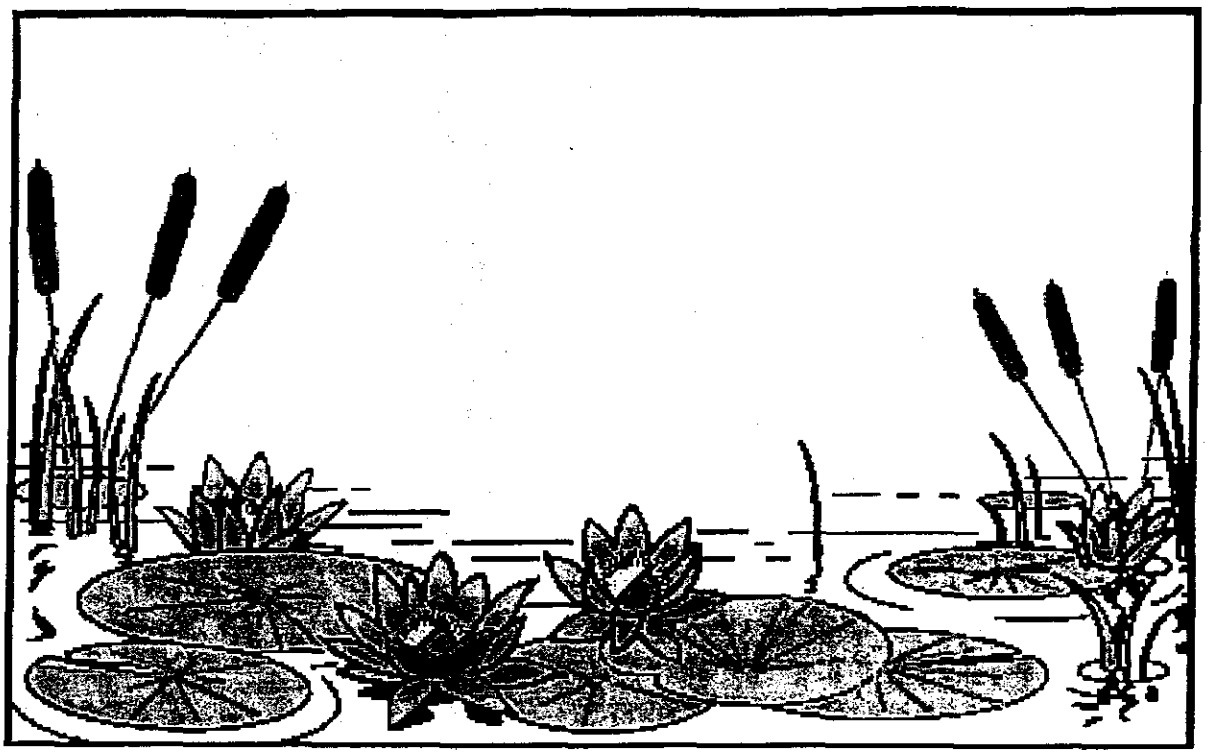
Wetlands

Nature's Water Wonders



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Science Explorers

A Science Enrichment Program For Teachers

2002-2003 Program

Wetlands – Nature's Water Wonders

Introduction

"Wetlands are areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, bogs, and similar areas." Definition of wetlands by the U.S. Army corps of Engineers and the U.S. Environmental Agency since the 1970's for regulatory purposes.

To make this quotation a little clearer and easier to understand, one might say that wetlands are areas of land that are saturated or covered with water for at least some part of the year. They are our vital link between land and water. They support plants that often cannot survive elsewhere. They are transitional areas between land and deep water. They are found from high mountainous areas to the valleys and basins of the lowlands. They are found in wet areas, as well as arid (dry) areas. In arid Colorado, wetlands comprise a mere 2% of our land and the amount is shrinking. These beautiful, diverse regions are productive lands performing important functions in our watersheds. They are of great value to people, animals and numerous species of plants. The one common element in all wetlands is water – the key to life.

Although all wetlands may not appear "wet", water plays a part in these diverse landscapes. A desert spring may not run all year, it may even skip a year. A peat bog may feel spongy underfoot and not seem wet, but both are types of wetland environments.

Wetlands are the transition zone between terrestrial and aquatic environments. The actual boundaries of a wetland may be difficult to define as the plants may overlap into the neighboring environments, some of the soil may dry out at certain times of the year, and many of the animals living in wetlands are mobile. Three things must be present for the land to be defined as an actual wetland:

- A hydrologic regime – the presence of water
- Hydric soils
- Hydrophytic plants

In wetlands, there is a **hydrologic regime** or water will be present for some part of the year. The depth and duration of flooding will vary from season to season and from year to year. The water from wetlands may come from many sources,

such as snowmelt, run-off, tides, groundwater, streams, rivers, springs, or rain. Changes in the level of the water can cause profound changes in the organisms, both flora and fauna, residing within the wetland.

While the water is not always apparent, its presence will be indicated in some way:

- The ground may be spongy.
- Mud or dried mud may be present in low areas.
- Water or salt staining may be present on plants or tree trunks.
- There may be topographic evidence of water.

Wetlands vary in size, ranging from small prairie potholes to large expanses along coasts and rivers, such as the Amazon River. Wetlands also vary in terms of location and types. Coastal marshes dominate the East Coast, while playas are found in the interior of the Southwestern U.S.

Hydric soils, the soils found in wetlands, are soils that are saturated with water either at the surface or in the root zone long enough during the growing season to develop anaerobic conditions in the upper layer. Because of the saturated environment and the lack of oxygen, anaerobic bacteria (bacteria not requiring oxygen) often accomplish decomposition, which results in the sulfur smell often associated with wetlands. Wetlands soils that are dominated by organic material (decomposing plants) are called peats, fens or mucks. In these soils, plant accumulation builds faster than decomposition can break it down. These areas tend to be dominated by grasses and herbaceous plants.

Wetland soils are one of two types: organic soils or mineral soils. Soils high in mineral content (sand clay and silt) tend to form in warm, wooded wetlands that the water saturates for only part of the year. In these areas, the organic decomposition keeps up with the accumulation.

Wetland soils will have one of the following characteristics:

- A sulfur smell
- A green, dark gray, brown, or black color
- Mottled coloring
- Mottling along plant rootlets
- "Gleyed" soil – gray, blue-gray, gray-green color
- Water collecting in the hole dug for the soil sample

The flooded environment plus the lack of oxygen, limits the types of plants that can survive in these conditions. Wetland plants are called **hydrophytic plants**, and like all plants, they need to exchange gases for their respiration and photosynthesis. Hydrophytes must adapt to waterlogged conditions and do so in many ways. Reeds have long, oxygen transmitting tubes, water lilies and duck weed have the ability to float on the water, and cypress trees have buttressed trunks (knobs that jut out of the water and take in oxygen). These adaptations to

wetland environments and the ones listed below allow hydrophytes to survive in anaerobic conditions often have to do with capturing and carrying oxygen.

- Shallow or exposed roots that pick up surface oxygen
- Plants with hollow tubes to transport oxygen to the roots
- Floating plants with roots that dangle in the water
- Plants with knobs on the roots that reach above water level
- Thickened trunks

Some plants are found only in wetlands, some are found in both wetlands and "uplands" and some are found only in uplands. Plants are classified by the categories listed below:

Obligate Wetland Plant – a plant that occurs over 99% of time in wetlands
Facultative Wetland Plant – a plant that occurs 67-99% of time in wetlands
Facultative Plant – a plant that occurs 34-66%of time in wetlands
Facultative Upland Plant – a plant that occurs 1-33% of time in wetlands
Upland Plant – a plant that occurs less than 1% of time in wetlands

Activity 1: Status of Wetlands

Background Information:
Throughout history, humans have found little value in wetlands and have destroyed them for various reasons. Often with the early settlers, streams were diverted and canals built to drain the land for agricultural use. Wetlands became orchards, pastures, and fields of vegetables.

With rapid population growth from the 1900's on, the wetlands of the United States have been disappearing at an alarming rate. Not only were they filled for agricultural uses but for housing, retail construction, roads, and manufacturing. Some of the salt marshes along the Gulf and the oceans were dredged to form harbors for shipping. At this point in time, over half of America's wetlands have been destroyed and the losses are continuing.

Concepts:

- There are fewer than 50% of the wetlands left in the United States.
- Wetlands are being filled in for many reasons: housing, roads, industry, and agriculture.

Student Objectives:

1. Using a poem, the students will depict how humans have interacted with and degraded wetlands throughout history.
2. The students will draw illustrations to create a visual aspect of the poem.

Materials:

- Copies of the poem, "Down by the Bay"
- Drawing paper

- Markers

Procedure:

1. Distribute copies of the poem to the students.
2. Divide the students into groups and divide the poem into stanzas or couplets.
3. Have each group of students draw a picture or image to illustrate the part of the poem they were given.
4. Have the students read their part and show their illustration to the class.
5. Display the illustrations.

Down By The Bay

From Project Home Planet, by Susan Vanderburg

Long ago, on a quiet bay,
An Indian family decided to stay.
They built their homes from cedar trees.
For their food, they turned to the seas.

They gathered clams and mussels too,
But never more than they could use.
Salmon fed them all year long,
And they offered thanks in prayer and song.

One day a giant ship appeared.
To the men on board, one thing was clear;
This bountiful land, there was no mistaking,
Had wood, and furs, and fish for the taking.

Before long, more white people came,
Built trading posts, and hunted game.
More ships now came into the bay,
And some of the animals moved away.

Next, settlers came from over the land,
With wagons and seeds and dreams and plans.
They built their farms and soon saw how
The rich, flat marsh could easily be plowed.

To keep the sea away from the crops,
The farmers built walls of heavy rocks.
They diked off part of the beautiful bay,
And many more animals moved away.

More settlers came and wanted a town,
But the shore by the bay was soggy ground.
The marshland looked like a muddy place,
A grassy place just going to waste.

So they filled it with dirt and built wide piers.
They dredged out the harbor so ships could come nearer.
The dredgings were piled on the shores of the bay,
And many more animals moved away.

People made money by logging trees.
Logs could float down the river with ease.
Soon, the mouth of the river was filled
With logs awaiting their turn at the mill.

The saw blades screamed; the wood chips flew.
Wagons carried lumber, and ships did too.
The chips and bark settled into the bay,
Many animals wished they could move away.

Now the town has grown to a city,
The noise and the garbage aren't very pretty.
Canneries border one stretch of shore.
They process fish for the local stores.

A marina was built for pleasure boats.
On the water more gas and oil floats.
Factories dump wastewater into the bay,
And not many animals care to stay.

People have always looked at the bay
And thought, "What a great place for humans to stay."
They used the bay to meet their needs,
(Or in some cases, to satisfy greeds.)

They didn't know that the bay, left alone,
Was a valuable place, all on its own.
"What good is a muddy old bay," you might say?
Just look what a marshland can give us each day!

For migrating birds, a resting ground,
A more suitable place could hardly be found.
For young salmon coming down from a stream,
A place to feed and get used to the sea.

For baby animals of every kind,
A better nursery would be hard to find.
The marsh is a natural filter too,
Trapping pollutants that enter the slough.

For living things, a saltmarsh can yield
More food than produced in a farmer's field.
The marshland food chains even include
Humans who harvest the bay's rich food.

Next time you gaze at a grassy bay,
Remember the poem you heard today.
Remember the value of this special place,
To all creatures, including the human race.

Question and Observations:

1. Describe three ways in which wetlands can be degraded. (Housing, roads, industrial, landfills, or manufacturing, etc.)
2. How have the wetlands in your region of Colorado been used? (Answers will vary.)
3. Can you think of a way to help replace and replenish wetlands? (Answers will vary.)

Classroom Extensions:

- Set the poem to music and use percussion or musical instruments.
- Have the class perform the poem as a play.

Activity 2: Audubon Wetlands Poster

Background Information:

The importance of wetlands to wildlife is significant. Wetlands provide water, a rich and diverse supply of food, shelter, and space for a variety of animals - all the essentials of life. They are an irreplaceable habitat. They serve as a nesting, breeding, and feeding, as well as shelter and refuge to numerous animals. Many animals inhabit wetlands for their entire lives (beaver, muskrat, frogs, and fish) and many use it as a stopping point during migration or inhabit them during only part of their life cycle (migratory waterfowl and toads). Some animals only visit wetlands for drinking or feeding, such as deer, coyote, raccoons.

Wetland plants provide nutrition for many of the inhabitants or transients. Moose and waterfowl feed on the plants living in the wetlands. Dead and decaying plants, detritus, is the most important food material ingested by fish and invertebrate marine life in coastal marshes.

Concepts:

- Wetlands provide food, water, shelter, and space for many species of animals.
- Wetlands provide a habitat for many varieties of plants.

Student Objectives:

1. The students will examine a wetland poster and discover the large variety of inhabitants.
2. The students will use the poster to compare salt water and fresh water wetlands, the similarities and the differences.
3. The students will examine the poster to discover the many ways that animals utilize the wetlands.

Materials:

- National Audubon Society's, *Wetlands – Wonders Worth Saving*, poster
- Data sheet of questions

Procedure:

1. Examine the freshwater marsh side of the poster and answer the questions on the data sheet. (See Appendix 1)
2. Do the same for the saltwater marsh side of the poster.
3. Compare the two, their similarities and differences.

Classroom Extensions:

- Visit a freshwater marsh and try to spot some of the animals and plants in the poster.
- List the animals in the poster that are found in Colorado.
- Are any of the plants considered invasive species in Colorado? Find out which ones and research what our state is doing about them.

Activity 3: Wetland Ecosystems

Background Information:

Wetlands form the boundaries between land and water. They are areas of very diverse flora and fauna. Many of these animals and plants live only in the wetlands. Many animals may be transient and visit daily, or even migrate into the wetland these areas, for food, water, shelter, or space and then leave. Whether a permanent inhabitant or a transient, these animals, and the plants that live in the wetlands, depend on the wetland for life. The wetland is an ecosystem dependent on the surrounding water and land.

When a wetland is filled in for human use, the entire ecosystem that is dependent upon the wetland may be destroyed. If any part of the wetland changes, even the non-living components, the ecosystem may be damaged irreparably. All the animals and plants in a wetland ecosystem are dependent upon one another to survive.

Concepts:

- Wetlands have permanent and transient inhabitants.
- These inhabitants, both the flora and fauna, depend on the wetlands to survive.
- If the wetlands change through human disturbance, an entire ecosystem can be altered or destroyed.

Student Objectives:

1. The students will role play different wetland components (both living and non-living) and create a web with string that connects each component.
2. The students will demonstrate the importance of all parts of an ecosystem to each other.

Materials:

- Photos, drawings, or signs with names of the components in a wetland ecosystem
- String
- Scissors

Procedure:

1. Allow each student to choose a component of the ecosystem, or assign one to him or her. Components will include: sun, water, bacteria, phytoplankton, algae, water lily, cattails, trees, zooplankton, insects/bugs, crayfish, salamanders, frogs, painted turtles, ducks, muskrats, beavers, minnows, trout, snapping turtles, snakes, otter, mink, diving birds (cormorant), wading birds (heron), eagle, and humans.
2. Discuss the definition and the importance of each of the components of the ecosystem.
3. Using a large ball of string or yarn, start with water and ask the students which members of the wetlands use water. Connect the students with yarn as they demonstrate the relationships. To keep from becoming too tangled, cut the string between each relationship.
4. Repeat with the sun. Then repeat with all the members of the wetland ecosystem.
5. Eventually it should be clear that all members of this ecosystem are related. To demonstrate this, pull on one piece of string and see how many students feel the tug.
6. Have each student who feels that pull, pull on all the strings that he/she is holding.
7. Consider the pull on the string a disturbance in the ecosystem, it will be clear that a disturbance to one member of an ecosystem will affect all members.

Questions and Observations:

1. Which part of the ecosystem is the most important? (All parts of an ecosystem are related and all are important to each other.)
2. What are the functions of each part of the ecosystem? (Answers will vary.)

Appendix 1

Questions for the Wetland Poster

1. What are the indications that are found in the poster that this is a wetland (not including the poster's title)? (Presence of water and hydrophytes)

2. What are mammals? (Animals with a backbone – vertebrates, breathe with lungs, give birth to live babies, feed babies with milk) What mammals are using this wetland? (Muskrat, Meadow Jumping Mouse, Mink, Marsh Rabbit)

3. What is a reptile? (Vertebrates, lay soft, leathery eggs, dry, scaly skin, breathe with lungs) What reptiles are using this wetland? (Painted Turtle)

4. What is an amphibian? (Vertebrates, eggs with no shell, breath with lungs, gills, or skin, go through metamorphosis, and have moist, slimy skin) What amphibians are using this wetland? (Pickerel Frog, tadpoles, newt)

5. Why must amphibians lay their eggs in water? (Their eggs have no shell and would dry out without being emerged in the water.)

6. Name four birds on this poster that are native to Colorado. (Red-winged Blackbird, Great Blue Heron, Ring-necked Pheasant, Mallard)

7. What is an invertebrate? (An animal without a backbone) Name at least four invertebrates in this poster. (Damselfly, Diving Beetle, Snail, Freshwater Mussel, Mosquito larvae, Amphipod)

8. Name some of the animals that are permanent wetland inhabitants (live in a wetland all year)? (Painted Turtle, Pickerel Frog, Muskrat, Snail, Freshwater Mussel, Mosquito Fish, Amphipod)

9. Which of these animals are transient wetland inhabitants or visitors? (Birds and many of the mammals) Why are they in the wetland? (Food, water or shelter)

10. Describe a connection between a plant and an animal. What is the term to describe this connection? Mallard/duckweed –primary consumer/producer in the food chain)

11. Describe a connection between two animals. What is the term to describe this connection? (Mosquito fish/Mosquito larva – predator/prey)

12. How does the freshwater marsh seem to differ from the salt marsh? (Answers will vary.)

EPA's Suggested Reading for Middle School Students

ESTUARIES, WHERE RIVERS MEET THE SEA, Laurence Pringle. The MacMillan Co., New York; 1973; 56 p.; glossary; grades 5 to 7; NF

Summary: Superb photographs and simple, concise text. Explores bays and salt marshes, with descriptions of plant and animal life above and below water, including the complex, interrelationships between tides, grasses, crabs, fishes and birds.

Comment: Estuaries are among the most productive ecosystems in the world, some producing twenty times as much food as an equal area of open sea. Salt marshes may produce ten tons of plants a year compared to the best wheat fields, which yield only seven tons. The following passage from Estuaries, Where Rivers Meet the Sea indicates how valuable estuaries are to all of us:

"Whether you live close to an estuary or far away, your life is tied to salt marshes and eelgrass meadow. Whenever you eat scallops, oysters, clams, sole or many other kinds of seafood, your body receives energy from estuaries."

EVERGLADES COUNTRY, Patricia Lauber. The Viking Press, New York; 1973; 125 p.; grades 5 to 8; NF

Summary: Very informative and accurate. Provides an account of the Florida Everglades, with its unique plant and animal life. Author refers to Everglades National Park as a "huge reach of grassy water." Describes this internationally unique and valuable wetlands system known as the Everglades as well as the constant, heavy pressure to develop this area. It includes discussions of the defeat of proposed construction for an expansive airport, and ongoing irrigation for agricultural practices that have changed the "grassy water" to barren land.

Comment: Everglades Country provides the student with a respect, understanding and appreciation for this special environment, its inhabitants and the threats to its existence. Perhaps it will encourage students to identify ways to actively conserve wetlands.

