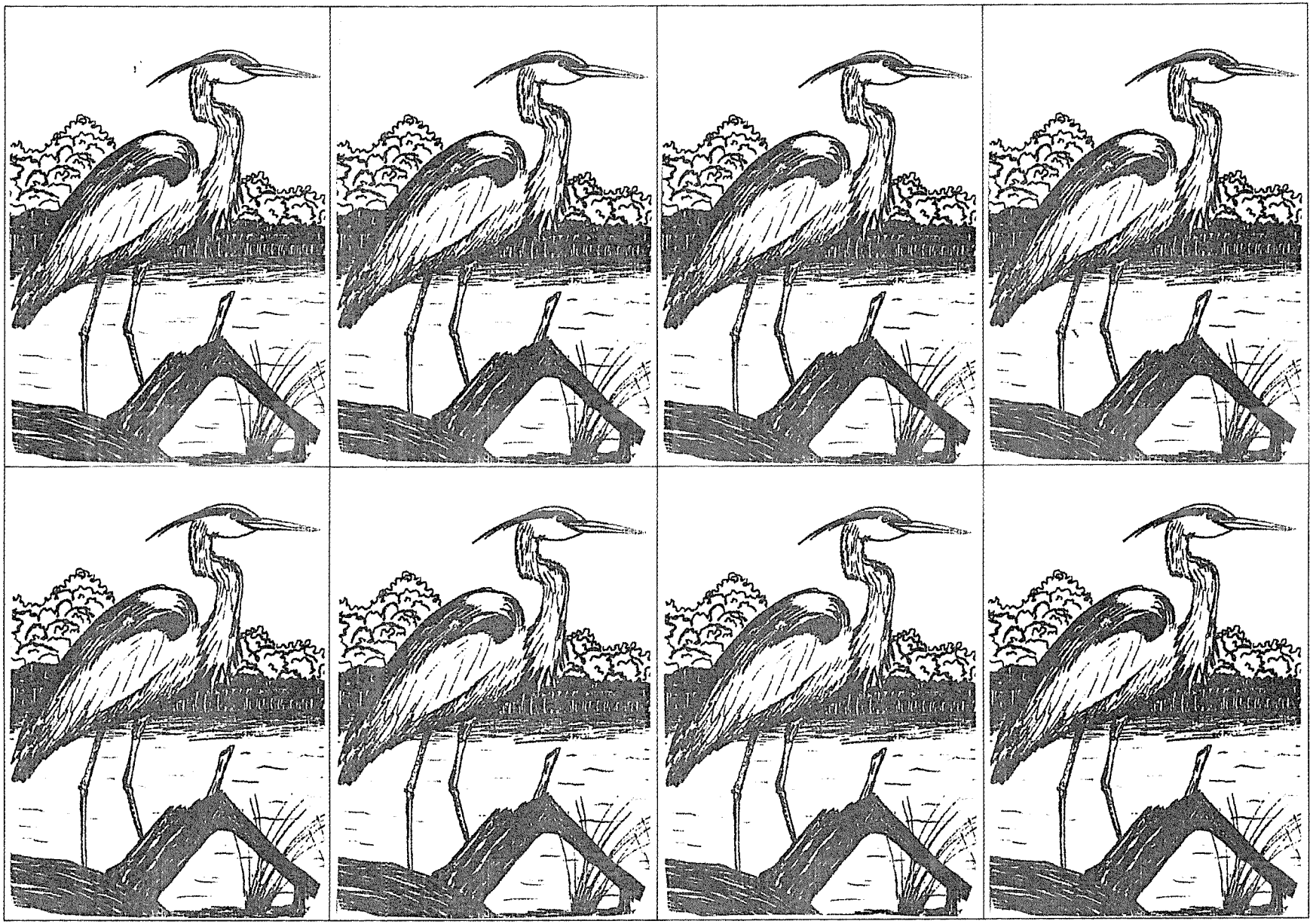
Who Am I Cards (front #3)

1 Nontidal and tidal freshwater wetlands and deepwater wetlands that are contained within a channel of moving water along rivers and streams. They are permanently flooded and have a salinity of less than 0.5 ppt.	2 Animals that live in this habitat must have adaptations for the harsh conditions of crashing waves, extremes in temperatures and water depth.	3 These are low-lying areas in pine uplands where the water table is near the surface and the ground is kept moist by seepage.	4 These wetland habitats come in a variety of sizes and shapes and the water level in them varies from dry to permanently flooded. They form where the underlying rock is limestone.
5 These wetland habitats make up more than 475,000 continuous acres along Georgia's coast. They are periodically flooded by salt water due to tidal cycles.	6 Wetland habitats that form where freshwater is diluted by saltwater. The salinity in these habitats range from 18 ppt to 0.5 ppt.	7 These habitats occur through out the Coastal Plain. They are important in treating run-off wastes, storing water, and serving as nesting and refuge areas for waterfowl. The dominant plant has "knees" that extend above the water level.	8 These nutrient-poor acidic wetlands are dominated by pine trees. Their name means "swamp on a hill".

Who Am I Cards (front #4)

9 Nontidal freshwater wetlands that are dominated by trees, shrubs, or persistent emergent plants. The majority of Georgia's freshwater wetland habitats are this type.	**10** This type of wetland habitat is characterized by ever changing water levels and temperatures. They are located in sheltered coastal areas where fresh and salt water mix.	**11** This type of wetland contains water with a salinity that is greater than 30 ppt. They are located directly along the coast and are alternately exposed and flooded by tides. They are exposed to the high energy of waves and currents.	**12** This habitat consists of a soggy soil that is made up of clay and silt that is deposited during slack tide. This habitat is located at the edge of the salt marsh and only the surface layers of its substrate contain oxygen.
13 These wetland habitats are dominated by oak trees and occur in isolated depressions along the borders of ponds, rivers, and streams.	**14** Grasses and sedges dominate this wetland habitat.	**15** These oval shaped wetlands contain tannic water and are located mostly in sandy areas in the Southeastern portion of the Coastal plain. The Okefenokee Swamp is the most famous one.	**16** Nontidal and tidal freshwater wetlands that are situated in topographic depressions. They are permanently flooded and are usually larger than 20 acres. They make up only 1% of Georgia's freshwater wetlands.

Who Am I Cards (Back) - Make 4 Copies



A WALK THROUGH THE SALT MARSH

Note To The Teacher: This is not designed to be xeroxed and handed out to students, but rather as a guide for you to develop your field trip to the salt marsh.

As you walk through the salt marsh, describe it in similes:

The salt marsh is like a sponge: absorbing flood tide and excessive store waters, then slowly releasing it back into the surrounding environment.

The salt marsh is like a filter: absorbing toxins, indefinitely in mud, with *Spartina* absorpting, and neutralizating some toxins prior to release.

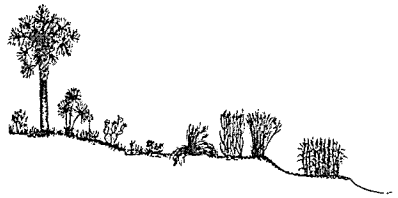
The salt marsh is like a nursery: calm and protected, etc.

The salt marsh is like a bodyguard: providing protection for young and mature organisms, from plankton to fiddlers, to birds through grasses, sediments, hammocks, etc.

The salt marsh is like an all you can eat buffet: providing food for everyone, from bacteria to blue crabs, "now serving, all herbivores, carnivores, and omnivores, 24 hours a day!"

To remember all this, take a tote bag of the following "goodies" with you to review at the end of your trip through the salt marsh (do not let the students see these): a kitchen sponge, a coffee filter, a baby rattle, a water gun, plastic knife, fork, and spoon.

Prior to entering the salt marsh, take a look around, point out the low and high marsh, salt pans, hammocks, and tidal creek (if available).



Things to do and look for:

Low Marsh/Tidal Creek Area:

1. Compare the height of *Spartina* to that in the high marsh. This is a good place to talk about the importance of *Spartina*: tremendous biomass, no need for fertilizers or cultivation or harvesters, etc.
2. If a tidal creek is accessible, check for the direction of water movement, orient the students to the location of the beach/ocean, decide whether the tide is ebbing or flooding. This is a good time to talk about the importance of tides to the salt marsh.
3. Drop a plankton net. While it is in the water, discuss with the students that these waters are the nursery grounds of the sea. Discuss the importance of maintaining healthy waters for meroplankton to develop, holoplankton to grow and phytoplankton to thrive. Explain that 85% of our oxygen is produced by phytoplankton and it is where many food webs begin, etc.
4. Explain that the salt marsh not only provides protection for young, protection for the mature, and oxygen for us, it also has, for so many years, shared its beauty with us through art and poetry (Sydney Lanier's Marshes of Glynn).

Submitted by Georgia Graves, Coastal Encounters Nature Center

5. Have the students look around for "Art In The Marsh". Relate it to "human" finger painting except that these beautiful works of art are accomplished by pincers, paws, and webbed feet. (On a sunny day when the texture of the mud is just right, fiddler crab burrows can look like big flowers.)
6. If the marsh is dry enough, you may want the students to make plaster casts of the animal tracks they see.
7. Test salinity levels with a hydrometer (or refractometer if you have one) and thermometer. The hydrometer measures the density of the water. The thermometer measures the temperature. Use the Salinity Chart to convert the density to salinity. Remember that the average salinity of ocean water is 35 ppt (parts per thousand). Discuss what could cause the water of the salt marsh to be higher or lower than the average.
8. Use nets to catch immature crabs, fish, commercial shrimp, and grass shrimp. Relate the importance of grass shrimp as a nutrient provider because of its ability to ingest *Spartina*, releasing some of its nutrients through its waste or as they are ingested by larger organisms.
9. Look for fouling organisms on pilings. Barnacles, mussels, and other organisms that grow on objects in the water are called fouling organisms. They get their name because these organisms also grow on the hulls of ships and create drag that slows down the ships and increases their fuel consumption. Discuss their adaptations and why they are called "fouling" organisms.
10. Have the students grab a handful of black anaerobic mud and take a whiff. Have the students canvas the marsh looking for all the living "stuff" and discuss how these living organisms eventually die and that bacteria, living in the mud, decomposes, the dead matter and give off hydrogen sulfide.
11. Take a sample of low marsh mud. Have the students rub it between their fingers and describe how it feels. Collect enough of the low marsh mud to make a slide for later viewing (compare the low marsh mud with high marsh mud that you will collect later).
12. Look for plants and organisms of the low marsh. You will usually find *Spartina*, some glasswort, mussels, periwinkles, mud fiddlers, mud crabs, and marsh crabs. Discuss their adaptations. (In the late spring--listen for the beautiful trill of the Marsh Wren and if you are lucky you may see a nest of intricately woven blades within the grasses of *Spartina*).

Move Toward the High Marsh Area:

1. Point out the differences between the low and high marsh: height of *Spartina*, firmer sediment, variety of plants. Look for salt crystals on the *Spartina* blades, and evidence of sand fiddler burrows. This is a great place to talk about the adaptations to "harsh marsh" conditions that lead to neighboring salt pans.
2. Taste some glasswort (sea pickles) and saltwort. Compare their leaf adaptations to those in your backyard.
3. Catch a mud fiddler and a sand fiddler. Compare and contrast their characteristics and let the students figure out their adaptations: eye stalks, regeneration, etc.

4. Have the students get up close and personal with a fiddler crab burrow -- these savvy little inverts have adapted so well -- they are even neat housekeepers and excellent chefs, preparing delicious meals right from the walls of their burrows! These burrows also benefit the marsh by aerating sediments (similar to earthworms). Use the feeding balls around the burrow areas to explain the detritus origin and benefits to food chains.

Submitted by Georgia Graves, Coastal Encounters Nature Center

5. Collect sand from the high marsh and compare it to the sand (mud) of the low marsh. Compare their feel and observe both with a discovery scope (or microscope).

High Marsh Area:

1. Discuss the adaptations of *Spartina*:
   -exuding salt which crystallizes on the leaves (have the students run a wet finger down a blade then taste!)
   -pumps oxygen to roots through aerenchyma, thereby oxygenating *Spartina* and surrounding sediments benefiting other plants as well.
2. Use a shovel or spade to dig next to a *Spartina* plant. Around the roots, the mud will be stained a rust color. This is rust and that oxygen does reach the roots. The rust is formed by oxidation of the iron in the mud.
3. Have each student find a periwinkle snail.
   A. Have them put it up against their throat and hum. The periwinkle will come out of its shell.
   B. Discuss the adaptations of the periwinkle:
      -thick shell (more protection from birds, crabs, terrapins)
      -can withstand desiccation (drying out) for considerable periods

   C. The periwinkle has a mutualistic symbiotic relationship with *Spartina*. The periwinkle obtains its nutrition by scraping algae off *Spartina* blades. This enables the *Spartina* to photosynthesize more effectively.

   D. The periwinkle snails have an internal biological clock that tells them when to climb up *Spartina* blades to stay above the water line. Blue crabs like to eat the periwinkles and have been observed shaking the *Spartina* grass to dislodge the periwinkles from their protective perch!

Salt Pans:

1. This is a great place to discuss evaporation and desiccation. Explain how salt pans develop; the benefits of the marsh's ability to flush water through twice daily; and factors that render these areas barren.
2. When conditions are right: hot day, neap tide cycle, little or no rain for a few days prior, our salt pans look as if they are covered with snow! Have the students lick their finger, lightly drag it across the salt pan and taste. They will taste salt, not sand. Oh, how that salt builds up!
3. Near salt pans are great places to estimate how many fiddler crab burrows there are. Use 4 meter sticks (or yard sticks) per group of students to mark off a square meter (yard), then count all the burrows in that squared off area. Do this for several areas. Then figure the average. Multiply the average by 4,900 (the number of square yards per acre). The answer equals the approximate number of burrows per acre.
4. Have several students toss out hoola hoops. Then they should count the number of each type of plant and other organisms in this area of the high marsh - record this information. Repeat the same procedure for the low marsh. Compare and discuss the results.

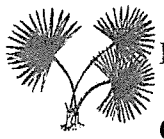
Submitted by Georgia Graves, Coastal Encounters Nature Center

Hammocks:

1. Discuss how they form, the typical plants and their importance as shelter, food, protection.

Typical plants of hammocks:

A. Southern Red Cedar (it is really a juniper and not a cedar): the scientific name *Juniperus silicicola* means 'juniper living in sand'. These plants love lime and are sometimes indicators of shell middens. The berries are an important food source or birds.



B. Cabbage Palmetto, *Sabel palmetto* (palmetto means little palm). Their shiny, black fruits are food for raccoons, grackles, and robins.

C. Grounsel-tree, *Baccharis halimiflora*: has gray green foliage. The leaves smell of camphor. It is also called cotton bush or Consumption weed and was made into a tea for sore throats.

D. Wax Myrtle, *Myrica cerifera* (cerifera means wax bearing). Crush the leaves and smell. They smell of bayberry. The Wax Myrtle is also known as the southern bayberry. Colonialists used to harvest the wax coated berries for use in making candles. Native Americans taught us to crush the leaves and to apply them to our skin as a quick and non-toxic insect repellent. The Wax Myrtle is one of the most important plants for birds. They provide underbrush for shelter, and the berries provide upwards of 50% of some birds' diets (such as the tree swallow).

2. This is a good place to discuss the importance of planting and maintaining native plants. Native plants require little care when compared to exotics, where the need for pesticides, chemical fertilizers, etc. are necessary. These chemicals eventually make their way into our waters.
3. Have the students look around the vast expanse of the marsh. Explain that the number one inhabitants are PLANTS!. Who cares for them? Not landscapers, no lawn maintenance crews, just mother nature!!
4. Have the students stop and listen for the beautiful trill of the marsh wren and the distinctive call of the red winged black bird (konk-la-ree).
5. The base of the hammock has the same plants as the marsh border: sea oxeye, marsh lavendar, salt or spike grass.

Marsh Boarder:

1. During the spring and fall, look for blooming flowers like marsh asters, marsh fleabane, sea oxeye, marsh lavendar.
2. Look for coffeebean snails and talk about their limitations.

Do not forget to go back to collect your plankton specimens. If you have a field microscope, look at them on the spot. If not, take them back to the classroom to observe.

When you leave the marsh, do not forget to pull out your tote bag of goodies to review, "the marsh is like....".

If nothing else, the most important message or lesson a teacher can leave with her students, concerning the salt marsh, or any other wetland area for that matter, IS ITS RELATIONSHIP TO HUMANS - so make the connections!!

Submitted by Georgia Graves, Coastal Encounters Nature Center

A Marsh Walk Through The Earth Day Nature Trail

Directions: As you walk along the trail, follow the directions listed here and answer the questions by reading the appropriate signs or posters.

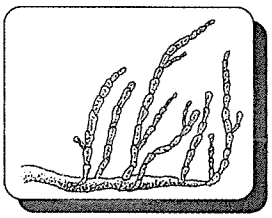
As you enter the trail on the first boardwalk, look to the right for the Sea Oxeye Sign.

