

Wetlands Ecology

Grades 5-12

Teacher's Information, Pre-trip and Post-trip Activities



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Wetlands Ecology

Standing at the edge of a salt marsh at low tide with a cloud of greenhead flies around your head and the odor of rotten eggs assaulting your nose you might come to the conclusion of many before you; that wetlands are foul, disease ridden wastelands. Take a closer look and you will discover a beautiful natural system that produces more food energy than the most productive agricultural fields.

This booklet contains information and activities to help prepare you and your class for your trip to the Wetlands Institute. The activities are designed for pre- and post-visit sessions. However, feel free to use the activities in a manner best suited to the needs of your class.

PRE-VISIT ACTIVITIES

1. Are there any wetlands in your community? In the activity **On The Map!** Your students will identify wetland areas in their communities and test their map reading skills.
2. Wetlands are more than just swamps, marshes and bogs. **Keying Into Wetlands** will introduce your students to the many different kinds of wetlands. They will use a key to identify twenty types of wetlands found in the eastern United States.

POST-VISIT ACTIVITIES

1. **To Develop Or Not To Develop, That Is The Question!** is a role playing game in which your students will become developers and the citizens of a coastal community, debating a proposed development plan that would destroy wetlands.



2. Now that you have explored a coastal salt marsh you may wish to visit other types of wetlands. There are several wonderful wetland field trip opportunities in New Jersey and Pennsylvania. **One Good Wetland Deserves Another** lists a few wetland areas you might consider as your next field trip site.

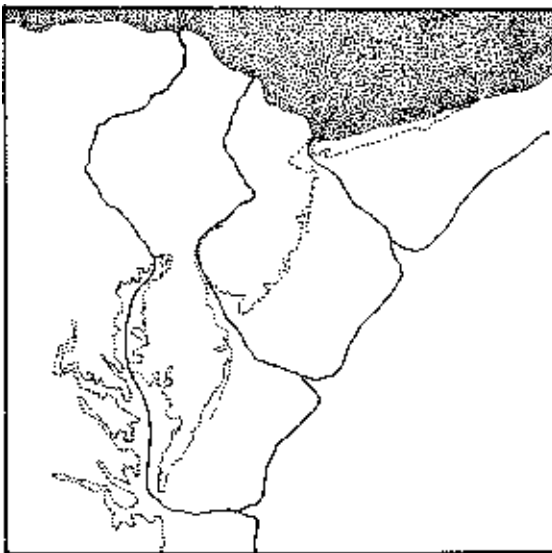
What are Wetlands?

The word wetland is used to describe areas where the soil is saturated or covered by water for some part of the year. Wetland plants, or **hydrophytes**, are adapted for life in these wet, oxygen poor soils. There are many different types of wetlands. They occur in both fresh and saltwater. Each can be identified by its dominant or common plants. Scrub-shrub wetlands, also known as bogs, are dominated by small trees and shrubs. Forested wetlands, or swamps, are forests of trees like red maple, white cedar, bald cypress and mangroves which grow well in wet places.

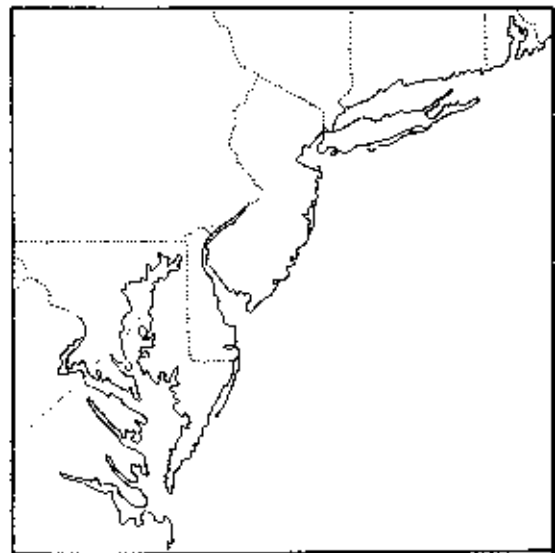
The wetland that surrounds the Institute is an emergent wetland, dominated by grassy plants. This wetland is commonly known as a salt marsh because it grows in sea water. Travel a few miles inland and you may find freshwater marshes as well. Salt marshes are found all along the Atlantic coast in shallow, calm waters protected from the force of ocean waves. North of New Jersey they are relatively small and found in protected coves and bays. From New Jersey southward to Cape Canaveral, Florida salt marshes occur in an almost continuous band behind a string of **barrier islands**. South of Cape Canaveral salt marshes are replaced by **sub-tropical** mangrove swamps.