EXPLORING THE GREAT SWAMP, George Laycock. David McKay Company, Inc.; 1978; 58 p.; grades 5 to 8; NF

Summary: Very Informative and well illustrated. Author Laycock conveys a sense of intrigue and adventure as the author defines wetlands and some of their values and functions. Describes swamps, including the history and vegetative communities that comprise some swamps of North America. In Exploring the Great Swamp, George Laycock investigates scientifically accurate facts, eye-witness accounts, history and legends of the great swamps such as the Great Dismal Swamp located on the border between Virginia and North Carolina, the Okefenokee Swamp in Georgia and the Alakai on a Hawaiian mountaintop.

Comment: Exploring the Great Swamp presents good information about swamps in different areas of the country. The reader will learn that while these places are all swamps, each swamp is unique and differs widely from other swamps.

LOOK WHAT I FOUND*, Marshal T. Case. The Chatham Press, Inc., Riverside; 1971; 95 p.; grades 5 to 7; NF

Summary: Contains useful information on setting up an aquarium either at home or in the classroom, for studying plant and animal life, including those found along the edge of wetlands. Discourages disturbing wetlands, and encourages students to release living things they capture to their native habitats once finished looking at them.

Comment: *In Look What I Found, author Michael T. Case provides* information for students to learn first hand what constitutes a wetland through building a model of a wetland either at home or in the classroom.

MISTY OF CHINCOTEAGUE*, Marguerite Henry. Rand McNally and Co., Chicago; 1946; 176 p.; grades 5 to 8; F

Summary: Fiction based on fact; occurs along the barrier islands of Maryland and Virginia; Assateague Island, where according to legend shipwrecks in colonial times occurred and stranded fifteen ponies in wild, grassy marshlands; and neighboring Chincoteague Island, home of children Maureen and Paul. Classic narrative of Paul and Maureen's adventures acquiring three ponies: a wild mare, stallion and colt during annual round up and lessons learned in the process.

Comment: Many students love horse stories. Assateague Island is a National Wildlife Refuge where ponies still roam free and every year there is a round up like the one described in Misty of Chincoteague. All the incidents in the story are real and happened at one time or another along the barrier islands and grassland marshes. Accurate descriptions of the marshes and barrier islands are incorporated.

THE MYSTERY OF THE BOG FOREST, Lorus J. Milne and Margery Milne. Dodd, Mead and Company, New York; 1984; 128 p.; grades 5 to 7; index; NF

Summary: Attractive, well done and accurate, with index. Explains the origins of bogs, their special attractions and their unique plant and animal life. Lists plants and animals occurring in wetlands, providing scientific name and range. Describes the formation of bogs from peat moss as it spreads out from shore, and the usually harsh, physical characteristics that limit the plant community to life forms specially adapted to wetlands, emphasizing the adaptation of carnivorous plants.

Comment: The Mystery of the Bog Forest provides helpful background information on bogs and their unique and unusual types of vegetation. A student may want to visit a bog after reading this book. Bogs are great to investigate in groups. Authors Margery and Lorus Milne also describe the very old artifacts found deep in bogs.

A NATURALIST'S SKETCHBOOK, Clare Walker Leslie. Dodd, Mead and Company, New York; 1987; 121 p.; grades 7 to 12; NF

Summary: Creative, new method for studying wetlands. Leslie presents a calendar year of pages taken from ten naturalist journals daily covering the period 1977 to 1987. Provides helpful notes on drawing, demonstrating a new way of seeing nature. Drawings of waterfowl, paddling painted turtle and hooded mergansers in a pond with notes describes author's experiences during the day in margins.

Comment: A Naturalist's Sketchbook, like Leslie's earlier, Nature Drawing: A Tool for Learning is simply about developing a new tool for learning and is highly recommended for learning to see and study nature in a new way. It is an excellent tool for experiencing and learning about marshes and other wetlands through "seeing."

OF MEN AND MARSHES, Paul L. Errington. The Iowa State University Press, Ames; 1957; 150 p.; grades 7 to 10; NF

Summary: Accurate but not too technical description as dedicated naturalist unveils little known world of wetlands life; encompasses prairie marshes and marsh-dwelling animal societies such as muskrat (Errington is "The muskrat expert") and water birds in glaciated regions of Midwest and far West, and Southeast. Portrays ducks filling skies and covering waters, shorebirds running on mudflats, fishes in shallows; describes living things adjusting to changes such as muskrats during flood and drought, waterfowl in migration during a snow storm.

Comment: Of Men and Marshes takes a humanistic and historic perspective to describe human impacts on marsh communities. By paralleling human to marsh societies, Errington expresses the need for reverence toward the ancient interrelationships of native plants, animals, soils, and climates. He suggests that man demonstrates he is civilized by preventing unnecessary destruction of the remaining marshlands and other existing wild places.

"Greater familiarity with marshes on the part of more people could give man a truer and more wholesome view of himself in relation to Nature. In marshes, Life's undercurrents and unknowns and evolutionary changes are exemplified with a high degree of independence from human dominance as long as the marshes remain in marshy condition. Marshes comprise their own form of wilderness. They have their own life-rich genuineness and reflect forces that are much older, much more permanent, and much mightier than man."

Note: Since this book is out of print, it may be hard to find.

PITCHER PLANTS: THE ELEGANT INSECT TRAPS, Carol Lerner. William Morrow and Company, New York; 1983; 63 p.; grades 5 to 8; NF

Summary: Excellent drawings, paintings and text. Contains a glossary, an index and a list of places with collection of pitcher plants and other

carnivorous (insect-eating) plants. Portrays a group of plants known as pitcher plants, which are unique to bogs along the East coast. These unusual plants are unable to obtain nutrients from acidic soil conditions and have adapted by consuming insects to live.
Comment: Pitcher Plants: The Elegant Insect Traps and similar books on insectivorous or carnivorous plants are highly recommended for learning about these unusual and rare plants, and will enable students to gain an understanding of the unique adaptations plants and animals make in response to the special ecological conditions found in wetlands systems.

POND LIFE*, George K Reid, Ph.D. Western Publishing Company, Inc.; New York; 1967; 160 p.; grades 6 to 10; index; NF

Summary: Popular, accurate and informative book in the Golden Guide Series. Describes and illustrates in color some of the most common of the thousands of animals and plants that inhabit ponds and other wetlands, lakes and streams. First section includes valuable information on the characteristics of ponds, examining several of the many different types of ponds and wetlands (cypress swamps, bogs, and mountain bogs). Discusses water characteristics and the different habitats found in freshwater systems, including the littoral or wetland habitat extending from the water's edge outward as far as rooted plants grow. Suggestions for when to visit, where to look, how to make exciting discoveries, and how to observe, collect and release live specimens.
Comment: Pond Life defines ponds as quiet bodies of water so shallow that rooted plants may grow completely across them. By definition, ponds are one type of wetland. Although there are many different kinds of wetlands and each is unique, Pond Life explains well the physical and biological factors common to most wetlands, as well as how plants and animals live in community together.

THE SNOW GOOSE*, Paul Gallico. Alfred A. Knopf, Inc., New York; 1940; 56 p.; grades 5 to 12; NF

Summary: Haunting, moving and tender account during World War II. Setting is an abandoned lighthouse on a low, far-reaching desolate expanse of grass, reeds, and half-submerged meadowlands on the Essex coast of England. Snow Goose wanders from home in Canada to England and is wounded by hunters in nearby marsh. Twelve year old girl, Fritha, daringly brings wounded Snow Goose to lonely, deformed man, Rhayader, who cares for wild, wounded animals. Once healed, "Great White Bird" returns annually. When war breaks out, Rhayader sets out across the sea to rescue marooned men in bad weather, unknowing of Snow Goose overhead. Remainder of story is a mystery but fragmentary and is based on words from pub and local residents: Rhayader is successful, however, what became of him is unknown and of the Snow Goose it is written:

"The Great White Bird with the black-tipped pinions that saw it all from the beginning has returned to the dark, frozen silences of the northlands from whence it came." (p. 56)

Comment: The Snow Goose is a true story that occurs along the coastal wetlands of Great Britain and is garnered from many sources and many people. Apparently, the hero was last seen rowing soldiers across the sea to safety time and again, with the Snow Goose accompanying him. Following is a passage from The Snow Goose:

"The Great Marsh lies on the coast between the village of Chelmbury and the ancient Saxon oyster-fishing hamlet of Wickaeldroth. It is one of the last wild places of England, a low, far-reaching expanse of grass and reeds and half-submerged meadowlands ending in the great saltings and mud flats and tidal pools near the restless sea." (pages 3-4)

WILD AND SCENIC RIVERS, National Geographic Society. Washington, D.C.; 1983; 200 p.; grades 6 to 9; NF

Summary: Stunning photographs and informative text on America's rivers, including many riverine wetlands as those along the Little Pee Dee River in South Carolina, the floodplain wetlands of Minnesota's Big Fork River, and the Bayou Penchant, a 30-mile marsh environment in Louisiana.

Comment: Many wetlands occur along rivers. Wetlands also often occur at the headwaters of rivers. For example, Wild and Scenic Rivers cites the source or headwaters of Wisconsin's Riverer Noire or Black River as bogs and swamps. The book describes state and national efforts to preserve these and other riverine systems, as well as people who work to protect them.

THE WIND IN THE WILLOWS*, Kenneth Grahame. Charles Scribener's Sons, New York; 1908; 259 p.; grades 6 to 10; F

Summary: Classic, delightful story featuring adventures of animals along a riverbank, wetland habitats and other low-lying areas. Star characters include Mole, Rat, Toad and Badger. Whether it is the adventures boating with Rat or Toad in his motor car, wetlands are never far off: along the river, besides the meadows, on the bank where Rat's house is found or beside the pools where Otter hides. Below is an excerpt from a conversation between Mole and Rat, as Mole speaks about enjoying boating and water:

"What?" Cried the Rat, open-mouthed; "Never been in a-you never-well, I - what have you been doing then?"

"Is it so nice as all that?" asked the Mole shyly.

"Nice? It's the only thing," said the Water Rat solemnly, as he leaned forward for his stroke. "Believe me, my young friend, there is nothing - absolutely nothing - half so much worth doing as messing about in boats." (pages 6-7)

Comment: The Wind In The Willows is for those who are or remain young at heart. Wetlands occur along the rivers, and many of us enjoy activities in riverine wetlands, much like the characters in this book. The Wind In The

Willows portrays the interconnectedness of wetlands, rivers, meadows, woods, and the lives of animals and humans.

THE YEARLING*, Marjorie Kinnan Rawlings. Charles Scribner's Sons, New York; 1938; 428 p.; grades 7 to 10; F

Summary: This cherished classic that takes place in the shallow springs and pools, sawgrass rivers and adjacent meadows and wooded swamps in and around the Florida Everglades. Story is about a boy growing up in a poor family, his attachment to adopted, semi-tame fawn, the fawn's repeated invasion of his father's corn field, the tragedy that follows, and the painful maturing these experiences bring. Excellent characters, realistic experiences and accurate descriptions of landscapes.

Comment: The Yearling mirrors author M.K. Rawling's own, real life experiences when she emigrated from the bustling life of the city to write in a country surrounded by the Florida Everglades. It is based on her personal relationship with a neighboring family and a youth who faced the very real trials of growing up in a poor, rural family with a father attached to the bottle. Her writings also describe the surrounding wetlands, typical of the Florida Everglades, as indicated in the quote below:

"There was suddenly a strip of hammock land, and a place of live oaks and scrub palmettos. The undergrowth was thick, laced with cat-briers. Then hammock, too, ended and to the south and west lay a broad open expanse that looked at first to be a meadow. This was the saw-grass. It grew knee-deep in water, its harsh saw-edged blades rising so thickly it seemed a compact vegetation." (pages 32-33)

Students are encouraged to read M.K. Rawling's autobiography, Cross Creek, which also has much on wetlands. Both The Yearling and Cross Creek have been made into movies.

Colorado State Model Content Standards

Geography:

Standard One: Students know how to use and construct maps, globes, and other geographic tools to locate and derive information about people, places, and environments.

Introduction: Benchmarks 1.1.1, 1.1.3, 1.3.1, 1.3.2, 1.3.4
Hydrology: Benchmarks 1.1.1, 1.1.3, 1.3.1, 1.3.2, 1.3.3, 1.3.4, 1.3.5
Hydrophytic Plants: Benchmarks 1.3.3, 1.3.4
Hydric Soils: Benchmarks 1.3.2

Standard Two: Students know the physical and human characteristics of places, and use this knowledge to define and study regions and their patterns of change.

Introduction: Benchmarks 2.1.1, 2.1.2, 2.3.1, 2.3.2
Hydrology: Benchmarks 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1, 2.3.2
Hydrophytic Plants: Benchmarks 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1
Hydric Soils: Benchmarks 2.2.1, 2.2.2, 2.2.3, 2.2.4, 2.3.1

Standard Three: Students understand how physical processes shape Earth's surface patterns and systems.

Introduction: Benchmarks 3.1.1, 3.1.2, 3.1.3, 3.2.1, 3.2.2
Hydrology: Benchmarks 3.1.1, 3.1.2, 3.1.3, 3.2.1, 3.2.2
Hydrophytic Plants: Benchmarks 3.1.1, 3.1.2, 3.1.3, 3.2.1, 3.2.2
Hydric Soils: Benchmarks 3.1.1, 3.1.2, 3.1.3, 3.2.1, 3.2.2

Standard Four: Students understand how economic, political, cultural, and social processes interact to shape patterns of human populations, interdependence, cooperation, and conflict.

Introduction: Benchmarks 4.1.3, 4.2.1, 4.2.2, 4.3.1, 4.3.3, 4.3.4, 4.4.1, 4.4.2
Hydrology: Benchmarks 4.1.3, 4.2.1, 4.2.2, 4.3.1, 4.3.3, 4.3.4, 4.4.1, 4.4.2, 4.5.1, 4.5.2

Standard Five: Students understand the effects of interactions between human and physical systems and the changes in meaning, use, distribution, and importance of resources.

Introduction: Benchmarks 5.1.1, 5.1.2, 5.1.3, 5.2.1, 5.3.1, 5.3.3, 5.3.4, 5.3.5, 5.3.6
Hydrology: Benchmarks 5.1.1, 5.1.2, 5.1.3, 5.2.1, 5.3.3, 5.3.4 ,5.3.6
Hydrophytic Plants: Benchmarks 5.1.1, 5.1.2, 5.1.3, 5.3.4, 5.3.6
Hydric Soils: Benchmarks 5.1.1, 5.1.2, 5.1.3, 5.3.4, 5.3.6

Standard Six: Students apply knowledge of people, places, and environments to understand the past and present and to plan for the future.

Introduction: Benchmarks 6.1.1, 6.1.2, 6.1.3, 6.2.1
Hydrology: Benchmarks 6.1.1, 6.2.1, 6.2.2

Science:

Standard One: Students understand the processes of scientific investigation and design, conduct, communicate about and evaluate such investigations.

Introduction: Benchmarks 1.1, 1.2, 1.6, 1.7, 1.10
Hydrology: Benchmarks 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10
Hydrophytic Plants: Benchmarks 1.1, 1.3, 1.4, 1.5, 1.6, 1.7, 1.9, 1.10
Hydric Soils: Benchmarks 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 1.10

Standard Two: (Physical Science) Students know and understand common properties, forms, and changes in matter and energy.

Hydrology: Benchmarks 2.1.1, 2.1.2, 2.2.1, 2.2.2, 2.3.1, 2.3.2, 2.3.5
Hydric Soils: Benchmarks 2.2.1, 2.1.1, 2.1.3, 2.2.1, 2.3.2, 2.3.4, 2.3.5

Standard Three: (Life Science) Students know and understand the characteristics and structure of living things, the processes of life, how living things interact with each other and their environment.

Introduction: Benchmarks 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.2.2, 3.2.4, 3.2.5
Hydrology: Benchmarks 3.1.4, 3.1.5, 3.2.4
Hydrophytic Plants: Benchmarks 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.3.3, 3.4.3, 3.4.5
Hydric Soils: Benchmarks 3.1.4, 3.2.4, 3.2.5

***Standard Four:* (Earth and Space Science) Students know and understand the processes and interactions of Earth's systems and the structure of Earth and other objects in space.**

Introduction: Benchmarks 4.1.5
Hydrology: Benchmarks 4.1.4, 4.1.5, 4.3.2
Hydric Soils: Benchmarks 4.3.2

Standard Five: Students know and understand interrelationships among science, technology, and human activity and how they can affect the world.

Introduction: Benchmarks 5.1, 5.2, 5.3
Hydrology: Benchmarks 5.1, 5.2, 5.3
Hydrophytic Plants: Benchmarks 5.1, 5.2, 5.3
Hydric Soils: Benchmarks 5.1, 5.2, 5.3

Standard Six: Students know that science involves a particular way of knowing and understand common connections among scientific disciplines.

Introduction: Benchmarks 6.4
Hydrology: Benchmarks 6.2
Hydric Soils: Benchmarks 6.1, 6.2, 6.4

Reading and Writing:

Standard One: Students read and understand a variety of materials.

Introduction: Benchmarks 1.1
Hydrology: Benchmarks 1.1
Hydrophytic Plants: Benchmarks 1.1

Standard Two: Students write and speak for a variety of audiences.

Introduction: Benchmarks 2.2, 2.4, 2.6
Hydrology: Benchmarks 2.2, 2.3, 2.4, 2.6
Hydrophytic Plants: Benchmarks 2.2, 2.4, 2.6
Hydric Soils: Benchmarks 2.2, 2.4, 2.6

Standard Three: Students write and speak using conventional grammar, usage, sentence structure, punctuation, capitalization, and spelling.

Introduction: Benchmarks 3.2, 3.3, 3.4, 3.6
Hydrology: Benchmarks 3.2, 3.3, 3.4, 3.6
Hydrophytic Plants: Benchmarks 3.2, 3.3, 3.4, 3.6
Hydric Soils: Benchmarks 3.2, 3.3, 3.4, 3.6

Standard Four: Students apply thinking skills to their reading, writing, speaking, listening, and viewing.

Introduction: Benchmarks 4.1, 4.2, 4.4,
Hydrology: Benchmarks 4.1, 4.2, 4.3, 4.4
Hydrophytic Plants: Benchmarks 4.1, 4.2, 4.3
Hydric Soils: Benchmarks 4.2, 4.3

Standard Five: Students read to locate, select, and make use of relevant information from a variety of media, reference, and technological sources.

Introduction: Benchmarks 5.3, 5.4
Hydrology: Benchmarks 5.3, 5.4
Hydrophytic Plants: Benchmarks 5.3, 5.4
Hydric Soils: Benchmarks 5.3, 5.4

Standard Six: Students read and recognize literature as a record of human experience.

Introduction: Benchmarks 6.1, 6.2

Math:

Standard One: Students develop number sense and use numbers and number relationships in problem-solving situations and communicate the reasoning used in solving these problems.

Introduction: Benchmarks 1.1
Hydrology: Benchmarks 1.1, 1.4

Standard Two: Students use algebraic methods to explore, model, and describe patters and functions involving numbers, shapes, data, and graphs in problem-solving situations and communicate the reasoning used in solving these problems.

