



WONDERFUL WETLANDS: WHY DO WE NEED THEM AND WHAT CAN THEY DO FOR US?

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Grade Level

High School

Subject area

Life Science, Marine, or Environmental Science

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1. **Activity Title:** Wonderful Working Wetlands
2. **Focus:** Wetlands work to provide a variety of services and to help the coastal environments. This lesson plan goes through the different types of wetlands, their functions, the factors that may cause their decline, and ways to help maintain or rebuild wetlands. The activity is a simple demonstration to help students visualize the services wetlands provide, and the debate helps students understand how wetlands are important to different parts of the community.
3. **Grade Level/Subject:** Middle School to High School Environmental Science, Earth Science, Biology
4. **VA Science Standard(s) addressed:**
 - a. *Earth Science 8: The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans.*
 - i. Dependence of freshwater resources and the effects of human usage on water quality
 - b. *Earth Science 10: The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations.*
 - i. Physical and chemical changes related to tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations
 - ii. Systems interactions
 - iii. Economic and public policy issues concerning the oceans and the coastal zone including the Chesapeake Bay.
 - c. *Biology 1: The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which*
 - i. Hypotheses are formulated based on direct observations and information from scientific literature
 - ii. Variables are defined and investigations are designed to test hypotheses;
 - d. *Biology 8: The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems.*
 - i. The effects of natural events and human activities on ecosystems
 - ii. Analysis of the flora, fauna, and microorganisms of Virginia ecosystems.
5. **Ocean Literacy Principles Addressed**
 - a. *Ocean Literacy Principle #1: The Earth has one big ocean with many features.*
 - i. Wetlands are an important part of the coastal ocean
 - b. *Ocean Literacy Principle #5: The ocean supports a great diversity of life and ecosystems.*
 - i. Wetlands are habitat to many fisheries species, as well as a resting ground for migratory birds.
 - c. *Ocean Literacy Principle #6: The ocean and humans are inextricably interconnected.*
 - i. Humans are both damaging and restoring many wetlands.

6. Learning objective/outcomes

- a. Students will be able to explain the importance of different kinds of tidal wetlands and where they might find each type.
- b. Students will be able to demonstrate the important aspects of a wetland by designing a model wetland and explaining its features to a wider audience (i.e., the class).
- c. Students will be able to assess the current challenges that wetlands face

7. Total length of time required for the lesson

- a. 45-60 minutes – Overview PowerPoint and discussions within (see procedure)
- b. 15-20 minutes – Activity – Cost of a Beach House and Discussion
- c. 30-75 minutes – Activity – Wetland in a Jar
- d. 10-20 minutes – Wrap-Up of Activity
- e. 45-60 min – Debate
- f. Not all parts are required, and some activities may be eliminated for time purposes

8. Key words, vocabulary

- a. Wetland - a land area that is saturated with water, either permanently or seasonally
- b. Salt Marsh - an area of coastal grassland that is regularly flooded by seawater
- c. Mangrove - Mangroves are shrubs or small trees that grow in coastal saline or brackish water. The term is also used for tropical coastal vegetation consisting of such species
- d. Stressor – a condition, action, or thing that can cause large amounts of stress to an ecosystem, such that it can degrade that ecosystem
- e. Water quality - a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose
- f. Habitat - the natural home or environment of an animal, plant, or other organism
- g. Shoreline squeeze – when a bulkhead or other hard structure is built along a shoreline, erosion removes the wetland area at the margin and structures prevent the addition of area by migration onto adjacent uplands
- h. Carbon storage – the ability for an area to permanently or semi-permanently store carbon and keep it out of the atmosphere
- i. Blue carbon – carbon captured by coastal ecosystems, such as wetlands
- j. Contaminant - a polluting or poisonous substance

9. Background information

- a. See PowerPoint associated with lesson plan as well as the **References** section (for more information, see papers cited within referenced papers).

10. Student handouts and other materials needed

- a. “Tidal Wetlands” PowerPoint presentation
 - i. Handout for students to fill out during presentation (“Tidal Wetlands Handout_Blank”)
- b. Activity sheets
 - i. Cost of a Beach House
 - ii. Wetland in a Jar for Group A
 - iii. Wetland in a Jar for Group 1
 - iv. Shareholder Cards (for Debate)
 - v. Shareholder ID cards (for debate)

11. Materials & Supplies, A/V/Tech Support

a. SEE “Teacher’s Guide – Wetland Activity.docx” for more information

- Mason Jars and lids (at least the ring that screws on the top)– 1 per team (see below)
- Beakers or measuring cups – 1-3 depending on the class and how it is split
- Cheesecloth – enough to have one piece for each mason jar lid
- Colored water (i.e. water with some food coloring) – enough so each team has 200 mL or 1 cup
- Student Worksheets (“Wetland in a Jar”)
- *Materials to fill mason jars* – will depend on class, and not all supplies are necessary and these are just suggestions. Feel free to add other supplies that you may already have!
 - Sponges
 - Pipe cleaners
 - Soil
 - Foil
 - Small rocks
 - Cotton balls
 - Beads
 - Beans
 - Paper scraps
 - Sand
 - Fabric scraps