Formation

Twenty thousand years ago ocean levels were about 400 feet lower than they are today. Most of the ocean's water was frozen in the glaciers that covered much of North America. The coastline then was about seventy miles east of where it is today. The climate changed and the glaciers began to melt around 15,000 years ago and sea levels began to rise. Between three and five thousand years ago sea level rise slowed to about a few feet a century. The salt marshes that we see today began to develop.



coastline 20,000 years ago



coastline today

Along the shallow Atlantic coast ridges of sand became long, narrow islands as surrounding areas were submerged by the rising sea. As sea level rose, these islands, through the action of wind and waves, migrated along with the receding mainland shoreline. These barrier islands protect the mainland from the destructive forces of the ocean. In the calm, protected waters behind the islands mud and silt dropped to the bottom and developed into mud flats that were exposed at low tide. Grasses able to withstand inundation in sea water became established on these flats. Seeds or sections of root may have been carried from another marsh by the tide. Seeds may also have been carried onto the flat on the feet of migrating birds.

Once rooted the grasses spread by underground stems called rhizomes. As marsh grasses spread they catch sediments, building up the level of the marsh. As the marsh developed, tidal currents scoured channels creating meandering marsh creeks.

Zonation



Through the centuries the marshes have grown not only in area but also in elevation. Look closely and you will notice a series of zones each dominated by a different **community** of plants and animals. The zones mark very subtle changes in elevation. Relatively few species of plants can grow in salt water environments. On the upland edge of the marsh grow plants that can tolerate exposure to wind borne salt spray. Red cedar, bayberry, groundsel tree and poison ivy are common trees and shrubs found along the marsh edge. Seaside goldenrod, yarrow and a few other flowers also grow here. *Phragmites*, a tall, fast growing reed, not able to tolerate inundation by salt water often is found along this upland edge.

High Marsh

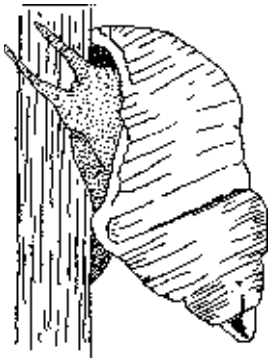
The next zone is dominated by a low growing shrub called marsh elder or high tide bush. It grows on slightly lower ground which is flooded by **spring tides**. Where marsh elder stops, usually abruptly, the high marsh zone begins.

The plants in the high marsh are inundated only for a few days each month during especially high tides called spring tides. This zone is dominated by two grasses, *Spartina patens*, or saltmeadow hay and salt grass. They may occur in pure or mixed stands. Saltmeadow hay is a fine, wiry grass usually no more than two feet tall. The weak leaves usually are bent by the wind into swirling mats called **cowlicks**. Dead grass from previous years collects beneath this mat. Small salt marsh snails feed among the dead grass. Several species of insects may be found feeding on the grass. They are preyed upon by a variety of spiders. Salt grass is coarser, with leaves projecting from the main stalk at a pronounced angle. Sea lavender is often found growing in this zone. Its small purple flowers bloom in late summer on a wiry, branching stalk up to two feet tall. The stalks remain standing well after they die and are conspicuous in the winter marsh.



Low Marsh

As the ground slopes lower it is inundated for varying periods of each high tide. This zone is called the low marsh. Dominated by salt marsh cordgrass, *Spartina alterniflora*, it appears as a monotonous expanse of grass. Cordgrass is coarser than the high marsh grasses with long 1/4 to 1/2 inch wide leaves. Most of the low marsh is covered by a short form of cordgrass, usually less than two feet tall. Where a marsh creek cuts through the low marsh, roots are inundated for most of each day. This results in conditions that are ideal for cordgrass growth. Here a narrow band of cordgrass four to six feet tall is found. Salt marsh periwinkles live on the blades of tall cordgrass. They feed on the algae which coats the grass. They move up and down the blades above the tide level to avoid predation by fish, crabs and terrapins. Grasshoppers, leafhoppers and a few other insects feed directly on the plants of the low marsh.

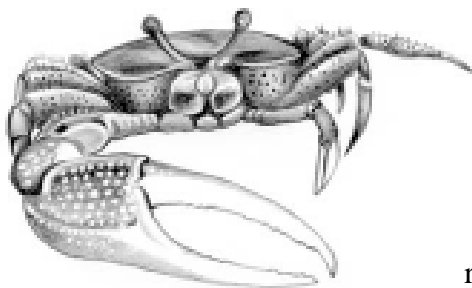


Cordgrass is a **perennial**. Its roots and **rhizomes** live year after year; however, the leaves and flower stalk die each fall. In the winter, wind, ice and tides break off the dead part of the plant. The dead grass is decomposed by bacteria and fungi and slowly breaks down into smaller and smaller pieces. This mixture of dead plant material and the organisms decomposing it is called **detritus**. Many organisms in the marsh ingest this detritus and digest the **decomposers**. The plant material is returned to the marsh undigested. It is repeatedly recolonized by decomposers and ingested by other organisms until eventually the decomposers break it all the way down to its component compounds. Detritus is an important part of the salt marsh **food web**. Various species of worms, mollusks, crabs and fish feed on detritus. An acre of salt marsh may produce up to 10 tons of grass each year. While much of the detritus produced remains in the marsh large amounts may be transported by tides to nourish nearby ocean waters. This detritus contributes immensely to the productivity of coastal ocean waters.