Introduction: Benchmarks 2.3
Hydrology: Benchmarks 2.3

Standard Three: Students use data collection and analysis, statistics, and probability in problem-solving situations and communicate the reasoning used in solving these problems.
Introduction: Benchmarks 3.7
Hydrology: Benchmarks 3.4, 3.5, 3.6
Hydric Soils: Benchmarks 3.4, 3.5, 3.6

Standard Four: Students use geometric concepts, properties, and relationships in problem-solving situations and communicate the reasoning used in solving these problems.
Hydrology: Benchmarks 4.1, 4.2, 4.5
Hydric Soils: Benchmarks 4.1, 4.2, 4.5

Standard Five: Students use a variety of tools and techniques to measure, apply the results in problem-solving situations, and communicate the reasoning used in solving these problems.
Hydrology: Benchmarks 5.1, 5.2, 5.5, 5.6
Hydric Soils: Benchmarks 5.1, 5.2, 5.5, 5.6

Standard Six: *Students link concepts and procedures as they develop and use computational techniques, including estimation, mental arithmetic, paper-and-pencil, calculators, and computers, in problem-solving situations and communicate the reasoning used in solving these problems.*
Hydrology: Benchmarks 6.1, 6.3
Hydric Soils: Benchmarks 6.1, 6.3

History:

Standard One: Students understand the chronological organization of history and know how to organize events and people into major eras to identify and explain historical relationships.
Introduction: Benchmark 1.2.3, 1.3.1, 1.3.2

Standard Two: Students know how to use the processes and resources of historical inquiry.
Introduction: Benchmark 2.1.1, 2.2.1, 2.2.2, 2.2.3, 2.3
Hydrology: Benchmark 2.3

Standard Three: Students understand that societies are diverse and have changed over time.
Introduction; Benchmark 3.1.2, 3.2.2, 3.2.3, 3.2.4

Standard Four: Students understand how science, technology, and economic activity have developed, changed, and affected societies throughout history.
Introduction: Benchmark 4.1.2, 4.1.3, 4.2.1, 4.2.2, 4.2.4, 4.3.1
Hydrology: Benchmark 4.1.2, 4.1.3

Standard Six: Students know that religious and philosophical ideas have been powerful forces throughout history.
Introduction: Benchmark 6.3.3

Hydrology

Background Information:

The **hydrologic regime**, the pattern in, above, and below the groundwater flow, is a critical parameter of wetlands. To be considered a wetland, water must be present covering the soil or near the surface for at least part of the growing season. Areas considered wetlands may be saturated or covered with water for the entire year, but in many locations, the water may be present for a short period of time, and the parcel of land may appear to be completely dry for the rest of the year. Wetlands may be found in the mountains, in cities, and along the edges of rivers, irrigation ditches, streams, and coasts. Water runs downhill due to the force of gravity, so wetlands are almost always found in low-lying areas. They are found in almost every county in the United States. They are found in almost every climatic zone as well. To be considered a true wetland region (although water may not always be apparent, it is still present), one of the following conditions must occur:

- The ground may be spongy
- Mud or dried mud may be present in low areas
- Water or salt staining may be present on plants or tree trunks
- There may be topographic evidence of water
- Standing or flowing water may be observed during the growing season
- Debris may be lodged in trees or piled against other objects by water
- Thin layers of sediments may be deposited on leaves or other objects
- Soil may be waterlogged during the growing season

Wetlands differ in size and shape. Not all are the familiar cattail-ringed ponds that we picture. While over 50% of Americas' wetlands have been filled in, the ones that remain vary greatly in size, shape, and location. There are numerous types of wetlands found across the United States and many of these are found in Colorado. They vary because of the topography of the surrounding land, climate, vegetation, human disturbances, soils, and chemistry. There are two major categories of wetlands with many sub-types falling into each of these general categories: coastal (tidal) wetlands and non-tidal wetlands.

Coastal (tidal) Wetlands (approximately 5% of the wetlands in the US) are found along the Pacific, Gulf, Alaskan, or Atlantic coasts. (Needless to say, there are no coastal wetlands in Colorado.) The salt water and the tides create harsh climates for flora to survive and many will be void of vegetation and are only mud or sand flats. Often found near estuaries, where seawater and salt-water mix, the salinity of these marshes may vary. Coastal wetlands may be fresh water, salt water, or brackish water, which is created when ground water, rivers, and run-off (fresh water) mix with the salt water in these marshes. Some salt tolerant herbs and grasses like cordgrass, saltgrass, glasswort, and black rush have adapted to this harsh environment and provide shelter for the coasts from storms and

hurricanes. These areas typically have a high rate of productivity due to inflow of nutrients and organic material. Examples of coastal marshes are:

Saline Tidal Marshes
- Lower marsh covered and then exposed daily by tides
- Vegetation is predominately smooth cordgrass, spikegrass, and blackgrass
- Fauna may include: the clapper (a type of rail – a bird) and the Great Egret

Mangrove swamps
- Found in subtropical or tropical regions, like Florida, in this country and Puerto Rico
- Characterized by salt loving (*halophytic*) trees, shrubs, and other plants growing in brackish to saline waters
- In the US there are three species of mangroves: black, white, and red
- Found in estuaries
- Mangrove trees have long stilt-like roots to anchor them. They have knobs of exposed roots that help with the intake of gases, because most of the roots are submerged
- Fauna include: worms, oysters, barnacles, protozoa, fish, shrimp, wading birds, pelicans, and the endangered American crocodile

Fresh Water Tidal Marshes
- Tidal marshes that form above the salt water and do not mix with salt water
- Form upstream of estuaries, but are still influenced by tides
- Diverse species of flora, including cattails, wild rice, arrowhead and pickerelweed

Inland Wetlands (95% of the country's wetlands) are found most commonly along the floodplains of streams and rivers, along the edges of lakes and ponds, and glaciated pockmarks in the terrain. Here groundwater, precipitation or run-off keep the soil saturated for part or all of the year. There are many types of non-tidal wetlands and many are unique to a certain region of the country. They are quite diverse and many are listed below. Examples of inland marshes are:

Swamps
- Primarily fed by surface water
- Freshwater or salt water
- Very wet saturated soils during the growing season and standing water at other times of the year
- Dense undergrowth of rich, green vegetation
- Characterized by trees (forested swamps) or woody shrubs (shrub swamps) – are often found next to each other
- Highly organic, nutrient-rich black soils
- Flora in forested swamps include: cypress, cedar, alder, red maple, pin oak, willows, hemlocks, gum
- Trunks of some tress may flare, called knees

- Flora in shrub swamps include: buttonbush, willow, dogwood, swamp rose
- Fauna include: freshwater shrimp, crayfish, clams, the American crocodile, wood ducks, river otters, cottonmouth snakes

Freshwater (Inland) Marshes
- Periodic or permanent freshwater, vary in depth from a few inches to 1-6 feet
- Little or no peat deposition
- Neutral pH, nutrients plentiful
- Highly organic, mineral-rich soils of sand, silt, and clay
- Receive water mostly from surface water, including: floodwater, runoff, snowmelt, or groundwater
- Abundant plant and animal life
- Emergent and soft stemmed vegetation that has adapted to saturated soil conditions, i.e. cattails, reeds, and bulrushes, no trees
- Animals present may be: red-winged blackbirds, yellow headed blackbirds, great blue herons, otters, muskrats, minks, frogs, turtles, snakes, salamanders

Wet Meadows
- A fresh water marsh
- Occur in poorly drained basins
- Receive water from: irrigation, precipitation, or seasonal snowmelt
- Found mostly in the Midwest, common in Colorado below 9000'
- Often dry in summer, look like stretches of grasslands
- Vegetation often darker than the surrounding areas
- Highly fertile soil
- Dominated by herbaceous plants: sedges, bulrushes, cattails, grasses
- Helps in flood and pollution control
- Aids in groundwater recharge

Prairie Potholes (Sloughs)
- A type of freshwater marsh
- Pockmarks (depressional wetlands) left by glaciers after their retreat 12,000 years ago
- Found in Canada and the Dakotas, Iowa, Wisconsin, Montana, and Minnesota
- Receive water from ground water, snowmelt, and rain
- Some temporary, some permanent, more than half have been drained or altered for agricultural use
- Submerged and floating aquatic plants in deeper water and bulrushes and cattails around the perimeter, sedges grow next to the upland
- Over one-half the migratory waterfowl depend on them for their survival and reproduction

Riparian Wetlands
- Occur along moving water courses, such as rivers and streams
- Receive large amounts of water from the melting of mountain snowpacks
- Most common wetland found in Colorado

Playa Lakes
- A type of freshwater marsh
- Shallow
- Nearly level area at the bottom of an undrained desert flat-bottomed basin
- Found in low lying areas of southern high plains in the US in Colorado, New Mexico, West Texas, Oklahoma, and Kansas– help recharge the Ogallala Aquifer
- Receive water from rainfall and runoff, may dry out during the year (*ephemeral*)
- Carved by wind or land subsidence
- Salt Water Playas - fed from underground (aquifers)
- Blackbirds, teal, mallards, whooping cranes, bald eagles, salamanders, sandhill cranes, jackrabbits, raccoons, mayflies and dragonflies are common in playas

Vernal Pools
- A type of freshwater marsh
- Water pools in bedrock or hard clay
- Shallow
- Seasonal (ephemeral) – develop in spring and may dry out in summer or fall
- Depressional wetlands found mostly on the West Coast
- Size from small puddles to shallow lakes, usually found in a gentle sloping plain of a grassland
- Critical habitat for wildlife adapted to breeding in this area – ducks, hawks, egrets, frogs, and other amphibians

Forested Wetlands
- High country wetlands that form around springs
- Form over hard bedrock, granite, or other igneous rocks
- Nutrient poor, acidic and low in salts
- Occur in valleys surrounded by spruce and pine forests
- Many sedges

Wet Prairies
- Found mostly in the Midwest and common to Colorado
- Similar to wet meadows but remain saturated longer
- Receive water from intermittent streams, ground water, and precipitation

Shrub Wetlands
- Freshwater
- Mostly woody shrubs less than 6 meters in height
- Occur along rivers, streams, lakes and reservoirs
- One of the most widespread in the US

Fens
- High country wetlands that form around large springs (fed by ground water)
- Peat forming (soils low in oxygen, so they do not decompose but form peat)

- Because water flows over limestone or dolomite rocks, high in calcium carbonate and other salts
- Tend to be alkaline
- Support calciphytes (calcium-loving plants): grasses, sedges, reeds, rushes, and wildflowers
- Usually in the Northern Hemisphere
- Tend to occur in glaciated areas
- Generally associated with low temperatures and short growing seasons

Bogs
- Formed in cool, wet areas where drainage is poor
- Peat accumulating
- Usually in the Northern Hemisphere in glaciated areas
- Waterlogged soil lacks oxygen
- Acidic freshwater with spongy peat deposits
- Evergreen shrubs, trees, cranberries, and blueberries, carnivorous plants, i.e. sundew and the pitcher plant
- Floor covered with sphagnum and other acid tolerant mosses
- Only water source is rainwater
- May have been a fen that was separated from its groundwater supply
- Low in nutrients
- Plants and animals living in bogs must be tolerant of the unique challenges of the physical and acidic, waterlogged, low nutrient environment

Pocosins
- Algonquin word meaning "swamp on the hill" evergreen shrub and trees dominate
- Found in the Atlantic Coastal Plain from Virginia to Florida
- Usually no standing water, but a shallow water table saturating the soil for most of the year, may become very dry in spring or summer
- Found in broad, flat, upland areas far from large streams
- Like most bogs, rain provides most of the water
- Waterlogged, nutrient-poor, acid soils - mostly peat and sand with some charcoal from periodic fires
- Flora: bay trees (red, loblolly, sweet), and evergreen shrubs like: titi, zenobia, and fetterbush
- Fauna: black bears, red cockaded woodpecker

Activity 1: Functions and Values of Wetlands

Background Information:
What are wetlands and are they really needed? Are those mosquito-infested wastelands that smell like rotten eggs really of value? Wouldn't they make a nice area for the new housing development or shopping center? When talking about wetlands, these are some of the questions often heard being asked. In the recent

past, people have thought of wetlands as places to avoid or fill in. We are just beginning to realize their significance. Wetlands are protected by the Clean Water Act under Section 404.

Over the past century the State of Colorado and most of the United States has lost at least 50% of its wetlands. This year in particular, with our dry winter and spring and all the forest fires, we may regret losing those wetlands more than ever! The importance of wetlands has become a very critical issue and one that may become still more important. The quality of the wetland, the *topography*, the location, and the timing of the presence of water often help to determine the functions of that particular wetland and its role in the environment. Some of the functions may include: *ground water* recharge, *flood* control, water purification and filtration, *erosion* control, recreation, education, wildlife habitat, and research.

Wetlands provide homes for many plants, especially the *carnivorous bog plants* that could not grow in other locations. Abundant vegetation and shallow water provide fish and wildlife with diverse and safe habitats. Wetlands provide all the necessary elements to sustain life for animals: food, water, shelter, and space. They provide areas to reproduce, eat, and rest for many species of waterfowl and migratory birds. Eighty per cent of the bird population in the United States depend on wetlands at some time during their life cycle. Humans, for the most part, tend to stay away from swamps and bogs. Nesting shore birds, migratory waterfowl, and many types of fish and amphibians depend on wetlands. The prairie potholes of the Upper Midwest with its warm summers, shallow lakes and rich soils, is considered one of the most important wetland regions in the world for the breeding and feeding of migratory waterfowl. Mangrove swamps are important regions for shrimp nurseries. Many of the endangered species in Colorado, for example the wood frog, dwell in our wetlands. And mammals throughout the United Sates, such as muskrat, beaver, deer, and marsh rat are year round wetland inhabitants, along with some of the indigenous reptiles like alligators and crocodiles.

The vernal pools that often dry out during the hotter months of the year are important areas for animals that require a dry season in their life cycle. Seeds, eggs, or cysts begin to grow and the adults reproduce (when the ponds are again filled with water). Playas store rainfall in the driest parts of the country, and they provide moisture, when there is little elsewhere in the dry Southern High Plains regions.

Besides being important habitat for animals and plants, wetlands provide many other important functions. They are a major factor in flood control. Studies have confirmed the correlation between loss of wetlands and downstream flooding. During periods of rainfall and snowmelt, wetlands collect rain and runoff thus reducing the amount of runoff flowing downstream. Wetlands act as natural sponges and slowly release water that has been stored over a period of time. Wetlands store runoff, which reduces the velocity and the impact of floods. During

periods of drought, when water levels are lower in rivers, wetlands release their water and vegetative matter (which helps to feed the fish) into the rivers.

Erosion of the soil in and around wetlands is impeded because of the rooted aquatic and emergent plants surrounding and residing in the wetlands. The root systems allow the soil to stay in tack and it does not wash away with the water. Erosion control efforts in some areas often include planting emergent flora.

Tidal wetlands also protect coasts from hurricanes and tropical storms. Mangrove swamps and coastal marshes act as a sponge, which buffers and controls the fury of the waves. Studies have shown that 1/2 the normal wave energy is dissipated within the first 3 meters of land, in which wetlands are present.

Not only do wetlands act as buffers for the fury of floods and storms, but they also trap some of the sediment from runoff and act as a natural filter. Consequently, allowing the *surface water* that drains out of the wetlands is cleaner, purer, and has a reduced sediment load. Pollution is also retained by wetlands. As the water flows slowly through the wetland, sediments and pollution settle to its floor. The vegetation in the marsh uses the fertilizer that is in the runoff as nutrients. This fertilizer would be considered a pollutant in the surface water. The roots act as sieves to cleanse the water that runs through the wetland. Pesticides, fertilizers, human waste, animal waste, and heavy metals are just some of the pollution that wetlands bury before releasing the water. The plants may absorb some of the pollution or the *anaerobic bacteria* that reside in these environments may process it. Wetlands are so good at absorbing pollutants and cleaning the water that replicas of marshes are now being built by man for that purpose. Because they utilize these nutrients, freshwater marshes are one of the most productive ecosystems on Earth. They support large varieties of plants and animals.

Wetlands, especially marshes, also help to recharge the ground water in the soils below them. This is an important function during drought, such as this summer in Colorado. As water is filtered through wetlands, much of the water that enters our aquifers is clean. Depending on the permeability of the wetland soil, the amount of water entering the ground can be very significant. Playas help support agriculture in the regions where they are found. They provide water for irrigation and help to recharge the Ogallala Aquifer. Unfortunately, the water in this aquifer is used for drinking water and irrigation faster than it is being recharged. Thus the water level of the Aquifer, like many aquifers worldwide, is dropping.

Another important function of a wetland is that the plants in the wetland are producing oxygen for the atmosphere through the process of *photosynthesis*. They take in carbon dioxide and give off oxygen, important to the survival of all animals on Earth. Water hyacinth is not only one of the endangered manatees' primary sources of food, but it also has high potential as an energy producer.

The *peat* that is formed in the peat bogs may be harvested and burned as fossil fuel. Unfortunately, peat is a non-renewable resource and burning it may produce air pollution. But in Finland, Ireland and the former Soviet Union, it is a major source of fuel. In this country, timber from swamps is used as fuel and for building materials.

Pocosins, in the East, remove some of the pollutants deposited by rainwater. The acid from the rain is then slowly released from these wetlands into estuaries, helping to maintain the proper pH for the fish living in them. Keeping the fish populations healthy is important to both the recreational and fishing industries.

Humans use wetlands in various ways other than fuel and building materials. One of the most important values is recreation. We use wetlands for fishing, camping, bird watching, boating and just plain having fun. But unfortunately, with the continual building and development, we have filled in wetlands and will eventually be faced with the negative consequences of these actions. Many plants that humans consume for food are grown only in wetlands, such as cranberries, blueberries, and rice. Unfortunately, because of the richness of the wetland soil, humans are draining many for agricultural uses. Wetlands also function as biological laboratories and educational field stations.

Over 75% of the fish that are commercially harvested in the United States come from wetlands. Add to the commercial fishing, the shellfish, and hunting and trapping (fur) industries, wetlands have a huge economic influence on the towns and cities around them.

We need to preserve the wetlands that we have left in each state and pass any educational information on to others. Perhaps through education (much of which can be carried out in these "living classrooms"), future generations will come to value these sulfur smelling, mosquito filled wetlands.

Concepts:

- Wetlands act as habitat for many plants and animals.
- Wetlands serve as a means to help prevent floods.
- Wetlands filter out pollution from the water and purify it.
- Wetlands are buffers for the shorelines during tropical storms and hurricanes.
- Wetlands provide recreational sites, educational sites, and food for humans.
- Fuel and timber can be harvested from wetlands.

Student Objectives:

1. Students will build working wetlands models.
2. Students will be able to list at least five functions of wetlands.
3. Students will observe the wetlands model acting as a device to reduce the size and volume of water flowing into a body of water, which will help prevent flooding.

4. Students will observe and calculate the amount of pollution (debris) entering and exiting a wetland.

Materials:

- USGS *Wetlands: Water, Wildlife, Plants, and People!* Poster (See Appendix 1 - the poster has been reduced to 80%))
- Slides of different types of wetlands
- Data sheet for wetlands runoff and flooding (See Appendix 2)
- Play dough or clay
- Baking pan or plastic shoe box
- 200 ml of clear water
- 5 Tablespoons of potting soil
- Sponge
- Piece of Astro-turf
- Straight pins

Vocabulary:

Anaerobic bacteria, carnivorous bog plants, flood, erosion, ground water, peat, photosynthesis, surface water, topography

Procedure:

Adapted from USGS Wetlands Model Activity

1. Review the poster and discuss the various types of wetlands and their functions.
2. Spread a sloping layer of modeling clay or play dough over one-third of the baking pan or the shoebox to represent land. Make sure the clay is sealed to the edges of the box. The students may build streams and decorate the clay with twigs and leaves and branches and things that may simulate people, plants, and buildings.
3. Cut a piece of sponge to cover about one-third of the shoebox. This will represent a wetland. The remaining one-third of the shoebox will represent water.
4. Cut a piece of Astro-turf to cover the sponge and secure with straight pins if necessary. This must fit snugly on the sponge so water will not flow between it and the sides of the box.
5. Have the students simulate a rainstorm by *gently and slowly* pouring 200 ml of water over the land (clay). Have the students describe what happened. Then remove the wetland (sponge and Astro-turf) and pour out, measure, and record the amount of the remaining water.
6. With the wetland still removed, have the students again pour, gently and slowly, another 200 ml of water over the land. Give the students time to discuss what they observed. Then have them pour out, measure and record the amount of water. Compare this amount with the amount left in the box when the wetland was in place.
7. Replace the wetland. Spread the soil over the land and again gently and slowly pour 200 ml of water over the land. Have the students compare the water that ends up in the wetlands with the water that they poured over the land. Remove

the wetland and let the students examine it. Pour out the water remaining in the box.

