Bringing Wetlands to Market Part 2 Exercise 1
The Process of Science: Developing research questions

Focus question

What are scientists studying in the Bringing Wetlands to Market project, and why did they choose those parameters?

Performance tasks

Students will be able to describe the major research topics and at least 3 parameters being studied in the Bringing Wetlands to market project. Students will be able to explain how methane emissions are related to wetlands.

Overview
In this exercise, students will learn what questions scientists are studying in the Bringing Wetlands to market project. They will review some of the parameters and discuss how methane emissions are related to wetlands.

Time Required
Two 45-minute class sessions

Background for teaching

One of the major goals of the Bringing Wetlands to Market project is to provide research-based information about how wetlands store and exchange carbon and greenhouse gases. To address this complex task, scientists in the Bringing Wetlands to Market project collaborated to identify the types of data that should be collected. The video and optional readings will help students learn about the process of science, including how scientists identified the research questions, designed methods to answer them, chose the sampling sites, coordinated with colleagues to relate their part of the project to the other parts, and communicated with stakeholders.

Procedure

1. **The scientists speak**
   Review with students the guiding questions for the video "How Wetlands are Studied: Field Research for Bringing Wetlands to Market project," then show the video. You may choose to stop at each section to discuss the questions.

   How wetlands are studied: Field Research for the Bringing Wetlands to Market project
   http://wbnerrwetlandscarbon.net/2013/01/23/field-research-video/
   Video is 4 minutes 48 seconds. Time, topic, and guiding questions for each section are given.

   0 - 0:30 Intro; where scientists are from & basic info
   Question: What are some institutions involved in this project?
   Waquoit Bay NERR, Woods Hole Marine Biological Laboratory, USGS, University of Rhode Island

   0:35 – 1:25 How this research will inform management decisions; find out how much CO2 is stored in wetlands
   Question: Who might use the information generated by the project?

Coastal managers, communities that have wetland resources
1:30 – 2:10 Greenhouse gas emissions; develop new type of chamber and new instruments to measure gases and changing levels
Question: What is the chamber for?
The chamber is used to monitor the changing level of gases over a time period

2:15 – 2:50 Nitrogen input; sample at 4 sites with different N loading
Question: What is the difference in the 4 sites?
The sites have different levels of development

2:55 – 3:45 Description of some parameters measured & plant studies
Questions: What are some of the parameters being measured? What is meant by an indicator?
Answers will vary. An indicator is a parameter that can be used as a proxy for another factor.

3:48 – 4:48 Restoration and conservation managers will get tools to help support decision making; must consider salt marsh migration toward upland as sea level rises
Questions: What information will the project generate that may be useful to coastal managers?
The project will generate information about carbon uptake and storage capacity of wetlands, which may mean they can be part of carbon markets.

Where do salt marshes "migrate" and why is this a concern for coastal managers?
Salt marshes migrate inland when sea level rises. This could change flood zones, and many communities have little undeveloped space where future marshes could extend.

2. **Why is it important to do this research?**
   Have students read and discuss questions for "Coastal Blue Carbon: Part of the Solution to Climate change" and "Methane from Wetlands: A Heated Debate." Both readings are presented in the student reading *"Why is it so important to do this research?"* below.

Research in the Bringing Wetlands to Market Project:
Why is it so important to do this research?

1. If you have not shown students the engaging and informative video, "Two Minutes on Oceans with Jim Toomey: Blue Carbon" , show it now as background for this discussion.

2. Have students read "Coastal Blue Carbon: Part of the solution to climate change" and "Methane from Wetlands: A Heated Debate" included below; you may also refer

to in the "Blue Carbon Fact Sheet" and "Salt Marsh Carbon May Play Role in Slowing Climate Warming" readings introduced in Part 1, Exercise 2.

Ask students to write or be prepared to discuss the answers to these questions after reading the documents:

a. Why is it important for scientists to study carbon storage in wetlands?

Wetlands could help take excess carbon dioxide from the atmosphere, which could help slow climate change.

b. What are the sources of nitrogen coming in to coastal marshes, and how does excess nitrogen affect carbon storage in wetlands?

Nitrogen can come from septic systems, fertilizers, stormwater runoff, and from the air as NOx compounds produced by combustion. The excess nitrogen can make plants grow too rapidly to store much carbon in their roots, reducing the capacity of the wetland to sequester carbon.

c. Why is methane (CH_4), as well as carbon dioxide (CO_2), a focus of the study?