1. How does the sea oxeye spread? _____
2. Look out over the marsh beyond the sea oxeye. You will see a sand pan (also known as salt pan, salt pond or sand flat) and juncus grass. Explain what a sand pan is.

3. When you enter the first picnic area, your teacher may want you to test the air temperature, soil temperature, pH, and porosity. Air Temp. _____ Soil Temp. _____ Soil pH _____ Porosity of soil _____

After you have completed your tests, follow the trail to the left toward the Osprey Nest.

4. On the left of the trail, just before you reach the observation deck, go to the edge of the salt pan and look for a plant called glasswort, break off a small piece and taste it. Describe its taste: _____



Complete the following tests at the salt pan: Air Temp. _____ Soil Temp. _____ Soil pH _____ Porosity of soil _____

Go back to the trail and stop at the Birds of Prey Sign:

5. What is another name for birds of prey? _____
   List seven birds of prey. _____
   List several of their adaptations for their lives as birds of prey. _____
   _____

6. Before going onto the observation deck, look to the right and you should see a pole with a platform on top. This was put there for an Osprey to build a nest. Is this being used for a nest? _____. How can you tell? _____

Go onto the observation deck and look for the Belted Kingfisher sign.

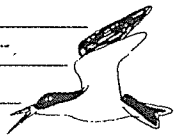
7. How does the Belted Kingfisher feed? _____
   Belted Kingfishers are very territorial and will greet you at the start of their territory and say good-bye at the end of their territory. In other words, they do not fly into another Kingfisher's territory.

8. To the left you should see Prickly Pear Cactus. Describe the adaptations of the prickly pear.
   _____

Now, turn around and go back to the picnic tables. Look for the Sugarberry Tree Sign.

9. Describe the bark of the Sugarberry Tree. _____
   Now go to the covered display area and find the poster "How Do Birds Make a Living on the Coast".
10. What do you notice about the beaks of the various birds? _____
    Why is there such a variety of beak sizes and shapes? _____
    Describe the unusual hunting strategy of the Osprey. _____

Why do birds swallow fish head first? _____
Where do birds thrive? _____
Why is salt water not a problem for birds? _____
Describe some of the techniques of the "plungers" for catching their food. _____
_____



Describe the "cutwater" strategy of the Black Skimmer. _____
_____

11. Find the Marine Mammals of the Western Hemisphere poster: List the types of animals that are considered marine mammals. _____
12. Find the Sea Turtles of the World poster: List the 8 types of sea turtles: _____
_____
What is the name of the largest sea turtle? _____ The smallest? _____
The Loggerhead is the most common sea turtle in Georgia. According to the poster, what does the Loggerhead sea turtle eat? _____
13. From the Trout and Drum poster, answer the following: Why are Trout and Drums called coastal ground fish? _____ Where are the fewest numbers caught? _____ Why are Trout and Drums considered top predators? _____ What is the major concern for these fish? _____
14. How do migratory birds use wetlands? _____
15. What is the single most important influence on wetlands? _____ Explain _____
_____
16. How do trees such as Water Oak, Hackberry, Sycamore, Black Willow, Overcup Oak, and River Birch survive in a wet habitat? _____
_____
17. Why are wetland plants important to the wetland? _____
18. Why are wetlands considered nature's nurseries for young birds, mammals, fish, frogs, turtles, snakes, crayfish, and insects?
19. Name several plants, animals, and birds that are found in coastal salt marshes. _____
_____

Leave the covered shelter and follow the South Loop of the trail. Look for the Wax Myrtle sign.

20. Describe the Wax Myrtle: _____
How is it important to wildlife? _____
Crush some of the leaves in your hand and smell them. Describe this smell _____
_____.

Continue along the trail and turn right at the Sand Flat Observation Deck sign. Once at the Observation Deck:

21. Describe any birds that you see. If you don't see any, look around for tracks or other evidence of life and describe what you see.

22. What plants do you observe? _____
23. Look across the sand flat. In the distance you can see several hammocks. What is a hammock? _____

Go back along the trail and turn right at the sign. As you walk along, listen for any sounds of life. Describe what you hear.

At the picnic table, turn right and look for the Wading Bird sign.

24. List the birds that are considered wading birds: _____
    Describe the adaptations of wading birds. _____
    Continue along the trail and look for the Animal Track sign before the bridge.
25. How do you know animals are around if you cannot see them? _____
    _____
    Describe any signs of animals you see as you cross the bridge. _____
    _____

26. After reading the Clapper Rail sign, describe the adaptations of the Clapper Rail. _____
    _____

27. Find the Black-Crowned Night Heron sign and explain when it feeds. _____
28. How can you tell a Snowy Egret from other egrets? _____
    How does it stir up its prey? _____
29. If there is water in the tidal creek, throw a stick in and try to determine whether the tide is coming in (flooding) or going out (ebbing). What is the tide doing? _____
30. Next, find the Little Blue Heron sign and explain how the adult is different from the immature one. _____

31. Find the Great Egret sign. Describe the Great Egret and explain why the population of these birds decreased at the turn of the century.

32. Lean over the bridge railing and look into the marsh below. Look for fiddler crabs and describe what they are doing. (You will need to be real quiet so you will not scare them).

    Continue on until you come to the Red Cedar sign.
33. Is the Red Cedar a true Cedar? _____ What is it? _____ How do animals use the Red Cedar? _____
    Continue along the trail and turn right at the Observation Tower sign. Look for the Yaupon sign.
34. What is the Yaupon? _____
    How is it different from the Christmas Holly? _____
    Explain how local Indians used the Yaupon. _____
    _____

    Continue along the trail to the right towards the Observation Tower. At the tower, climb the steps and look for the Redwing Black Bird sign.
35. How is the male Redwing different from the female? _____ How do they use the marsh for nests and food? _____
36. How can you identify an Osprey in flight? _____ Where do Osprey build their nests?

37. Why was the Brown Pelican put on the endangered species list? _____

Use the binoculars to observe the marsh. Describe what you see.

Go down the steps and out to the lower observation deck. Stop at the Great Blue Heron sign.

38. Why do you often see Great Blue Herons standing motionless in the marsh? _____

From it's picture, describe the various adaptations of the Great Blue. _____

39. Find the Cordgrass sign and explain why it grows farther north than the mangroves. _____

Why is Cordgrass an important marsh plant? _____

40. When and where does the Raccoon feed? _____

They do something unique before eating their food. Describe what they do. _____

41. Describe a Fiddler Crab and explain how it got its name. _____

42. Find the Salt Barrons sign. These are also called salt pans, salt or sand flats, or salt ponds.

How do they form? _____

43. Saltwort is usually one of the first plants to grow in the marshes and salt flats. Why is this so? _____

44. Read the Salt Marshes sign. From the information here and other information you have gained along this trail, explain why salt marshes are important.

Go back along the trail the way you came. At the fork, take the North Loop, to the right.

45. Stop at the Marsh Elder sign and describe it's characteristics. _____

Continue along the trail, following the signs back to the entrance. At the South Loop sign, turn right. Find the Food Chain sign.

46. All food chains begin with _____. Draw a marsh food chain.

Continue along the trail, following the signs back to the Entrance!!!

ADOPT A WETLAND TO STUDY

Many of the ideas and suggestions included in this activity have been adapted (with permission) from the Georgia Adopt-A-Wetland program of the Department of Natural Resources and Environmental Protection Division. To obtain official Adopt-A-Wetland materials and to register your wetland call 912-356-2809, 404-656-0099, or 404-656-0069.

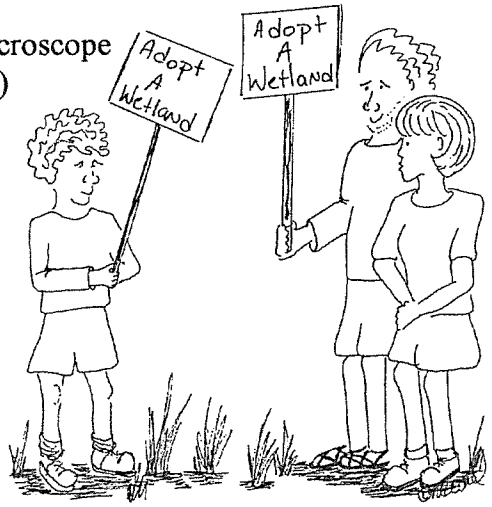
OBJECTIVES: 1. To investigate the function and values of a wetland.
2. To identify the plant and animal species that depend on that wetland.
3. To compare the soil characteristics, hydrology, and physical properties of the water within a wetland.

MATERIALS:

Test kits for the various water characteristics you will be studying. The major biological supply companies have snap kits (Chem Mets) for pH, dissolved oxygen, ammonia, nitrites, and salinity, etc., and bacteria or fecal chloroform that are inexpensive, simple, and safe for all ages to use.

Other Materials might include:

soil thermomter
pH paper (if not using a kit)
Wetland Wheels (if freshwater)
measuring tape
collecting bowls, jars, or bottles
buckets (for collecting water)
"Key to Soil Texture By Feel"
"Color Me Wet" soil chart
discovery scope or field microscope
salinity chart (see appendix)
shovel
air/water thermometer(s)
plankton net
hydrometer
dip nets
secci disk
kick net or seine net (if water is accessible)
Plant ID sheets for the appropriate wetland type



PROCEDURE:

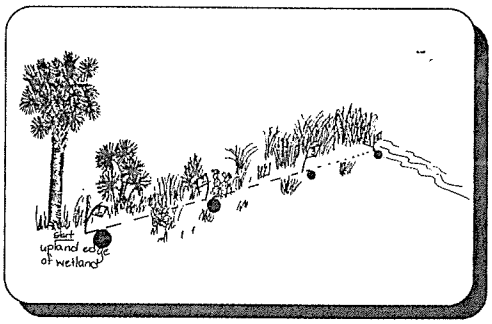
Identify a wetland for your study. If the area is on private property be sure to obtain permission to use it. What type of wetland is it?

Before going to the wetland:

1. Discuss the local history and uses of your wetland (you may have to do some research on this). Discuss how the local citizens regard this wetland. As a class, discuss the functions and values chart for your wetland.
2. Decide on what tests the class will make and how often (once at the beginning of the year and once near the end of the school year; once a month, etc.)
3. Discuss what materials you will need when you go to your wetland. Will you need boots/waders or old shoes?

4. Gather all the materials you will need to make your study. Practice using test kits and wetland wheels.

At the wetland:



1. Before entering the wetland, make a visual survey.
2. Use a measuring tape to measure a transect through the wetland to the water source. The first station should be near the upland edge of the wetland and the last station in the water.
3. If you a doing a plankton study, drop your net before beginning the other investigations. Retrieve it after about 30 minutes.
4. Conduct the decided upon investigations at each station. You may use the data sheets provided or prepare your own. Plant and animal investigations should be done within a five foot square around your station.
5. Retrieve the plankton net and observe the plankton under the field microscope or take it back to the classroom for study later.

Register your wetland with the Georgia Adopt-A-Wetland program.

OBSERVATIONS:

1. Record all observations on the charts. Be sure to record the date for each observation.
2. Did you notice any difference in the soil temperature at the different stations? Describe the differences.

3. Describe any differences in soil texture, color, and smell across your transect.

3. Which station had the greatest variety of plants?
   Which station contained the greatest number of plants?
   Explain why this is so.

4. Around which station did you notice the most animals or evidence of animals?
   Explain your answer.

5. Account for the differences in the differences in the number of and types of plants and animals across your wetland.

CONCLUSIONS: Explain the type of wetland that you have adopted. Discuss how it is and how it is important to the plants and animals that live there. Explain how this wetland is important to the local citizens of the area.

Wetland Function and Values Chart

As a class, discuss the following characteristics of your wetland and rank them from 1 - 5, with 5 being the most important. Keep in mind that all functions are not necessarily values and vice versa.

Wetland Characteristic	*Wetland Function*	*Value to Community*
Recreational Values: ◆ hunting permitted? ◆ fishing for food or sport? ◆ nature trails or wildlife observation locations?		
Fish, Wildlife and Plant Habitat: ◆ wetland in migratory bird pathway? ◆ nesting of birds in wetland? ◆ habitat for mammals, birds, fish, amphibians, and reptiles?		
Intrinsic: ◆ only 'natural' or green area in community? ◆ site for scientific research? ◆ habitat for endangered or threatened species?		
Economic: ◆ timber, fish, shellfish production? ◆ tourist attraction? ◆ timber or vegetation harvested?		
Educational: ◆ nature preserve or county park? ◆ nature center or interpretive trail which is easily accessible? ◆ historical artifacts in or around wetland?		
Flood Storage: ◆ located in headwaters of the watershed? ◆ downstream in watershed? ◆ is it a Riverine wetland? ◆ is it large enough to store and diminish flood waters?		
Groundwater Recharge and Discharge? ◆ recharge for community's drinking water supply? ◆ does community rely heavily on groundwater for water supply?		
Erosion Control: Channel and Shoreline: ◆ does a prominent river or stream run through the community? ◆ wetland associated with river, coast, or lake?		
Water Purification: Surface and Groundwater: ◆ filter runoff water and release clean water? ◆ trap polluted runoff or excess nutrients?		

Visual Survey of Your Adopted Wetland

Wetland Type: _____ **Location of Wetland:** _____
(give address if known) _____

Date of Survey: _____ **County:** _____

Temperature: _____

Cloud Cover: (check one) [] clear [] partly cloudy [] overcast

List the major cloud type or types:

Check one of the following: [] not raining [] raining [] rain within last 24 hours
[] rain within last 48 hours

Describe any sounds you hear:

Describe any smells:

Do you see any birds? ____ If so, describe where they are and what they are doing.

Describe any man-made features near your wetland.

In the space below, draw a rough sketch of your wetland. Show where the water source is and the locations of visible plants (and animals). Be sure to indicate which way is upland.

Adopt-A-Wetland Data Chart #1

Record the information about the plants, animals, and soil of your wetland in the chart below. Use your wetland wheels (if a freshwater wetland), "Color Me Wet" and "Soil Texture by Feel" charts, plant identification sheets that are appropriate for your type of wetland, and the Animal Tracks drawings.

Station #	Name and # of each plant type	Name and # of each animal or animal evidence found	Soil temp	Soil pH	Color of soil (use chart)	Texture of soil (Use key)	Smell of soil
#1							
#2							
#3							
#4							
#5							

Adopt-A-Wetland Data Chart #2

Station #	Temp.	pH of	Turbidity	Salinity	DO (dissolved oxygen)	Ammonia	Nitrites	Organisms Present types and # of each (use plankton , dip, kick, or seine nets)
#1								
#2								
#3								
#4								
#5								

INTERDISCIPLINARY ACTIVITIES

SOCIAL STUDIES:

1. Use the information in the History section to make a time line.
2. Prepare migration reports and a migration map of the birds commonly seen in wetlands.
3. Research some of the wetland laws.
4. Study historical uses of salt marshes by the Indians and the colonists.
5. Study the history of the fishing and/or shrimping industry in Georgia and how it is dependent on wetlands.
6. Interview an older local resident about the changes in land use during his/her lifetime.
7. Research how early inhabitants used wetlands. Make a video using drawings or creative dramatics.
8. Research the Altamaha River. Discuss its importance as a wetland area.
9. Write a series of newspaper articles about the importance of wetlands and submit them to the local newspaper.
10. Develop a survey for use in their neighborhood, to test their neighbors knowledge of wetlands.
11. Research the importance of salt marshes on the commercial fishing industry.
12. Write a new wetland law.
13. Encourage local and state officials to issue proclamations declaring May as American Wetlands Month in your community.
14. Research how wetland plants were used by Indians and other early settlers.

LANGUAGE ARTS:

1. Write a "Biography of a Marsh". Describe events that may have happened from to it from the marsh's point of view. The biography can be factual or imaginative.
2. Write "Wetland Poems".
3. Sit quietly for about 5 minutes listening to the sounds of the "Swamp" (or any other wetland habitat). What sounds do you hear? Write a poem or a story entitled "The Sounds of the Swamp".
4. Mystery Bird Descriptions: Have students write a description of a bird they saw in a wetland. Exchange papers and using field guides or pictures from this manual, have other students try to identify the "Mystery Bird".
5. Have students write legends, fables, or songs about their experiences in a wetland.
6. Have the students write a story about a wetland creature. Then have them change their story into a play. The students could perform the play or create a stage and puppets to present their play.
7. Creative writing: Finish the sentence by writing a short story.
   "If I were a freshwater marsh and the floods came, I would ....."
   "If I were marsh mud and pollutants came in, I would ....."
   "If I were a wetland and the bulldozers came, I would ....."
8. Write a story about the travels of water through a wetland.