Shallow depressions that hold water after each high tide can be found in the high marsh. As the water evaporates the mud becomes too salty to support most marsh plants. *Salicornia* or saltwort, a very hardy plant is able to grow in these salty depressions. In late fall *Salicornia* turns bright red, adding a brilliant touch of color to the low marsh.



Marsh creeks meander through the low marsh. Along creek banks rockweed, a species of brown algae, grows attached to the stems and roots of cordgrass. Rockweed also attaches to the hard shells of ribbed mussels which burrow into marsh banks and attach by special threads to cordgrass rhizomes and roots. The banks of marsh creeks are pockmarked with the burrows of fiddler crabs. During low tide when the banks



are exposed these crabs can often be seen scurrying across the mud. Males can be identified by the one enormous claw. Females have two very small claws. The small claws are used to scrape up mud from which the detritus is removed and ingested. The sand that remains is regurgitated as small balls that are often seen in piles near burrow entrances. The male's large claw is not used for feeding but in ritualized territorial and courtship displays. When the tide rises the crabs retreat to their burrows to escape predators.

Marsh creeks are inhabited by many species of fish and other marine organisms. Diamond-back terrapins are the only reptile found in the salt marsh. They spend most of their lives in marsh creeks and bays. They may occasionally haul out on a bank to bask. Females emerge each spring to lay eggs in a shallow nest excavated in a nearby upland area above the reach of the tide.

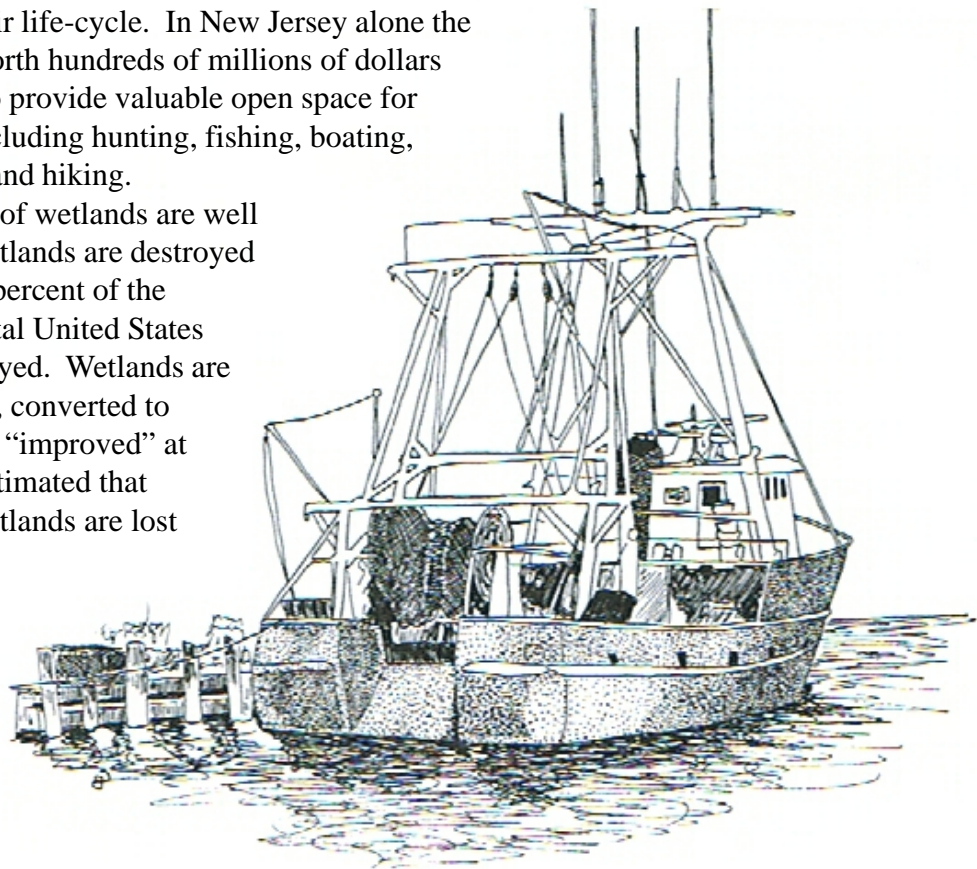
The low marsh is dotted with many ponds of various sizes called salt **pannes**. They may be only a few inches to three or four feet deep. They do not dry completely and are populated by mummichogs, sheepshead minnows, grass shrimp, crabs and other small organisms. Wigeon grass, an underwater plant, may grow in the deeper ponds. They are important feeding sites for several species of birds. During the summer herons, egrets, gulls and terns feed in mixed groups of up to several hundred birds in shallow pannes. Each day these **aggregations** must find new pannes in which to feed because they simply eat all of the fish. However, pannes are repopulated by fish on each spring tide. In the winter, waterfowl will feed on the animals and plants found in the pannes.