8. Repeat step 7 without the wetland in place and observe the results. Discuss the results.

Questions and Observations:

1. How did the wetland (sponge and Astro-turf) affect the amount of water left in the pan? (The wetland absorbed much of the water, acting like a buffer to the floodwaters.)
2. What did the wetland do for the water that had the soil in it? (It acted much like a sediment trap, removing many of the soil particles suspended in the flowing water.)
3. How can muddy water affect fish and wildlife? (It will plug up the fish's gills and not allow them to breathe, then they will die. The muddy water prevents light from reaching phytoplankton and plants and they will die, because light is their source of food. If the plants are prevented from accomplishing photosynthesis, it will affect the entire food chain.)
4. How does this sediment affect other water users? (Sediment must be removed before water is useable for drinking, swimming, or bathing.)

Classroom Extensions:

- Have children visit an actual wetland near the school before and after a rain to measure the water level and calculate the rate of water flowing into the wetland and out of the wetland.
- Adopt a wetland as a class project. Work with your local chapter of the Audubon Society to put up bird boxes. Record the wildlife found there. Keep a journal of the seasons of the year, which animals use the wetland, at which times, and for what during the year. Call the Audubon Wetlands Campaign at 202-547-9009 or the local Audubon Chapter.
- Look up and read about the Clean Water Action, Section 404 that protects wetlands.
- Make your own play dough for the activity.

  Combine:

  1 cup flour
  1/4 cup salt
  2 T. Cream of Tartar

  Combine and then add to above:

  1 cup water
  1 T. oil
  Food coloring

  Heat over medium heat. When forms a ball – knead on floured breadboard. While cooking, it will look globby, but it will work.

Activity 2: Lily Pad Lake

Background Information:
"What can be done with the swamp, the bog, the marsh?" These are questions that people through the years have often asked. "That desirable piece of land at the end of the lake would be perfect for the highway to the airport, a housing development, a restaurant with a view..." It seems that humans over the past 50 years have found many uses for wetlands other than just remaining wetlands. Over the last five decades, we have filled in over 50% of America's wetlands and now we are beginning to see the negative results. Land use decisions are not easy ones to make and often many factors, some unforeseen, need to be considered. Compromise often plays a big part in these decisions, because they are so difficult for those involved.

Throughout history, people have found little value in leaving wetlands alone. The rich fertile soil has been turned into fields for crops, grazing, and orchards. What we often do not stop to consider is that human use of land affects wildlife habitat. Human priorities are for ourselves, usually not for wildlife. We want a good life with modern conveniences. Years ago, vacant land was often viewed as an area to be developed or altered in some way. Today, many humans realize that this may not only be detrimental to humans but also to the environment. More thought is put into developing an area. It is difficult to find a balance in preserving the environment at all costs and developing land for agriculture or economics.

Human growth in any *ecosystem* needs to be monitored. Naturally occurring growth has limits imposed by a balance of energy within the system. Without enough of the essentials for life (food, water, shelter, and space), growth will not occur. But where humans are involved, often the essentials of life for all the inhabitants of an ecosystem are not taken into account. Then the balance of the ecosystem is altered. Starting from the soil microbes up to the apex predators, a balance of all organisms must be complete for the ecosystem to thrive. When humans impact the growth of an ecosystem, we must be aware that the natural balance of food, water, shelter, and space must be maintained to keep the system healthy. This is true for all ecosystems, not just wetlands. Not only must we be aware of the impact on new ecosystems that we want to disrupt, but also the impact of those that have already been disturbed. What will the impact be if we build neighborhoods, a retail outlet, a school, or an airport? This has become a major challenge for responsible citizens.

Concepts:
- Over 50% of the wetlands in the United States have been destroyed in the past 50 years.
- Ecosystems are a delicate balance of the flora, fauna, and the habitat surrounding them.
- Any building or change may disrupt the natural balance of an ecosystem.
- All living things need food, water, shelter, and space to survive.

- There may be positive besides negative results in building in a wetland.
- Land use is a complex issue, with pros and cons, the outcome of which does not necessarily satisfy all involved.

Student Objectives:

1. Students will evaluate pros and cons of how different structures and human uses impact a wetland.
2. Students will design land use and developments around an existing wetland.
3. Students will be given a "donated parcel of land" and decide the best way for the land to be used, both economically and ecologically for the wetlands and the nearby inhabitants.
4. Students must come to a consensus on the land uses.

Materials:

- Map of the Lily Pad Lake, the donated property, and the surrounding marshes (See Appendix 3)
- Scissors
- Masking tape
- Land use cutouts (See Appendix 4)
- Pro/con data sheet for the land use cutouts (See Appendix 5)

Vocabulary:

Consensus, ecosystem

Procedure:

Adapted from the EPA, "People and Wetlands" pamphlet, the "Loon Lake and Dragonfly Pond" Activities

1. Students will be given one set of land use cutouts and one map of Lily Pad Lake. The town, Lakeville, surrounding Lily Pad Lake is a very small bedroom community for the nearby city. The community only has a few businesses that provide most of their daily needs: a grocery/hardware store, dry cleaners, restaurant, fire station, and a gas station that sells sporting goods items for the tourists. The children are bused to a different town for school. There is some farming and agriculture (cornfields and peach orchards). But most of the townspeople either work in tourist trade or in the nearby city. The town has a small hotel with tourist cabins that are rented out to hunters or fishermen. The wetland that is managed by the Department of Fish and Wildlife has a season for duck hunting.
2. After cutting out the land use cutouts, the students must decide where to place them on their Lily Pad Pond map. Each land use cutout must be placed very carefully after much consideration. Students should discuss and list the pros and cons of locating each cutout in a specific place. They are responsible for arranging the pattern of land use around the lake. They should discuss with each other many factors, such as: wildlife habitat, runoff, what this positioning will do to areas downstream, pollution and waste, convenience to humans, and economics.

3. Each cutout must be used, they may not overlap, and they may not be cut smaller. There is no right or wrong location. The students need to be aware that they are responsible for the health of this lake. Choices may be very difficult. Compromises may be necessary. In the end, everyone should agree. Solutions to the problems, such as the recycling of petroleum wastes, should be resolved.
4. *Use masking tape, so that the cutouts may be repositioned, if needed.*
5. After the cutouts are in place, the donated parcel of land will be the next land use with which the students need to work. A very wealthy old Lakeville resident, Miss Kally, recently passed away and left the town of Lakeville a large parcel of land. Having no family, Miss Kally's only request was that the land be used to serve the best interests of Lakeville. This land is at the east end of Lily Pad Lake and has a wetland plus several acres of higher ground. Needless to say, there are many groups within Lakeville that are interested in the land - *and* how and if it will be developed.
6. These groups include:
    - Lily Pad Lake Recreation Association – This group is made up of citizens whose livelihood is tied to recreation, mostly through tourist trade. They propose that the city keep the land and build a boat launch, fishing pier, and park area at the east end of the property. Their plan includes a small kiddy park, play field, and parking lot for about 25 cars. They would build a bathroom/barbecue kitchen facility.
    - Lakeville Economic Development Council – This is a new group that would like to provide more local jobs for the citizens of Lakeville. They have located a buyer who would purchase Miss Kally's property for 1.5 million dollars. The buyer plans to build a fisherman's resort on the property. This would entail channeling the small stream and filling the marsh to the channel's edge. This placement would allow fishermen to fish right off the back porch of the resort, which would overhang the water. There would be a parking lot for 40 cars, a service building with laundry facilities, and a kitchen/dining area for up to 50 people.
    - Friends of a Feather – This is a nationally recognized group with an active local chapter. They purchased the north marsh several years ago and left the land protected as a waterfowl habitat. The national organization offered the local chapter a grant that would purchase the land for wildlife protection for $500,000. The parcel would be annexed to the north parcel and provide nearly twice the habitat in one continuous piece.
    - Department of Wildlife – The state agency feels that it would be in everyone's best interest to hold the land for the future and only open it for duck hunting during hunting season. They have offered to provide port-a-potties and personnel to regulate hunting. They also propose 10 camping sites with fire pits at the south end and a dirt road for access. They would charge a small users' fee to offset expenses.
    - Lakeville Business Association – This organization includes most of the business and shop owners in Lakeville. They would like the city to sell the southern portion of the land for housing. They propose that the land be

divided into 1/2-acre lots and that utilities be brought into the area. The lots would each have their own septic system, since Lakeville has no sewage treatment facility. They feel the increase in population would provide their businesses with more year-round customers and would stabilize the local economy.

- Department of Social Services – This state agency is willing to purchase the parcel of land for $750,000 to build a children's orphanage. Not only would this provide jobs for many of the people in Lakeville but also it would bring families into the town waiting to adopt children. They propose a large housing facility with kitchen/dining/laundry facilities and playground outdoors. A parking lot would be built for 20 cars. They would have their own septic system. .This would be built on the south side of the property, so that the wetlands would not be disturbed.
- Caring Clinic – This group of local doctor's is interested in the city donating the land to set up a small clinic on the south end for the locals. There is no doctor or dentist in town and the town's residents need to go into the nearby city for any kind of medical emergency. After a head-on car collision last year, in which 2 people died before they could get medical attention, the citizens of Lakeville have been discussing the idea of a clinic with great interest. The clinic would have a 24-hour emergency staff and a small parking lot for 10 cars.
- Lakeville Department of Education - The Department of Education proposes building an elementary school on the southwest portion of the land. There would be a small school building, Kally Elementary, with a parking lot for 15 teachers' cars, a driveway for student pick-up and drop-off, and a small playground. This new school would allow the youngest children to no longer be bused. The DOE states the wetland would remain intact with little impact from the school and that the students could start an Adopt-A-Wetland Program starting with their own wetland. The students, educated in conserving wetlands, could go home to educate their parents.

7. With the students acting as a planning committee for the City of Lakeville, they must take all of these proposals and discuss the difficulties and attributes of each plan. The students will not be voting on the plan they like the best. They need to discuss all the plans and come to a *consensus* of opinion. Consensus provides for open discussion and generates more creative solutions.
8. Firm ground rules, including common courtesy and respect, need to be established before the discussions open. No name calling, no interrupting, and each planning committee member must be allowed to speak, if they wish, and be listened to by all the other members.
9. When a solution seems to be reached, have the students write it down. All students must state that they are in consensus with the solution. This means that even though they may not fully agree with the decision, they agree to support the decision. Although this may not give all groups their preferred outcome, it will lead to an outcome that all will support. Consensus takes more time than simply voting, but the outcome is usually worth it.

Questions and Observations:

1. Look at the various land uses in this activity. How might each minimize its negative impact to the area? (Answers will vary.)
2. What can you do to minimize the effects of your individual activities on the local streams and wetlands? (Answers will vary.)
3. After seeing the other groups building plans for land use around Lily Pad Lake, would you change how you developed the area or keep it the same? (Answers will vary.)

Extensions:

- Have the students discuss and list things that they can do to reduce the potentially damaging effects of their own lifestyle on their downstream habitats.
- Trace a stream or river from your community to the sea. Locate potential problem sites along this stream. Have the students suggest how to increase the quality of these locations.
- Hold a debate on wetlands. Should they be protected? How? To what extent?
- Learn how our government helps develop, control, and protect natural resources.
- Study how wetlands were used historically. Research the Swamp Acts of 1849, 1850, and 1860, which encouraged the conversion of wetlands.
- Have students attend a planning commission meeting in their community.
- Write letters to lawmakers and organizations that could protect wetlands.

Glossary

- Anaerobic bacteria – Bacteria living, active, or occurring in the absence of oxygen.
- Carnivorous bog plants – Wetlands plants that have the ability to attract small insects or animals which they consume.
- Consensus – General agreement of opinion
- Ecosystem - An ecological community
- Erosion – A washing or wearing away of the Earth's surface
- Flood – A great volume of water overflowing land, a deluge
- Ground water – Water that lies beneath the land surface and in the pore spaces of the rock and sedimentary material; also called percolating water.
- Hydrology – The study of the behavior/movement of water in the atmosphere, earth's surface and underground.
- Peat – Partially carbonized vegetable matter (mosses) that is found in bogs and peatlands; can be used as fuel and fertilizer.
- Photosynthesis – The process by which green plants and some other organisms synthesize carbohydrates from carbon dioxide and water using light as an energy source, usually releasing oxygen as a byproduct.

- Surface water – Water on or above the surface of the land, including lakes, rivers, steams, ponds, flood water, and runoff.
- Topography – The relief features of a land area

Resources

Literature:

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National Research Council, Wetlands Characteristics and Boundaries, National Academy Press, 1995.

Hammer. Donald A. Creating Freshwater Wetlands, Lewis Publishers, 1992.

Global Wetlands Old World and New, edited by William J. Mitsch, Elsevier Publishers, 1994.

Mitsch, W.J., And J. G. Gosselink, Wetlands, Van Nostrand Rheinhold, 2000.

Wow! The Wonders of Wetlands An Educator's Guide, a Partnership between Environmental Concern Inc. and The Watercourse, 1995.

Horn, Prof. Henry, Tour Guide to the Institute Woods, Dept. of Ecology & Evolutionary Biology, Princeton University, 1996.

Websites:

http://www.epa.gov/OWOW/wetlands/science/readlist.html#anchor1063866 – Suggested reading list for children of various ages on wetlands topics

http://www.envirolink.org/EnviroLink_Library/Water – Resource for Environmental Information – great graphics

http://www.coloradoriparian.org – the Colorado Riparian Association

http://www.weather.com – The Weather Channel

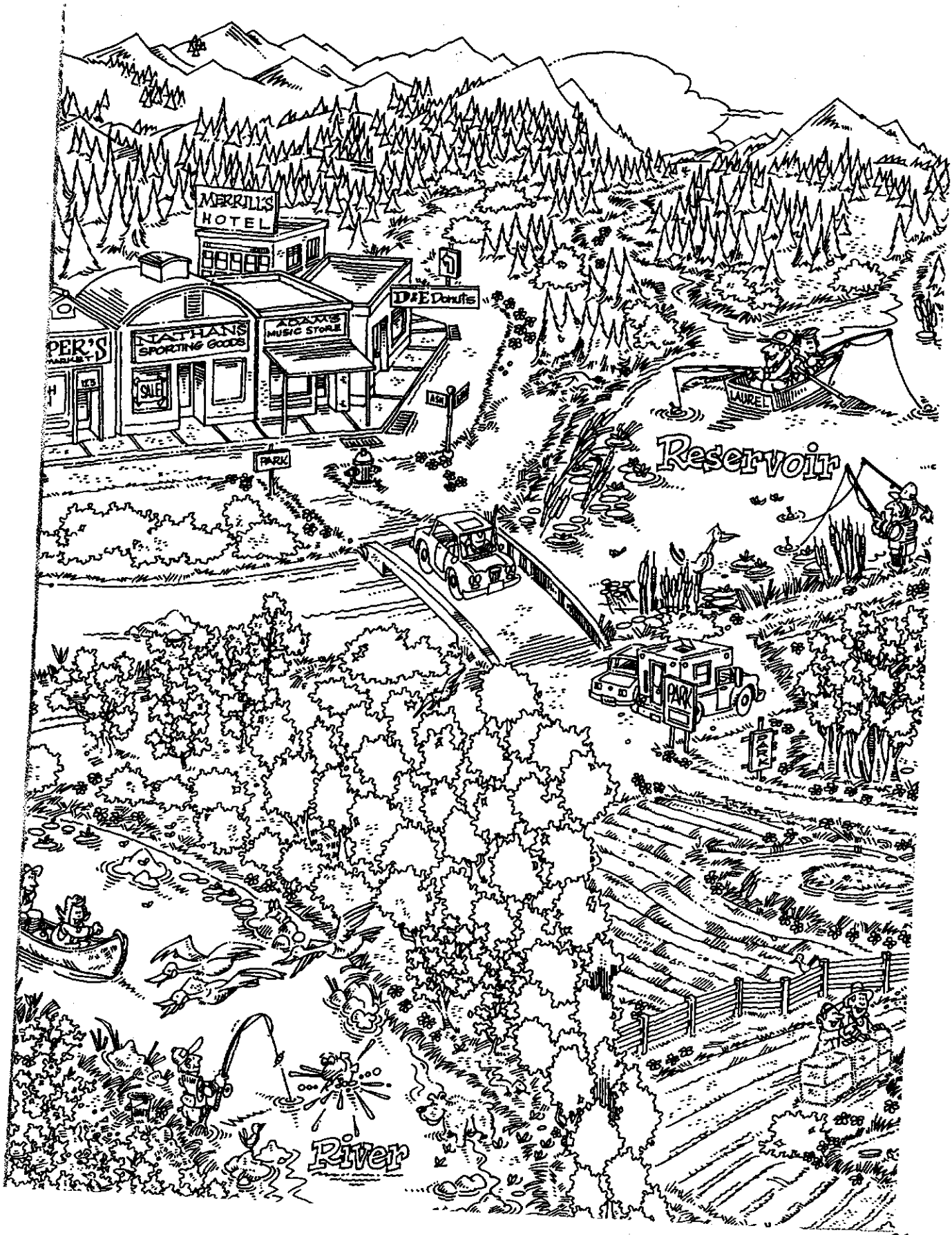
http://www.themouth.org/water.html – Facts about different types of wetlands

