EES 022: Exploring Earth

Name________________________

Today's Date____________

Lab Due Date____________

Carbon in the Environment

Abstract:

You will be collecting data on the carbon stocks within three general land types, a cultivated field, an abandoned field, and a reclaimed forest. The data collected will be used in later labs to analyze the changes in carbon storage and release due to land use change.

To be completed BEFORE Lab:

Visit http://www.ei.lehigh.edu/esse/carbon to learn about carbon and the carbon cycle.

Lab Goals/Objectives:

1. Collect multiple soil cores from three different land use types.
2. Identify age of a reclaimed forest using tree cores.
3. Record tree diameter and number of trees per unit area within the forest.
4. Prepare and analyze soil respiration experiments.

Key words:

- Biomass
- Carbon density
- Respiration
- Sequestration
- Carbon flux
- Soil profile

Materials:

- This handout
- Tree corers
- Soil corers
- Sieves
- Plastic bags
- Sample bags
- Gloves
- Markers
- Soil respiration manometer
- Data Sheets
- GPS
- Camera
- Hand Trowel
- Chalk

Introduction

Carbon moves within the environment through a biogeochemical cycle important for sustaining life on our planet. Atoms of carbon that compromised rocks millions of years ago have traveled a torturous path through many environments and changed chemical form to eventually end up in the living tissue of yourself and other organisms.

This assignment will focus on one small part of the global carbon cycle, carbon that is temporarily stored modern soil and plant material. Our investigation will gather information on the effects that our use of the environment has on quantity and distribution of carbon within these terrestrial environments.

Section 1: Soil Carbon

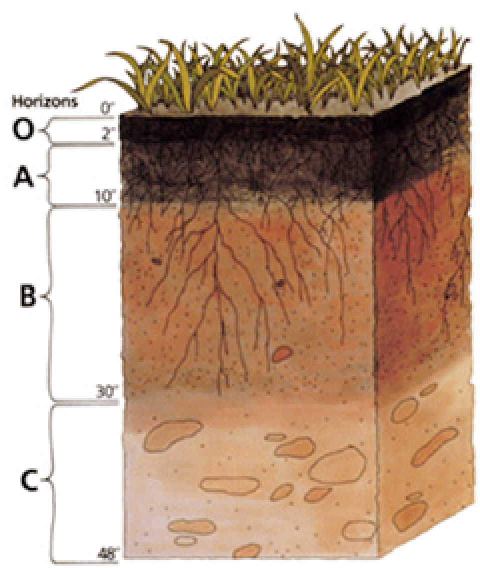


Fig. 1 An idealized soil profile.

Soils are formed through the weathering of [rock] and the breakdown of organic matter (e.g. plant litter, animal waste, microorganisms) to humus (found in the O horizon), a dark nutrient-rich material. Because of these two ingredients, soil is said to be composed of both organic and inorganic material. For our lab we are most concerned with the organic components of soil, since this is where the majority of carbon is stored within soil. Calculating just how much carbon is stored in this thin layer of material over a large area is a difficult task due to environmental varaibility such as rainfall, temperature, and plant communities, selecting a small study area we can limit and characterize the variability to understand the relationship between carbon storage and land use. This lab will collect multiple soil samples from the same geographic area to estimate the size of this important carbon resevoir in three different land use types, an active agricultural field, a reclaimed forest, and a mown lawn.

Questions to Consider

Knowing that the decay of plant litter contributes a significant proportion of carbon in organic rich soils, how would the three land use types differ in dead and decaying litter inputs?

What activities involved in growing crops or managing a manicured lawn may affect your expected observations?

Fig. 2 An index map of the Goodman campus and the lab study area.

Procedures

Within each land-use group a TA will assist you in extracting two soil samples from a shallow soil pit.

Each group will be responsible for collecting a GPS location of the soil sample, a digital photographs of the area, and completing the attached data sheet recording sample number, sampling depth, depth of O horizon, and general description of sampling site. The samples will be sieved back in the lab, removing all visible plant roots and woody matter.

Using a hand trowel and plastic sample containers insert and remove $5cm^3$ of soil at 5cm depth. Place the material into a labeled sample bag for the soil respiration experiment back at the lab.

Section 2: Woody Biomass

The storage of organic carbon in the soils results from the decay of plant litter and biomass that accumulates above ground. The carbon that accumulates from the growth of root systems and trunks of trees represent a temporary carbon reservoir with a storage time equivalent to the average life span of the tree specie. We will estimate the size of this carbon reservoir by conducting a tree count within the forest stand.