What Value, Wetlands?

Wetlands are incredibly important **ecosystems**. Many species of plants and animals spend their entire lives in wetlands. Many others find food in wetlands, use them as nesting or nursery grounds or stop in them to rest during migration. Wetlands also help to maintain water quality. Marsh grasses slow run-off and allow sediments to fall out of **suspension**. Marsh plants remove excess **nutrients** and marsh mud can remove toxic **heavy metals** from the water.

Wetlands are also important to humans. Wetlands can control floods and reduce erosion during storms. Coastal wetlands protect the mainland from the destructive power of storm waves. The impact of wetlands on commercial fisheries should be obvious. Almost seventy percent of commercially important fish and shellfish depend on wetlands during some stage of their life-cycle. In New Jersey alone the commercial fishery is worth hundreds of millions of dollars each year. Wetlands also provide valuable open space for recreational activities including hunting, fishing, boating, canoeing, birdwatching and hiking.

While the values of wetlands are well known, large areas of wetlands are destroyed each year. At least fifty percent of the wetlands in the continental United States have already been destroyed. Wetlands are still being drained, filled, converted to farmland, built upon and “improved” at an alarming rate. It is estimated that almost 1,000 acres of wetlands are lost every day. Only through universal understanding and appreciation of these beautiful and valuable natural areas can we hope to save the precious wetlands that remain.



On The Map!

More than half of all the wetlands that were found in the United States when European settlement began have been destroyed. Wetlands have been drained or filled to provide land for agriculture, airports, landfills and housing developments. Many of our country's largest cities have been built on filled wetland. Even in the face of this destruction wetlands still exist in most communities including large cities. Are there any wetlands in your community?

In this activity your students will discover that wetlands can be found everywhere. It will also test their map reading skills. You will need copies of the United States Geological Survey (USGS) topographical map for your community. Topo maps can be purchased at sporting goods stores that carry outdoor recreation equipment, some marinas and directly from the USGS.



Procedure

If you have several copies of the map, divide the class into small groups. You could also make photocopies of the map for your students to use. Discuss with the class the features they might find on a topographical map. What do the lines represent? (changes in elevation). What do the different colors represent? (blue = water, green = land with vegetation, brown = rock.). Find symbols that represent human alterations to the landscape, such as roads, buildings, dams etc.

This symbol  represents wetlands.

Different kinds of wetlands can be identified using a topo map. Emergent wetlands are areas of white with superimposed wetland symbols. Forested wetlands are green areas with wetland symbols. Do both kinds of wetlands exist in your community?

Extensions

1. Use maps of different areas of your state of the United States to compare and contrast the wetland areas of diverse regions with those of your community. Use maps of rural, suburban and urban areas. Discuss how wetlands have been impacted in these different areas.
2. Use old maps of your community to compare the amount of wetland area today with the amount of wetland area in the past. Has the amount of wetland decreased or stayed the same. Your local library or historical society are possible sources of old maps. You may even be able to get copies of older USGS topo maps.

3. After locating wetlands in your community take a field trip to one or several of these areas. Be sure to find out first who owns the areas and get permission to visit them. You may wish to contact your local or state government agency in charge of natural resources to find out about wetland areas near your community open to the public. If you do visit a local wetland, be sure not to cause an adverse impact on the area.

Keying Into Wetlands

When scientists want to identify something they have never seen before, they often use a key. In this activity your students will try to identify wetlands using data cards and the following key. On each card is a description of a wetland. The job of your students is to use the key to identify what type of wetland each card represents.



Procedure

A key is fairly simple to use. Each student or group of students should get a data card. Have your students read the cards. To start, go to number one on the key. Read the two statements found at number one and choose the one that best applies to the data card. After each statement is a number or the name of a wetland. If the correct statement is followed by a number go to that number. Repeat this process until they come to a statement followed by a type of wetland. Have your students write the name of their wetland in the space provided on the data card. Use the following answer key to determine if they correctly identified their wetland. If they incorrectly identified a wetland have them try again. If time allows you may wish to have your students identify the wetland on several cards.