Appendix 1


KENAI KING
Estuary
Mangrove Swamp

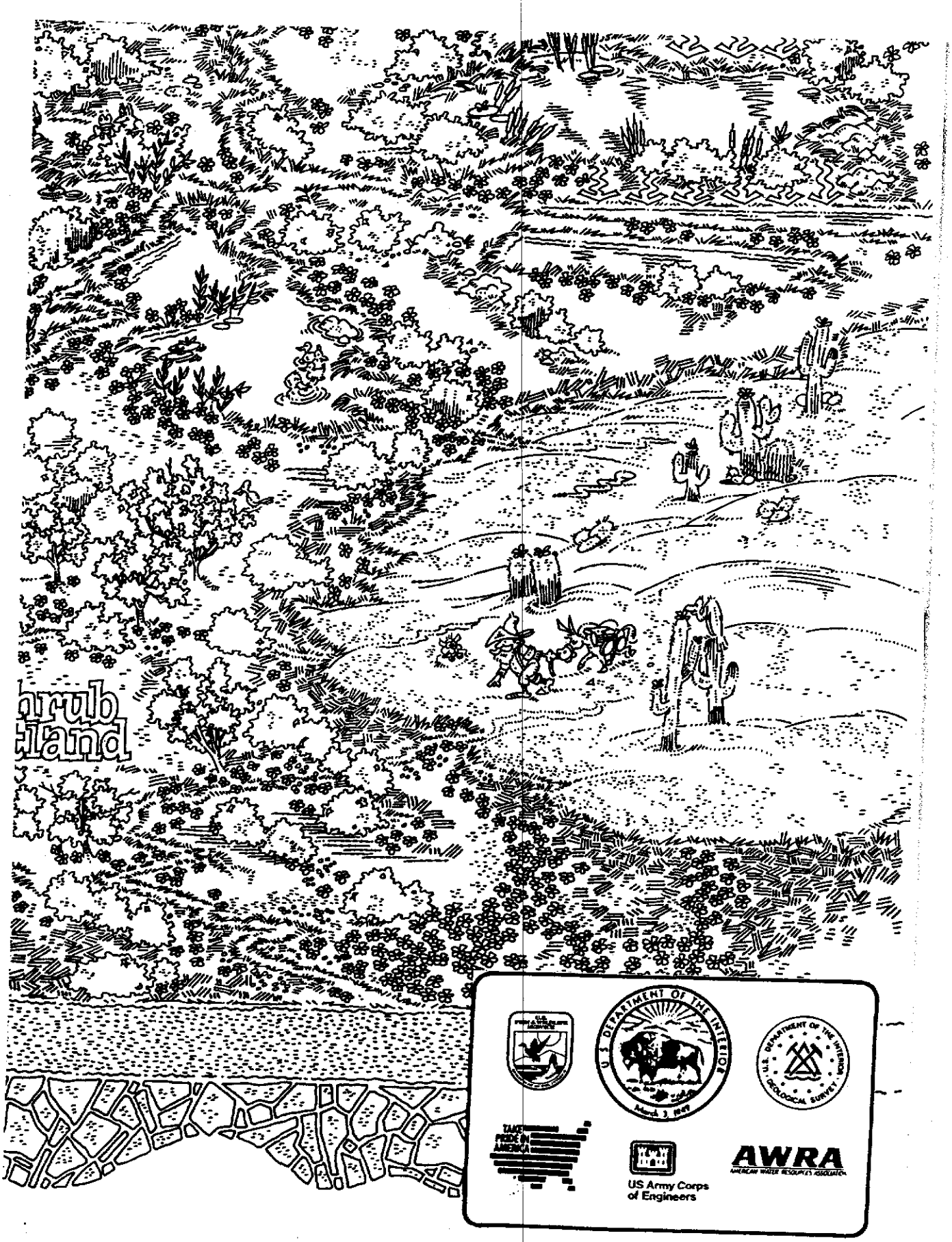

Life, Plants & People!
BEAVER WOOD POND
TRAIL
Lake
Forested Wetland
PIERS
DIVING


SARA'S
BOOK STORE
JAMIE'S
DANCE STUDIO
DANCE


MERRILL'S
HOTEL
D&E Donuts
NATHANS
SPORTING GOODS
ADAMS
MUSIC STORE
SALE
PARK
LAUREL
Reservoir
PARK
PARK
River


hrub
etland
Wet Meadow
Turner's
WILDLIFE
REFUGE
land
arsh
We
Aquifer


Forested
Wetland
TRAIL
TEMPORARILY
CLOSED
Macdonald's
FARM
Wet Meadow


hrub
tland
US Army Corps
of Engineers
AWRA

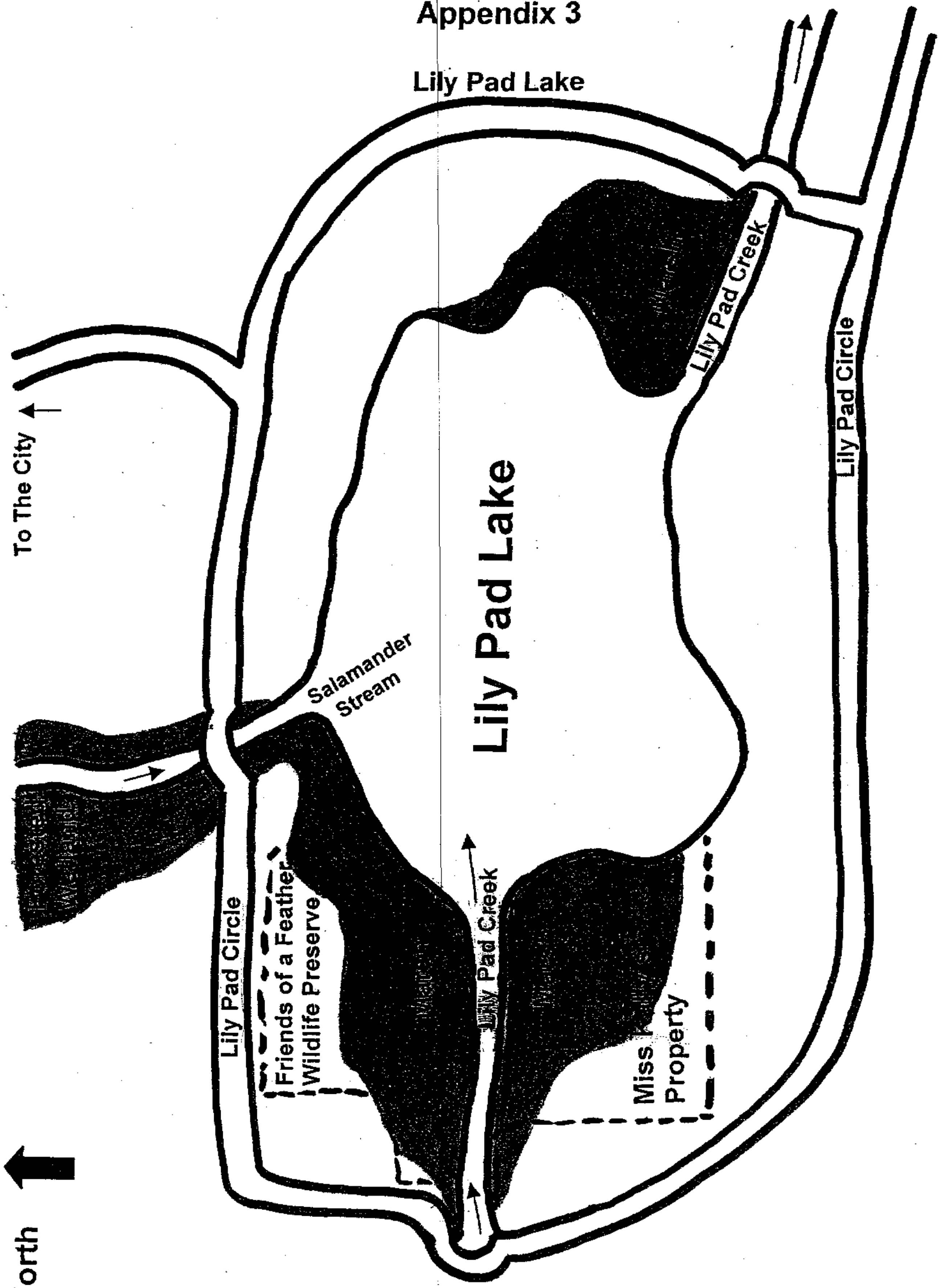
Appendix 2

Data Sheet for Wetlands Runoff and Flooding

With wetland in place: 200 ml water	**Amount of water left:**	**Observations:**
Without wetland: 200 ml water	**Amount of water left:**	**Observations:**
With wetland in place: Soil added	**Clarity of water:**	**Observations:**
Without wetland: Soil added	**Clarity of water:**	**Observations:**

Appendix 3

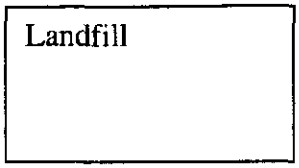
Lily Pad Lake



Appendix 4

Land Use Cut Outs

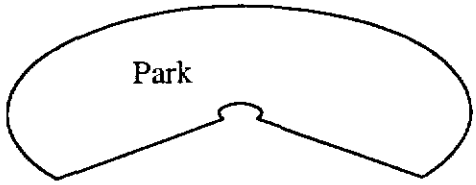
Landfill



Dry Cleaners
"DC "

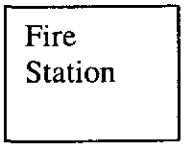
Grocery/Hardware

Park



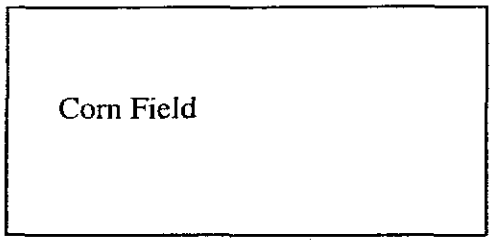
Gas Station/Sporting Goods

Fire Station

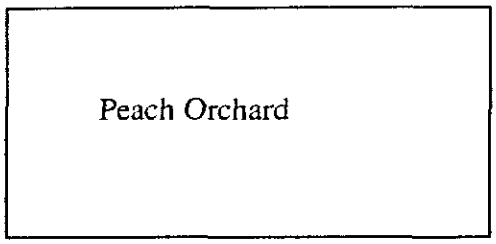


Restaurant

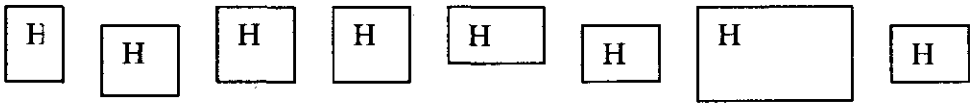
Corn Field



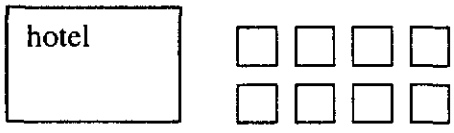
Peach Orchard



Homes: "H"



Hotel and Cabins:



Boat landing and Dock

Appendix 5

Pros and Cons for the Land Use Cut Outs

Land Use:	Pros:	Cons:
Landfill		
Dry cleaners		
Grocery/Hardware		
Park		
Gas Station/ Sporting Goods		
Fire Station		
Restaurant		
Corn field		
Peach Orchard		
Homes		
Hotels and Cabins		
Boat Landing and Dock		

Hydrology Assessment

Multiple Choice:

1. Wetlands act as: (1point)
    a. Habitat for birds and mammals
    b. Nurseries for fish
    c. Buffers from hurricanes
    d. All of the above

2. Some of the animals that can be found in a wetland are: (1 pt.)
    a. River otter
    b. Mussel
    c. Scorpion
    d. Eagle

3. Mangrove swamps are: (1 pt.)
    a. Forested
    b. Found in Florida
    c. Found in estuaries
    d. Have many types of animals dependent upon them

4. An estuary is: (1 pt.)
    a. Fresh water
    b. Salt water
    c. A place where fresh and salt water meet
    d. Mountainous

5. Colorado has: (1pt.)
    a. Mangrove swamps
    b. Prairie potholes
    c. Wet meadows
    d. Riparian wetlands

6. Wetlands have: (1 pt.)
    a. Little value
    b. Many values
    c. Are disappearing in the united States
    d. Help to recharge groundwater

7. Ecosystems are: (1 pt.)
    a. A delicate balance of plants, animals and habitat
    b. A good spot to build a city
    c. A community
    d. None of the above

Short Answer:

8. Hydrology can be described as: (2 pts.)
9. List and describe five functions of wetlands. (2 pts.)
10. How do wetlands act as a sponge? (2 pts.)

Performance Task:

Using the information gained in this workshop, design a wetland habitat for an animal that you will create. What kind of food, water, shelter, and space does this animal need? Will it be a permanent resident of the wetland or will it move in and out? Why? What are five adaptations that your animal has to allow it to live in this habitat? Give your animal a name, both common and scientific, that would help to describe the animal and its habitat. Share this animal with the class.

Hydrophytic Plants

Background Information:
Hydrophytic vegetation is defined herein as the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present. Definition by US Army Corps of Engineers

Wetland habitats, ecosystems unlike any other, are home to many unique species of plants, called hydrophytes. *Hydro* means water and *phyte* means plant, so these plants are water plants. Wetland plants are uniquely adapted for life submerged in or floating on water. (Plants that live totally underwater are labeled submerged aquatic vegetation.) Hydrophytes have evolved ways to obtain oxygen in waterlogged soils, to reproduce underwater, to rid themselves of excess salt, and to adapt to changing water levels. Many factors such as: light, temperature, soil texture, permeability, and man-induced disturbance influence where and which hydrophytic plants grow in which wetland.

All plants need sunlight, oxygen, and a way to reproduce. Hydophytes are atypical in that the soil they grow in is saturated (the spaces between the soil particles are filled with water). The soils where upland plants reside are well aerated or oxygen is present in the spaces between soil particles. Because wetland plants live in anaerobic conditions without oxygen, they must develop ways to bring oxygen into their cells. There are many ways that these plants may adapt to living and surviving with their roots in anaerobic conditions. Some of these adaptations include:

- Aerenchyma – the primary adaptation that wetland plants use. Air spaces in roots and stems that allow the transport of oxygen.
- Leaves that float in shallow water, some may have air bladders
- Knobby "knees," a part of the roots, that jut up above the waterline
- Buttressed trunks that are swollen above the high water line to help anchor the plant
- Pneumatophores - shallow or exposed roots that pick up oxygen from the surface (snorkel roots)
- Plants that float on the surface of the water
- Spongy stems

Although plants give off oxygen through the process of photosynthesis, they also require oxygen to respire. In photosynthesis, plants use energy from the sun, carbon dioxide, and water to create oxygen, sugar, and water. Roots need a source of oxygen, whether it comes from air in the surrounding soil or in some type of wetland plant adaptation for respiration.

To help identify wetland plant species, the U.S. Fish and Wildlife Service has created a list ranking each species on a five-category basis. Because different species of plants may occupy different ecological habitats in throughout the country, these lists are regionalized. Some plants are found only in wetlands, some will be found in wetlands and "uplands" and some found only in uplands. They are classified by the categories listed below:

- Obligate Wetland – 99% or greater of the individuals of a species occur in wetlands. Examples may include:
  watercress, buttercup, water lily, duckweed, cattails, bulrushes, American Three Square
- Facultative Wetland – 66-99% of the individuals of a species occur in wetlands. Examples may include:
  tufted hairgrass, horsetail, common reed, alder, dogwood
- Facultative – 33-66% of the individuals of a species occur in wetlands. Examples may include:
  box elder, some types of rushes
- Facultative Upland – 1-33% of the individuals of a species occur in wetlands. Examples may include:
  greasewood, western hemlock
- Upland – Less than 1% of the individuals of a species occur in wetland. Examples may include:
  cactus, yucca

If a site that is being studied or observed is dominated by species of vegetation that are ranked as wetland or facultative wetland, is flooded for at least part of the growing season, and has hydric soil, it is a good indication that the site may be considered a wetland. The presence of scattered individuals of an upland plant species in a community dominated by hydrophytic species is not a sufficient basis for concluding that the area is an upland community. Likewise, the presence of a few individuals of a hydrophytic species in a community dominated by upland species is not a sufficient basis for concluding that the area has hydrophytic vegetation and is therefore a wetland.

Activity 1: Cattail Dissection

Background Information:

Adapted from WOW! The Wonders of Wetlands, Wetland Weirdos Activity.

Plants develop special characteristics to help them adapt to the unusual conditions that they must survive in when living in wetlands. Special characteristics develop over time when attempting to survive in unique situations. Only the fittest will survive in each ecosystem. All the *adaptations* work together to enable the plants to bring in nutrients, oxygen, water, and sunlight; the basic needs for survival. Although hydrophytic plants may be submerged in water for all or part of the year, by the end of the summer, they could be living in arid conditions due to the evaporation of that water. They may have to adapt to living

in *brackish* water, water that is somewhere between fresh water and salt water. They may have to adapt to flooding or swiftly moving streams that tug and pull at their root structures. They may have to adapt to living in acidic conditions or catching insects for nutrients.

Wetland plants are some of the most diverse and interesting flora in the plant kingdom. One of the most common of the hydrophytic flora is the cattail. It is often seen in ditches along roadsides, along running streams, and at the edges of ponds. Cattails are *emergent* plants. They have submerged roots while the stems and leaves grow up out of the water. The brown "hot dog" shaped flower structure is a common sight in the late spring and summer. This is the female flower, while in spring and early summer a smaller, thinner structure will be found above it. This is the male flowering structure. Although it is edged with brown, if the flower is pulled apart, thousands of white fluffy particles will emerge. The particles are actually ovaries and are very lightweight so they can be dispersed by the wind. If these ovaries are pollinated, they will become fertilized seeds with a bulb at the tip. Cattails not only reproduce by these fertilized seeds which will *germinate* or grow, but also by *rhizomes*. Rhizomes are traveling roots that grow horizontally underground, forming new plants. The new plants are genetically identical to the parent plant. Typically plants reproduce by rhizomes when under stress. Wetland environments put stress on plants because there is so little oxygen in the soil. Rhizomes aid in asexual reproduction of the cattail, while the germinated seed is an example of sexual reproduction.

Because the roots are submerged in the wetland, the cattail has developed long thin tubes within its stem structure to transport oxygen to the root system. These long thin leaves overlap like a celery or leek plant at the soil level forming a bulbous-like structure. This bulb at the plant's base is edible and tastes like cucumber. The plant's *vascular tissue* system (transport system) is found within the leaves. There are two parts to the vascular system in a leaf: *xylem* and *phloem*. These tubes are supported by woody tissue to allow the xylem to transport water and the phloem to transport food. If a cross section is cut in the cattail's leaf, a honeycomb looking woody structure can be seen that supports the xylem and phloem tubes.

The stem that braces the flower of the cattail also has tubes inside. These tubes transport water and oxygen and are called *aerenchyma*. The oxygen is transported to the roots because they are in anaerobic conditions. These can also be found in other emergent wetland flora, such as: bulrushes and horsetails. Sometimes wetland plants will have the aerenchyma on the underside of the leaves. These enable leaves to float, such as duckweed and water lilies.

Concepts:

- Wetland plants have adapted to survive in anaerobic soil conditions.
- Emergent plants have roots that are submerged in water.

- Cattails are emergent plants that have oxygen transporting tubes in their stems called aerenchyma.
- Cattails have food and water transporting tubes, xylem and phloem, in their leaves.
- Cattails can reproduce sexually with seeds or asexually with rhizomes.

Student Objectives:

1. The students will examine the stems and leaves of cattails and horsetails.
2. The students will recognize that wetland plants adapt to their habitat with unique physical structures, often not found in upland plants.
3. The students will draw and label a cross section of a cattail leaf.

Materials:

- Hand lenses
- Student microscopes
- Cattails – leaves and flowers
- Horsetail stems
- Plastic Ziploc® bags
- Water
- Paper towels

Vocabulary:

Adaptations, aerenchyma, arid, brackish, emergent, germinate, phloem, rhizomes, vascular tissue, xylem

Procedure:

1. Carefully collect, with permission, some horsetail and cattail stems, leaves, and flower structure.
2. Have the students examine each part of the plants. Have them draw in their journal or on a piece of paper what the entire plant looks like and label the parts that they will be looking at under the hand lens or microscope.
3. Cut the leaf across and examine the cut edge under a microscope or with the hand lens.
4. If the shoot is available, cut a cross section of that and allow the students to taste it.
5. Cut a cross section piece of the stem and look at it with a hand lens and under the microscope.
6. Pull some of the fuzz apart from the flowering structure (the brown, hot dog shaped part of the stem). Look at that under the microscope.
7. If there are fertilized seeds present, put a few of them in a plastic Ziploc® bag with a wet paper towel. In about three weeks, the seeds should germinate.

Questions and Observations:

1. Are both sides of a cattail leaf the same? (No, one side is concave and one is convex.)

2. Is the leaf flat or does it have some thickness? (It is thick because of the tubes and their supporting structure inside it.)
3. *Describe the taste of the base of the stem, the shoot, if available.* (Cucumber-like)
4. What is the white spongy stuff inside the leaves and what is its purpose? (Supporting structures, made of starchy material. This supports the tubes that carry food and water throughout the plant.)
5. What is inside the stem that supports the flowering structure? (Pithy material that supports the tubes that transport oxygen to the plant.)
6. When the flowering structure was pulled apart, were all the ovaries the same? (Answers will vary, but if the seed was pollinated, it will be a bulb at the tip of the fuzzy material.)
7. Why would the cattail have so many fruits or pollinated seeds? (Survival of the fittest, this allows for some of the seeds to germinate and grow.)
8. How might the cattail seeds be pollinated? (Answers will vary: wind, bees, birds.)

