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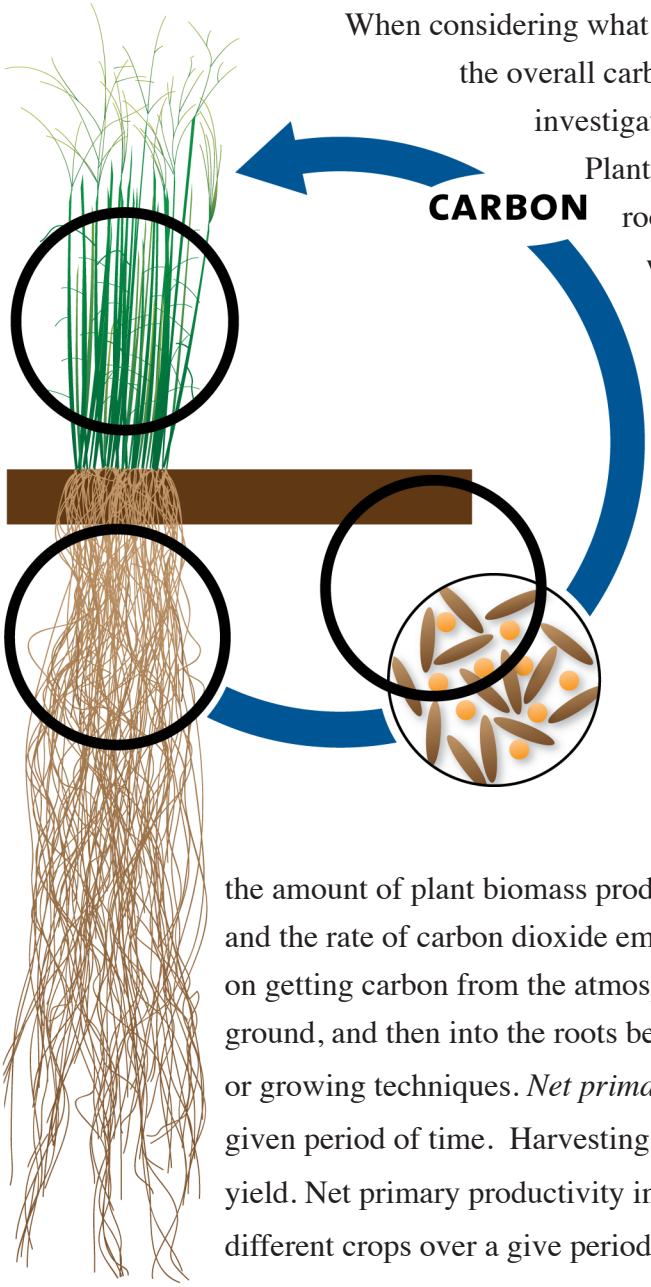
Field Investigations: Biomass Yield and Root Growth in Crops

Consider what you know about photosynthesis and cellular respiration. How does carbon become part of a plant? Which part of the plant? In what ways does the carbon get released from the plant? Where does it go?



When considering what plants to grow for sustainable biofuels we must look at the overall carbon cycle of all the steps involved in production. These investigations focus in on what happens on the field and underground. Plants *sequester*, or capture, carbon in their leaves, stems and roots in a variety of molecules, including carbohydrates, which can be harvested to make biofuels. Normally, some of the plant is left behind on the field or underground after harvesting. Soil microbes may then consume those roots, or pieces of dead plants and return carbon dioxide to the atmosphere through cellular respiration. Decisions farmers make as to what to plant, how to plant and then later, how and when to harvest these crops affect soil microbial activity and decomposition rates--influencing how much and how quickly carbon from the plants is returned to the atmosphere.

When comparing potential feedstocks (crop options) and field treatments for biofuel production, scientists measure the amount of plant biomass produced above ground, the rate of root growth below ground, and the rate of carbon dioxide emissions from the soil. In this investigation we will focus on getting carbon from the atmosphere into the plant--first into the leaves and stems above-ground, and then into the roots below-ground, making comparisons between different species or growing techniques. *Net primary productivity* is useful to investigate plant growth in a given period of time. Harvesting above ground, this provides information on the potential yield. Net primary productivity in roots gives an idea of the carbon sequestration potential of different crops over a give period of time.

In this activity, you will design an experiment to measure plant growth rates in the field to gather data to help determine the best crop choice for biofuel production.