Methane is a greenhouse gas that traps heat more effectively than carbon dioxide. It is a byproduct of anaerobic (airless) respiration by microbes, which occurs naturally in wetland soils. Little is known about how much methane is stored in wetlands or the conditions under which it is released. This research will supply crucial information to fill a gap in our knowledge that will help us understand some of the consequences of degradation of coastal wetlands.

d. How does the research relate to efforts to restore degraded wetlands or preserve undeveloped wetlands?

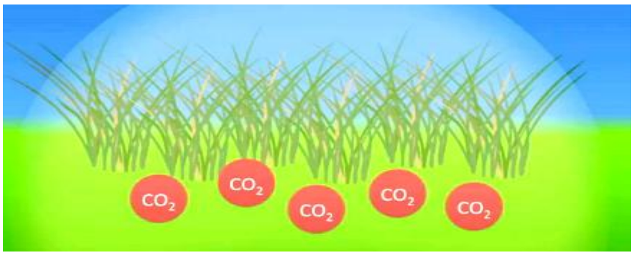
If wetlands are preserved and functioning properly, they can take up carbon dioxide from the atmosphere and store it for long periods. The more wetland area available, and the healthier they are, the more carbon can be stored.

Reading 1: Coastal Blue Carbon: Part of the solution to climate change

Adapted from http://www.habitat.noaa.gov/coastalbluecarbon.html

Note: For a more complete treatment of this topic, visit the web site or view the "Blue Carbon Fact Sheet"

Healthy coastal habitat is not only important for seafood and recreation, it also plays an important role in reducing climate change. Salt marshes, mangroves, and seagrass beds absorb large quantities of the greenhouse gas carbon dioxide from the atmosphere and store it, thus decreasing the effects of global warming. These types of habitat are known as carbon sinks and contain large stores of carbon accumulated over hundreds to thousands of years.



Using more scientific lingo, coastal blue carbon is the carbon captured by living coastal and marine organisms and stored in coastal ecosystems. Salt marshes, mangroves, and seagrass beds play two important roles:

- **Carbon sequestration**—the process of capturing carbon dioxide from the atmosphere, measured as a rate of carbon uptake per year
- **Carbon storage**—the long-term confinement of carbon in plant materials or sediment, measured as a total weight of carbon stored

Why are wetlands important for helping to slow climate change?

Current studies suggest that mangroves and coastal wetlands annually sequester carbon at a rate two to four times greater than mature tropical forests and store three to five times more carbon per equivalent area than tropical forests. Most coastal blue carbon is stored in the soil, not in above-ground plant materials (biomass), as is the case with tropical forests.

Although coastal habitats provide a great service in capturing carbon, their destruction poses a great risk. When these habitats are damaged or destroyed, not only is their carbon sequestration capacity lost, but stored carbon is released and contributes to increasing levels of greenhouse gases in the atmosphere. As a result, damaged or destroyed coastal habitats change from being net carbon sinks to net carbon emitters. Unfortunately, coastal habitats around the world are being lost or degraded at a rapid rate, largely due to coastal development for housing, ports, commercial facilities, and recreation pressure.

Cape Cod salt marsh impacted by recreational fishing and herbivores
Photo: Tyler Coverdale

Research suggests that nitrogen from septic systems, stormwater runoff, and the air can significantly reduce a wetland's ability to store carbon. In some cases, high nitrogen pollution can increase the rate at which carbon breaks down in coastal wetland soils, leading to the release of carbon dioxide and nitrous oxide (a greenhouse gas that is about 300 times more powerful than carbon dioxide). Additionally, when wetlands are damaged or destroyed for development or agriculture, they release their store of soil carbon, which contributes to climate change and permanently removes that wetland as a natural sink for future carbon. Maximizing the potential of wetlands to store carbon must not only include protecting and restoring these areas, but also reducing the amount of nitrogen that enters them.

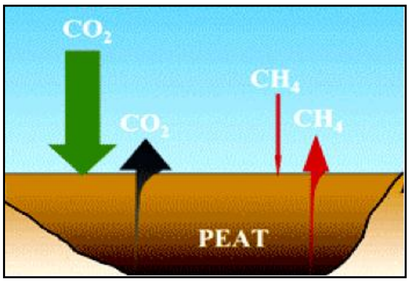
Reading 2: Methane from Wetlands: A Heated Debate

From "An unseen carbon sink" Nature Reports: Climate Change Vol. 3 Dec 2009

Did you know? *Methane is 25 times as powerful as carbon dioxide at trapping heat. It is a natural product of microbial action in wetlands.*

Globally, wetlands store an estimated 300 to 700 billion tons of carbon. "The existing storage of carbon in wetlands approaches the amount of carbon you have in the atmosphere," says Jon Kusler, associate director of the Association of State Wetland Managers.