Classroom Extensions:

- Discover what adaptations the animals that inhabit wetlands may have.
- Look at other wetland plants and observe the inner structures of their leaves and stems.

Activity 2: Wetlands Plant Identification Wheel

Background Information:

Wetland plants have to adapt to some fairly unusual habitats. They may have to live in very acidic conditions, such as a peat bog, be rooted in the bottom of a pond with long stems allowing the leaves to reach the water's surface for sunlight and oxygen, or have to catch insects for food to survive.

The types of plants and soil in the area and the presence of water are identifying factors of a wetland. If all the plants are removed by construction, the soils and presence of water may still indicate that it is a wetland. Some plants, like cattails and water lilies, may be synonymous with wetlands, but others may be wetland plants in some areas of the country, while they are upland plants in other areas. Learning to identify the wetland plants in your area may not only be fun but important in identifying whether an area is actually a wetland. Classifying a plant as a wetland plant may be done with the use of a *dichotomous key*, a plant identification field guide, or with the wheel constructed in the following activity. In many regions, the appearances of wetland plants may change throughout the year. In the winter, many plants die back, loose their leaves or die off. *Deciduous* trees (i.e. cottonwood or willow) loose their leaves in the winter whereas *evergreen* (i.e. pine trees) keep their leaves all year long, loosing some at various times of the year but not all at once. In spring, the plants may be just emerging from the soil or growing leaves again. In summer, flowers may appear,

which will give way to fruits, and may give the plant yet another totally different appearance.

Many factors aid in identifying wetland plants:

- Presence of flowers
- Presence of fruits
- The type of stem - woody or herbaceous
- Arrangement of leaves – opposite, alternate, or whorled
- Structure of leaves - simple or compound leaves. Compound leaves may be palmate or pinnate
- The shape of the leaf – round, oval, or lance-like
- The type of leaf edge – toothed, smooth, hairy, lobed

The presence of flower and fruits may only happen at certain times of the year and make identification through them alone very difficult. The stems and leaves, if present, are surer ways to distinguish the plant. How the leaves are arranged on the stems may help to catalog the plant. Leaves may be *opposite* where each leaf is positioned directly across the stem from another leaf. They may be *alternate*, where each leaf grows on opposite sides of the stem but at different elevations along the stem. The leaves may grow in a *whorled* pattern, where many leaves grow out of the same place on a stem, like spokes on a bicycle. Leaves may grow in a singular pattern (simple) or a grouped pattern (compound). If they are compound, they may be classified either as *palmate* (shaped like the palm of a hand) or *pinnate* (shaped like a feather).

The shape of a leaf may also be a distinguishing factor in classifying a plant. The leaves may be round, oval or shaped like a spear, lance-like. The edges of the leaves may be *entire* (smooth), hairy, toothed (jagged) or lobed (wavy). The color of leaves may also be used as an identifying feature (green, gray-green, or reddish), but the color may also change during the year.

Concepts:

- Wetland plants adapt to the hydrology and soils in a wetland.
- Leaves, fruits and flowers may emerge at different times of the year and a plant's appearance may change dramatically throughout the year.
- Plant identification may be done with a dichotomous key, field manuals, or a plant identification wheel.
- Wetland plants may be upland plants in different regions of the country.

Student Objectives:

1. The students will utilize a dichotomous key to identify wetland plants.
2. The students will construct a plant identification wheel to identify wetland plants.
3. The students will be able to describe the differences between submerged aquatic plants and emergent plants.

4. The students will be able to describe the differences between trees and shrubs.

Materials:
- Copies of the wetland plant identification wheel (See Appendix 1)
- Dichotomous key (See Appendix 2) Adapted from "WOW! The Wonders of Wetlands", This Plant Key is all Wet Activity.
- Scissors
- Brads (paper fasteners)
- Clear contact paper, if laminating the wheel
- Samples of wetland flora – either preserved or freshly collected (if freshly collected, ask permission first and take only as little as necessary)

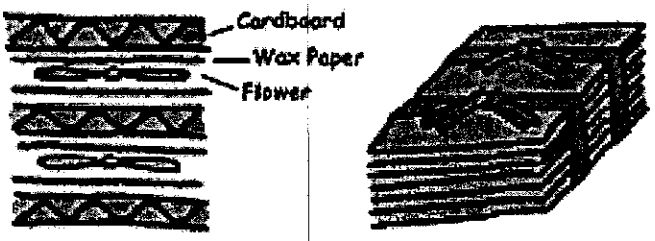
Vocabulary:
Alternate, deciduous, dichotomous key, entire, evergreen, opposite, palmate, pinnate, whorled

Procedure:
1. Cut out the two pieces of the wheel and the wheel holder.
2. Punch a hole in the center of the three pieces, as indicated on the pattern with a pen or pencil.
3. Place the wheel pieces back to back and wrap the holder around them. Fasten them together with the brad. The wheel should spin freely inside the holder.
4. Along with the wheel, use the dichotomous key to identify plant samples.
5. Divide the students in half and give one half a dichotomous key to work with and the other the plant identification wheel.
6. Give each group of students one half of the plant samples.
7. Have each group of students identify the samples and then switch with the other group to identify the other half of the samples.
8. Have the students compare their results.

Questions and Observations:
1. What is the difference between a tree and a shrub? (A tree has a single main stem and stands tall, 20 feet or more when mature. A shrub has multiple stems and is much shorter.)
2. What is the difference between an emergent plant and a submerged aquatic plant? (An emergent plant roots are in wet soil or soil that has been wet, with the stems and leaves growing out of the water. A submerged aquatic plant has its roots, stems and leaves submerged - or at least the stems and roots, while the leaves may float on top of the water.)
3. Was your identification of the samples the same as the other group? (Answers will vary.)

Classroom Extensions:
- Collect species of plants from other local ecosystems (other than wetlands) and identify them. Make a dichotomous key for them.

- Collect other wetland species of plants and make an identification key for them.
- Make your own flower press to collect a preserve samples of wetland flora.



Materials:

- 3 sheets of corrugated cardboard
- Craft knife
- Scissors
- Ribbon
- Wax paper
- Plant specimens

Procedure:

1. Cut three 7 inch by 10 inch rectangles out of cardboard. Use your craft knife, if this is too difficult to do with scissors.
2. Cut four 7 inch by 10 inch rectangles out of wax paper.
3. Layer the cardboard, flowers, and wax paper as shown in the diagram above. Since the flowers are between the pieces of wax paper, they will be protected while they are pressed.
4. Cut two pieces of ribbon long enough to tie around your flower press, and tie it down tightly.
5. Allow the flowers to press for a day or so
6. Unwrap the flower press to reveal the results! Remove these flowers, and then press some more.

Tip:

For more layers, just cut more cardboard and wax paper, and make the ribbon longer to fit over the taller flower press.

Activity 3: Create-A-Plant

Background Information:

Adapted from the EPA's "Washington's Wetlands Pamphlet".

Wetland plants are unusual. These hydrophytes (water loving plants) are uniquely adapted for living in their habitat whether that is a freshwater marsh, swamp, stream or *estuary*. They have evolved ways to obtain oxygen in water-logged soils, to reproduce underwater, to rid themselves of excess salt, to adapt

to changing water levels, or to attract insects for food where no other food is available, thus enabling them to survive in habitats where other plants cannot.

Looking at the form and life cycle of a plant tells us a lot about how it is adapted for survival. Natural selection, or "survival of the fittest," is the theory that those organisms best suited for survival live to reproduce and pass on those genes. Adaptations that enable an organism to survive in its habitat are fascinating to study.

One of the largest challenges to a wetland plant's survival is its ability to get air. Leaves, stems or any other green, photosynthetic organs need to take in carbon dioxide, and release oxygen gas. When light is unavailable or it is too cold to photosynthesize they must also take in oxygen, since they cannot produce it without light. Roots always need a source of oxygen. Plants that live in well-aerated, upland soils get air directly from the atmosphere and through the soil. Wetland plants must have adaptations to aid in gas exchange, such as air roots, *buttress roots*, spongy stems, and other air-filled tissues.

Concepts:
- Hydrophytic plants are water loving plants.
- Wetland plants must be able to get oxygen even though they are rooted in anaerobic soil.
- Only the hardiest of the plants will survive to breed and produce seeds for the next season.

Student Objectives:
1. The students will create a wetland plant for a specific habitat.
2. The students will be able to demonstrate their understanding of wetland plant adaptations by describing their plant to the other students.

Materials:
- Art and/or recycled materials, such as: Styrofoam, Popsicle sticks, toothpicks, pipe cleaners, foil, yarn, toilet paper tubes, egg cartons, paper cups, clay
- Plant Adaptation Chart (See Appendix 3)

Vocabulary:
Buttress roots, estuary

Procedure:
1. Discuss what kinds of adaptations a plant would need to survive in a wetland. How could it manage to stay upright in soggy soil? How could it get oxygen to its roots? If it grows in salty water, how could it get rid of the salt in the water? How could it survive the constant influx and outflow of tidal waters? How could it disperse its seeds? How could it obtain nutrients if the soil is nutrient-poor?

2. Divide class into 7 or 8 groups. Pass a habitat card to each group. Make Habitat cards from the topics below:
    - The plant lives submerged in a pond.
    - The plant lives along a swiftly moving stream.
    - The plant lives in an estuary.
    - The plant lives along the edge of a freshwater marsh.
    - The plant lives in a bog and must capture insects for nutrients.
    - The plant floats on the surface of a pond.
    - The plant lives at the shore next to the ocean.
    - The plant lives in an area that has water in the winter and spring, but the ground dries out completely by summer.
3. Provide art materials for the students to create their plants.
4. Have the students share their "plants", scientific names, and common names with the rest of the groups.

Questions and Observations:

1. What are the special adaptations that each plant has to survive in its environment? (Answers will vary.)
2. Was the plant created an obligate wetland plant, a facultative-wetland plant, a facultative plant, a facultative–upland plant, or an upland plant? (Answers will vary.)

Classroom Extensions;

- Have students list types of real plants that may be found in each Habitat card category.
- Have students write a story about their plant and its habitat.

Glossary

- Adaptations - Adjustments to environmental conditions; modifications of an organism or its parts that make it more fit for existence.
- Aerenchyma – Air (pore) spaces in plant roots and stems which allow the diffusion of oxygen from aerial portions to the roots.
- Alternate - Leaves that grow on different sides of the stems from each other at alternate elevations along the stem.
- Arid – Dry, lacking water, desert-like
- Brackish – Containing a mix of fresh and salt water
- Buttress roots – Tree trunks that are swollen above the high water line.
- Deciduous – A plant that looses its leaves in the winter.
- Dichotomous key – An index for the identification of organisms based on a series of choices between alternate characteristics.
- Emergent – Rising above a surrounding medium, as in wetland plants protruding above the water level.

- Entire - When referring to the shape of leaf edges, entire means smooth.
- Estuary – The lower course of a river where the current is met by ocean tides. Waters fluctuate between nearly fresh and nearly salt water.
- Evergreen – A plant that keeps its leaves in the winter.
- Germinate - To begin to sprout or grow
- Opposite – Leaves that grow out of the same place on a stem, but on opposite sides of the stem.
- Palmate – An arrangement of leaflets that looks like the palm of a hand.
- Pinnate - An arrangement of leaflets that look like a feather.
- Phloem - Vascular tissue in a plant through which food is distributed.
- Rhizomes - Underground horizontal stems
- Vascular tissue – The supportive and conductive tissue in plants, supporting the xylem and phloem.
- Whorled – Many leaves that grow out of a stem at the same place, all the way around, like the spokes of a wheel.
- Xylem – The vascular or woody tissue through which water flows.

Resources

Literature:

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Reid, George K., Pond Life: A Golden Guide, Golden Press, 1967.

Slater, B.E., W.O.W.: The Wonders of Wetlands, an educator's guide, Environmental Concern, Inc., St. Michaels, MD 21663, 1991.

Wetlands and Wildlife, Alaska Wildlife Curriculum, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK 99802.

Websites:

http://www.epa.gov/owow/wetlands/education – EPA's wetland website

http://www.funology.com/boredombusters/bb018.cfm – Flower press directions

http://www.wetlands.com/coe/87manp3a.htm – US Army Corps of Engineers Wetlands Delineation Manual

http://www.wetland.org/kids/plants.htm – Identifies many wetland plants

http://www.nwi.fws.gov – U.S. fish and Wildlife Service – National Wetland Inventory

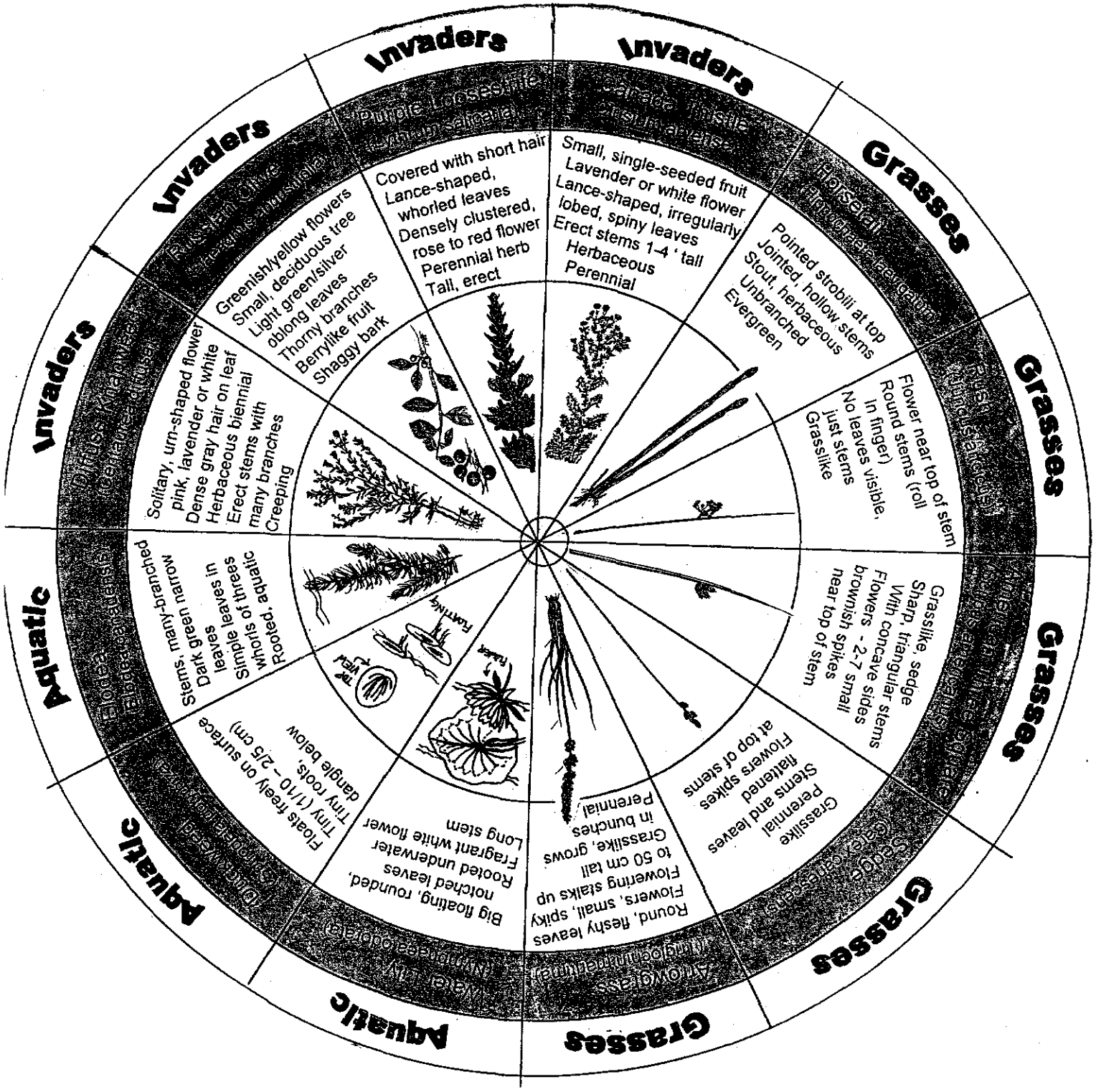
http://aswm.org – Association of State Wetland Managers

http://www.ucsusa.org = Union of Concerned Scientists

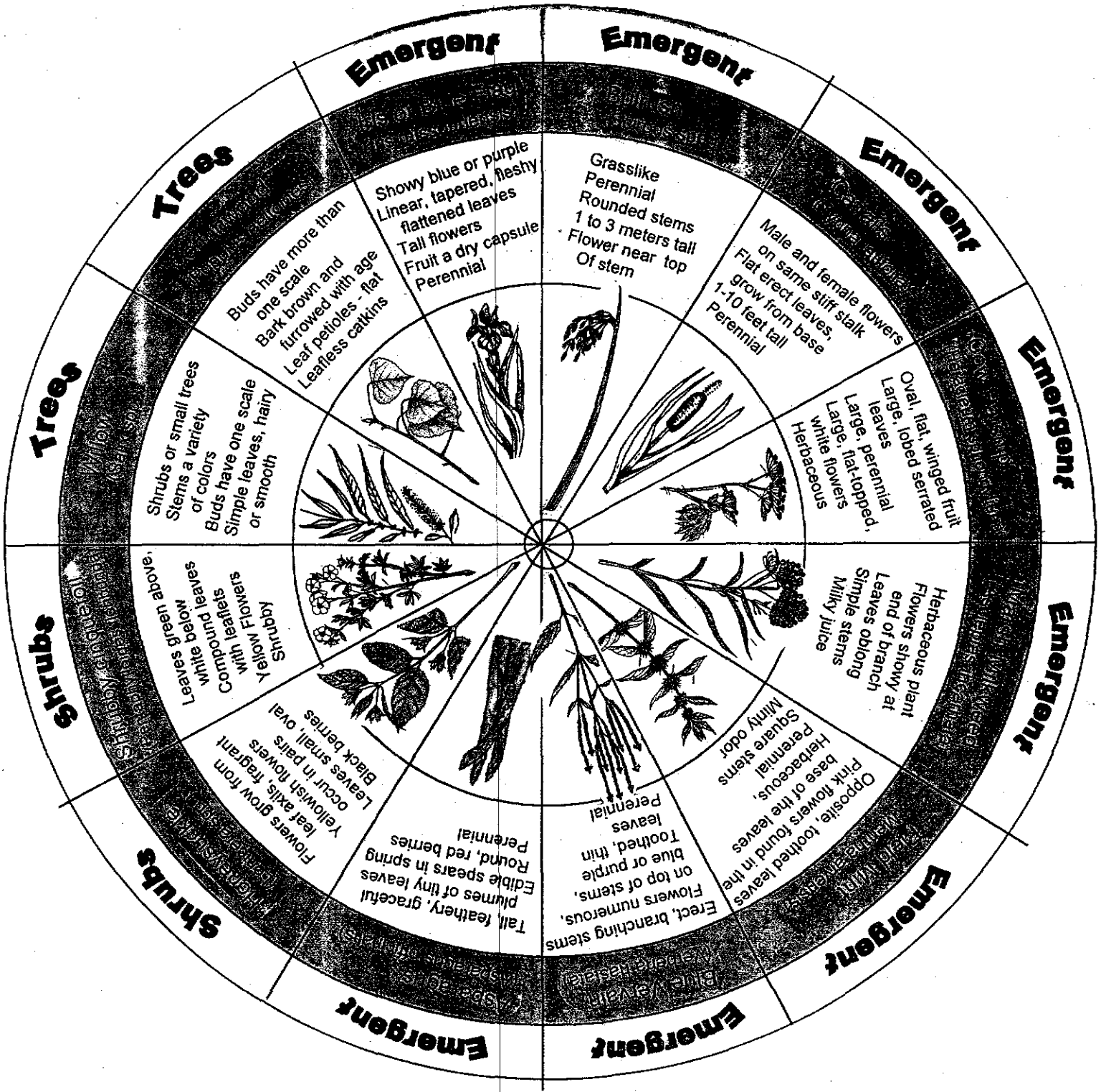
http://www.ucmp.berkeley.edu/glossary/gloss5/biome/wetlands/wetlandsgallery.htm – University of California Biome Website with wetland pictures, can be made into overheads and slides

EPA Wetlands Hotline:
1-800-832-7828, 9 a.m. – 5 p.m. (EST).