9. Use the history of wetlands and wetland trends fact sheet to write a historical fiction story that could have taken place in Georgia's wetlands.
10. Write a "Wetlands Mystery" book.
11. Write a wetland recipe book.
12. Start a wetland pen pal program with students from other nearby schools or from out of state schools.
13. Organize a wetlands essay contest for your school.
14. Have the students create a wetlands picture/alphabet dictionary. The dictionary should include words that begin with each letter of the alphabet and in some way relate to wetlands.

ART:

1. "Shapes of the Wetlands". Find as many different shapes as possible and make a collage of wetland shapes.
2. Paint a picture using different items found in a wetland. Use pigments from plants, leaves, stems, sand, mud, etc.
3. Make clay models of a favorite animal seen in a wetland.
4. Leaf or grass prints: Collect leaves/grass from a wetland to take back to the classroom. Place leaf/grass on newspaper. Using a sponge or brush, add paint to the leaf/grass. Put leaf/grass with paint side down onto cloth, construction paper, etc., cover with newspaper and press or use a rolling pin. Be creative: the students can make wall hangings, note paper, placemats, etc.
5. Leaf or grass rubbings: place leaf/grass under paper. Using crayon or pencil, rub over it.
6. Splatter prints: Use leaves, shells, sand dollars, seaweed, etc., thinned paint, old toothbrush, small piece of wire screening or thin stick. Arrange object to be painted on the paper. Dip toothbrush into the paint and let any drips fall back into the paint container. Hold toothbrush several inches above the paper and rub the bristles against the screening or stick, spattering paint onto the paper around your object.
7. "Wetland Mural": Divide the class into groups. Each group draws a different type of wetland on a strip of butcher paper. Tape all habitats together.
8. "Wetland Diorama": Have students build a diorama of a wetland inside a shoe box.
9. Make "Wetland Clay": Mix one cup mud and one-half cup corn starch, pour in boiling water and mix well. Cook briefly until mixture thickens. Wait a minute or so for the mixture to cool. Use imagination and model into your favorite wetland shape. Place on a flat cooking sheet and bake at 275° until dry (can dry without oven).
10. Create a wetland bulletin board. Have students bring in newspaper articles.
11. Make "Camouflage Tubes". Have students choose an animal from a wetland habitat and decorate a toilet paper tube with twigs, grasses , sand etc. to depict the camouflage adaptations of that animal for survival in its habitat.
12. Wetlands are excellent locations for photography. Take pictures of lines, trunks of trees, patterns of palmetto, cypress knees, etc.
13. Take slides and sound recordings of various wetland areas and prepare a multi-media presentation.
14. Design T-shirts, bumper stickers, stamps and posters with catchy slogans which tell the importance of wetlands.
15. Conduct a wetland photo shoot and create a display of the students photos.

MUSIC:

1. Have the students write songs about wetlands to the tunes of familiar songs. Songs could be written to the following tunes:
   Ten Little Indian Boys
   Row, Row, Row Your Boat
   Did You Ever See a Lassie?
   Rudolph the Red-Nosed Reindeer
   Home on the Range
   Over the River and Through the Woods
   This Land Is Your Land
   While Strolling Through The Park One Day

MATH:

1. Make graphs of the information collected in various activities: compare the salinity, dissolved oxygen, pH, nitrites, etc. of various wetland locations Make air temperature comparisons at different wetland locations.
2. Find the surface area of various wetland locations. Find the average size for each, mean, median, mode, etc. Graph results and compare the size of the different wetlands.
3. Prepare graphs of the plant and/or animal life found in each type of wetland. Find the percentages of each animal/plant found in each.

SCIENCE:

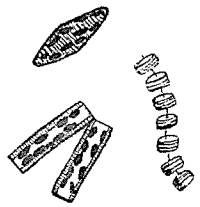
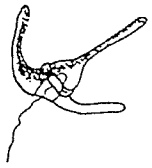
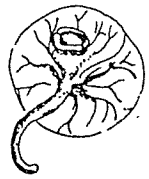
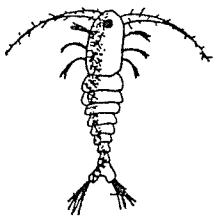
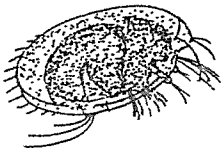
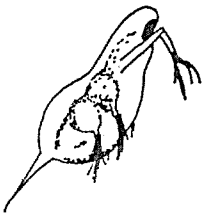
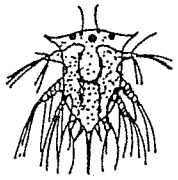
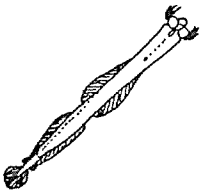
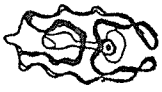
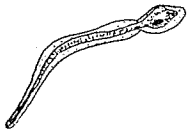
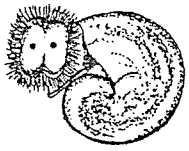
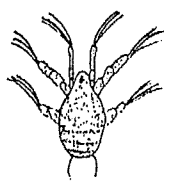
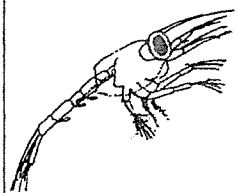
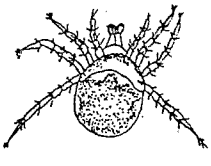
1. Go on a "Bird Behavior Hunt". Observe the behavior and movement of the birds in a wetland. Record your observations and discuss why they behaved or moved as they did.
2. Measure the velocity of a wetland water source. Measure about 5 yards downstream along the water source (mark the beginning and ending of the measurement). Drop a piece of wood or grass into the water at the beginning. Time how long it takes for the wood or grass to float the 5 yards. Divide this time by 5 or whatever distance you measured. This is the speed the water was flowing. It would be interesting to compare the speed of the water during incoming and outgoing tides.
3. Make an underwater viewing can. Cut both ends out of a coffee can. Attach a strip of clear plastic or plastic wrap over one end with a large rubber band.
4. Establish the "WETLAND TRAVEL AGENCY". Students should prepare travel itineraries for migratory residents of the wetlands. These itineraries may be written as travel tickets, and then plotted on world maps.
5. Play "Estuary Quest" or "Marsh Quest" or "Wetland Quest", etc. Divide the class into teams. Each team is competing against the other teams. Pin or tape the name of an estuary (marsh or wetland) resident (use fact sheets for this information) on the back of each student. Each member of each team gets one turn to ask teammates 4 questions. These questions can only be answered by yes or no. If the student guesses his identity on the first question he/she earns 4 points for his team, 3 points if guessed on second question, 2 points if guessed on third question and 1 point if guessed on fourth question. After each team member has had a turn,

talley the total points earned by each team. The winning team is the team with the most points.

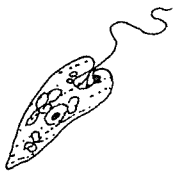
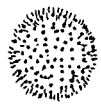
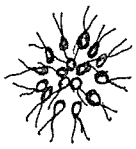
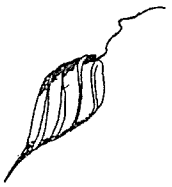
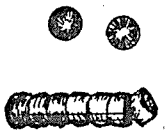
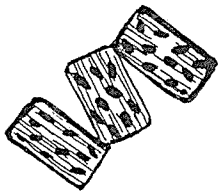
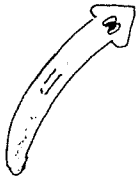
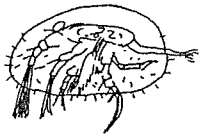
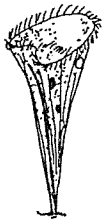
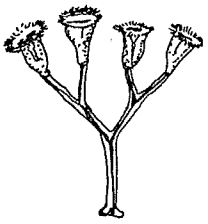
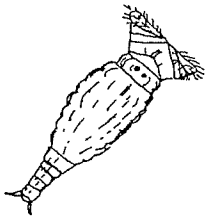
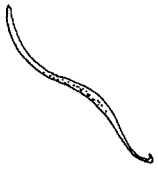
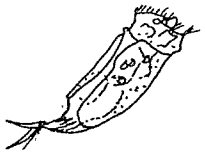
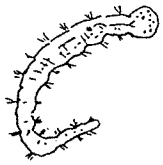
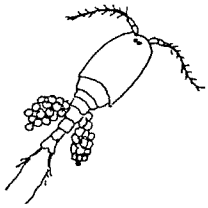
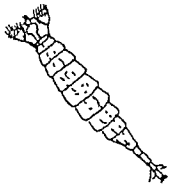
6. Have each student create a food chain for each type of wetland. Then take these food chains and create food webs. Be sure to discuss how loss of one member of a food chain in one habitat can affect the food chains and webs in other habitats.
7. Wetland scavenger hunt. Before visiting a wetland, prepare a list of items that the students should look for. Be as creative as possible. Some items might include: a bird track, bird feather, Styrofoam, an old shoe, a bone, plastic, algae, snail shell, milk carton, aluminum can, tin can, fishing line, rope, etc. Divide the class into teams of 4-6 students. Give each team a section of the beach in which they can search and a time limit. All teams must bring their items to teacher for verification. (Be sure to save any trash and remove it from the wetland) The team with the most items wins.
8. Microbial study: collect samples of mud or sand from various locations in a salt marsh. Prepare a culture of each for bacteria. Make slides and examine the bacteria. Compare the different bacteria found in each environment. (Remember that you can use Millipore Samplers to do this).
9. Have students create a food web or an energy pyramid for the various types of wetlands. Discuss how, even though they are separate habitats, they may be interdependent on each other. Many of the same organisms are members of the food web or pyramid of one or more habitats.
10. Make an adaptation card game: Draw pictures of various wetland organisms (both plant and animal) on one side of an index card. Use the pictures and make a list of as many adaptations of each organism as possible. Write the adaptations on separate cards. Use the cards to play a game of concentration. Place all the cards face down on the table in a big square. Turn over two cards; if the picture matches the adaptations, you may keep the pair and turn over two more cards. A turn ends when the two cards do not match up. The number of players will depend on the number of cards available for the game.
11. Make a list of the benefits to humans that wetlands provide. Distinguish between commercial benefits and recreational ones. Make sure that the list includes only those aspects that have no adverse effects on wetlands. Make a similar list of those detrimental effects that humans have on wetlands. Discuss way in which wetlands can be saved or protected.
12. Study the feeding habits of birds that are on a salt marsh. Are they feeding on insects, worms, crustaceans, shellfish, grasses, or other things?
13. Have students participate in a replanting of wetland plants.
14. Take students on a canoe trip through a wetland.
15. Have students host a "Wetlands Awareness" night at their school or celebrate an "American Wetlands Month Celebration Day" with cosponsors and wetlands events throughout the day.
16. Adopt a beach and plant Sea Oats or adopt a swamp and plant Cypress trees. Plants can be ordered from The Liner Farm (1-800-300-1484).
17. Sponsor a "Wetland Olympics" at the school.
18. Adopt A Wetland.

Identification Guides

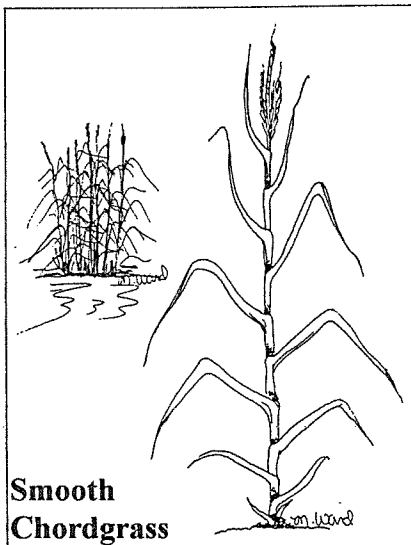
Indentification Guide to Some Common Marine Plankton

 *Diatoms*	 *Dinoflagellate*	 *Gymnodinium*	 *Gonyaulax*	 *Noctiluca*
 *Tintinnid*	 *Copepod*	 *Rotifer*	 *Ostracod*	 *Branchopod*
 *Barnacle Cyris*	 *Barnacle Nauplis*	 *Skeleton shrimp*	 *Scud*	 *Crab Zoea*
 *Crab Megalops*	 *Arrow Worm*	 *Polychaete Worm*	 *Flat Worm*	 *Sea Urchin*
 *Starfish Larvae*	 *Sea Cucumber*	 *Fish Egg*	 *Fish Larvae*	 *Tunicate Larvae*
 *Veliger Larvae*	 *Lucifer*	*early*  *Shrimp Larvae*	*late*  *Shrimp Larvae*	 *Salt Water Mite*

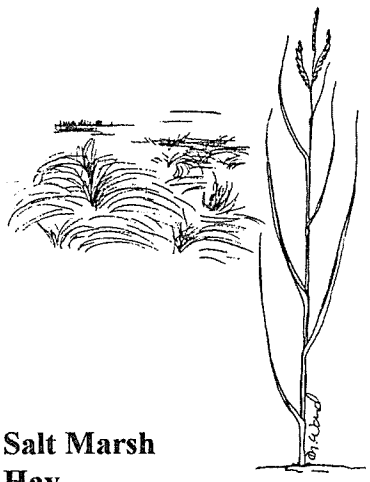
Indentification Guide to Some Common Freshwater Plankton

 *Euglena*	 *Peridinium*	 *Volvox*	 *Chlamydomonas*	 *Ceratium*
 *Gonium*	 *Phocus*	 *Lapocineils*	 *Cocconeis*	 *Stephanodiscus*
 *Cyclotella*	 *Tabellaria*	 *Dugesia*	 *Ostracod*	 *Paramecium*
 *Stentor*	 *Amoeba*	 *Loxodes*	 *Zoothamnium*	 *Philodina*
 *Daphnia*	 *Nematode*	 *Vorticella*	 *Carchesium*	 *Euchlanis*
 *Oligochaete*	 *Cyclops*	 *Rotaria*	 *Lacrymaria*	 *Euplotes*

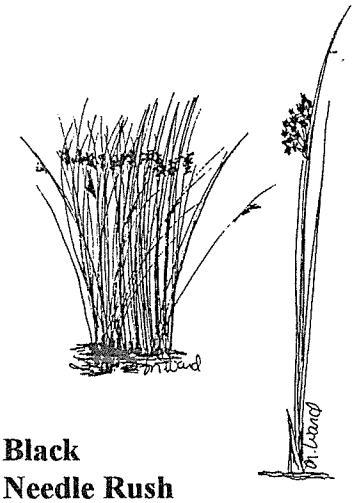
Identification Guide to Some Common Plants of Coastal Salt Marshes



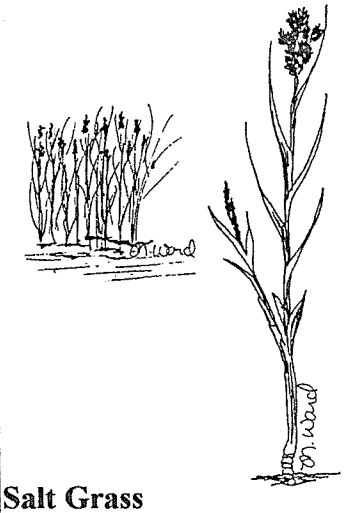
Smooth Chordgrass



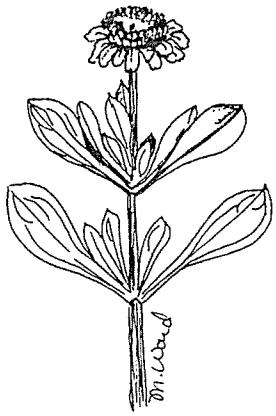
Salt Marsh Hay



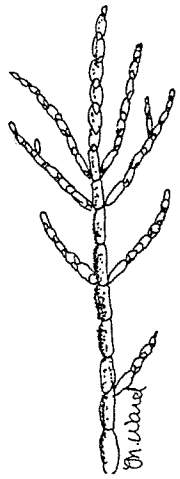
Black Needle Rush



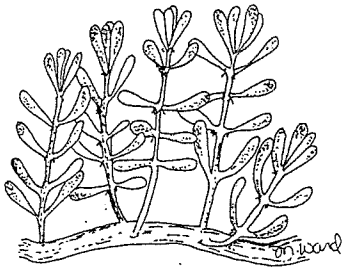
Salt Grass



Sea Oxeye Daisy



Glasswort

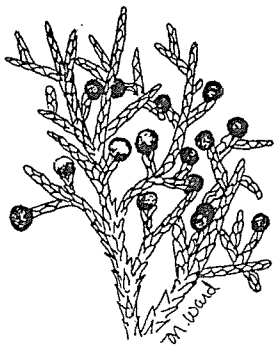


Saltwort

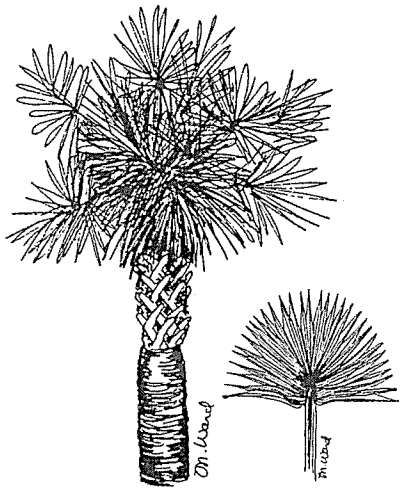
Bayberry (Wax Myrtle)