Answers

- | | |
|-----------------------|-------------------------------------|
| A. Low Salt Marsh | K. Tamarack Swamp |
| B. Northern Shrub Bog | L. Southern Hardwood Swamp |
| C. Saw Grass Prairie | M. Non-Persistent Fresh Tidal Marsh |
| D. Aquatic Bed | N. High Marsh |
| E. Fresh Tidal Marsh | O. Estuarine Scrub-Shrub Wetland |
| F. Freshwater Marsh | P. Cedar Swamp |
| G. Dune Shrub Wetland | Q. Southern Shrub Bog |
| H. Cypress Swamp | R. Spruce Swamp |
| I. Peat Bog | S. Non-Persistent Fresh Marsh |
| J. Mangrove Swamp | T. Northern Hardwood Swamp |

Keying Into Wetlands

1.	Water salinity is 0.5 ppt or higher.....	2
	Water salinity is less than 0.5 ppt.....	5
2.	Dominant plants are trees or shrubs.....	3
	Dominant plants not trees or shrubs.....	4
3.	Mangroves are dominant plants.....	Mangrove Swamp
	Marsh elder is dominant plant.....	Estuarine Scrub-Shrub Wetland
4.	Regularly flooded by tide.....	Low Salt Marsh
	Irregularly flooded by tide.....	High Salt Marsh
5.	Water is influenced by the tide.....	6
	Water is not influenced by the tide.....	7
6.	Dominant plants only stand above the water during the growing season.....	Non-Persistent Fresh Tidal Marsh
	Dominant plants remain standing throughout the year even after they die in winter.....	Fresh Tidal Marsh
7.	Plants are submerged or floating.....	Aquatic Bed Plants
	Plants are emergent.....	8
8.	Dominant plant is moss.....	Peat Bog
	Dominant plant is not moss.....	9
9.	Plants are trees or shrubs.....	10
	Plants are not trees or shrubs.....	18
10.	Plants are shrubs.....	11
	Plants are trees.....	13
11.	Labrador tea and black spruce are dominant.....	Northern Shrub Bog
	Labrador tea and black spruce are not present.....	12
12.	Leatherleaf is dominant shrub.....	Southern Shrub Bog
	Bayberry is dominant shrub.....	Dune Shrub Wetland
13.	Needle-leafed trees are dominant.....	14
	Broad-leaved trees are dominant.....	17
14.	Trees are deciduous.....	15
	Trees are evergreen.....	16

- 15. Tamarack is dominant tree..... **Tamarack Swamp**
 Bald cypress is dominant tree..... **Cypress Swamp**

- 16. Black spruce is dominant tree.....**Spruce Swamp**
 White cedar is dominant tree.....**Cedar Swamp**

- 17. Red maple is dominant tree.....**Northern Hardwood Swamp**
 Sweet gum and Tulip are dominant trees.....**Southern Hardwood Swamp**

- 18. Dominant plants only stand above the water
 during the growing season.....**Non-Persistent Fresh Marsh**
 Dominant plants remain standing throughout the
 year even after they die in winter.....19

- 19. Saw grass is dominant plant.....**Sawgrass Prairie**
 Dominant plant is not saw grass.....**Freshwater Marsh**



A. Salt water floods this wetland every day. The dominant plant is smooth cordgrass.

F. The plants in this non-tidal, freshwater wetland, dominated by grasses, rushes and sedges, remain standing year-round.

B. Standing fresh water is not always present. Dominant plants are the shrub Labrador tea and stunted shrub-like spruce trees.

G. This non-tidal freshwater wetland occurs only in low areas between coastal dunes. The shrub bayberry is the dominant plant.

C. Fresh water may cover this wetland only during the summer and late fall during the rainy season. The dominant plant saw grass grows year round.

H. Bald cypress, a large deciduous needle-leaved tree is the dominant plant in this freshwater wetland.

D. This wetland occurs along the edges of non-tidal rivers, lakes and ponds. It is dominated by plants that grow completely under water or have leaves and flowers that float on the surface.

I. This non-tidal freshwater wetland is only found in the far north. Only a few species of moss and lichen can live on its acidic soil.

E. This freshwater wetland occurs along rivers influenced by tides. Cattails and other dominant plants remain standing all year.

J. This saltwater wetland only occurs in the U.S. in southern Florida. The dominant plants are salt tolerant mangrove trees.

K. The dominant plant of this northern freshwater wetland is tamarack, a deciduous needle-leaved tree.

P. This non-tidal fresh wetland is dominated by white cedar, a needle-leaved evergreen tree.

L. Fresh water may cover the ground in this wetland only part of the year. It is dominated by broad-leaved trees like sweet gum, bay and tulip trees.