Appendix 1
Plant Identification Wheel



Appendix 1 cont.
Plant Identification Wheel



Remember to look closely at the leaves, flowers and stem arrangement of each plant.

Cut Line

What does it look like? >

Directions:

1. Find a wetland plant to identify.
2. Turn the wheel until you find a picture that looks like the plant.
3. Check the plant to make sure it is correctly identified.

Description of the plant. >

What is the scientific name? >

What is the common name? >

What type of plant is it? >

Cut out this wedge

Wetland Wheel

Fold Line

Wetland Wheel

What type of plant is it? >

Cut out this wedge

What is the common name? >

What is the scientific name? >

Description of the plant. >

What does it look like? >

Directions:

1. Find a wetland plant to identify.
2. Turn the wheel until you find a picture that looks like the plant.
3. Check the plant to make sure it is correctly identified.

Remember to look closely at the leaves, flowers and stem arrangement of each plant.

Cut Line

Appendix 2
Plant Classification Key

1. Does the plant have rigid, woody stems?
   a. Yes - go to 2.
   b. No - go to 9.

2. Is the plant 20 feet tall or taller?
   a. Yes – it is a **tree**, go to 3.
   b. No – go to 6.

3. Does this tree have white, smooth bark, cottony seeds, alternate leaves with toothed edges, and flattened petioles (leaf stalk) near the leaf that makes the leaf shake in the wind?
   a. Yes - it is a **Cottonwood**.
   b. No - go to 4.

4. Does this tree have simple, alternate, long, narrow, leaves, woody stems, and can grow with one trunk or many, like a shrub?
   a. Yes - it is a **Willow**, may also grow as a shrub in some wetlands (see 8 below).
   b. No – go to 5.

5. Does this tree have small, oval gray-green leaves on woody stems, branches with thorns and small, green, oval berries (olives)?
   a. Yes – it is a **Russian Olive**, and is an invasive species in Colorado.
   b. No – go back to 2.

6. Does the plant have many stems?
   a. Yes – it is a **shrub**, go to 7.
   b. No – it is a young tree, **sapling**.

7. Does the shrub have orange berries occurring in pairs or yellow flowers, small oval leaves, woody stems with multiple trunks?
   a. Yes – it is a **Honeysuckle**.
   b. No – go to 8.

8. Does the shrub have brown, shedding bark, compound leaves in groups of five, with yellow flowers, and multiple stems?
   a. Yes – it is a **Shrubby Cinquefoil**.
   b. No – go back to 8.

9. Does the plant have a soft stem, not rigid or woody?
   a. Yes – go to 10.
   b. No – start over at 1.

10. Is the plant growing under the water (submerged)?
    a. Yes – it is an **aquatic plant**, go to 11.
    b. No – go to 14.

11. Does the plant float freely on the surface with very small leaves, in groups of two, with roots dangling below?
    a. Yes – it is **Duckweed**.
    b. No – go to 12.

12. Does the plant have large, rounded, floating, notched leaves with white fragrant flowers on a long stem, with roots secured in the bottom of the lake, or pond, etc.?
    a. Yes – it is a **Water Lily**.
    b. No – go to 13.

13. Is the plant rooted in the bottom, with branching stems, many dark green, simple leaves in whorls of three?
    a. Yes – it is **Elodea**.
    b. No – go back to 10.

14. Is the plant growing with roots or part of the stem growing underwater, in wet spongy soil, or soil that appears to be wet at one time, with the rest of the plant growing above the water?
    a. Yes - it is an **emergent plant**, go to 15.
    b. No - go to 24.

15. Is the plant emerging with thick, edible stalks in spring? In summer, may be observed as feathery, tall (about one meter high), thinly branching stems with small, 1 cm long needle like leaves? In the fall, red berries will appear.
    a. Yes – it is **Asparagus**.
    b. No – go to 16.

16. Does the plant have erect branching stems, with numerous small, blue or purple flowers on the top of the stems, and thin, toothed leaves?
    a. Yes - it is **Blue Vervain**.
    b. No – go to 17.

17. Does the plant have opposite, toothed leaves, with small, pink flowers at the base of the leaves (in summer only), a minty smell, and square stems?
    a. Yes – it is **Mint**.
    b. No – go to 18.

18. Does the plant have showy, pink flowers at the end of the stem (in spring and early summer) or pods (in late summer), milky secretions, large, oval, opposite leaves?
    a. Yes – it is **Marsh Milkweed**.
    b. No – go to 19.

19. Does the plant have large, lobed, serrated leaves, with large flat–topped flowers followed by oval, flat, winged fruit?
    a. Yes – it is **Cow Parsnip**.
    b. No – go to 20.

20. Does the plant have long, thin, fleshy leaves that form at the base, brown flowering structures that look like hot dogs, and stands up to 3 meters high?
    a. Yes – it is a **Cattail**.
    b. No – go to 21.

21. Is the plant grass-like with long rounded stems, up to 2 meters tall with multiple brown flowers at the top of a stem?
    a. Yes – it is a **Bulrush**.
    b. No – go to 22.

22. Does the plant have linear, tapered, fleshy, flattened leaves about 1 meter long with showy blue or purple flowers on erect stems in the spring?
    a. Yes – it is an **Iris**.
    b. No – go to 23.

23. Is the plant tall and erect, with lance-shaped whorled leaves, that are densely clustered, and tall flower spikes that bloom in rose to red?
    a. Yes- it is **Purple Loosetrife** and is an invasive species!
    b. No – go to 24.

24. Is the plant grass-like?
    a. Yes – go to 25.
    b. No – go back to 1.

25. Is the plant grass-like, with flattened stems and leaves, and small brown flower spikes at the ends of the leaves?
    a. Yes – it is a **Sedge**.
    b. No – go to 26.

26. Does the plant have rounded, long, thin, fleshy, grass-like leaves, grow in clusters, and have long (up to 50 cm tall) flowering stalks, covered with small brown flowers?
    a. Yes – it is **Arrowgrass**.
    b. No – go to 27.

27. Is the plant grass-like, with sharp, triangular stems with concave sides and flowers that are 2-7 small brownish spikes part way up the stem?
    a. Yes – it is **American Three Square**.
    b. No – go to 28.

28. Is the plant grass-like, *round stems*, *no* visible leaves, with small brownish flowers attached near the top of the stem?
    a. Yes – it is **Rush**.
    b. No – go to 29.

29. Does the plant have long, pointed, jointed, hollow, unbranched stems or jointed whorled branches that emerge from the stem joints?
    a. Yes – it is **Horsetail**.
    b. No - go to 30.

30. Does the plant have lance-shaped, irregularly lobed, spiny, leaves, erect spiny stems (up to 1 1/2 meters high) with lavender or white flowers at the top of the stem?
    a. Yes – it is **Canada Thistle** and is an invasive species.
    b. No – go to 31.

31. Does the plant have a solitary, urn-shaped flower, either blue or white, erect stems with many branches (or in spring may be found as a rosette on the ground), dense, gray hair on small, lobed leaves?
    a. Yes – it is **Diverse Knapweed** and is an invasive species.
    b. No – go back to 1.

Appendix 3
Wetlands Plant Adaptations Chart

Adaptation:	Advantage:	Examples:
Submerged Plants:		
thin skin	absorb nutrients from water	milfoil, pondweed
flexible stems	will bend, not break	most wetland plants
finely cut leaves	increase surface area for absorbing sunlight to photo-synthesize	milfoil, elodea
Floating Plants:		
air bladders	floating (no roots)	water hyacinth
digestive juices	eat insects for nutrients	bladderwort
hanging roots	absorb nutrients	duckweed
Rooted Plants:		
large, floating leaves	reach sunlight to photosynthesize	lilies
stomata on leaf's upper surface	allow gas exchange	lilies
flowers smell	attract insects to pollinate	yellow water lily
Emergent Plants:		
spongy stem	transport gases	cattails
large breathing pores	exchange gases	willows
air filled roots	get gases from upper plant	willows
roots in air	get oxygen	mangroves
buttress roots	get oxygen	cypress
gas-transporting tissues	transport oxygen and carbon dioxide	cordgrass
rot-resistant wood	prevent decay	cedar, cypress
tall, narrow plants - with no branches, long leaves	reduce resistance to water, so leaves won't break in water	cattails, reeds, bulrushes, sedges, rushes
flowers small, up high	keep out of water	sedges, reeds, rushes
long, creeping rhizomes	anchor plant in soft soil	reeds, rushes, bulrushes
buds on rhizomes	reproduce quickly and form dense colonies	reeds, rushes, sedges, bulrushes

Adaptation	Advantage	Examples
Salt-tolerant Plants:		
gummy, hairy, waxy skin	prevent salt absorption	gumweed, pickleweed, cinquefoil, sea thrift
holds water in cells	maintain water supply	pickleweed
oxygen-rich layer around root	obtain oxygen	cordgrass
exudes salt crystals	*rid of excess salt*	saltgrass
salt drops on tips of leaves	rid of excess salt	pickleweed
large, hardy seeds	maintain salt balance in cells; to keep salt water from flowing in	pickleweed
low, sprawling form	reduce water loss from wind exposure	pickleweed, *jaumea*
small flowers	uses little energy	sedges, rushes, bulrushes
parasitic	obtain nutrients from other salt marsh plants	dodder
Bog Plants:		
sticky, sweet smelling	attract insects for nutrients	sundew, pitcher plant
leaves upright	reduce surface area for drying out *from exposure* to the sun	Labrador tea, *cranberry*
thick, fuzzy, rolled leaves	prevent water loss from evapotranspiration	Labrador tea
live symbiotically with fungi	obtain nutrients	orchids, heath plants

Hydrophytic Plants Assessment

Multiple Choice:

1. Some of the adaptations that wetland plants make to their environment are: (1point)
    a. Flying buttresses
    b. Spongy stems
    c. Knobby knees
    d. Floating leaves

2. Plants that live in wetland have a hard time: (1 pt.)
    a. Obtaining nutrients
    b. Obtaining oxygen
    c. Obtaining sunlight
    d. Obtaining carbon dioxide

3. Anaerobic means: (1 pt.)
    a. Without carbon dioxide
    b. Without oxygen
    c. With carbon dioxide
    d. With oxygen

4. Emergent plants are: (1pt.)
    a. Plants that are just sprouting
    b. Plants that live under water
    c. Plants whose roots are submerged
    d. Plants that have dry roots

5. Examples of emergent plants are: (1 pt.)
    a. Cattails
    b. Yucca
    c. Bulrushes
    d. Tomatoes

6. Hydrophyte means: (1 pt.)
    a. Water fighter
    b. Water plant
    c. Active fighter
    d. Active plant

7. Xylem and phloem are: (1 pt.)
    a. Tubes inside plants
    b. A new rock group
    c. Food and water transportation devices
    d. How a plant brings in oxygen

Short Answer:

8. Describe the differences between obligate wetland, facultative wetland, facultative, facultative upland, and upland plants. (2 pts.)
9. List five kinds of emergent plants and five kinds of aquatic plants. Are any of these trees, shrubs, or grasses? (2 pts.)
10. Draw a picture of a cattail and label the parts: leaves, female flower, male flower, stem, bulb, roots. (2 pts.)

Performance Task:

Using the information given in this workshop, construct a dichotomous key for the jeans people are wearing in your classroom to determine the most popular kinds of jeans. Write a hypothesis. Graph your results. Label the x-axis and the y-axis and title your graph. Run this experiment for five days. Summarizing your data, write a conclusion and compare your results to your classmates' results.

Hydric Soils

Background Information:

A hydric soil is a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. (US Department of Agriculture (USDA) Soil Conservation Service (SCS) 1985, as amended by the National Technical Committee for Hydric Soils (NTCHS) in December 1986). Because a wetland is saturated and covered with water either all or part of the year, the soil that lays underneath is saturated as well, making wetland soil very different from upland soil. This water saturation leaves little space for oxygen and most wetland soil is in an anaerobic (low oxygen) state. The lack of oxygen leads to the growth of bacteria that carry out anaerobic respiration. During this process of respiration, sulfide compounds are released into the soil. The sulfur is what gives wetland soil the smell of rotten eggs. These sulfide compounds are also responsible for the very black color of some wetland soil.

Soil is hydric, if a hole is dug, and it collects water for at least part of the year. If water is present in an 18" hole for at least two weeks during the growing season, it is legal evidence of a wetland. Many of the wetland soils will form a ball if picked up and rolled between the fingers, because the moisture keeps the soil particles together.

A hydric soil may be either drained or undrained; a drained hydric soil may not continue to support hydrophytic vegetation. The wetland area may be drained to create land for farming and agriculture. Therefore, not all areas having hydric soils will qualify as wetlands. Only when a hydric soil supports hydrophytic vegetation and the area has indicators of wetland hydrology may the soil be referred to as a "wetland" soil.

Even if wetland soil is dry, as it may be during certain times of the year, it can be identified by its color. The color may be: black, dark gray, brown, or green. The soil may also be classified as gleyed, (gray, blue-gray or green-gray in color). Or the soil may take on a mottled reddish appearance. This reddish or even black coloration may be a result from mineral staining.

Hydric soils may be classified into two broad categories: organic and mineral. Organic soils (Histosols) develop under conditions of nearly continuous saturation and/or inundation. All organic soils are hydric soils except Folists, which are freely drained soils occurring on dry slopes where excess litter accumulates over bedrock. Organic hydric soils are commonly known as peats and mucks. With this type of soil, plant accumulation occurs more rapidly than decomposition, so the soil layers grow thicker each year. These organic soils tend to develop in areas that stay saturated for large portions of the year and are dominated by mosses or herbaceous emergent vegetation.

All other hydric soils are mineral soils. These tend to form in areas that are saturated only part of the year, such as warm wooded environments. Organic decomposition keeps pace with the accumulation. Mineral soils have a wide range of textures (sandy to clay-like) and colors (red to gray). Mineral hydric soils are those periodically saturated for sufficient duration to produce chemical and physical soil properties associated with a reducing environment. They are usually gray and/or mottled immediately below the surface horizon or they have thick, dark-colored surface layers overlying gray or mottled subsurface horizons.

Some mineral soils found in wetlands can be composed of sandy material. Three soil features may be used as indicators of sandy hydric soils, including:

- High organic matter content in the surface horizon. Organic matter tends to accumulate above or in the surface horizon of sandy soils that are inundated or saturated to the surface for a significant portion of the growing season. Prolonged inundation or saturation creates anaerobic conditions that greatly reduce oxidation of organic matter.
- Streaking of subsurface horizons by organic matter. Organic matter is moved downward through sand as the water table fluctuates. This often occurs more rapidly and to a greater degree in some vertical sections of a sandy soil containing high content of organic matter than in others. Thus, the sandy soil appears vertically streaked with darker areas. When soil from a darker area is rubbed between the fingers, the organic matter stains the fingers.
- Organic pans. As organic matter is moved downward through sandy soils, it tends to accumulate at the point representing the most commonly occurring depth of the water table. This organic matter tends to become slightly cemented with aluminum, forming a thin layer of hardened soil (spodic horizon). These horizons often occur at depths of 12 to 30 inches below the mineral surface. Wet spodic soils usually have thick dark surface horizons that are high in organic matter with dull, gray horizons above the spodic horizon.
  Note: In recently deposited sandy material (e.g. accreting sandbars), it may be impossible to find any of these indicators. In such cases, consider this as a natural atypical situation.

Wetland soils are responsible for aiding in water filtration and flood prevention. As the water flows through the wetlands, the soil absorbs some of the sediments suspended in the water, and a smaller amount of the sediments are released into the stream or river. Also, as the water flows through the wetland, this water is filtered by the wetland and some of the pollutants, pesticides, fertilizers, and toxins are left behind in the wetland to be absorbed by the wetland soils.

Activity 1: Sedimentation

Background Information:
The average American family uses about 200 gallons of water a day for drinking, laundry, bathing, at school, at work, watering lawns and gardens. The wastewater that flows down the drain can be treated and reused. Nature and constructed wetlands may play an important part in treating wastewater.

A great example of this is found in the California town of Arcata. This is a town that proves that ingenuity is a match for high-tech engineering in turning sewage into a natural resource. The water in their marsh came from the drains and toilets of the town just across the railroad tracks. This body of water is part of the Arcata Marsh and Wildlife Sanctuary, a 154-acre wetlands park wedged between Northern California's Humboldt Bay and the small city of Arcata (pop. 15,000). The quiet and perfectly pleasant-smelling park has turned Arcata, 280 miles up the Pacific coast from San Francisco, into a tourist stop and bird watching Mecca. It also enables the town to meet the state's strict sewage-discharge standards. Since 1986, partially treated sewage from the town's conventional primary-treatment plant has been meandering through the park's chain of man-made marshes. There and in the marshes farther along the chain, Arcata does the same thing with its sewage that other towns do - it lets the appetites of various one-celled microbes go to work on the organic ingredients. After a two-month odyssey, it is piped into Humboldt Bay. The discharged marsh water is generally clearer and cleaner than the water already in the bay. Contrary to popular belief, raw sewage (or wastewater, as engineers prefer to call it) is 99.9 percent pure H_2O.

As water flows through the wetlands, sediment and soils from runoff, toxic waste and chemicals, fertilizer, and dissolved minerals are some of the many things that settle onto the wetland sediments. Fast flowing water caries larger particles as well as small-sized particles. As water slows, sediments settle out and in still water, even very fine particles of sand or silt eventually fall to the bottom of the wetland. Water collects in wetland basins and stays there for a while before it is either slowly released into the ground (*groundwater*) or flows into a connecting stream or river. While water is sitting in the wetland, particles settle out of the water column. This settling of the particles to the bottom is referred to as *sedimentation*. The water then flows into an adjacent waterway with a lower sediment load. As the sediment gradually builds, the wetland may fill in and no longer be a wetland. This process, called succession, is a natural way wetlands are filled.

Concepts:
- Wetlands act as a natural filtration plant for polluted water.
- As water flows into a wetland, sediment settles to the bottom.
- Over many years the settled sediment may eventually fill in a wetland

Student Objectives:

1. Students will construct a model wetland to observe sedimentation.
2. Students will predict which of the sediments are most dense and will settle to the bottom first.

Materials:

- One liter plastic jars with lids
- Water
- Measuring spoons
- One tablespoon each of:
  - Sand
  - Gravel or small pebbles
  - Leaves and grass
  - Potting soil
  - Wood chips or bark
  - Salt

Vocabulary:

Sedimentation, succession

Procedure:

1. Have the students place all the materials in the jar.
2. Fill the jar almost to the top with water and attach the lid tightly.
3. Have the students predict which of the materials will settle first after they shake the jar up.
4. Write down the predictions. Ask them if they think all the material will settle.
5. Shake the jar and record the results.