Yaupon Holly

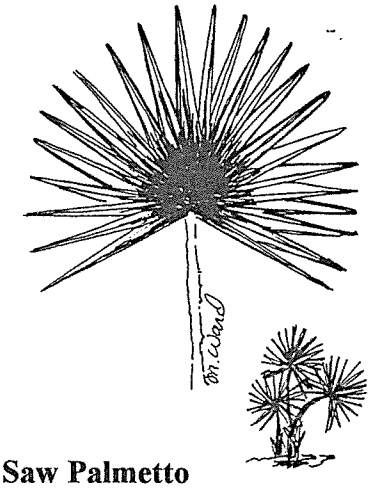
Identification Guide to Some Common Plants of Coastal Salt Marshes



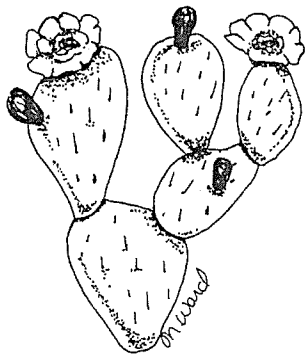
Red Cedar



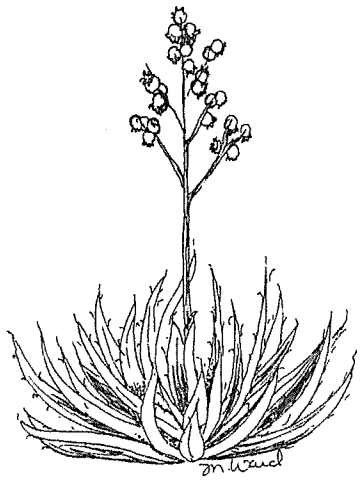
Cabbage Palmetto



Saw Palmetto

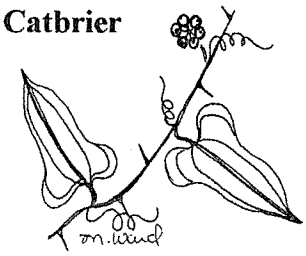


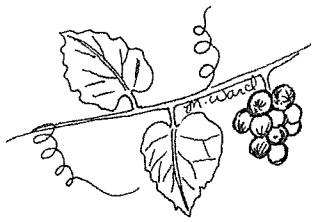
Prickley Pear



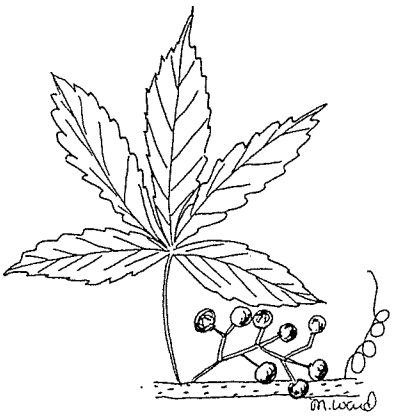
Spanish Bayonet

Catbrier





Muscadine Grape



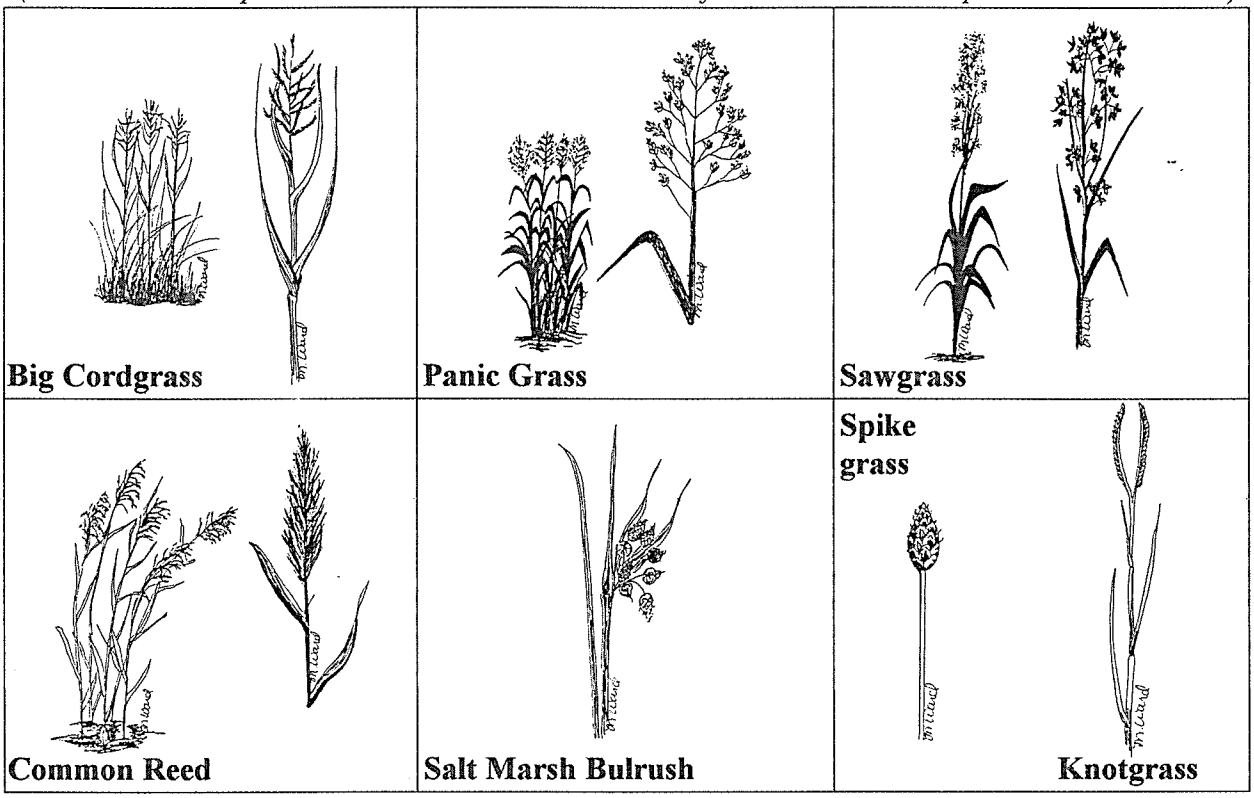
Virginia Creeper

Pepper-vine

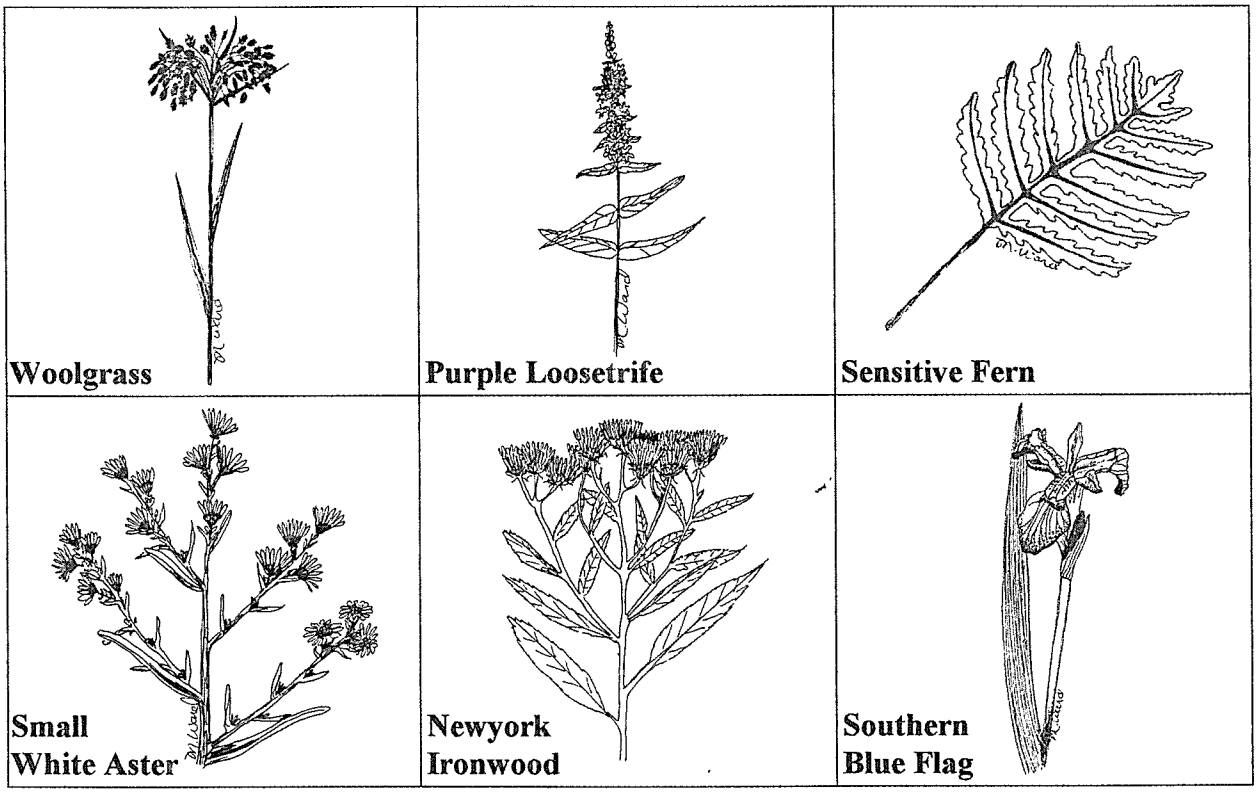
Morning Glory

Identification Guide to Some Common Plants of Brackish Marshes

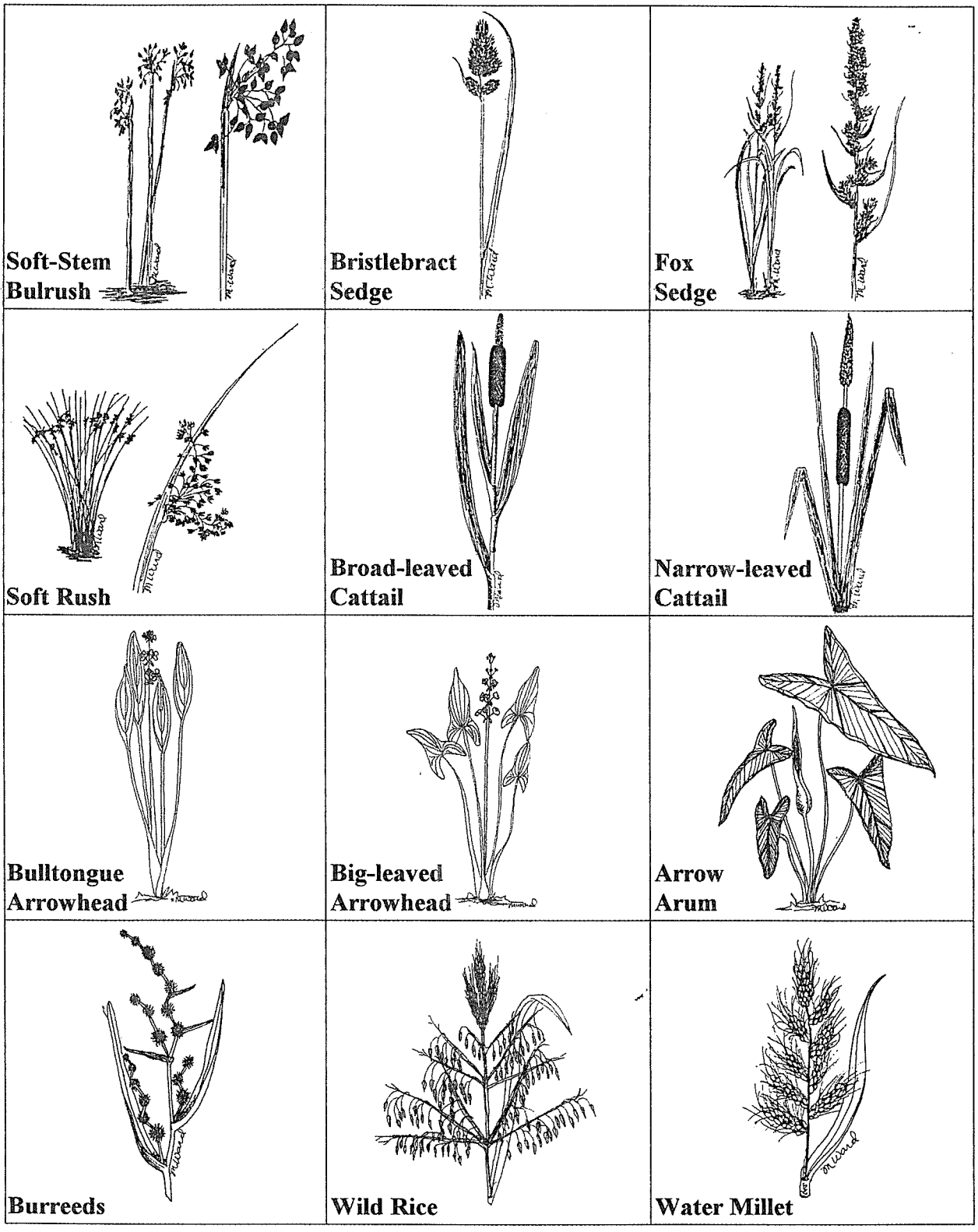
(In addition to the plants shown here, brackish marshes often contain the same plants as a salt marsh)



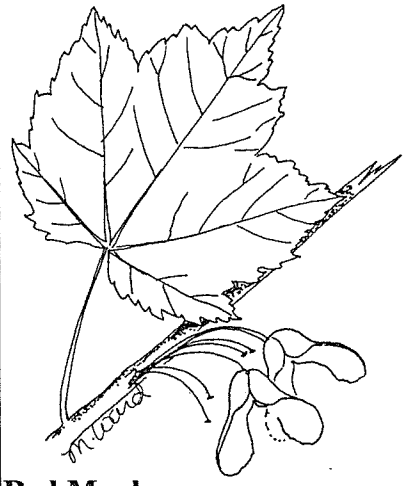
Identification Guide to Some Common Plants of Wet Meadows



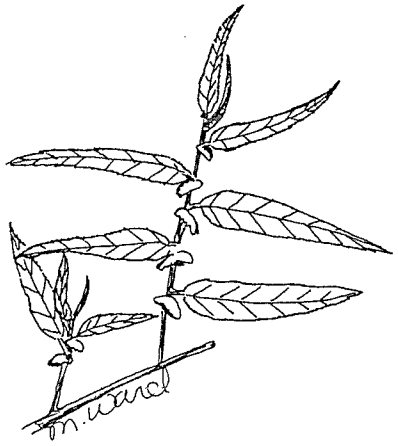
Identification Guide to Some Common Plants of Freshwater Marshes