Q. This non-tidal freshwater wetland, not found north of southern New Jersey is dominated by the shrub leatherleaf.

M. This freshwater wetland is influenced by tides. Wild rice and pickerelweed, the dominant plants, decompose quickly after they die and are only found during the growing season.

R. This northern freshwater wetland is dominated by black spruce, a large, evergreen, needle-leaved tree.

N. The dominant plants in this saltwater wetland are saltmeadow hay and salt grass. They are only flooded for short periods each month.

S. This freshwater wetland is found along the edges of slow-moving tidal rivers. Wild rice, pickerelweed and arrow arum are only found during the growing season.

O. This saltwater wetland is dominated by the shrub marsh elder. It is only flooded by occasional storm tides.

T. This non-tidal freshwater wetland is dominated by red maple, a broad-leaved tree.

To Develop or Not to Develop? That is the Question.

Teacher Information

In the following activity your students will take part in a mock town council meeting to decide the fate of a small tidal wetland, an adjacent forested area and a proposal to construct a housing development on the site. The students will assume the roles of individuals and groups involved in this debate. The following information will help you prepare your students for the activity.

Procedure

1. Assign roles to the students. Pick one individual to act as moderator during the council meeting. This student is responsible for maintaining order, recognizing speakers and in the case of a tie vote among the council persons, casting the deciding vote. Chose four other students to act as council persons. Their role is to listen to prepared presentations, ask questions to clarify points of view and then to use the information presented to vote for or against the development proposal. Divide the remainder of the class into six groups. Assign each group one of the following roles.

- A) *Citizens Environmental Group*: is opposed to the development on the grounds that it will may increase the chances of flooding during times of heavy rain in developed areas downstream.
- B) *Local Fishing Club*: is opposed to the development on the grounds that it will result in reduced water quality in the stream and will destroy habitat vital to fish populations in the river.
- C) *Wildlife Biologist*: is opposed to development because it will result in destruction of habitat for migratory birds including songbirds, shorebirds, wading birds, raptors and waterfowl. The loss of habitat will also impact local breeding birds.
- D) *Developer*: feels he/she bought the property and should have the right to develop it in any way to make a profit.
- E) *Construction Workers Organization*: is in favor of the development because it would provide many jobs for its members.
- F) *Chamber of Commerce*: in favor of development because the new residents would boost the local economy by spending money at local businesses.

2. Give the students copies of the student reading page and give them some time to do some research on wetlands.
3. After each student has done some research have them meet with their groups to plan their presentation for the meeting. Each group should then chose one person to act as spokesperson during the meeting. That person will state their groups opinion, offer any information in defense of that opinion and answer questions posed by council members.
4. After all groups have made their presentations and there are no further questions, council members should secretly vote for or against the development. The moderator should also vote at this time. Votes are collected by the moderator and revealed to the rest of the class. The moderator's vote is only revealed in order to resolve a tie among the council members.

After the meeting and the vote, discuss the outcome of the activity. Ask the students if they feel that their meeting was like a real council meeting that might take place in their community.

Extensions

1. What regulations or laws are on the books to protect wetlands from harmful human activities? Contact local, county, state and federal agencies to find out about laws regarding wetlands in your community or state.
2. Have the students do research projects on different kinds of wetlands. Have them address questions regarding; geographical range of their wetland, common plants and animals of that wetland; how the wetland is important to humans, and if and how the wetland been adversely affected by humans.

