Bringing Wetlands to Market Field Studies and Guidance for Adopting a Wetland
Field study parameters and carbon content of plants

This document provides guidance for students to design a **field study** and suggested methods to **collect data** for their research questions.

Planning a student field study

Using a wetland identified in exercises from the Bringing Wetlands to Market curriculum, or another local wetland or coastal ecosystem, students can identify one or more research questions and design a sampling plan. When choosing a topic for the research question, it is valuable to consider local issues, and make the field study part of a stewardship or community service project.

As the technology component of the project, students could select or design an instrument, equipment, or a method for investigating each research question, and propose practices for low-impact sampling, to protect their study site from damage.

If your students can't get to a wetland in person, they can still carry out a study by adopting a site at an Estuarine Research Reserve. Each Reserve has data on several parameters available from several sites, and all the data is accessible via the graphing application (here) introduced in BWTM Part 2 Exercise 2.

Students can choose a site at a NERR, and then proceed with designing a research plan using System Wide Monitoring Program data to investigate their questions. For more information about their NERR site and if they have questions, students can contact the Education Coordinator or Research Coordinator at their chosen Reserve. Visit the NOAA web site to find a Reserve and staff contact information

Planning and conducting the field study

Ask students to work in small teams to plan a field study. Their plan should include

a. A testable research question, if possible related to a question in the Bringing Wetlands to Market study

b. 2 to 5 parameters to observe or measure and why they will be sampled

c. A map of their preferred study area and chosen sampling sites

d. The instruments they will need to use

e. A data sheet

f. A plan for reviewing data and making graphs or visualizations to display results

g. A plan for communicating their results: who will the audience be? How will students tell their story?

Students will find it useful to compare their results with data from the Bringing Wetlands to Market project (http://www.waquoitbayreserve.org/research-monitoring/salt-marsh-carbon-project/) when it becomes available, or from another Reserve in the National Estuarine Research Reserve System. The larger data sets available from the System Wide Monitoring Program (SWMP) will help them decide if the data they collect is representative or unusual, and they can find out the range of variability for their parameters by consulting the NERRS data.

Resources for reference data and field studies
Graphing tools for NERRS data here
Instructions for graphing tool (educational website)

Suggested parameters for student field studies
The following parameters do not require much specialized equipment and can yield useful information about a wetland. Use procedures from links here for suggested protocols. The first three parameters (as well as many others) are measured in the SWMP monitoring system, and a wide array of data sets are available through the graphing applications noted above. A basic guide to interpreting data for some coastal wetland parameters is included below.

Temperature of air, water, and/or soil
This parameter is relevant for plant growth, evaporation rate, and climate change. Water temperature determines its capacity for dissolved gases, including oxygen and carbon dioxide. The GLOBE protocol for water temperature includes practical considerations. The GLOBE protocol for air temperature is here.

Sunlight or photosynthetically active radiation (PAR)
This parameter is directly related to photosynthesis, plant growth, and carbon uptake.
It can be measured with a data logger or a light meter. Free applications are available for mobile devices that will allow students to measure light levels in the field. SWMP weather stations measure PAR.

Salinity (saltiness)
Salinity determines what types of plants can survive in an area, and influences how much oxygen and carbon dioxide can dissolve in the water. Salinity can be measured using a simple aquarium swing-arm hydrometer or a refractometer.

Plant community structure and diversity (what species are in a certain location)
Plant study should include ID of major plant types; it could include transect and/or quadrat surveys and estimates of percent plant cover. Here is an example of an ID guide for the southeastern US Coastal marsh plants of SE US . Check online for an identification guide to wetland plants in your area.

Sediment cores

Besides using a sediment core to identify wetland soils as outlined in the BWTM Basic field Studies document, students can take one or more sediment cores to learn about past conditions in the marsh and storm events. Have the students examine different sections of the core samples to find evidence for past conditions, such as storm events, which may show up as a layer of sand in an otherwise organic core.

At right is an image of a marsh core with a changes in layers associated with a tsunami in 1700. For more information about this, contact the South Slough NERR education coordinator.