Identification Guide to Some Common Plants of Forested Wetlands

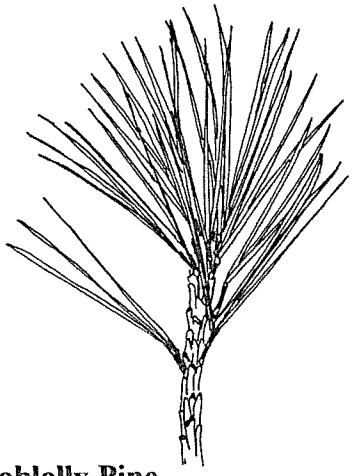


Red Maple

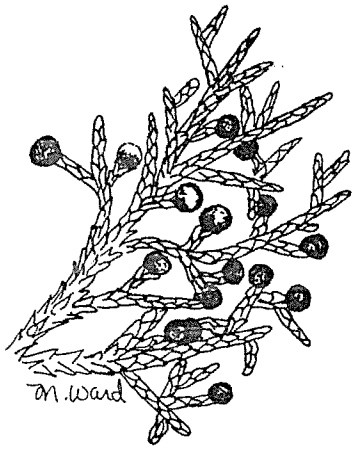


Black Willow

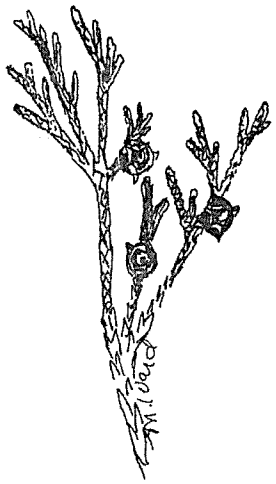
Green Ash



Loblolly Pine



Eastern Red Cedar



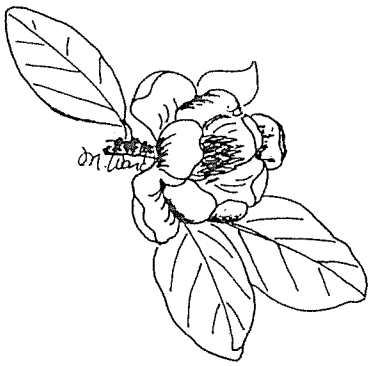
Atlantic White Cedar

Overcup Oak

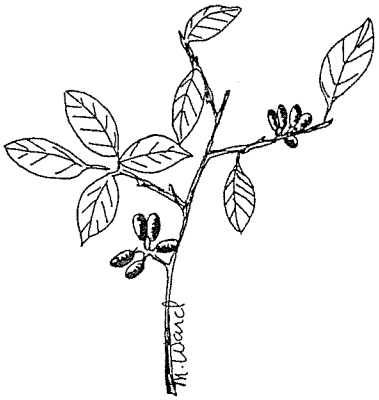
Water Hickory

Silky Dogwood

Identification Guide to Some Common Plants of Forested Wetlands



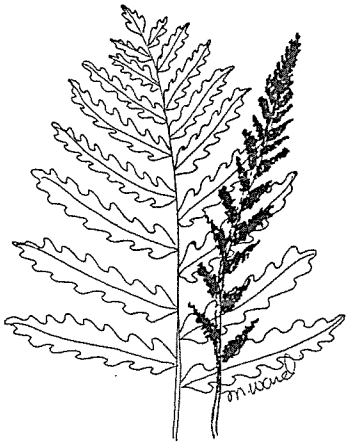
Swamp Magnolia



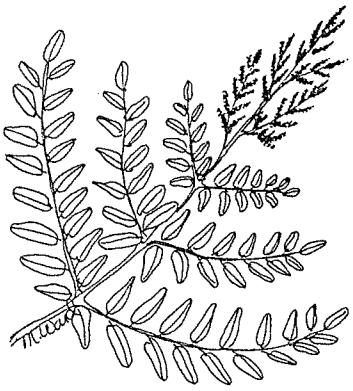
Spice Bush

Swamp Azalea

Highbush Blueberry



Cinnamon Fern

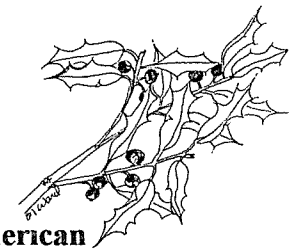
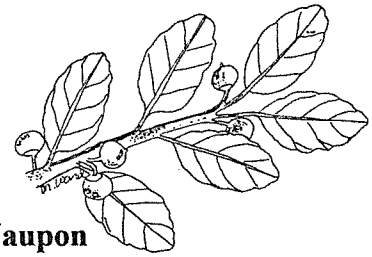
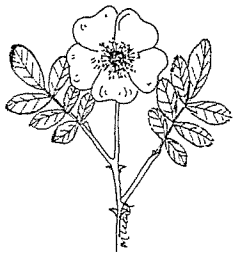
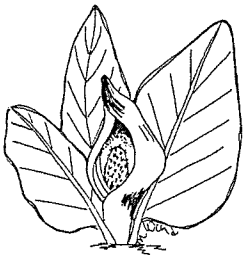
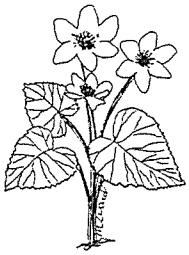
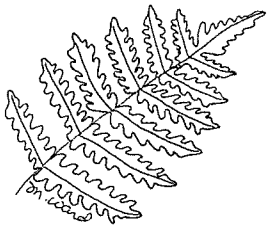
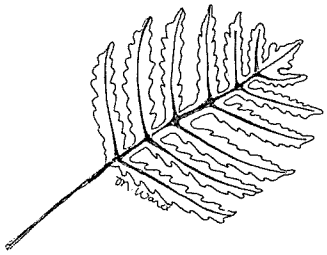
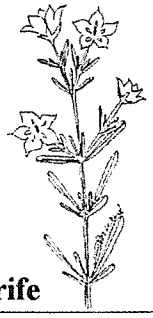
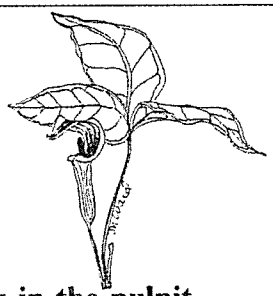


Royal Fern

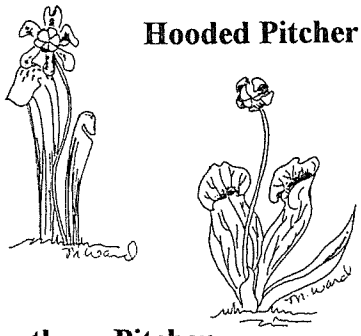
Slender Spikegrass

Virginia Creeper

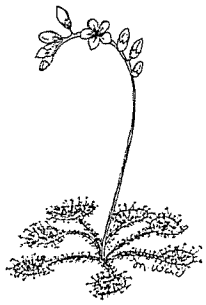
Identification Guide to Some Common Plants of Shrub/Scrub Swamps

 Swamp Willow	 American Holly	 Yaupon Holly
 Buttonbush	 Silky Dogwood	 Sweet Pepperbush
 Speckled Alder	 Swamp Rose	 Skunk Cabbage
 Marsh Marigold	 Jewelweed	 Marsh Fern
 Sensitive Fern	 Loosestrife	 Jack-in-the-pulpit

Identification Guide to Some Common Bog Plants



Northern Pitcher

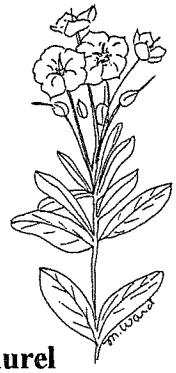


Round-leaved Sundew

Highbush Blueberry

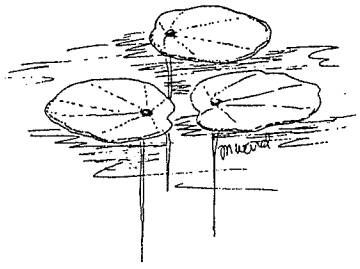
Leatherleaf

Swamp Azalea



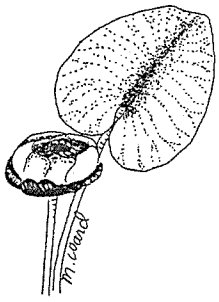
Bog Laurel

Identification Guide to Some Common Plants of Shallow Freshwater Ponds and Seeps

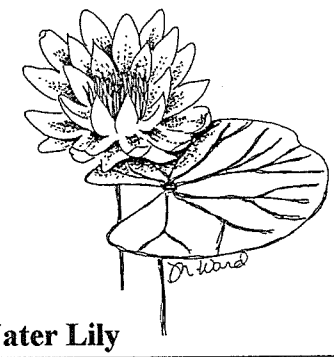


Duckweed

Mosquito Fern



Spatterdock



Water Lily

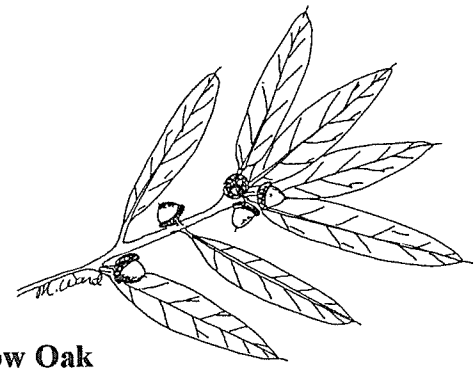
Pondweed

Hornworts

Identification Guide to Some Common Trees of the Swamp

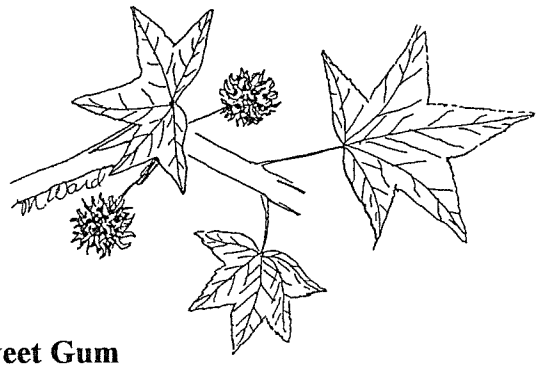
Water Oak

Laural Oak

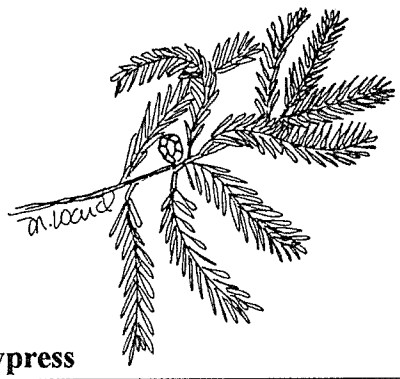


Willow Oak

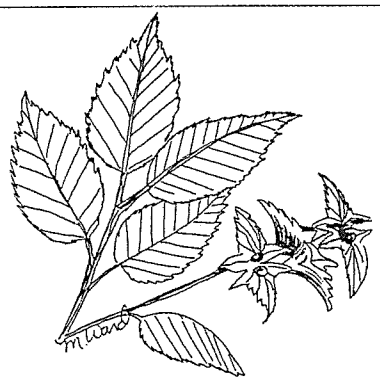
Green Ash



Sweet Gum



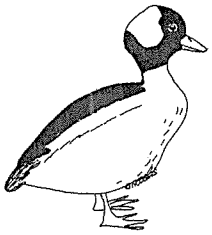
Bald Cypress

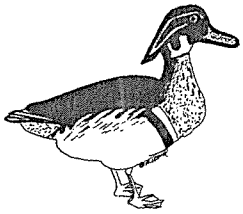


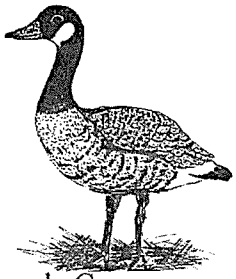
Ironwood

Water Tupelo

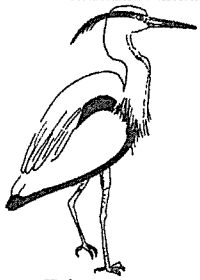
Identification Guide to Some Birds Common to Various Wetland Habitats

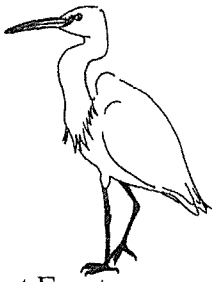

Bufflehead

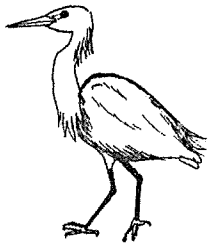

Wood Duck

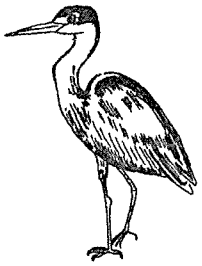

Canada Goose

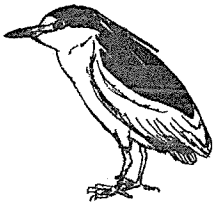

Least Sandpiper

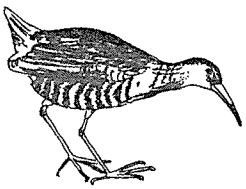

Great Blue Heron


Great Egret


Snowy Egret

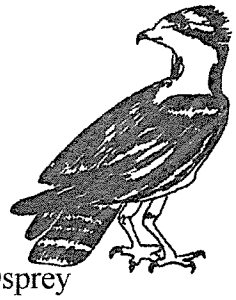

Little Blue Heron

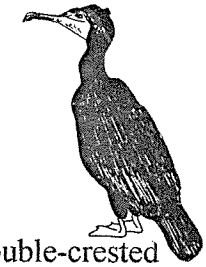

Black-crowned Night Heron

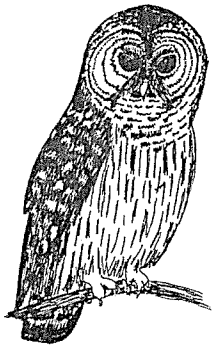

Clapper Rail

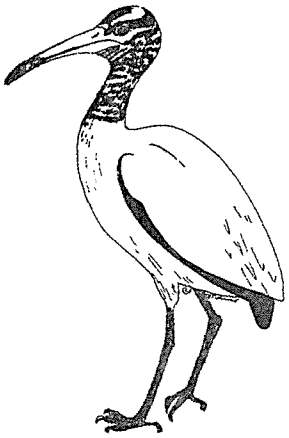

Marsh Wren

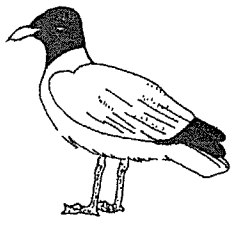

Red-winged Blackbird

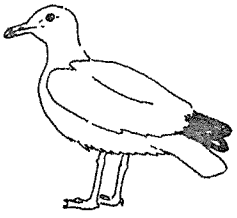

Osprey


Double-crested Cormorant

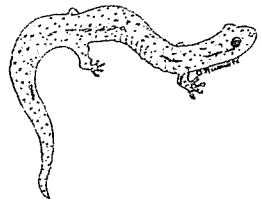
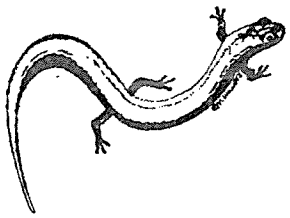
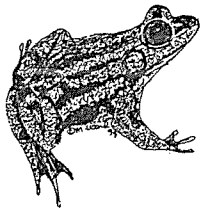
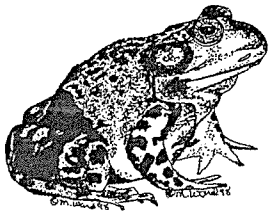
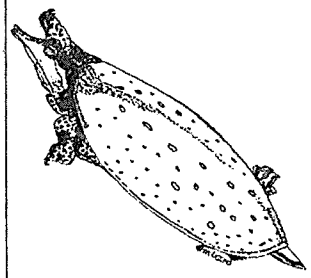
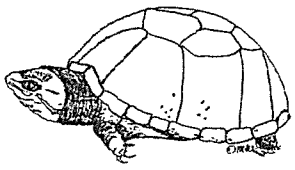
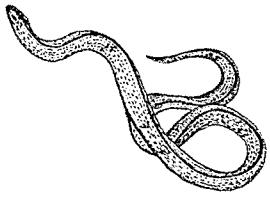
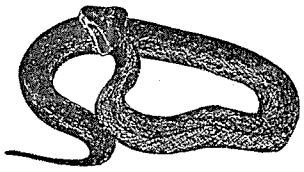
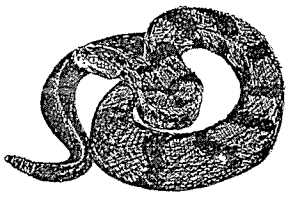
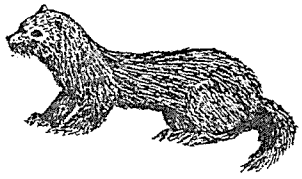
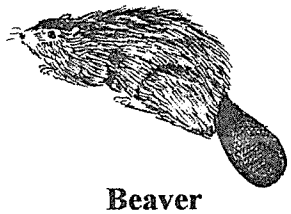
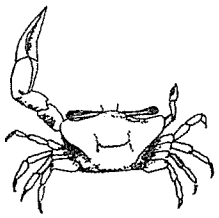