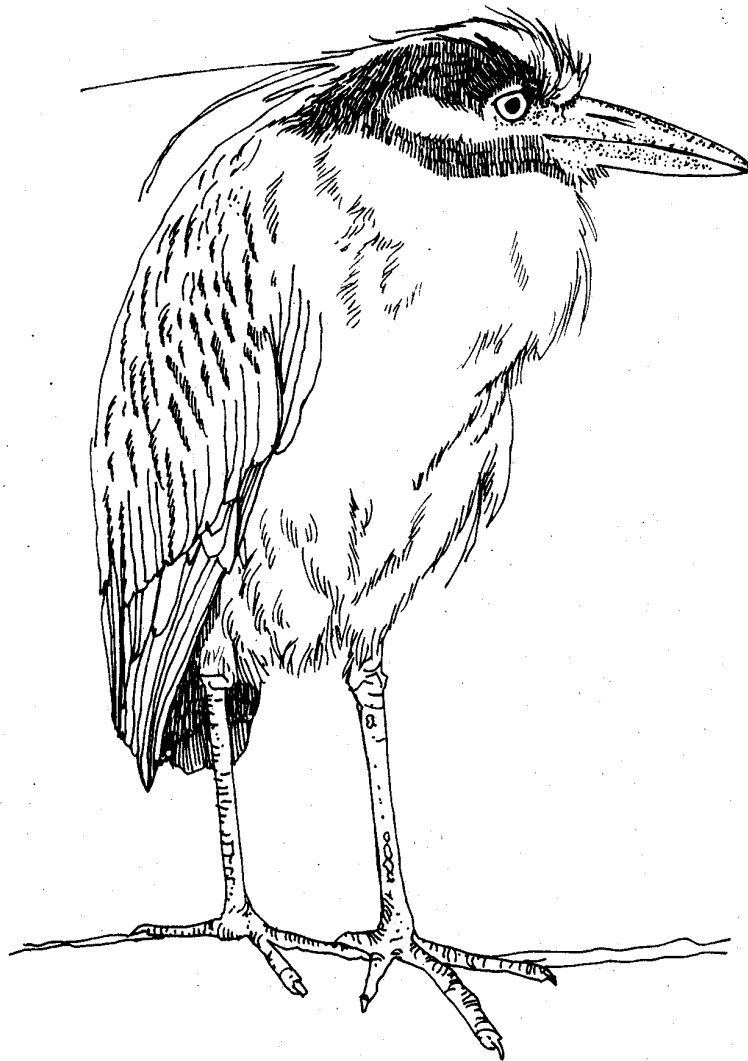
Student Information

The Placid River flows through a heavily urbanized area along the mid-Atlantic coast. The tidal stretches of the river have mostly been crowded by industrial and residential development. However, one privately owned area is still in a relatively natural state. In the shallows along the shoreline are estuarine salt marshes and wide intertidal mud flats. Adjacent to the marshes is a one hundred and fifty acre woodland. While seemingly small and insignificant, the area supports an impressive variety of wildlife. The river's mudflats attract thousands of migratory shorebirds, of several species, during spring and fall migration. Endangered peregrine falcons are occasionally seen in pursuit of shorebirds over the river. Herons and egrets search for small fish in the shallows during the warmer months. The nearby forest are feeding areas for migrating songbirds while a few species remain to nest.

The property was recently purchased by a developer who has submitted a proposal to the town council for a townhouse development he wishes to build on the site. The plan calls for filling large areas of wetlands and clearing much of the forest. Several community groups have voiced opposition to the plan. However several other groups have come out in support of the development. A council meeting has been arranged to discuss the proposal and allow all parties to make their opinions known. When all arguments have been heard, the council will vote to grant or deny permits for the development.

Procedure

1. After you have been assigned a role you will be given some time to do research about wetlands and wetland issues. Always keep in mind the point of view of the group you are representing even if it is different from your own.
2. Work together with your group to formulate the ideas you wish to present to the council. You may be asked questions by the council persons so be prepared to answer any questions you think they might have.
3. One person in each group will be assigned as spokesperson and will present your group's ideas to the council. They should be the only person to speak during the meeting.
4. The council persons will listen to all arguments and vote for or against the proposal when all presentations and questions are completed. Ballots are passed to and read by the moderator.
5. The moderator is responsible for conducting the meeting. The moderator will recognize speakers and maintain order at all times. The moderator also votes with the council. The moderator's vote is only revealed in the case of a tie.



One Good Wetland Deserves Another

Now that you have gotten your feet wet at the Wetlands Institute you may wish to learn about other types of wetlands. There are several wonderful field trip opportunities in the Pennsylvania and New Jersey area that will introduce your class to swamps, bogs, freshwater and brackish marshes. The following is a list of a few suggested sites. You may wish to contact your local or state natural resources agency or your state field office of the Nature Conservancy to find out about other wetland field trip opportunities near your community.

Great Swamp National Wildlife Refuge

The Great Swamp National Wildlife Refuge is located in Basking Ridge, New Jersey only a short distance from New York City. Great Swamp is one of the few undisturbed wetland areas remaining in northern New Jersey. Several boardwalks take you right into the heart of the swamp.

Refuge Manager
Great Swamp National Wildlife Refuge
RD #1, Box 152
Basking Ridge, New Jersey 07920
(201) 766-2489

Tinicum Marsh National Environmental Education Center

Tinicum Marsh lies on the southwestern edge of Philadelphia. It is an excellent example of a tidal freshwater marsh. The center, with its boardwalks and trails, makes for easy exploration of this wonderful wetland.

Refuge Manager
Tinicum Marsh National Environmental Education Center
Suite 104 Scott Plaza 2
Philadelphia, Pennsylvania 19113
(215) 365-3118

Hackensack Meadowlands Development Commission Environment Center

The Hackensack Meadowlands Development Commission Environment Center and DeKorte Park are located in Lyndhurst, New Jersey. The center is a wonderful outdoor laboratory for exploring human impacts on wetlands.