Scott Bridgham at the University of Oregon in Eugene is "certainly in favor of conserving and restoring wetlands", but is concerned about "the M-word", referring to methane (CH_4), a short-lived greenhouse gas with 25 times the warming potential of carbon dioxide. In breaking down plant matter, microbes in peatlands release methane, which partly counteracts the positive climatic effects of CO_2 sequestration. The extent to which this happens varies from site to site, and measurements of both methane emissions and CO_2 sequestration are rare.



From: Peatlands in a climate change perspective, SLU

In studies in Ohio, scientists found that some of the wetlands draw down enough CO_2 that they are net carbon sinks despite their methane emissions. But while restoring wetlands can help protect their current carbon stores and improve their ability to sequester more, it also increases the amount of methane released, because anaerobic microbial activity increases as water level rises.

According to the Intergovernmental Panel on Climate Change's approach for estimating the balance, which some scientists challenge, the amount of methane released from intact wetlands typically appears to swamp out their carbon dioxide drawdown. In wetlands with large volumes of peat, though, the threat of losing some or all of the existing carbon stores trumps concerns about methane, which is why they are the favorite in the bid for carbon offset credits.

3: Getting the story: How scientists find out what's happening in the marsh

When beginning a field study, students sometimes want to study "the salt marsh" or "pollution." However, science is based on structured observations, testable questions, and replicable procedures, so factors and variables generally have to be measured one at a time. One of the greatest challenges of field studies is that many factors may influence each measurement.

Scientists are like journalists in some ways. They try to ask the best questions they can to find out what they want to know, and just as journalists may interview different people to get a story, scientists observe or measure more than one factor to make their information more complete. Scientists use specialized tools and instruments to get specific information on one or more parameters, factors that are measurable and relevant to the question.

Below is a table of some of the parameters being studied in the Bringing Wetlands to Market project. Scientists in the project are studying many other parameters; students will study a few of the listed parameters in their own wetland study to give them a better understanding of conditions and processes there.

Procedure

a. Distribute copies of the table of parameters to students, or project it for the class and give students a few minutes to review the information.

b. Choose one or two parameters in the table and ask students what a change in this parameter would indicate. Information about factors that influence many of the parameters is available in this tutorial designed especially for students
and in this table of information about water quality parameters

c. Choose a few parameters from the table and assign them to small groups of students. Ask the students to explain how each is related to one of the research themes of the project. Some of the research themes the scientists identified for this project are:

Quantify carbon sinks (uptake and storage processes) in tidal wetlands
Quantify greenhouse gas fluxes (flows) in tidal wetlands
Assess the impact of anthropogenic (human generated) nitrogen loading
Assess the impact of sea level rise

Bringing Wetlands to Market Research Parameters being studied (partial list)

<table>
<tr><th colspan="2">What is Being Measured?</th><th>Why is it Important?</th></tr>
<tr><td rowspan="3">Plant Properties</td><td>Biomass (plant material above and below ground)</td><td rowspan="3">We will analyze how these site conditions vary compared with greenhouse gas emissions, carbon stocks, and nitrogen loads in order to understand whether plant communities can be a useful “indicator” of the magnitude of these emissions.</td></tr>
<tr><td>Plant density (how closely spaced stems are)</td></tr>
<tr><td>Plant composition (types of species)</td></tr>
<tr><td rowspan="4">Climate Variables</td><td>Temperature</td><td rowspan="4">These parameters will be included in a model to represent the processes occurring in the marsh. We will investigate how they relate to greenhouse gas fluxes (movement or flow). They are thought to be some of the major controls on the magnitude and timing of these fluxes. The model may be useful to other scientists and resource managers to estimate the amount of carbon that is taken up and stored in a marsh under certain conditions.</td></tr>
<tr><td>Light</td></tr>
<tr><td>Precipitation</td></tr>
<tr><td>Wind</td></tr>
<tr><td rowspan="3">Soil Properties</td><td>Water level</td><td rowspan="3">We will analyze how these site conditions vary when compared with greenhouse gas emissions and carbon stocks in order to understand whether soil properties can be a useful “indicator” of the magnitude of these emissions.</td></tr>
<tr><td>Elevation</td></tr>
<tr><td>Salinity</td></tr>
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