12. Classroom/Lab/Field Study Setup

- a. For designing wetlands, students will need ample room to create their wetlands in small groups (medium-large tables)

13. Procedure:

- a. *Advance Preparation of materials:*
 - i. Teachers will need to pre-make enough food-coloring colored water so that each team (see “Teacher’s Guide – Wetland Activity.docx”) will have at least 200 mL of water
- b. *Lab set-up*
 - i. Arrange above materials in appropriate piles prior to activity so that students have access to all materials.
- c. *Introduction: PowerPoint Slides #1-8*
 - i. *Slide 1:* Introduce topic. “Today we’re going to discuss tidal wetlands, an important, but often ignored or unappreciated portion of the coastal ocean.”
 - ii. *Slide 2:* Objectives. This lesson has opportunities for students to learn about the different types of wetlands, the services wetlands provide, and the current challenges that wetlands face.
 - iii. *Slide 3:* Ask students what a wetland is. Could be done through class discussion or “Think-Pair-Share.” Explain that a wetland is an area that inundated or saturated with water most or all of the time. Under normal circumstances, wetlands support plants and animals that are used to living in water or saturated soils.
 - iv. *Slide 4:* Ask the students to give any examples of wetlands that they already know about. During this discussion/Q&A session, students may suggest areas that are not technically wetlands, such as a temporarily flooded area, a ditch, etc., but you can explain to the
 - v.

- students that a wetland is permanently or almost always under water or saturated with water, whereas some of their suggestions are only under water for a short period of time.
1. Slide has animations to click through a variety of examples of wetlands. After the students have talked through some examples of wetlands, ask students where they could find a wetland. Where are some major ones? (The Florida Everglades, The Great Dismal Swamp) Where are some local ones? (Depends on location, in Chesapeake Bay, they are found all over the coastal region)
- vi. *Slide 5:* "Salt marshes, freshwater marshes, and mangroves are some of the most important and abundant wetlands. Shown on this slide is a mangrove forest. The roots of these mangroves provide protection for many different types of animals while stabilizing the large trees in the water."
 - vii. *Slide 6:* "Salt marshes occur worldwide, and are found in between land and open saltwater. Because of their proximity to the ocean, they still experience tidal action, and can have large differences in their salinity daily. These areas are covered by grasses, such as *Spartina alterniflora*, that can tolerate higher salinities by using a system that can remove the salt from the water. Salt marshes are home to more than 75% of important commercial fisheries species, such as blue crab, shrimp, and many types of finfish. Many of these fish use this area as a nursery... leaving their larvae and juveniles in these areas because they are protected from stressful conditions and hungry predators."
 - viii. *Slide 7:* "Freshwater marshes are very similar to salt marshes, except there is no salt water in these areas. These marshes are located upstream of the salt front. The salt front is the leading edge of the seawater entering an estuary. Upstream from the salt front, there is no saltwater. These areas are close enough to the ocean that the tides still influence them (they still have the daily motions of high tide and low tide) but not close enough that saltwater can invade them. All of the plants and animals that live in the salt front are intolerant to salt."
 - ix. *Slide 8:* "Unlike salt marshes and freshwater marshes, mangroves are only found in tropical and subtropical regions. Other regions have winter temperatures that are too cold. There are three types of mangrove trees, red, black, and white, which are all adapted to live in harsh coastal areas. These trees are salt tolerant and can remove salt from the water, just like salt marsh plants. These trees have complex root systems that can slow water movement and provide habitat for many different species. Mangroves can be home to billions of worms, protozoa, barnacles, oysters, and many other types of invertebrates. These invertebrates can feed the fish and shrimp which also live in the mangrove system, and these fish and shrimp can feed wading birds, pelicans, and crocodiles."
 - x. *Optional computer/iPad activity* – ask students to look up some important wetlands, where they occur, what they look like, are they protected, etc.
- d. *Discussion* – PowerPoint Slide #9- What's going on with wetlands? Since we've been able to map wetland areas, there's been a loss of over 50% of total wetlands in the US alone. Ask the students if they have any idea why.
 - e. *Slide 10:* "Wetlands are stressed out. There are different types of stress that a wetland can experience. Natural stress can come about through natural events that are not affected by humans or climate change. Storm events fall into this category. If a storm is strong enough, it can damage or destroy wetlands. Even though wetlands can often buffer storms, if the storm is too strong or occurs over a very long time, it can severely damage or destroy a wetland."
 - f. *Slide 11:* "Humans can also create many challenges for wetlands. One way that we can hinder wetlands is through the creation of dams along waterways. Wetlands need a supply of sediment

to keep forming new area during sea level fluctuations. Sediment supply allows wetlands to move inland when water levels increase, and to grow taller (or accrete vertically) to withstand higher sea levels. Damming traps this vital supply of sediments that would normally go to a wetland, and thus can greatly damage a wetland's ability to survive in changing conditions. In other areas, mangroves are being cut down to make room for farms and urban areas, for lumber, and during times of warfare. Because mangroves are trees, it can take a much longer time for them to recover than areas covered in grasses (such as marshes)."