Measure the area of the designated tree stand by walking along the edge of the forest stand and recording way points using the GPS receiver. These points will be plotted to find the total area of the forest next week.

Using the diameter measuring tape and the diameter calipers record tree diameters greater than one inch within the designated area. Record these values on the attached data sheet. Use the chalk to identify which trees have already been recorded.

The diameter values will be used to estimate total biomass of each tree and the corresponding quantity of carbon sequestered in the woody material in next weeks lab. The tree count and area measurement will estimate the density of trees within the forest stand, a value that can estimate future carbon sequestration by tree growth if the adjacent agricultural land was abandoned.

Section 3: Timing of Field Abandonment

Like the majority of the Lehigh Valley, the stand of trees we are investigating was at one point active agricultural land. As farmland has been developed for residential use, communities have promoted the re-growth of trees on lands not utilized by developers. We will estimate the timing of agricultural abandonment by two methods, using the oldest tree ages and investigating historic aerial photography next week.

Using the tree count and diameter data locate and record the GPS location of the four largest trees, which most likely represent the earliest growth after the field was abandoned.

With the assistance of your TA take a core, half the length of the diameter, from each tree and using the magnifying lenses count the number of tree rings. A 2nd group member should independently re-count the same core and record the ring counts on the attached data sheet, along with the GPS location.

Back at the lab, sets of historic aerial photos will be provided which can bracket the timing of the field abandonment and subsequent growth of the tree stand. You TA will assist you in recognizing patterns within the photographs for identifying land-use type.

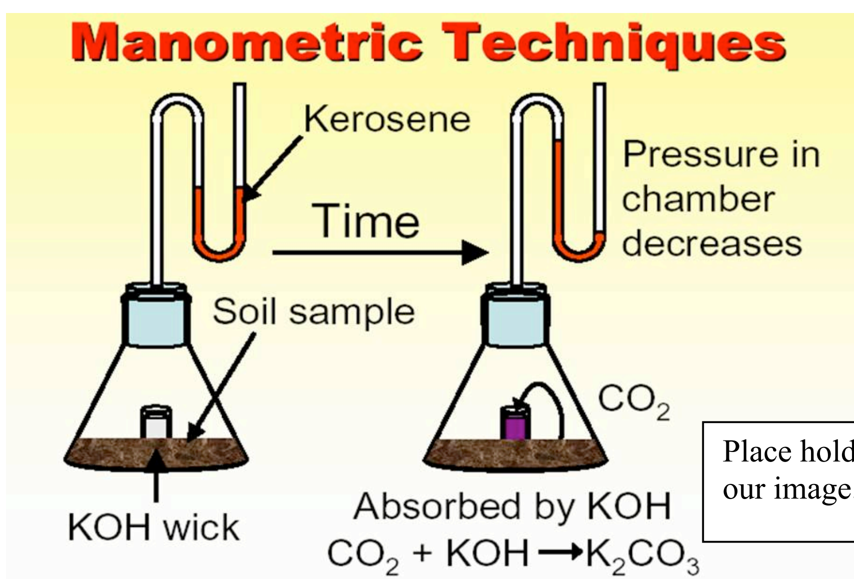
Section 4: Soil Respiration

Approximately 80% of the carbon within dead leaves and plant litter returns to the atmosphere as carbon dioxide through the respiration of decomposers like bacteria and fungi. The rate at which these organisms respire can be considered a flux rate of carbon from the biosphere to the atmosphere. Different bacterial communities within the different land use soils may have significant impact on this carbon flux rate, resulting in different accumulation rates of organic carbon within each soil. Using the non-sieved soil samples collected in the field, a laboratory experiment will be constructed to estimate the soil respiration rate from each land use type. The experiment uses a simple device called a manometer, which measures the pressure difference between a sealed container and the outside air. The pressure difference will be a measurement of how much carbon dioxide has been released over a ~24 hour period.

Once back in the lab you will first measure the result from the previous day's soil respiration experiment.

Using a ruler and marker carefully draw a line to indicate the height of the colored fluid column on each side of the manometer 'U'.

Measure the distance between your mark and the previous



Place holder for our image.

starting point for each column of water on either side of the ‘U’. Record the distance in mm on the graph sheet. Transfer this data to the class’ Excel spreadsheet.