Question and Observations:

1. Were the predictions that the students made correct? (Answers will vary.)
2. Which was the densest particle or the particles that settled first? (Gravel)
3. Which was the least dense particle? (Bark)
4. What happened to the salt?(Dissolved into the water.)
5. Is this fresh water still? If not, what is it called? (No, it is brackish water.)
6. Would more sediment fall to the bottom if the water was flowing quickly or slowly? (More sediment will fall to the bottom in slowly flowing water.)
7. Is succession a good thing to happen to a wetland? (Answers will vary.)

Classroom Extensions:

- Go to a wetland on a class trip and find the inlet and outlet. Collect water at each site and compare the clarity of the water.
- Take a class field trip to tour a water filtration plant.
- Have students estimate how much water their family uses daily and then check their water bill. Have them devise a plan for their family to cut down on water use. After several months, re-check the water bill and see if the plan has succeeded.

Activity 2: The "Giant Sponge" Effect

Background Information:
Wetland soil, *hydric soil*, acts like a giant sponge soaking up water. This is very important in times of flooding but also in times of drought, when the wetland can actually release some water back into the *aquifers* (*recharges* the *ground water* supply) through seepage. Recharging the ground water is important because this water, in our aquifers, is a large part of our water supply. Ground water will also gradually discharge into streams and rivers. During a flood, wetlands slow the incoming water down, stores it, and diverts some of it into our groundwater; therefore reducing flooding downstream. In the United States, destruction from floods costs between 3 and 4 billion dollars annually. Loss of wetlands in our flood plains has important economic consequences.

Different types of soil have different water holding capacities. In some soil, water will flow through more quickly than it will be absorbed. In a wetland, the soil will absorb much of the water that flows through it and this water will take the place of oxygen between the particles of soil creating an *anaerobic* condition. The oxygen will percolate (bubble) out of the soil when the water is absorbed. This soil that has water and no oxygen often smells of rotten eggs or sulfur from the decomposition of plant and animal life. Eventually some of this water may be added to ground water or it may flow to the wetland's outlet.

Concepts:
- Wetlands act like a giant sponge to absorb and slow down floodwaters.
- The water that is absorbed may be released into the wetlands outlet or seep into the aquifer.
- As water is absorbed by the wetland soil, oxygen percolates out of the soil, and is displaced by the water.

Student Objectives:
1. Students will examine different kinds of soil.
2. Students will observe water percolating through wetland soil, forcing oxygen out.
3. Students will determine which type of soil will absorb the most water.
4. Students will decide which type of soil will best help stall a flood.

Materials:
- Different types of soil:
  - Sphagnum moss
  - Potting soil
  - Sand
  - Gravel
  - Clay (*can grind up clay cat litter in a blender*)
- Mason jars
- Cheesecloth

- Data sheet (See Appendix 1)
- Water
- Scissors
- Timing device
- Measuring cup and spoons

Vocabulary:
Anaerobic, aquifer, ground water, hardpan, hydric soil, percolate, recharge

Procedure:
1. Fill each Mason jar one half full with one of the soil samples (gravel, sand, potting soil, clay, or sphagnum moss).
2. Slowly pour one half cup of water into the jars and observe what happens.
3. Cover the top of each jar with cheesecloth and screw on the open rim of each jar.
4. Wait five minutes to allow the water to soak into the soil samples. After 2 minutes and three minutes record any changes in the jars. While waiting for the water to soak in, observe which sample it soaks into first, second, etc.
5. After the five minutes is up, turn each jar upside down to pour the remaining, excess water back into the measuring cups. Record amounts of water left and observations.

Questions and Observations:
1. The water that pours back into the measuring cup is water the soil could not hold. How does each sample differ? (Answers will vary.)
2. Which sample did the water run out of the quickest? (Gravel or clay if the clay has formed an impenetrable layer on the top of it) The slowest? (Sphagnum moss)
3. What happened with the different samples at the two minute and three minute intervals? (Answers will vary, but the clay may have appeared to have stopped absorbing water and to have formed a solid layer of clay on the top, blocking the water penetration. This is common with clay that an impervious layer (*hardpan*) may form, allowing no water to penetrate, causing the water to remain on the surface forming a wetland.)
4. Which of the samples are most typically found in a wetland? (Soils that allow little or no penetration are more likely to form wetlands – clay, soil and sphagnum moss.)
5. How do wetlands prevent flooding? (Answers will vary.)
6. Why does having wetlands along a river or stream help to keep the stream flowing during the dry summer months? (The river or stream is constantly recharged by water that is slowly released from the wetlands, much like the moss keeps releasing water slowly for a long time.)

Classroom Extensions:
- Have the students test the soil in their backyards or the schoolyard for permeability.

- Have the students go to a local wetland and collect a soil sample. Determine what kind of soil it is and test it. Be careful about damaging the wetland plants when digging.
- Students could weigh each sample before and after the test instead of measuring the amount of water that did not penetrate the wetland.

Activity 3: The Color of Soil

Background Information:

Adapted from the EPA, "Field Studies – A Walk on the Wild Side"" pamphlet, The "Mucking About" activity

Wetland soils, also called hydric soils, are very different from *upland* soils. They are saturated with water for a long enough period to develop anaerobic conditions. This lack of oxygen leads to the growth of bacteria that carry out anaerobic respiration. Their metabolic processes cause them to release sulfide compounds into the soil, which is the rotten egg smell you encounter when working with wetland soils. These sulfides are also responsible for the very black color of soils containing iron.

Hydric soils can be identified by their color and texture, even if no water is present at the time. *Organic* soils have an abundance of dead plant and animal material in it that is slow to decay because of the lack of oxygen. Organic soil is usually found near the surface and ranges in color from black to dark gray to dark brown. This color results from the dead and decaying plant and animal material (organic matter). Because hydric soils lack oxygen, and oxygen is needed by many of the bacteria that break down organic material, the *decomposition* of organic material happens very slowly. These soils become very thick, and organic hydric soils have at least 18 inches of organic material.

Bogs are acidic and the high acid content slows down decomposition even more. In bogs, very little of the organic material breaks down and a very thick layer of material forms called *peat*. Peat soils are often a very dark brown in color.

Mineral soils have little organic matter present. They may be sandy, clay-like, or silty. Sometimes they are *gleyed*, which means they are mineral soils that are wet most of the time and have a gray, greenish-gray, bluish-gray, or neutral-gray cast. If these soils are wet and then dry, they may be *mottled* with brown, reddish, yellow, or even black spots. These are formed by alternately drying and wetting the soil or by root action. The presence of oxygen at these times allows the spots, which contain metals, to oxidize and form a lighter color. In soils with lots of iron, the spots are rusty looking. In magnesium-laden soils, they are blackish.

Wetland scientists use a Munsell® soil chart to identify soil color, purity and intensity. The color chart in this activity is a simplified version of the expensive Munsell® Color Chart.

The study of wetland soil is as simple as digging a hole and identifying soil color. The hole needs to be a minimum of 18 inches deep. Don't be surprised if your hole fills with water; that shows the hydrology that makes the wetland and its soil. The presence of water in the soil is how wetland scientists test for the wetland hydrology characteristic. If water is present in an 18" hole for two weeks of the growing season, it is legal evidence of a wetland.

Concepts:
- Wetland soils exist in anaerobic conditions unlike most other soils.
- Wetland soils may be identified by color, smell, or texture.
- Wetland soils may be distinguished from upland soils even though they may be dry.

Student Objectives:
1. Students will identify wetland soils
2. Students will be able to describe the physical characteristics of wetland soil
3. Students will create a wetland soil chart for classroom and field use.
4. Students will examine the wetland soils' texture, color, odor, and other features.

Materials:
- Copies of the blank color chart and observation chart (See Appendix 2)
- Scissors
- Box of 96 Crayola® crayons
- Soil Samples
- If collecting samples
  - Meter or yard stick
  - Shovel or spade
- **Optional** –
  - Hand lenses
  - Clear contact paper or laminating materials

Vocabulary:
Decomposition, gleyed, mottled, organic, peat, upland

Procedures:
1. Have samples of wetland soil available or go on a class field trip and collect samples.
2. Describe to students the characteristics of wetland soils.
3. Share with them the factors causing these traits.
   Hand out the appropriate color chart and crayons. Color the squares with the crayon color indicated above each square.

5. Have the students cut out the shaded holes. (If you want to keep these charts for future use, they may be laminated or covered with clear contact paper on both sides. Lamination is preferable, since it is more transparent.)
6. Have the student put the soil sample behind the holes in the chart and find the closest color. Use the chart to identify soil color.
7. Look for mottles.
8. Determine if the soil is a wetland soil by the color.
9. The best way for students to examine texture is to feel the soil. If the soil feels gritty, it has sand in it.
10. To find out if it is clay-like, have students roll the soil into balls and then try to push a ribbon of soil off the top until it breaks off. The longer the ribbon, the more clay in the soil.

Questions and Observations:

1. What physical characteristics of the soil did you observe? The color, the amount and type of organic material, the texture, smell, and was there mottling or patterns? (Answers will vary with the soil samples used.)
2. Can you find evidence of where your soil particle came from? (Answers will vary. Decaying, organic materials may resemble surrounding plants, particles in the mineral soils may be formed from nearby rock.)
3. Did you find any human-made items or materials? (Answers will vary.)
4. If so, how do you think it got there? (Litter may or may not decompose and become part of the soil.)
5. How does wetland soil compare to the upland soil you inspected in the samples - wetness, color, smell, and texture? (Answers will vary.)

Classroom Extensions:

- On a field trip, to a wetland, dig a hole about 2 feet deep. It is possible that you may have to dig deeper, if the area has been disturbed or filled with dirt from elsewhere. Examine the inside of the hole at the different depths listed in the soil observation chart. Remove globs of soil to be passed around and examined by students.
- Contact your local Natural Resource Conservation Service or Conservation District. They can supply you with soil survey maps for your area.
- Use soil chemistry kits to test soil pH, nitrates, and other factors.
- To find out how much organic material is in a sample of soil, take the dry soil and cook it in an uncovered crucible until no steam is given off and it is red hot. Reweigh and calculate percentage of organic material: (dry weight - weight after heating)/dry weightx100=%.

Glossary

- Anaerobic – The absence of oxygen
- Aquifer – A water-bearing rock formation
- Decompose – To decay
- Gleyed - Mineral soil that is or was always wet and is often gray, green-gray, or bluish in color, found in wetlands.
- Ground water – Water found in pores or cracks in sand, gravel, and rock beneath the land surface. Discharging groundwater sustains streamflow and supplies water to springs and wells.
- Hardpan – A layer of hard clay laying over soft soil.
- Hydric – Contains an abundance of water.
- Hydric soil – Soil that is wet long enough for anoxic (lacking oxygen) conditions to develop. The water in the soil forces air out. This soil is found in wetlands.
- Mottled – Marked with blotches of different colors
- Organic – Material derived from a living organism
- Peat – Partly decomposed vegetable matter found in bogs. When dried, can be used as fuel.
- Percolate – To pass through a porous substance. To seep or filter.
- Recharge – Water that seeps through the soil to replenish the aquifer.
- Sedimentation – Matter settling to the bottom of a liquid.
- Succession – Following in order. As one ecosystem dwindles and becomes obsolete, another will replace it.
- Upland – Any land at a slightly higher elevation than other land.

Resources

Literature:

Environmental Laboratory. 1987. Corps of Engineers Wetland Delineation Manual, Technical Report Y-87-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Tiner, R.W., In Search of Swampland: A Wetland Sourcebook and Field Guide, Rutgers University Press, Piscataway, NJ, 1998.

Soil Conservation Service. 1994. National Food Security Act Manual. *Title 180.* USDA Soil Conservation Service, Washington, D.C.

Soil Survey Staff. 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. USDA Natural Resources Conservation Service, Agric. Hdbk. 436, U.S. Government Printing Office, Washington, D.C. 869 pp.

Yates, S. Adopting a Wetland, 1989.

Soil Survey Staff. 1994. National Soil Survey Handbook. USDA Soil Conservation Service, Washington, D.C.

Washington Department of Ecology, Discover Wetlands, Wetlands Section, Mail Stop PV-11, Olympia, WA 98504, 1-206-459-6774.

Movies:
The Milagro Beanfield War. Rated R. A culture clash between farmers and developers over the water supply.

Websites:
http://www.wetlands.com/coe/87manp3b.htm – Definition of hydric soils

http://www.idahoptv.org/dialogue4kids/wetlands/idwetland.html – Kid-friendly wetlands website

http://www.wetland.org/kids/soilchart.htm – Crayola® crayon soil color chart

Appendix 1

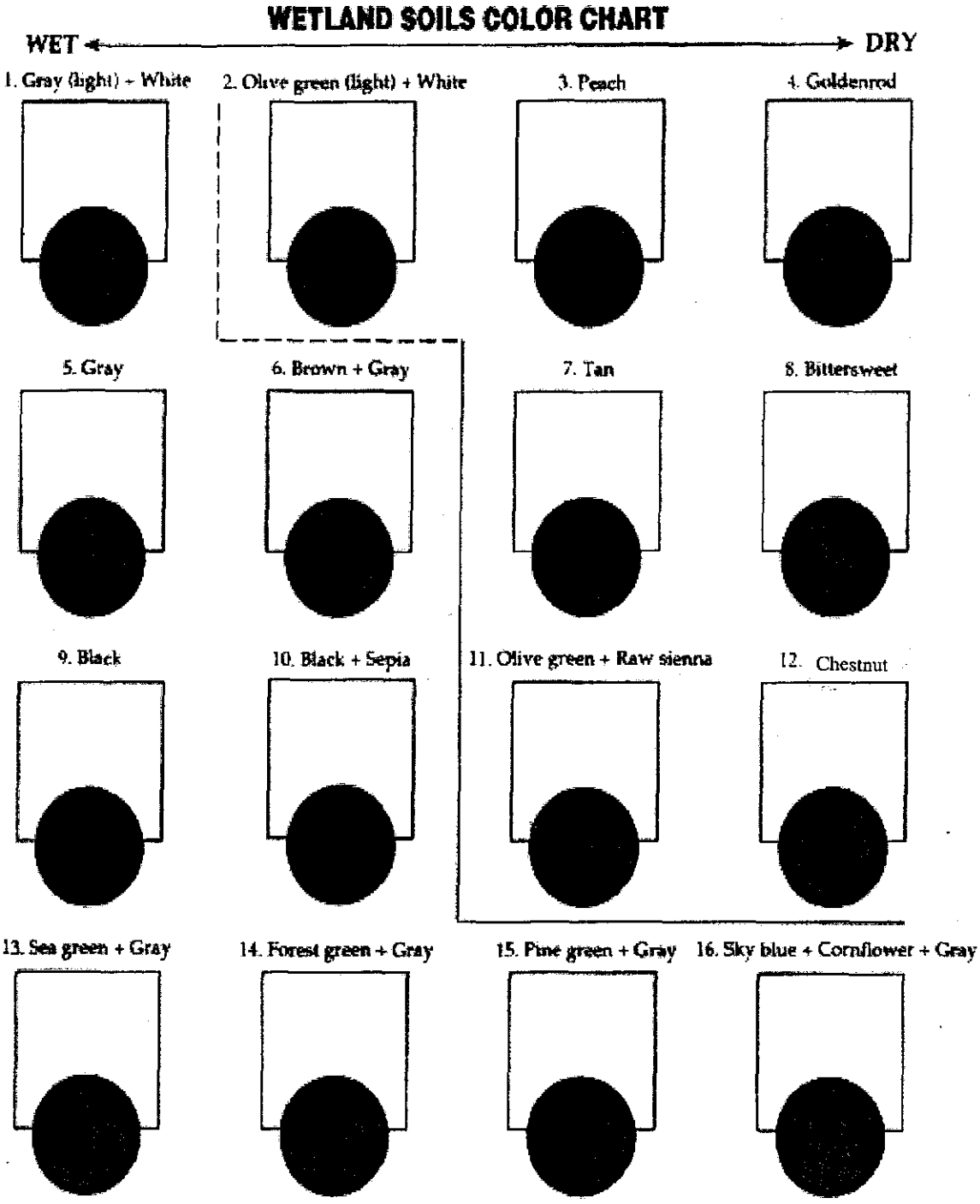
Soil Sample Data Sheet

Materials:	Appearance after 2 minutes:	Appearance after 3 minutes:	Appearance after 5 minutes:	Amount of water left:
Sphagnum moss				
Potting soil				
Clay				
Gravel				
Sand				

Appendix 2

Color with Crayola® Crayons

Numbers 1, 5, 6, 9, 10, 13, 14, 15, 16, and sometimes 2 are wetland soils. Soil matching numbers 4, 8, and 12 in spots or streaks may be mottled and may indicate minerals in the soil and seasonal wet soil.



Hydric Soils Assessment

Multiple Choice

1. Wetland soils are: (1 point)
    a. Food for many animals
    b. A filtration device
    c. Are anaerobic
    d. Are aerobic

2. Fertilizer that runs off farmland may: (1pt.)
    a. Feed wetland plants
    b. Kill the delicate plant life in a wetland
    c. Settle with the sediment load into a wetland
    d. Pass through the wetland with the flowing water

3. Hydric soil is: (1pt.)
    a. Found in upland areas
    b. An indicator that the area may qualify as a wetland
    c. May be acidic or alkaline
    d. Found in wetlands

4. To be considered hydric, soil should: (1 pt.)
    a. Collect water for part of the year
    b. Be found at a beach
    c. Form a ball if rolled between the fingers
    d. Have no decomposition

5. Hydric soils, may be formed of: (1 pt.)
    a. Minerals
    b. Sand
    c. Organic material
    d. None of the above

6. Mottled soil is: (1 pt.)
    a. Reddish
    b. Black
    c. Blue
    d. Stained by minerals

7. Gleyed soil is: (1 pt.)
    a. Blue-gray
    b. Green-gray
    c. Mineral soil
    d. All of the above

Short Answer:

8. Describe succession. (2 pts.)
9. Describe three different things that would lead you to believe that a soil is hydric. (2 pts.)
10. What happens to sediment as it flows into a wetland? (2 pts.)

Performance Task:

Using the knowledge gained in this workshop, go with classmates and sample a stream as it flows into wetland and as it comes out of the wetland. Write a hypothesis about what will happen to the water quality. Sample the temperature, the pH, the turbidity, and if a Hach kit is available, sample the dissolved oxygen. Record your procedure. Are there invertebrates in the water in either location? Sample the water one day a week for the next five weeks. Graph your results. Label the x-axis and the y-axis. Give the graph a title. Summarizing your data, write a conclusion and compare your conclusion with your classmates' results. Find someone in the city council with whom to share your results.

Resources

Pencils	Oriental Trading Co.	800-228-2199
Depression Slides	Carolina Biological	800-334-5551
Wetlands Poster	National Audubon Society	800-813-5037
Forceps	Boreal Labs	800-828-7777
Student microscopes	Carolina Biological	800-334-5551
Hand lenses	Carolina Biological	800-334-5551
Petri dishes	Boreal Labs	800-828-7777
Depression slides	Boreal Labs	800-828-7777
Sand	Lowe's Hardware Store	303-425-3323
Astro-turf	Lowe's Hardware Store	303-425-3323
Clay	Hobby Lobby	303-425-7363
Plastic shoe box	Target	303-425-0124
Potting soil	King Soopers	303-420-4611
Sphagnum moss	King Soopers	303-420-4611
Bark	King Soopers	303-420-4611
Cheesecloth	King Soopers	303-420-4611
Horsetails	Pier 1	303-422-0306
Wetland slides	Paul McIver	McIver.Paul@epamail.epa.gov