- g. Slide 12:* "Another human stressor is something called the "shoreline squeeze." In an unaltered setting, during sea level rise, wetlands can grow taller by accumulating sediment or move inland by taking over newly saturated lands (lands that were saturated by the higher sea level). If there is a wall or bulkhead there to protect coastal property from sea level rise and erosion, wetlands cannot move inland, because they are "squeezed" in between the rising water and a hard place (the seawall or bulkhead). Humans can also cause stress to wetlands through inputs of excess nutrients. Excess fertilizers from agriculture and land owners can often be taken up and removed from the system by wetlands. If there is an abundance of these fertilizers, the wetland plants will no longer have to search as far for nutrients, because they are readily available through these fertilizers, and will no longer create such extensive root systems. These root systems hold the wetland sediments and soils together and keep them from eroding. Without these complex root systems, the wetland soils can erode, leading to creek bank collapse, which can lead to further degradation of the wetland."
- h. Slide 13:* "Some impacts of climate change can have devastating effects on wetlands. Normally, wetlands are able to trap sediments from the water column to grow vertically to keep pace with climate change. If sediment supply is decreased due to damming or other human interaction, or if sea level rise is too rapid, wetlands can become submerged by rising seawater."
- i. Slide 14:* Think-pair-share/discussion for the class. What can we do to help wetlands? Discuss what the students think would be the best way to stop destroying wetlands and how to fix the ones that have already been degraded.
- j. Slide 15:* "Many people have begun to repair already damaged wetlands in the hopes of reestablishing the functions that these wetlands have provided in the past. Some people have begun to restore water paths of some wetlands. In areas where wetlands have become filled in due to high loads of sediment from erosion upstream or from inputs from other sources, some people have begun digging out the original water channel in the hopes that it will stimulate the wetland to reform and return to its previous status. Other people are trying to help degraded wetlands by planting new wetland plants, cleaning the water supply that enters it, and introduce new policies that will protect wetlands. Some organizations are creating wetlands to either extend the amount of land that wetlands are covering or to serve some sort of commercial purpose. Some cities are designing wetlands to act as wastewater treatment facilities to clean water leaving their city. Finally, some organizations are enhancing current wetlands by modifying and creating policies to protect these wetlands and planting important wetland plants or introducing important wetland aquatic species."
- k. Slide 16:* Either another discussion/think-pair-share or just a segue into the next section.
- l. Slide 17:* Why are wetlands important? "Healthy wetlands can provide a wide range of services, as well as offer cultural and economic value. All of these can be provided (for free!) from healthy wetlands, and as wetlands are degraded, we lose these services, or benefits, that wetlands provide."