Barred Owl


Wood Stork

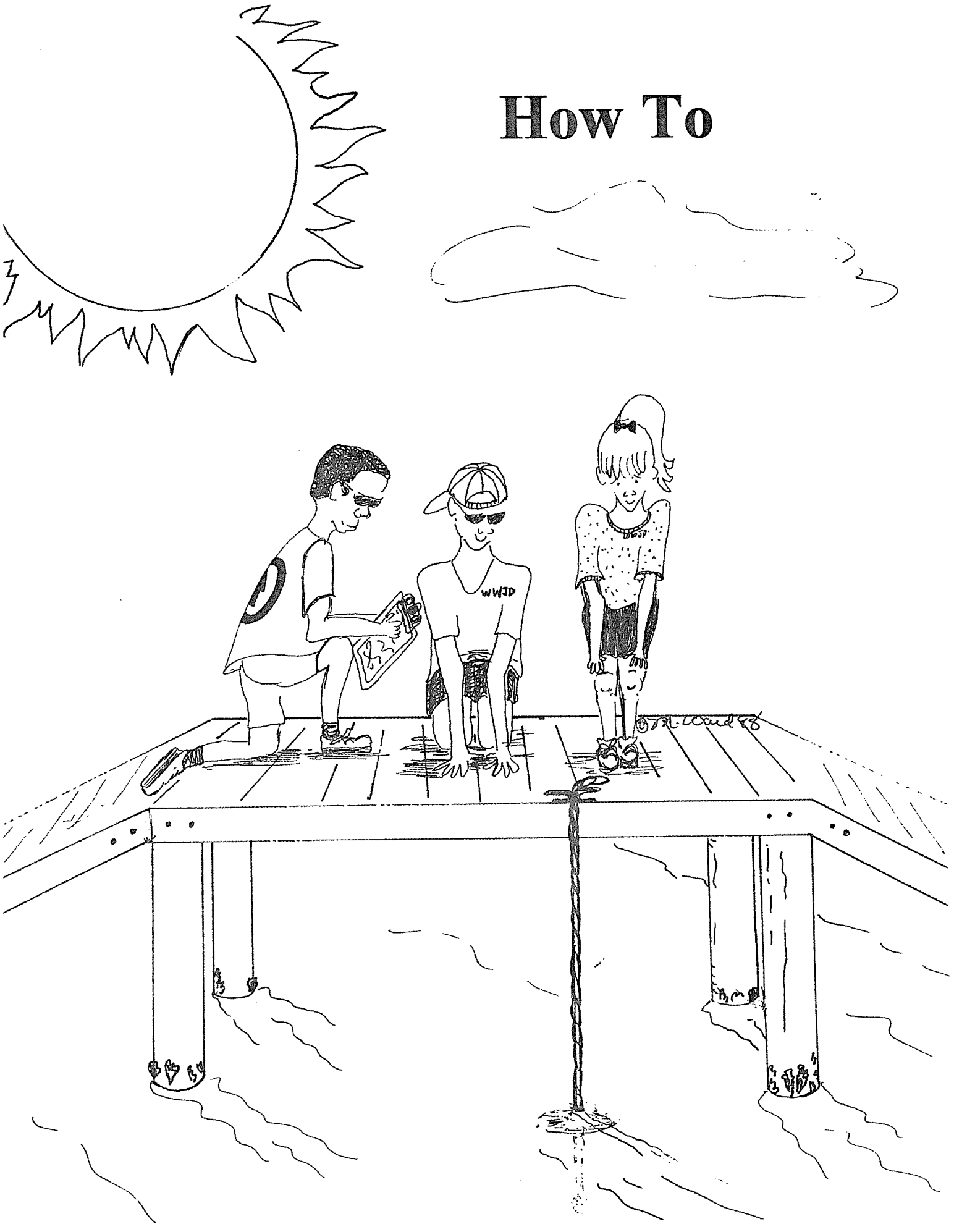

Laughing Gull


Ring-billed Gull

Identification Guide To Some Animals that Frequent Various Wetland Habitats

 Mud Salamander	 Dwarf Salamander	 Spring Pepper Frog	 Carpenter Frog
 Bullfrog	 Eastern Mud Turtle	 Spiny Softshell Turtle	 Stinkpot Turtle
 Black Swamp Snake	 Cottonmouth	 Timber Rattlesnake	 Raccoon
 Rabbit	 Muskrat	 Mink	 Beaver
 Opossum	 Fiddler Crab		

How To



Salinity Chart

Directions: Measure the density and temperature of your water sample. Locate the density under the hydrometer reading column, then move to the right to the column under the temperature closest to that of your sample. The number is the salinity of your water sample. The salinity is expressed in parts per thousand (ppt).

Temperature of the water

Hydrometer Reading	55°	60°	65°	70°	75°	80°	85°	90°
*1.000	*0.8	*1.1	*1.6	*2.4	*3.2	*4.1	*5.1	*5.9
*1.001	*2.1	*2.4	*2.9	*3.7	*4.5	*5.4	*6.6	*7.2
*1.002	*3.4	*3.7	*4.3	*5.0	*5.9	*6.8	*7.9	*8.6
*1.003	*4.7	*5.0	*5.6	*6.3	*7.2	*8.1	*9.2	*9.9
*1.004	*6.0	*6.3	*7.0	*7.7	*8.5	*9.4	*10.6	*11.2
*1.005	*7.2	*7.6	*8.2	*9.0	*9.8	*10.7	*11.9	*12.7
*1.006	*8.5	*8.9	*9.6	*10.3	*11.1	*12.2	*13.2	*14.0
*1.007	*9.8	*10.2	*10.8	*11.6	*12.6	*13.5	*14.5	*15.3
*1.008	*11.1	*11.5	*12.2	*12.9	*13.9	*14.8	*16.0	*16.7
*1.009	*12.4	*12.8	*13.5	*14.2	*15.2	*16.2	*17.3	*18.0
*1.010	*13.7	*14.1	*14.8	*15.6	*16.5	*17.5	*18.6	*19.4
*1.011	*15.0	*15.4	*16.1	*17.0	*17.8	*18.8	*20.0	*20.8
*1.012	*16.3	*16.7	*17.4	*18.3	*19.2	*20.1	*21.3	*22.1
*1.013	*17.6	*18.0	*18.7	*19.6	*20.5	*21.6	*22.6	*23.5
*1.014	*19.0	*19.4	*20.0	*20.9	*21.8	*22.9	*24.0	*24.8
*1.015	*20.3	*20.6	*21.3	*22.2	*23.1	*24.2	*25.4	*26.1
*1.016	*21.6	*22.0	*22.7	*23.5	*24.4	*25.5	*26.7	*27.6
*1.017	*22.9	*23.3	*24.0	*24.8	*25.9	*26.9	*28.1	*28.9
*1.018	*24.2	*24.6	*25.4	*26.1	*27.2	*28.2	*29.4	*30.2
*1.019	*25.5	*25.9	*26.7	*27.6	*28.5	*29.5	*30.7	*31.6
*1.020	*26.8	*27.2	*28.0	*28.9	*29.8	*30.8	*32.1	*32.9
*1.021	*28.1	*28.5	*29.3	*30.2	*31.1	*32.3	*33.4	*34.2
*1.022	*29.4	*29.8	*30.6	*31.5	*32.5	*33.6	*34.7	*35.6
*1.023	*30.7	*31.1	*31.9	*32.8	*33.8	*34.9	*36.0	*37.0
*1.024	*32.0	*32.4	*33.2	*34.1	*35.1	*36.2	*37.5	*38.2
*1.025	*33.2	*33.7	*34.5	*35.4	*36.4	*37.6	*38.8	*39.7
*1.026	*34.5	*35.0	*35.8	*36.7	*37.7	*38.9	*40.1	*41.0
*1.027	*35.8	*36.3	*37.1	*38.1	*39.2	*40.2	*41.5	*42.3
*1.028	*37.1	*37.6	*38.4	*39.4	*40.4	*41.5	*42.8	
*1.029	*38.4	*38.9	*39.7	*40.7	*41.8	*42.9		
*1.030	*39.7	*40.2	*41.0	*42.0				

TESTING WETLAND WATERS

This section contains descriptions of some of the chemical and physical properties of water that are often tested by scientists to obtain an indication of the conditions of the water. A test kit is required to test for most of these properties. Test kits can be obtained from any of the scientific supply companies listed in the "where to obtain materials and supplies" section of this guide. This author recommends using the **snap kits** (sometimes called Chem Mets) because they are simple to use, safe, and inexpensive.

pH

pH is a measure of the hydroxyl (OH^-) or hydrogen ion (H^+) content of water indicates its pH level. This determines whether the water is acidic or basic (alkaline). The pH scale ranges from 1 to 14. A pH of 7 is neutral and the water is neither acidic nor basic. A pH below 7 is acidic and a pH above 7 is basic. Because the pH scale is logarithmic and a one-unit change in pH equals a ten times change in the strength of the acid or base. For example, a pH of 2 is 10 times more acidic than a pH of 3.

Many biological, chemical, and hydrological processes affect the pH of the water. Changes in pH can be caused by atmospheric deposition, sediment load and storm or wastewater runoff. Acidification that occurs during storms can cause wide fluctuations in pH. When water with a low pH value comes in contact with certain chemicals and metals, the acid may cause these substances to become more soluble or more toxic than normal.

Each organism has its own optimum pH level. Most fish can tolerate pH values between 5 and 9 but the ideal range is between 6.5 and 8.2. Pure rain has a pH of 5.6 which is slightly acidic and ocean water has a pH of 8.3 which is slightly basic.

pH tests should be run as soon as a water sample is taken since changes in the temperature can change the pH. There are three methods commonly used to test for pH: Hydrion Paper, chemicals, and electronic meters. The simplest and cheapest method is to use Hydrion Paper. To test a sample of water using Hydrion Test Paper: 1) Obtain a water sample in a clean container. 2) Tear off approximately 3 inches of paper and immerse it into the water sample. Let it stand for a few seconds. 3) Remove the paper from the water and immediately compare the color of the paper with the color chart found on the test paper dispenser.

DISSOLVED OXYGEN (DO)

The amount of oxygen that is dissolved in the water is a very important indicator of the condition of the water. There are several ways that oxygen can get into the water: diffusion at the surface; aeration by breaking waves or tumbling over falls, rapids, or rocks; and by photosynthesis occurring in aquatic plants. Three-fourths of all the world's oxygen supply is produced by oceanic algae.

Temperature controls the amount of oxygen that water can hold. Warm water holds less oxygen than cold water if everything else is the same. In addition to temperature, the amount of oxygen

present is determined by the number of organisms using the oxygen, weather conditions, the time of day, the season of the year and the amount of decomposition or chemical activity occurring in the water, and the stillness of the water.

The amount of oxygen an organism requires depends upon its species, the temperature of the water and the physical state of the organism. Because of these variables it is difficult to predict an organism's specific oxygen demand. Most populations of marine fish require at least 4-5 ppm (parts per million) dissolved oxygen to live and up to 9 ppm to reproduce. When the dissolved oxygen content drops below 3 ppm, most fish die. Ideal oxygen conditions for freshwater fish is 7 ppm.

To test for dissolved oxygen, one needs a dissolved oxygen test kit. These are available from any science supply company. The directions on how to use the kit are different for each kit. Snap kits are available that are inexpensive and easy to use.

To collect water for dissolved oxygen testing, use a stoppered water sampling bottle. Push the bottle just below the surface and remove the stopper. When the bottle is filled and still below the surface, replace the stopper. There should be no visible air bubbles. If a bubble is visible, gently tip the bottle while still below the surface. If you cannot get the air bubble out, pour the sample out and start over. You will need the temperature of the water also. Place the thermometer in the water and leave it for three minutes.

TURBIDITY

Turbidity is a measure of the dissolved particles in water. It tells you how clear the water is or how far light penetrates into the water. The amount of dissolved particles in the water determines how deep sunlight will reach and therefore affects the photosynthesis (food production) that is conducted by phytoplankton and other plants in the water. Many wetland waters are naturally somewhat turbid because of the detritus, other nutrients and plankton it contains. When run-off from the mainland adds mud, sand, silt and pollution to the water the food production capacity of the plankton is adversely affected. The age of the wetland also affects its turbidity.

Scientists use a Secchi Disc to test turbidity (may be purchased from a scientific supply company or you may make your own). The Secchi disc is lowered into the water by a rope that is marked off in meters until it disappears. This depth is the depth to which light can penetrate.

To measure turbidity, use the turbidity index: 100 divided by the number of feet lowered before the Secchi disc disappears. If the disc disappears at 25 feet, the turbidity index is 4. If the disc disappears at 2 feet, the index is 50. There is a direct relationship between turbidity and pollution. 50 is more polluted or turbid than 2!

NITRATES, NITRITES, and AMMONIA

Nitrogen is a fundamental plant nutrient required by all living plants and animals for building protein. In aquatic ecosystems, nitrogen is present in many forms. In its molecular form, nitrogen

is useless for most aquatic plant growth. Blue-green algae, however, use the molecular form of nitrogen by biologically converting it to useable forms of nitrogen.
In the water nitrates stimulate phytoplankton growth which increases the food available for fish. However, when the phytoplankton grows excessively the dying plants use up oxygen and the other animals die from loss of oxygen. Large amounts of nitrates may enter the water with the runoff from lawns, farms, sewage, and from exhaust fumes and become available for rapid plant growth.

Nitrites may enter the water in the same way as nitrates. Nitrites can cause fish to become ill because it reacts directly with the hemoglobin in the blood destroying the blood's ability to carry oxygen. Concentrations of nitrite below 0.06 ppm seem to have little effect on cold water fish. The tolerable concentrations of nitrates for cold water fish are around 90 ppm.

Ammonia is formed when bacteria decompose proteins and urea and is highly toxic to fish and other aquatic organisms. When levels reach 0.06 ppm, fish can suffer gill damage and cold water species like trout and salmon die at levels of 0.2 ppm. When levels of ammonia reach 0.1 ppm, the water is considered polluted. The dangers posed by ammonia to fish depends upon such variables as temperature, pH, dissolved oxygen concentration, and the amount of carbon dioxide present. The lower the oxygen and carbon dioxide, the more poisonous the ammonia is to aquatic life.

PHOSPHATE/PHOSPHORUS

Phosphorus and nitrogen are essential nutrients for organisms that make up the aquatic ecosystem food web. Phosphorus is usually a growth limiting nutrient in most aquatic systems. Even a slight increase in phosphorus can cause undesirable consequences, such as accelerated plant growth, including algal blooms, low dissolved oxygen and even the death of certain fish, invertebrates, and other aquatic organisms.

There are three types of phosphates found in water: orthophosphates produced by natural processes such as sewage breakdown; polyphosphates associated with detergents; and, organophosphates resulting from the breakdown of organic compounds. Sources of phosphate include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and golf courses, failed septic systems, disturbed land areas, drained wetlands, and commercial cleaning preparations. It takes very high concentrations of phosphate to harm people, but only a slight increase can cause plants to grow wild. The ideal concentrations of phosphate in rivers and streams is around 0.1 ppm.

COLIFORM BACTERIA

Scientists often test for the presence of bacteria in our waters. A description of the types of bacteria and recommended testing procedures are stated in the activity "Using Millipore Samplers to Test for Bacteria in Wetland Waters" and will not be repeated here.

RECIPE FOR PREPARING SUCROSE SOLUTIONS USING GROCERY STORE SUCROSE (sugar) for the activity "Osmotic Pressures on Organisms in Aquatic Environments"

1. Place 342.3 g of sucrose (sugar) into a container and add enough distilled water to make one liter. Stir this until all is dissolved. You may need to leave this stirring overnight with a magnetic stirrer. This will give you 1 liter of a 1.0 M solution of sucrose. (You will need to **prepare 3 liters** for the Osmotic Pressures on Organisms in Aquatic Environments).
2. Save 1 liter of this 1.0 M sucrose solution. Use the other 2 liters to prepare the following concentrations.
   To prepare a 0.2-M solution: mix 200 mL of 1.0-M sucrose + 800 mL distilled water.
   To prepare a 0.4-M solution: mix 400 mL of 1.0-M sucrose + 600 mL distilled water.
   To prepare a 0.6-M solution: mix 600 mL of 1.0-M sucrose + 400 mL distilled water.
   To prepare a 0.8-M solution: mix 800 mL of 1.0-M sucrose + 200 mL distilled water.

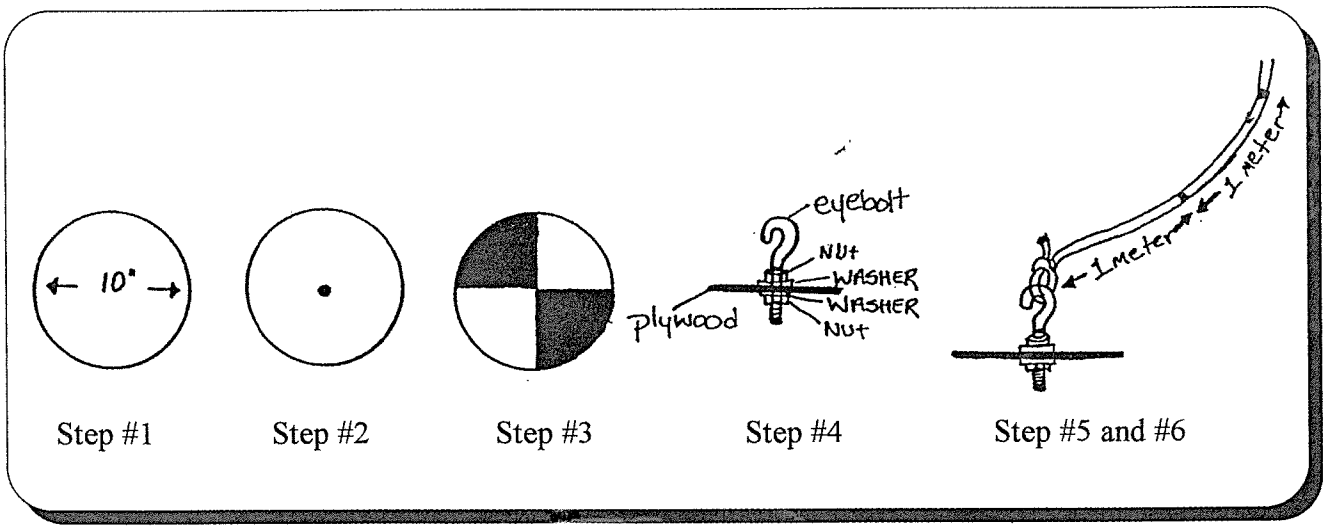
TO MAKE YOUR OWN SECCHI DISC

MATERIALS:

thin plywood or metal cut into a circle 10 inches in diameter
black and white enamel paint and paintbrush
two nuts and two washers
50 feet of strong chord or rope
drill
large eyebolt
measuring tape

PROCEDURE:

1. Cut the plywood or metal into a circle 10 inches in diameter.
2. Drill a hole large enough for the eyebolt to fit through.
3. Paint the circle black and white (like the pieces of a pie - one white, one black, etc.).
4. Push the eyebolt through the hole and keep it in place with a washer and nut on either side of the wood.
5. Tie the chord or rope to the eyebolt.
6. Mark the chord with a permanent marker every meter (or tie knots every meter).