Hackensack Meadowlands Development Commission Environment Center
2 DeKorte Park Plaza
Lyndhurst, New Jersey 07071
(201) 460-8300



Atlantic County Park

Atlantic County Park in Estell Manor offers miles of trails through forested wetlands, tidal marsh and bordering upland forests. The park offers the unique opportunity to compare two different kinds of wetland first hand.

Atlantic County Park
RD 20, Box 252A
Mays Landing, New Jersey 08330
(609) 645-5960

Whitesbog

Located in the New Jersey Pine Barrens, Whitesbog is the site of the first successful cultivation of blueberries. Wetlands found in this unique area include cultivated cranberry bogs, swamps and cedar bogs.

Pinelands Institute for Environmental Studies
120-13 Whitesbog Road
Browns Mills, New Jersey 08015
(609) 863-1765

Bibliography

- Ballantine, T. 1991. *Tideland Treasure*. University of South Carolina Press. Columbia, South Carolina.
- Bryant, T.L. and J.R. Pennock, editors. 1988. *The Delaware Estuary: Rediscovering a Forgotten Resource*. University of Delaware Sea Grant College Program. Newark, Delaware
- Carlson, C. and J. Fowler. 1979. *The Salt Marsh of New Jersey*. Stockton State College. Pomona, New Jersey.
- Coulombe, D.A. 1984. *The Seaside Naturalist: A Guide to Nature Study at the Seashore*. Prentice Hall. Englewood Cliffs, New Jersey.
- Fox, W.T. 1983. *At The Sea's Edge*. Prentice Hall Press. New York.
- Gates, D.A. 1975. *Seasons of the Salt Marsh*. The Chatham Press. Old Greenwich, Connecticut.
- Gosner, K. 1978. *A Field Guide to the Atlantic Seashore*. Houghton Mifflin Company. Boston.
- Harding, J.J., ed. 1986. *Marsh, Meadow and Mountain: Natural Places of the Delaware Valley*. Temple University Press. Philadelphia.
- Lippson, A.J. and R.Lippson. 1984. *Life in the Chesapeake Bay*. Johns Hopkins University Press. Baltimore.
- Perry, B. 1985. *A Sierra Club Naturalist's Guide to the Mid-Atlantic Coast, Cape Hatteras to Cape Cod*. Sierra Club Books. San Francisco.
- Roberts, M.F. 1979. *The Tidemarth Guide*. E.P. Dutton. New York.
- 1985. *The Tidemarth Guide to Fishes*. The Saybrook Press. Saybrook, Connecticut.
- Rothenberg, J. 1987. *Marshnotes: An Introduction to the Salt Marsh*. Calvert Marine Press. Solomons, Maryland.
- Silberhorn, G.M. 1982. *Common Plants of the Mid-Atlantic Coast: A Field Guide*. Johns Hopkins University Press. Baltimore.
- Snow, J.O. 1969. *Secrets of a Salt Marsh*. Guy Gannet Publishing Co. New York.
- Teal, J. and M. Teal. 1969. *Life and Death of the Salt Marsh*. Ballantine Books. New York.
- Tiner, R.W. Jr. 1985. *Wetlands of New Jersey*. U.S. Fish and Wildlife Service, National Wetlands Inventory. Newton Corner, Massachusetts.

Vocabulary

Aggregation a loose knit, social group containing individuals of the same species.

Barrier island a narrow, usually long, sandy island that forms along gently sloping shorelines and acts as a barrier between the mainland and the sea

Community all of the species which occur in the same habitat.

Cowlick tufts of grass twisted and turned to one side, as if licked by a cow.

Decomposer any organism that feeds by degrading organic matter.

Detritus fragments of organic matter and the bacteria and fungi decomposing the fragments

Ecosystem a community of organisms and their physical environment interacting as an ecological unit.

Food web the network of interconnected food chains of a community

Heavy metal metallic elements of high relative density; includes cadmium, copper, gold, silver, mercury, nickel, and zinc.

Hydrophyte any plant adapted to live in water or very wet habitats.

Nutrient basic compounds of which organic material is composed.

Panne a natural basin or depression, especially one containing water or mud, which may dry at certain times leaving a salt deposit.

Perennials plants which persist for several years with a period of growth each year.

Rhizome a more or less horizontal, underground stem.

Spring tide especially high and low tides caused by the combined gravitational pull of the moon and sun occurring on each new and full moon.

Sub-tropical of, pertaining to, or designating the regions bordering on the tropical zone.

Suspension a dispersion of fine, insoluble, particulate matter in a fluid.