The pressure difference results from the decomposers consuming oxygen within the sealed container and respiring carbon dioxide, which is absorbed by the KOH wick. The consumption of oxygen and absorption of carbon dioxide removes gas from the sealed container creating a small vacuum and pulling the column of fluid up the left hand side of the ‘U’ while the outside air pressure pushes down on the right hand side.

Your TA will empty out each of the sealed containers and weigh the new soil sample you have collected in the field.

Before transferring your soil samples to a clean manometer, carefully mark a new graph sheet with a line adjacent to each column of the “U” that indicates the starting position of the red fluid. Label the graph sheet with your group members’ names and Sample ID#.

Label the flask with your sample ID# and add the soil sample to the flask, ensuring an even surface, your TA will add the small container of KOH later.

Immediately seal the flask using the attached rubber stopper, careful not to disrupt the tubing.

Lab Date__________________

Group Members_______________________

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Soil Core Data

Forested Soil Sample ID#_______________________

GPS Lat/Long______________________________

Sample Depth (cm)___________ Depth of O horizon (cm)_______________

Agricultural Soil Core ID#_______________________

GPS Lat/Long______________________________

Sample Depth (cm)___________ Depth of O horizon (cm)_______________

Mowed Lawn Soil Core ID#_______________________

GPS Lat/Long______________________________

Sample Depth (cm)___________ Depth of O horizon (cm)_______________

Lab Date___________________

Group Members_________________________

____

Tree Diameter Data

Tree Count	Tree Diameter

Lab Date___________________

Group Members________________________

____

Tree Core Data

Tree Sample #___________

GPS Lat/Long ____

Tree Diameter __________

1st tree ring count ___________ 2nd tree ring count__________

Tree Sample #___________

GPS Lat/Long ____

Tree Diameter __________

1st tree ring count ___________ 2nd tree ring count__________

Tree Sample #___________

GPS Lat/Long ____

Tree Diameter __________

1st tree ring count ___________ 2nd tree ring count__________

Tree Sample #___________

GPS Lat/Long ____

Tree Diameter __________

1st tree ring count ___________ 2nd tree ring count__________

Lab Date___________________

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GPS Waypoints for Forest Area

Waypoint#	Latitude	Longitude

Carbon Lab Data Summary Notes

Soil Carbon Density

- Percent Carbon Concentration was measured each day and the standard error calculated.
- Assuming a bulk soil density of 1gm/cm^3 we can calculate the carbon density or mass of carbon per unit volume of soil.
- Applying the known or assumed depth of the O-horizon the carbon density per unit volume is translated to carbon mass per unit area of each of land use types.

Carbon Respiration Rates

- The mass of carbon released by the respiration of microorganisms was measured using the lab manometers.
- Again by applying the known or assumed depth of the O-horizon the respiration rates can be translated from a unit volume of soil to a unit area of land use type.
- Since the carbon respiration rate is a measurement of the decomposition of organic material by microorganisms and we know that microorganisms release 60% of the organic material they decompose, we can calculate how much carbon is transferred to the O-horizon of the soil. We can also calculate the total amount of carbon that was available for the microorganisms to decompose in the first place.

Tree Data

- All of our diameters measurements were placed in bins of different diameter ranges. The number of trees that fell within each diameter range tells us the frequency distribution of the trees within the forest stand.
- By applying the percent frequency distribution to our total tree tally we create an estimated size distribution of all the trees in the forest.
- Inputting the tree diameters into the Biomass Calculator yields how much cellulose is found in each tree.
- 60% of cellulose is carbon
- By adding all the carbon in each tree we find the total carbon that is being stored within the trees.
- Dividing the total biomass carbon by the area of the forest yields the carbon density per unit forest area.
- Dividing the number of trees within the forest by the forest area yields a tree density.
- As a forest ages the older trees represent the greatest portion of carbon stored within the forest. The USFS data models how carbon within an aging forest is sequestered.

Carbon Lab Presentation Requirements

Develop a question that can utilize the data we collected as a comparison of land use today, a projection of land use in the future, or a study of historic land use within the watershed or campus.

The introduction should outline your question, why it is scientifically significant, and present the location of the study.

Methods should clearly state how we collected the data and what steps you took to analyze the data, such as calculations or comparisons to other information.

Results and Analysis should clear state your findings and how the data supports your interpretation of the results.

Conclusion should restate the "take home message" of you study and relate how your study is a component of a greater system (i.e. the global carbon cycle, land use planning, global economic development, etc.). Feel free to expand upon how you study could progress in the future.