Step #1 Step #2 Step #3 Step #4 Step #5 and #6

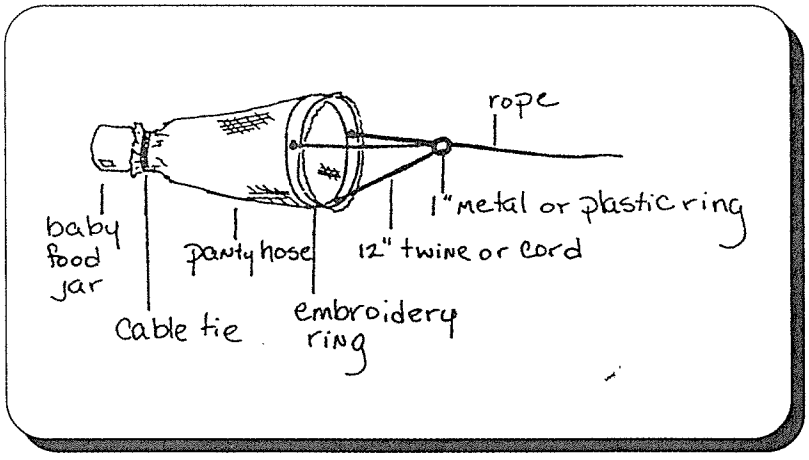
HOW TO CONSTRUCT YOUR OWN PLANKTON NET

MATERIALS:

1 pair pantyhose
5 inch or 6 inch plastic embroidery clamp
baby food jar (save lid)
36 inches of twine or heavy duty chord
metal or plastic ring, 1 inch in diameter
scissors
6 inch, nylon cable tie
electric hand drill with 3/16 inch drill bit

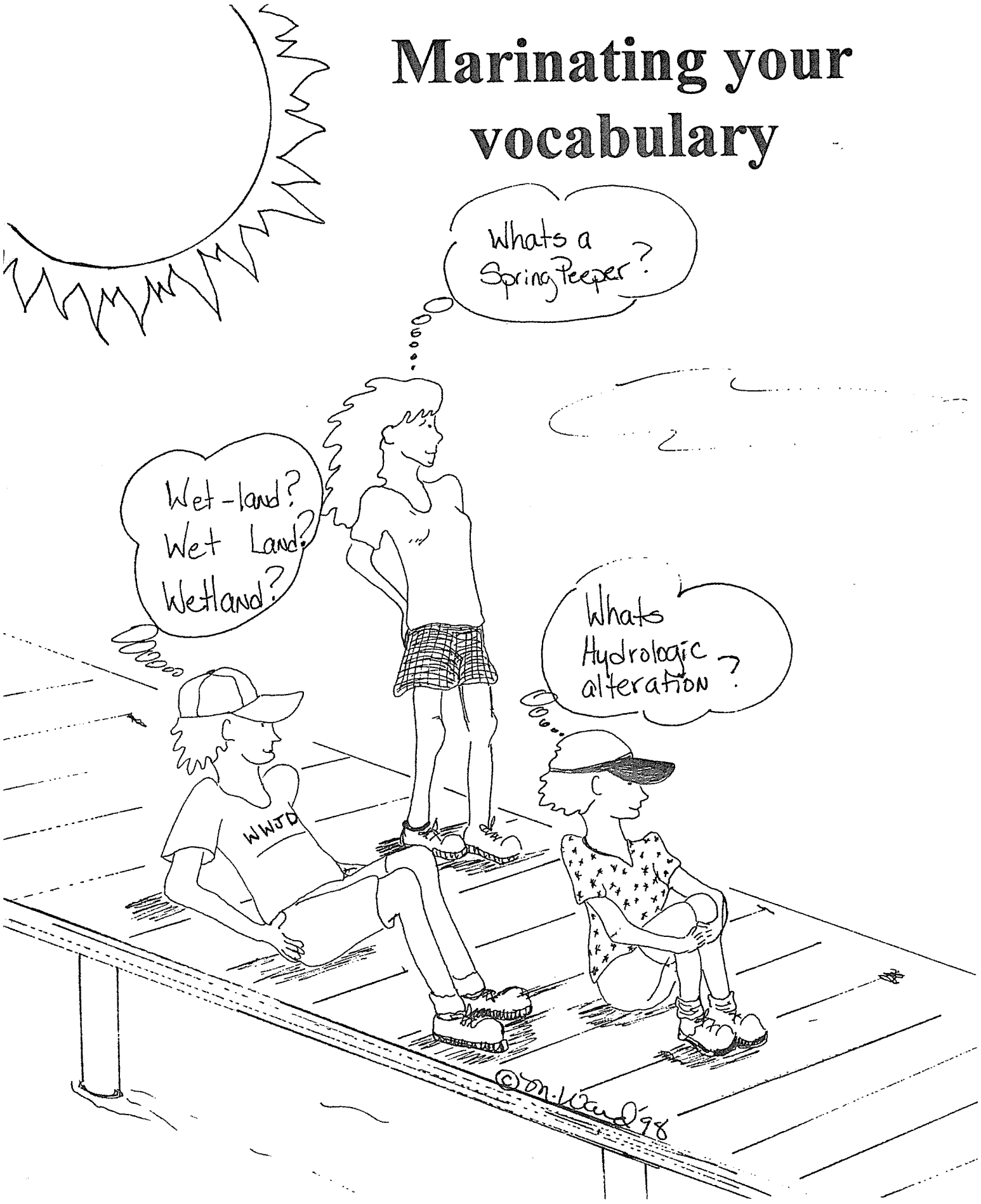
PROCEDURE:

1. Drill 3 holes through the embroidery ring, 120° apart.
2. Cut the twine or chord into three equal lengths (12 inches each).
3. Thread each piece of twine through one of the holes in the outer part of the embroidery ring.
4. Attach the other end of all three pieces of twine to the one inch metal or plastic ring (this is your tow ring)..
5. Cut one leg of the pantyhose near the top of the leg and about 1/2 way to the knee.
6. Clamp the widest part of the pantyhose in the embroidery ring.
7. Attach the other end of the pantyhose to the baby food jar with the cable tie.
8. Attach the rope to the tow ring.



NOTE: If your plankton net is too buoyant and will not sink below the surface, attach a fishing weight. Also, for sampling freshwater you will need to make the mouth of the net larger.

Marinating your vocabulary



MARINATING YOUR WETLAND VOCABULARY

Acid:	Any substance with a pH level below 7
Adaptation:	An alteration or adjustment, often hereditary, by which a species or individual improves its condition as it relates to its environment.
Aerobic:	Living, active or occurring only in the presence of oxygen.
Aesthetic:	Of or pertaining to the sense of beautiful.
Algae:	Unicellular, multicellular or colonial aquatic plants that have chlorophyll but do not have true roots, stems or leaves.
Algal bloom:	A rapid, dense growth of algae at the surface of lakes or rivers in response to excessive nutrients in the water; it is often caused by polluted runoff. Decomposition of algae from such a bloom depletes oxygen in the water, which can cause fish kills.
Anaerobic:	Living in the absence of oxygen.
Aquatic:	Lives in or on water.
Aquifer:	Underground sediments saturated with water.
Base:	Any substance with a pH level greater than 7.
Biodiversity or Biological diversity:	The sum of all species of plants and animals. An ecosystem is considered healthy when it supports the most diverse numbers and types of species it is capable of supporting.
Biogeochemical cycle:	The transport and transformation of chemicals in an ecosystem.
Biological oxygen demand (BOD):	The amount of oxygen required in the aerobic decomposition of organic matter in water over a fixed period of time.
Blackwater river:	A river that originates in the Coastal Plain. The dark, tea-colored water is stained by tannins leached from dead plant material through sand soils into the river.
Bog:	A wetland, usually with blocked drainage of acidic conditions, where cushion plants and peat moss (sphagnum) dominate.
Bottomland forest:	Low-lying forest in the floodplains of rivers; also known as river bottomlands. They are the most common river wetlands.
Brownwater river:	A river that originates in the Piedmont and Mountains; carries great loads of nutrient-rich sediments that give the water a brown color.
Buffer zone:	Land adjacent to a sensitive area that minimizes outside impact.
Carnivorous:	Meat-eating species.

Carolina bay:	A unique landform found primarily in the Coastal Plain of North Carolina, South Carolina, and Georgia. These shallow, oval depressions all have long axes aligned in a northwest to southeast orientation.
Carrying capacity:	The maximum number of organisms an area can support forever without being degraded.
Closed system:	A system that has little or no exchange of materials.
Coastal Plain:	An area extending from the ocean to the fall line at the edge of the Piedmont. It is a region of abundant wetlands.
Cypress knees:	The parts of cypress trees that stick up from the roots and look like knobby knees.
Decomposition:	The separation of organic or chemical matter.
Deepwater habitat:	Habitats that are permanently flooded lands lying below the deepwater boundary of wetlands. The surface water is permanent and often deep (greater than 2 meters) so that water, rather than air, is the principal medium within which the dominant organisms live.
Denitrification:	The process by which nitrogen is removed from soils by bacterial action.
Detritus:	Dead and decomposing plant and animal material.
Diatom:	Intricately designed unicellular or colonial algae with silica-impregnated cell. Occurs abundantly in fresh and salt water.
Dissolved Oxygen (DO):	Oxygen that is present in water.
Dredging:	The process of excavating materials from waters.
Ecosystem:	All of the organisms of a community and their environment that form an interacting system.
Emergent:	Objects or organisms that are partly in water and partly exposed, such as plants that are rooted in water but whose upper parts are aerial or floating. Emergent wetland vegetation includes erect, rooted, herbaceous vegetation, such as sedges, rushes, and grasses.
Ephemeral pool:	A temporary or seasonal wetland.
Endangered:	Any species that is in danger of extinction throughout all or a significant portion of its range.
Enhancement, wetland:	Improvement, maintenance and management of existing wetlands to benefit a particular function or value, possibly at the expense of other wetland values.
Epiphyte:	A plant that grows on another plant but does not get its nutrients from that plant.

Estuary:	The aquatic environment of a coastal stream or river that is subject to the tide of the body of water into which it flows; an area where fresh water and marine water mix.
Euryhaline:	Organisms that can tolerate wide changes in salinity.
Eutrophic:	Pertaining to a body of water containing a high concentration of dissolved nutrients; often shallow, with periods of oxygen deficiency.
Eutrophication:	A naturally occurring change that takes place after a water body receives inputs of nutrients, mostly nitrates and phosphates, from erosion and runoff of surrounding lands; this process can be accelerated by human activities.
Evaporation:	The conversion of water to vapor.
Evapotranspiration:	The loss of water from the soil by evaporation and by transpiration of water from plants.
Facultative:	Plant species that do not always occur in wetlands; one of five categories used to determine whether or not vegetation is hydrophytic. Facultative (FAC) species have a similar probability of occurring in wetlands and nonwetland sites; faculatative-wet (FACW) species have a higher probability of occurring in wetlands than in nonwetland sites; facltative-upland (FACU) species have a higher probability of occurring in nonwetland sites than in wetlands.
Federal Duck Stamp Program:	Administered by the U.S. Fish and Wildlife Service, this program raises money to buy or lease wetlands for water fowl habitats. It requires that all water fowl hunters over 16 years of age purchase a duck stamp to affix to their hunting licenses each year.
Federal Water Pollution Control Act (clean water act):	The law to restore and maintain the "chemical, physical, and biological integrity of the nation's waters."
Freshwater:	Water that contains at least one-half of 1 percent salt (greater than 5 ppt)
Floodplain:	The flat area of land adjacent to a stream; stores and dissipates floodwaters.
Food chain:	A succession of organisms in a community that constitute a feeding order in which food energy is transferred from one organism to another as each consumes a lower member and in turn is preyed upon by a higher member.
Food web:	Elaborate, interconnected feeding relationships in an ecosystem.
Forested swamp:	A type of wetland usually located in river floodplains containing trees.

Function:	Any biological, chemical or ecological process that a wetland performs, such as nutrient removal, wildlife habitat support and sediment trapping.
Gley:	Soil condition resulting from prolonged soil saturation which is manifested by the presence of bluish or greenish color throughout the soil; gleying occurs under reducing soil conditions resulting from soil saturation.
Greenway:	Linear, open space established along a natural corridor such as a riverfront, or along a scenic route.
Ground water:	Water found in pores or cracks in sand, gravel, and rock beneath the land surface. Discharging ground water sustains streamflow and supplies water to springs and wells.
Habitat:	The area or environment in which an organism lives.
Heavy metals:	Metallic elements (cadmium, chromium, copper, lead, mercury, nickel, and zinc) which are used to manufacture products; they are present in some industrial, municipal, and urban runoff.
Herbivore:	An animal whose diet consists primarily of plants; a plant eater.
Hydric:	Characterized by or requiring considerable moisture.
Hydric soil:	Soil found in saturated, anaerobic environments; usually characterized by a gray or mottled appearance.
Hydrologic cycle:	The process of water moving through, over, and around the Earth.
Hydrology:	Properties, distribution and effects of water on the Earth's surface, in soils and underlying rocks, and in the atmosphere.
Hydroperiod:	The seasonal level of water in a wetland includes the frequency, timing, duration, and amount of flooding.
Hydrophyte:	Vegetation that has adapted to thrive in wet conditions; typically found in wetland habitats.
Impermeable:	Substrate through which water cannot pass.
Indicator species:	An organism whose presence in a habitat serves as a marker for that habitat; cattails and bald cypresses in a natural habitat are indicators of freshwater wetlands.
Lacustrine:	A freshwater system associated with a lake.
Leachate:	Components draining from a source and moving with water through the soil.
Marsh:	An area of low lying wetland (salt or fresh) dominated by grasses.
Matrix:	A portion of soil that has a dominant color; in most cases, the portion of soil that has more than 50 percent of the same color.
Microorganisms:	Minuscule plants and animals; examples include bacteria, some fungi, and algae.