Have students take cores from two different areas, and do a smudge test for color to establish whether it is wetland soil; have them use observations to determine the general proportion of organic (plant-derived) vs. mineral (rock-derived) content. Organic soil tends to be more carbon-rich than mineral soil

Additional procedures are given below for using cores to find the percent of organic material in a wetland soil sample.

If you can't get a soil sample from your study area, you can use images of soil cores. Here is an image with a timeline and explanation: Marsh core image

When coring, students should keep in mind the motto "first, do no harm" as they plan their sampling; for example, if it is possible to examine a core and then return it to the ground or plug the hole, this should be done. A fun technical challenge for the students is to make their own coring tool. Some images of a homemade coring device can be seen here.

Data Loggers

If data loggers are available, they can allow sampling over extended periods and provide data to complement other observations and samples. Some data loggers are relatively inexpensive and can be used to measure air, water, or soil temperature and light levels. It is best if data loggers are waterproof, so they are suitable for deployment in a marsh or other wetland.

A combination of temperature and light measurements can be used for many research questions analogous to those in the Bringing Wetlands to Market project. For example, students could compare the amount of sunlight available to plants in a salt marsh to the light available on the ground in a woodland, or compare the influence of clouds on light levels and temperatures.

Engineering Design Challenge: Low-impact sampling

The students need to plan how to make observations and collect data without having a detrimental impact on the wetland. Ask them to design a method to allow access for many student researchers along the wetland border or along a marsh creek without compressing the soil or increasing erosion. Please don't allow your students to go out on the surface of the marsh, since trampling the plants with large numbers of students can have long-lasting negative impacts.

Finding the Carbon content of Soil or Plants

One of the goals of the Bringing Wetlands to Market project is to develop a tool to help local coastal managers calculate the value of local wetlands as carbon sinks. With these procedures, students can measure the amount of organic material in a core sample and estimate the amount of carbon in samples of wetland plants and in their study site. Detailed notes for measuring plant biomass are available here.

Estimating the amount of carbon in a plant sample

1. Calculate the amount of carbon in the plants growing in your wetland. You can use the GLOBE protocol for Graminoid Biomass (Graminoid refers to grass-like vegetation) but include the revised steps listed here. Note: The plants collected for this part of the study may be obtained while students are carrying out other field studies for this unit.

    a. Before going to the study area, have students read the "notes on measuring biomass" included below

    b. At the study area, have students use a field guide to identify the two or three most abundant plant species. Have students use quarter-meter or meter-square quadrats, or use tape measures or string, and estimate the number of individual plants of these three species per meter for representative sites. Estimate the total percent of your study site that is covered by one or more of these species. Record these estimates

    c. Students should take at least 5 samples of the most common plants and include as much of the root structure as possible, as long as the roots clearly belong to the plant they are sampling

    d. Place the plant samples in a dry paper bag and bring them back to class. Measure biomass using the GLOBE protocol. This requires a drying oven, which maintains a low heat over many hours. If your art department doesn't have an oven you can use, you or a student may have to dry the samples at home, or try setting them on a shelf near a sunny window.

    e. When you have found the biomass, the carbon content may be estimated by simply taking a standard fraction of the biomass. The UN Food and Agriculture Organization recommends this value:

$$C = 0.475 * B$$

    where C is carbon content by mass, and B is oven-dry biomass. Record this value for your samples of each plant species.

2. Next, students should calculate the amount of carbon in the peat or soil and estimate the volume of the peat.

   a. Use a trowel or soil coring device to take a sample of the peat down to at least 20 cm

   b. Examine the sample and estimate the percent organic material. If possible, take a sample back to school and dry it as you did the plant material. When it is dry, try to separate the organic (formerly living) material from the mineral (sand, pebbles, and clay) material, and weigh the organic component. If you cannot process a soil sample, assume the peat is about 50% organic; and of the organic matter, you can estimate it is about 50% carbon by mass.

   Alternative procedure for finding the percent organic material in a wetland soil core: This procedure was used as part of the South Slough NERR Teachers on the Estuary program in August 2013. The method uses the difference in pre- and post-drying mass of a sample, and requires use of a sensitive lab balance and access to a "muffle furnace" or kiln which can burn off organic content in a sample.