- m. *Slide 18:* “Wetlands are an important habitat for many different types of plants, birds, mammals, insects, fish, and other organisms. Because there are so many different types of wetland habitats, many different species can call wetlands their home. We’ve already mentioned how many different species use these areas as nurseries for their young, but other species, such as migratory birds, can use wetlands as “pit stops” during longer journeys.”
- n. *Slide 19:* “How do wetlands help protect other areas from storms? Wetlands can act as a buffer to slow down the inland movement of storm surges. In many storms with high wind speeds, winds and low pressure zones can form a bulge of water, called a storm surge, that can inundate coastal lands. When a storm surge encounters a wetland, it encounters resistance, due to the shallow water depths and the aquatic vegetation in wetlands. In salt marshes and freshwater marshes, the grasses in living in or near the water can slow down this bulge of water, and in mangroves, the thick, tangled roots can help to slow this water. This resistance reduces the height of the surge and slows the movement of the water, which can help nearby lands either not be flooded by this water or reduce the amount of flooding that they do receive. The wider the wetland buffer, the more protection the surrounding land receives.”
- o. *Slide 20:* “How can a wetland clean the water? Wetlands act as a filter to remove excess fertilizers and contaminants. Any excess fertilizers used by farmers or by landowners as well as contaminants in the water supply, such as cosmetics, pharmaceuticals, and pesticides, can leave terrestrial areas and enter a wetland. In a wetland, the plants can use the nutrients from the fertilizers and remove them from the water before they reach the coastal ocean. Toxins can be absorbed onto sediment particles in the water, which can effectively cancel out their toxicity, and settle out of the water and be removed from the system.”
- p. *Slide 21:* “Wetlands can also be a place of carbon storage. A new term, blue carbon, has been used to describe carbon that is stored in the soils of wetlands. This carbon can be stored in two ways: short term and long term. Short-term storage can occur when plants take up carbon dioxide from the atmosphere and use it to create biomass (leaves, roots, trunks) through the process of photosynthesis. Long-term storage occurs when these plants die and are buried in the soils and are no longer in contact with the atmosphere. While some degradation may occur (which would allow some of this carbon to escape back to the atmosphere through respiration of carbon dioxide), these plants are buried quickly, and the soils are constantly saturated with water, which makes normal degradation difficult. It is estimated that living organisms take approximately half of the atmospheric carbon up, and about half of this is stored as blue carbon in wetlands. So if wetlands are lost, all of this stored carbon could return to the atmosphere and increase the levels of greenhouse gases in the atmosphere.”
- q. *Optional Discussion* – how can we encourage people to not destroy their wetlands?
 - i. *Tax breaks, insurance rates, other economic things usually work well, but what are some other ways?*
- r. *Activity 1: Cost of a Beach House Activity.* The worksheets can be completed individually or in pairs. Students will decide what size beach house they would like, the land they’d like to own, etc. Because their beach house destroys a wetland, they must calculate how much it will cost for them to recreate their original wetland or try to alter their house to battle rising sea levels. The prices aren’t entirely realistic, but the point of the worksheet is to show that destroying wetlands not only has consequences for the environment, but can also the economy and personal property.
- s. *Activity 2: See Teacher’s Guide – Wetland Activity.docx*
- t. *Slide 22:* The activity. Some questions are provided to get the students thinking.

- u. *Discussion of activity (15-20 minutes)*
 - i. Use the wrap-up questions on the Teacher's guide for discussion with the students.
- v. *Break-down and Clean up Activity (5-10 minutes)*
 - i. Clean up should consist of students returning any unused materials to their original places and discarding any trash.
- w. Assessment: The Debate

14. Assessment

- a. This activity can be saved for a group project, a homework assignment, or another classroom activity. Unless assigned as a homework assignment, students should work in teams of 3-5 on this activity.
- b. Prior to assessment: instructors should give each group a role card for the debate. The roles are as follows:
 - i. National Park Ranger
 - ii. Construction Company
 - iii. Small Business Owner
 - iv. Environmental Scientist
 - v. Mayor (this can be the instructor or a group of students acting as the mayor and mayor's aids)
- c. Explain to the class that you will be holding a debate to discuss what to do with a wetland. The set up can be something like:
 - i. "In Townville, there is a natural wetland at the edge of a national park. As Townville's population grows, there is some debate as to what to do with this wetland. Some want to leave it alone because of the natural services it provides, some think that that land could be better used for other purposes. You are all town members that are at a Town Hall meeting to discuss what should be done with the land. In the end, the mayor (or mayor and mayor's aids) will have the final decision, but they must take into account everyone's arguments and points of view."
 - ii. Each group will have 20-25 minutes to create an argument and what they think the best plan of action is for the wetland in question. Each group will deliver a 5 minute speech on their argument and plan of action. The mayor will listen to each group and be given 5-10 minutes to deliberate. The mayor will then announce their decision to the group and explain what arguments they think were most valuable and how that helped to shape their decision.

15. References

- a. Deegan, L.A., Johnson, D.S., Warren, R.S., Peterson, B.J., Fleeger, J.W., Fagherazzi, S., & Wollheim, W.M., 2012. Coastal eutrophication as a driver of salt marsh loss. *Nature* 490: 388-394.
- b. Drake, B.G., 2014. Rising sea level, temperature, and precipitation impact plant and ecosystem responses to elevated CO₂ on a Chesapeake Bay wetland: review of a 28-year study. *Global Change Biology* 20: 3329-3343.
- c. Kirwan, M.L., Guntenspergen, G.R., D'Alpaos, A., Morris, J.T., Mudd, S.M., & Temmerman, S., 2010. Limits on the adaptability of coastal marshes to rising sea level. *Geophysical Research Letters* 37: L23401, doi: 10.1029/2010GL045489.
- d. Kirwan, M.L., & Megonigal, J.P., 2013. Tidal wetland stability in the face of human impacts and sea-level rise. *Nature* 504: 53-60.
- e. Kirwan, M.L., & Mudd, S.M., 2012. Response of salt-marsh carbon accumulation to climate change. *Nature* 489: 550-554.
- f. <http://www.epa.gov/wetlands>
- g. www.vims.edu/cbnerr (Resources and Education tabs, in particular!)