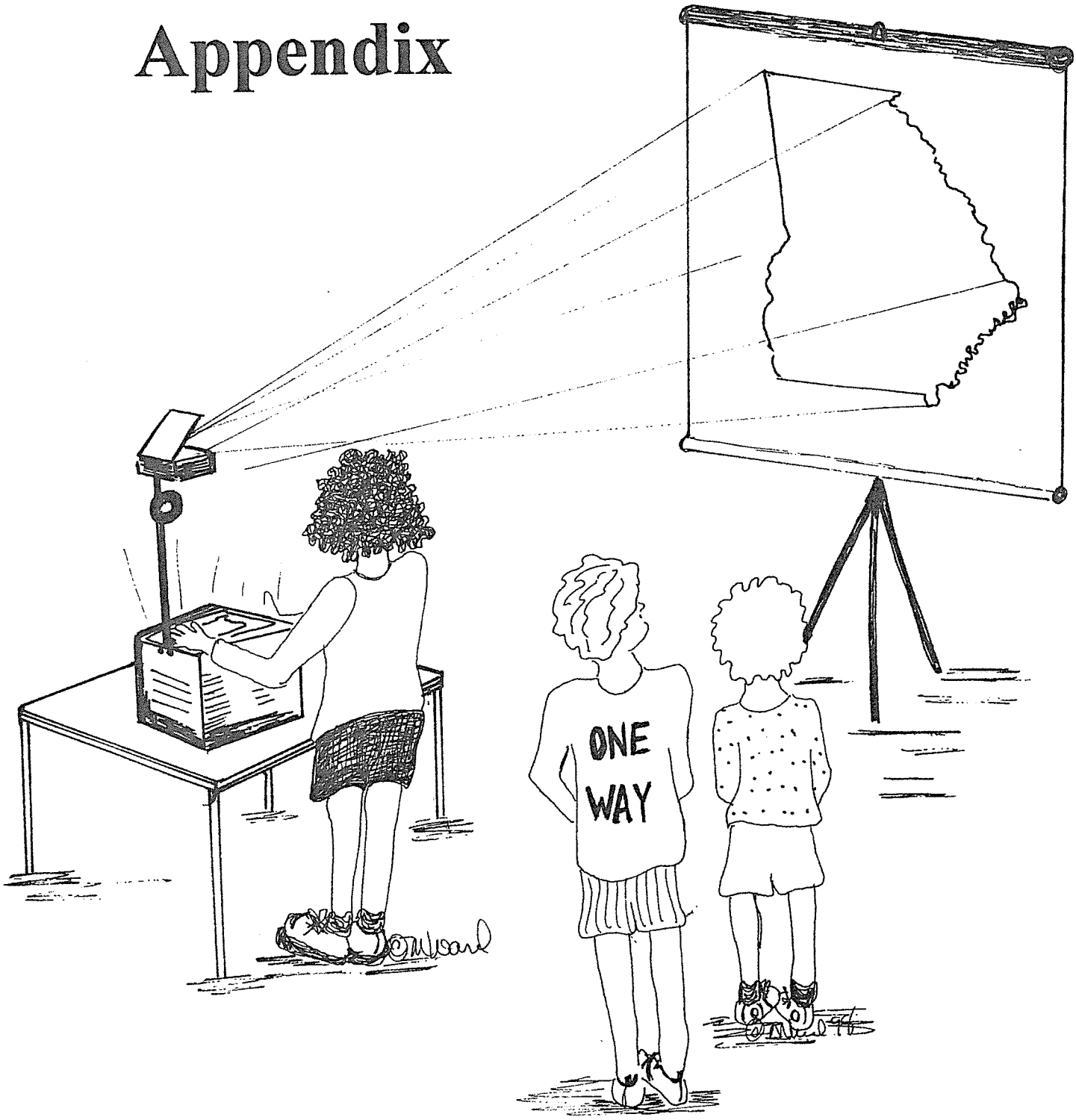
Migration:	The movement of a population away from and back to a point of propagation; sometimes requires more than one generation to complete the migratory cycle.
Mottles:	Blotches, streaks or spots of bright red and orange indicating the presence of a high water table.
National Water Quality Standards:	Maximum contaminant levels for a variety of chemicals, metals, and bacteria set by the safe drinking water act.
National Pollutant Discharge Elimination System (NPDES):	Part of the clean water act requiring municipal and industrial wastewater treatment facilities to obtain permits which specify the types and amounts of pollutants that may be discharged into water bodies.
National Environmental Policy Act of 1969 (NEPA):	Law that requires environmental impact statements to be submitted for any major construction project that uses U.S. federal money.
Native:	Originally living, growing or produced in a certain place; indigenous.
Neutral:	Any substance with a pH level of 7.
Nonpoint source pollution:	Pollution that cannot be traced to a single source.
North America Water Fowl Management Plan:	This plan includes a special fund established for enhancing, restoring, and acquiring important water fowl habitats in Canada, Mexico, and the U.S.
Nutrient:	A chemical needed by a plant for photosynthesis or by an animal for growth and survival.
Obligate:	Plant species that almost always occur in wetlands; one of five indicator categories used to determine if vegetation at a site is hydrophytic.
Oil Pollution Act:	Legislation that imposes substantial penalties and liability for oil spills in the ocean; violators are responsible for the cost of cleanup and restoration of natural resources.
Oligotrophic:	Lacking in plant nutrients and having an abundance of dissolved oxygen.
Omnivore:	Feeding behavior associated with eating both animal and plant substances.
Open system:	A system with a high degree of material exchange.
Osmoconformer:	An organism that has an internal cell concentration of water and salt, that closely matches that of the outer environment.
Osmoregulation:	The maintenance of optimal and necessary internal water concentrations in an animal by regulating the rate of ion (salts) uptake and excretion.
Osmoregulator:	Complex organism that can control the amount of water and salt in its body.

Palustrine:	Freshwater, shallow wetlands, such as marshes or bogs.
pH:	A measure of the concentration of hydrogen ions in a solution; the pH ranges from 0 to 14, where 7 is neutral and values less than 7 are acidic and values greater than 7 are a base (alkaline).
Photosynthesis:	The process where plants produce food in the presence of sunlight.
Physiology:	The function of a particular structure, organ or organism.
Phytoplankton:	Floating microscopic plants.
Plankton:	Minute animal and plant life in a body of water.
Pocosin:	A poorly draining freshwater wetland found in the Coastal Plain and characterized by peaty soils and a dense cover of mostly evergreen shrubs.
Point source pollution:	Pollution that can be traced to a single source.
Pollutant:	An impurity (contaminant) that causes an undesirable change in the physical, chemical, or biological characteristics of the air, water, or land that may be harmful to or affect the health, survival, or activities of humans or other living organisms..
Pollution:	Contaminants in the air, water, or soil that cause harm to human health or the environment.
Producer:	An organism that produces its own food.
Productivity:	The production of organic plant material.
Recharge:	Resupply of water to an aquifer.
Regulator:	An organism that has adapted to stress by developing means of controlling its exposure and reaction to stress.
Respiration:	The metabolic process by which an organism assimilates oxygen and releases carbon dioxide and other products of oxidation.
Resource Conservation and Recovery Act (RCRA):	Legislation passed in 1976 aimed at protecting the environment, including waterways, from solid waste contamination either directly, through spills, or indirectly through groundwater contamination.
Restoration (wetland):	Rehabilitation of a degraded wetland or a hydric soil area that was previously a wetland.
Raparian:	Typically occurring or growing along the banks of rivers and streams.
Rivers and Harbors Act of 1899:	Legislation regulating the discharge of refuse of any kind into navigable waters.
Riverine:	A freshwater system associated with a river.
Runoff:	Surface water that moves across the ground in sheets rather than in distinct channels.

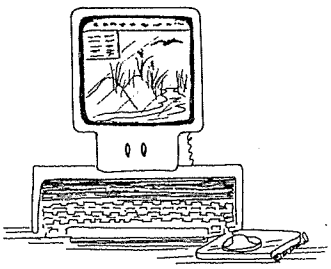
Safe Drinking Water Act:	A regulatory program passed by the U.S. Congress in 1974 to help ensure safe drinking water in the United States; sets maximum contaminant levels for a variety of chemicals, metals, and bacteria in public water supplies.
Salt marsh:	A coastal wetland periodically flooded with salt water and dominated by grasses and grasslike plants.
Secci disk:	A circular piece of metal or wood painted with alternate black and white quadrants attached to a line that is used to measure water clarity (the depth light penetrates water).
Sediment:	Soil particles such as sand, silt, clay, or tiny rock fragments that wash off land, become suspended in water and settle to the bottom of wetlands and other aquatic habitats.
Shrub swamp:	A wetland dominated by small, woody plants.
Silt:	Very fine soil sediment.
Sinkhole:	A natural depression in a land surface connected to a subterranean passage generally occurring in limestone regions and formed by solution or by collapse of a cavern roof.
Slough:	Stagnant swamp, marsh, bog, or pond. In coastal areas, they form between secondary or old sand dunes.
Sphagnum moss:	A spongy type of moss that thrives in wet, acidic soils common in many wetlands; it often further deteriorates to become peat.
Stenohaline:	An organism that can survive only within a very narrow range of saline conditions.
Substrate:	The mineral or organic material that forms the bed of a water body or the surface on which an organism grows.
Surface water:	Water that is on the Earth's surface, such as rivers, streams, reservoirs, lakes, ponds, and oceans.
Sustainability:	The goal of a system of development that meets the basic needs of all people without compromising the ability of future generations to meet their own life-sustaining needs.
Swamp:	Having waterlogged soils, at least part of the year, and supporting natural vegetation (mostly trees and shrubs).
Terrestrial:	Living on land or in the air, as opposed to aquatic (in water).
Texture:	The physical nature of soil due to the relative proportions of sand, clay, and silt.
Threatened:	Any species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
Tide:	The periodic rise and fall of ocean levels.
Toxic:	A harmful, destructive or deadly chemical substance.

Transpiration:	The process of giving off vapor in plants through pores (stomata).
Turbidity:	The presence of suspended solids in water; the cloudy condition caused by suspended solids in a liquid.
Unsaturated zone:	An area underground between the ground surface and the water table where the pore spaces are not filled with water, also known as the zone of aeration.
Value, wetlands:	Benefits that specific wetlands functions provide to humans, such as timber harvest, flood control, and sites for recreation.
Vascular plant:	Any stemmed or rooted plant.
Vernal:	Pertaining to or existing only part of the year.
Waterfowl:	Birds that live on or near the water.
Water table:	The top of the water within an unconfined aquifer.
Watershed:	An area of land that drains to a particular body of water.
Wetland:	Any area that, at least periodically, is waterlogged or covered with water.
Wetland complex:	The aggregation of wetlands and associated ecological features within a landscape.
Wet meadow:	The driest type of wetland. Usually there is little standing water, but the ground remains soggy for much of the year. Mainly grasses and vegetation that prefer moist soil will grow here.
Zonation:	The distribution of distinct zones of plant communities composed of different species.
Zone of aeration:	The area above the water table where openings in the soil, sediment, and rock are not saturated but filled with air.
Zone of saturation:	The zone where all open spaces in sediment and rock are completely filled with water.
Zooplankton:	Floating microscopic animals.

Appendix



Wetlands on the Web



Research the following web sites for more information on wetlands

http://www.webdirectory.com (Environmental Organization Web Directory)
http://www.epa.gov/OWOW/wetlands/facts/html
http://www.epa.gov/OWOW/PubList/pubcon.html
http://www.geog.ucl.ac.uk/~jthompso/worldwet.html (a list of wetland sites)
http://w3.iprolink.ch/iucnlib/themes/ramsar/ (wetland conservation)
http://www.epa.gov/ (EPA's site)
http://www.epa.gov/Region4Wet/other.html (Federal wetland sites)
http://www.epa.gov/emap/html/data/wetlands/
http://www.fws.gov/~r9endspp/contacts.html#CONTACTS (Endangered Species)
http://www.usgs.gov/themes/environ.html (Environment Theme home page)
http://www.usgs.gov/fact-sheets/earth-science-information/public-affairs-offic
http://www.envmedia.com (Environmental Media Corporation)
http:///www.ENVSTEW%SMTPGATE@FOURHCOUNCIL.EDU (Wetlands Poster)
http://www.fws.gov/~r4eao (U.S. Fish & Wildlife Service)
http://www.nwrc.nbs.gov (National Wetlands Research Center)
http://www.nwf.org/nwf/northeast/watersheds/index.html
http://h2osparc.wq.ncsu.edu/info/wetlands/wetlink.html (Links to Wetland Information)
http://www.epa.gov/ow/facts/contents.html (Wetland Fact Sheets)
http://cissus.mobot.org/MBGnet/fresh/wetlands/index/fresh/wetlands/index/htm
http://cissus.mobot.org/MBGnet/aqua/wetlands/animals.htm (Wetland creatures)
http://www.sciam.com:80/1998/0698issue/0698numbers.html (Scientific American: US Wetlands)
http://h2osparc.wq.ncsu.edu/info/wetlands/wetloss.html (Major Causes of Wetland Loss and Degradation)
http://www.nwi.fws.gov/ (National Wetlands Inventory)
http://www.nwi.fws.gov/Ecology.html (National & Regional Wetland Plant lists)
http://www.epa.gov.owow.owow/wetlands/ (EPA Wetlands Division)
http://www.envirolink.org/issues/esa (Endangered Species Act Online Resource Guide)
http://159.189.24.10/wetsci.html (Wetland Science Institute)
http://www.wetlands.com/index.html (Wetlands Regulation Center)

WHERE TO OBTAIN MATERIALS AND SUPPLIES

Brock Optical, Inc.
414 Lake Howell Road
Maitland, FL 32751
1-800-780-9111

Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215
1-800-334-5551

Connecticut Valley Biological Supply Company
82 Valley Road
Southampton, MA 01073
1-800-628-7748

Discovery Scope, Inc.
15721 Bernardo Hts. Parkway
Suite E 401
San Diego, CA 92128-3159
1-800-398-5404

Edmund Scientific
101 E. Gloucester Pike
Barrington, NJ 08008
609-573-6250

Environmental Media Corp.
P.O. Box 1016
Chapel Hill, NC 27514
1-800-ENV-EDUC

Forestry Suppliers, Inc.
Educational Products
P.O. Box 8397
Jackson, MS 39284-8397
1-800-543-4203

Georgia DNR Film & Video
205 Butler Street SE
Suite 1354
Atlanta, GA 30334
404-657-9851

La Motte Company
P.O. Box 329
Chestertown, Maryland 21620
1-800-344-3100

The Liner Farm
P.O. Box 701369
St. Cloud, FL 34770-1369
1-800-330-1484

National Geographic Society
1145 17th Street NW
Washington, DC 20036-4688
1-800-368-2728

Science Kit & Boreal Laboratories
777 East Park Drive
Tonawanda, NY 14150-6782
1-800-828-7777

VWR/Sargent Welch
P.O. Box 5229
Buffalo Grove, IL
1-800-727-4368

Ward's Biology
5100 West Henrietta Road
P.O. Box 92912
Rochester, NY 14692
1-800-962-2660

The Following are some recommended Wetland related videos:

Freshwater Wetlands: Life at the Waterworks: N. Carolina State Museum of Natural Sciences. 919-733-7450. Environmental Media Corp., P.O. Box 1016 Chapel Hill, NC 29901. Call 1-800-ENV-EDUC for a free catalogue.

Wetlands: Maligned Treasures: PA Dept. of Environmental Resources, Bureau of Water Quality Production, RCSOB, 6th Floor, P.O. Box 8554, Harrisburg, PA 17105-8554

Wetlands: Georgia's Vanishing Treasure: The Georgia Conservancy, 1776 Peachtree Street NW, Suite 400 South, Atlanta, GA 30309.

Altamaha River: Tri-Con Productions, 11 Palmetto Parkway, Hilton Head Island, SC 29926, 803-681-5000.

SOURCES OF INFORMATION

Additional wetland information may be obtained by contacting the following organizations

American Water Resources Association 5410 Grosvenor Lane Suite 220 Bethesda, MD 20814-2192	GA Dept. of Natural Resources Coastal Resources Division One Conservation Way Brunswick, GA 31520 912-264 - 7218	National Wildlife Federation 1400 16th Street, N.W. Washington, DC 20036-2266 202-797-6800
Association of Wetland Managers P. O. Box 269 1434 Helderberg Trail Berne, NY 12023-9746 518-872-1804	GA Dept. of Natural Resources Environmental Protection Division 205 Butler Street, SE Floyd Tower East Atlanta, GA 30334 404-656-4713	Georgia Project Wet Environmental Protection Division 7 MLK Dr. Suite 643 Atlanta, GA 30334 404-651-7031 Fax-404-657-7031 Attention: Petey Giroux
Cooperative Extension Service The University of Georgia 303 Hoke Smith Annex Athens, GA 30602-4356 706-542-8923	GA Dept. of Natural Resources Wildlife Resources Division 2070 U.S. Highway 278, SE Social Circle, GA 30279 770-918-6401	Soil & Water Conservation Commission P. 0. Box 8024 Athens, GA 30603 706-542-3065
DNR/Film & Video 205 Butler Street, SE Suite 1354 Atlanta, GA 30334 404-657-9851	GA Water & Pollution Control P. O. Box 798 Acworth, GA 30101 770-429-0187	U.S. Corps of Engineers Savannah District (CESA-OP-R) P. O. Box 889 Savannah, GA 31402-0889 912-944-5347
Environmental Concern Inc. P.O. Box P St. Michaels, MD 21663.	Izaak Walton League of America 707 Conservation Lane Gaithersburg, MD 20878 301-548-0150	U.S. Dept. of the Interior 75 Spring Street, N.E. Atlanta, GA 30303 Office of Environmental Affairs 404-331-4524
Environmental Media Corporation PO Box 99 Beaufort, SC 29901-0099 1-800-ENV-EDUC	National Audubon Society 613 Riverside Road Greenwich, CT 06830 203-364-0520	U.S. Environmental Protection Agency Corvallis Environmental Research Lab Wetlands Research Program 200 Southwest, 35th Street Corvallis, OR 97333

Fish & Wildlife Service National Wetlands Inventory -Maps 9720 Executive Center Drive Suite 101 Monroe Building St. Petersburg, FL 33702-2440 813-570-5412	National Coalition for Marine Conservation 5105 Paulsen Steet Suite 243 Savannah, Ga. 31405	U.S. Fish & Wildlife Service Publications Unit 4401 N. Fairfax Drive, MS 130 Arlington, VA 22203 703-358-1711
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