   If your site is a marsh, try to determine the **depth of peat** at your study site. This is an engineering challenge! Scientists use a “peat rod”, which is a metal or fiberglass rod about 1.5 cm wide and 120 cm long, and push it into the marsh peat until they feel that they have reached rock or sand. Since peat rods are expensive, students can suggest an alternative method or tool to measure the depth of the peat.

3. Determine the area of your wetland
   a. Use Google Earth to identify the wetland you will study. Use the "polygon" tool to outline and name the area.

   b. Go to the Earth Point web page. On this page, there are easy instructions and a tool for finding the area of your wetland based on the Google Earth polygon

4. Calculate the volume of the carbon in your wetland
   Plant carbon:
   - Multiply the average carbon mass for your one or two dominant plant species by the average number of plants per square meter. The number will be in grams of carbon per square meter.
   - Multiply that result by your estimate of the area in square meters covered by that species at your study site. This will be an estimate of the mass of carbon in the plants at your site, and the number will be in grams of carbon.

Soil carbon:

- Multiply the average mass per unit volume of the organic material in the soil cores by 0.5 to estimate carbon content for the soil in your study area. Calculate this in grams per cubic meter.
- Calculate the volume of wetland soil at your site by multiplying soil depth times area; you may have measured or estimated these for your study site. The result will be in cubic meters.
- Multiply these two numbers together to get an estimate of the mass of carbon in your study site in grams. You may wish to convert this to kilograms.

Add the calculated mass of the plant carbon to the calculated mass of the soil carbon to get a general estimate of the mass of carbon at your site.

Water Quality Parameters Information Sheet

Water Test	What It Measures	Natural Reading	Danger Reading	Influenced by	Comments
Water Temperature	Amount of heat in water	0° - 30° C	Generally above 27 C (81 F)	-- solar heat -- groundwater --industrial cooling	Many estuarine organisms have a narrow temperature tolerance range
pH	Acidity or alkalinity of water,	Freshwater is typically between 6 and 8; salt water generally 8 or higher	Below 6 or above 8.5; some freshwater areas may have natural pH of 5 - 6	-- local plants and soils -- acid rain -- atmospheric CO_2 -- chemical spills	Low pH levels affect the ability of organisms to incorporate calcium carbonate
Turbidity	Clearness of the water (NOT color)	0-10 NTU, Nephelometric Turbidity Units	Above 20 NTU	-- sediment -- excessive algae growth -- storms	Turbidity determines how much light can penetrate to reach seagrasses. It is an indicator of the level of phytoplankton or silt in the water and is closely linked with eutrophication.
Dissolved Oxygen	Amount of available oxygen in water (in between water molecules)	5-12 ppm (parts per million)	Below 5 = stress 1-3 = poor 0 = anoxic (no oxygen)	-- photosynthesis -- wind -- waves -- running water	D.O. is vitally important to estuary organisms. Warmer temps allow less O_2 to be dissolved. Decomposers may deplete d.o.
Dissolved Oxygen Percent Saturation	Amount of oxygen in water relative to calculated saturation level	0% (anoxia) to 200% (supersaturation)	Below about 70% = stress Below 50% = poor 0% = anoxic, fatal for many organisms Supersaturation, > about 120% can be harmful	~ photosynthesis ~ respiration ~ temperature ~ salinity ~ wind and wave action	A wide variation in d.o. saturation over the course of a day is a sign of eutrophication. Warm water holds less d.o. than cold; salty water holds less d.o. than fresh.
Salinity	Amount of salt in the water	0 ppt (parts per thousand) for freshwater; about 5 – 30 ppt for estuaries; about 35 ppt for oceans	Salinity can be 40 ppm or higher in salt marsh tide pool on a hot day; lethal for most estuary creatures.	--tide level -- rain events -- evaporation -- local geology & soils	Most marine and aquatic organisms are adapted to either fresh water (0 ppt) or sea water (35 ppt). Some estuarine organisms and anadromous fish can tolerate a wide salinity range
Water level	Depth of water	0 m (meters) if uncovered at low tide; up to tens of meters in estuaries	Depends on location; if normally submerged, 0 m is danger reading.	-- tides -- wind direction -- wind speed -- storms -- atmospheric pressure	Estuaries have wide variation in water levels. Some organisms must be able to survive both salt water inundation and exposure to air.