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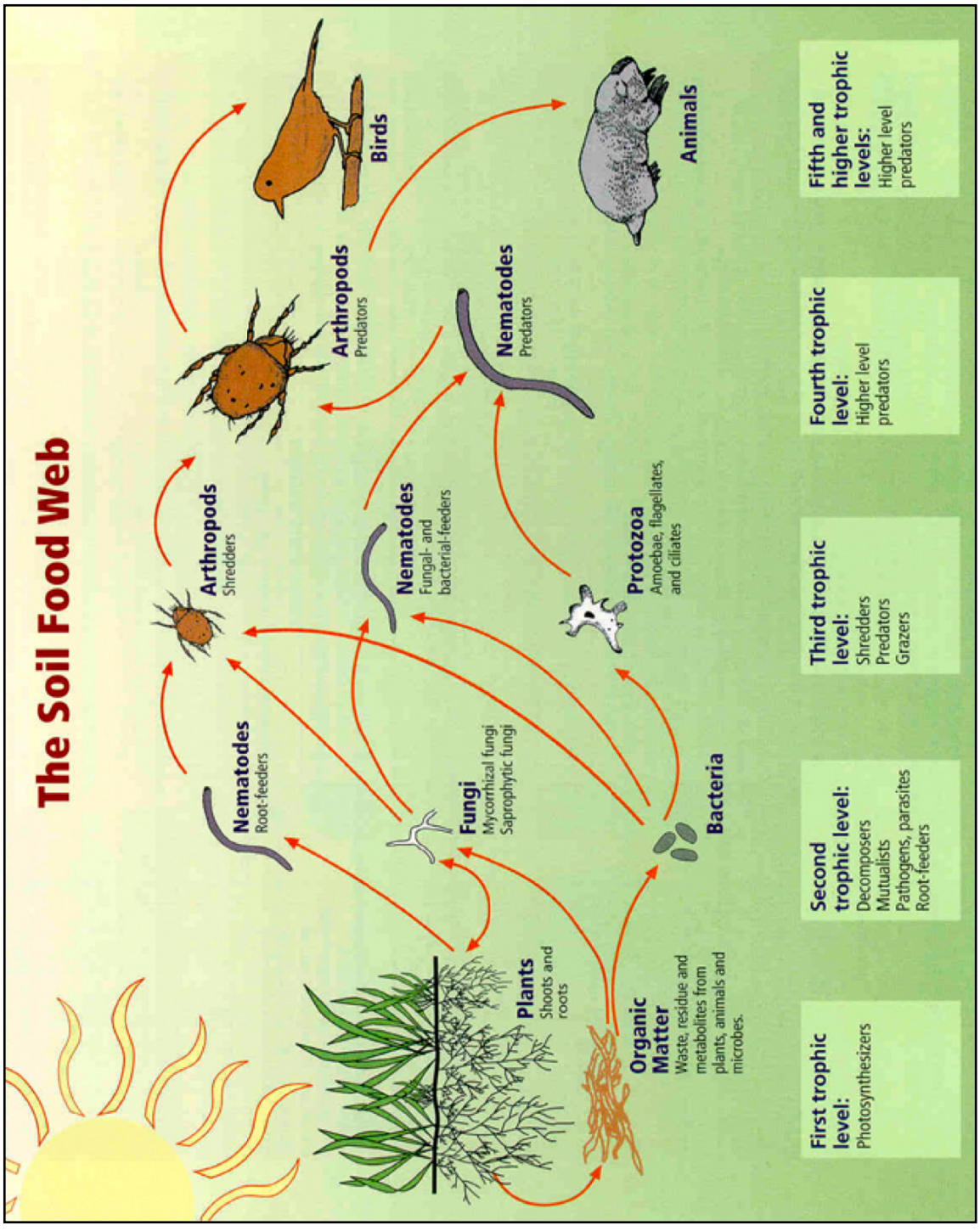

Soil food web showing plants, organic matter, microbes, invertebrates, and birds and mammals.
Image courtesy of USDA Natural Resources Conservation Service, *http://soils.usda.gov/sqi*

How does carbon enter this system?

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Experimental Design

1. What question will you investigate? Why is this of interest?

2. Which technique(s) will you use to collect data? How many replicates will you have?

3. Where will you do your sampling? (you may want to mark sites on a map) Why are you choosing those locations?

4. When will you do your sampling? Over what period of time? Why?

5. Do we need to take any precautions when walking out to or working in the sampling area? If so, please describe them and explain their necessity.

6. What is your hypothesis? Explain what you predict will occur and **why** using solid scientific reasoning.

7. Describe the type(s) of evidence you will collect and how they will be recorded. Use another piece of paper if necessary.

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Site Description

Observer's name _____

Site name _____ Date of observation_____

Address or latitude/longitude _____

Time of observation _____

Habitat description:

Type of vegetation _____ # species ____

Annual or perennial or mixed? _____

Vegetation height _____

Size of habitat _____

Soil cover? *None* *dense vegetation* *litter cover* *other* _____

Soil moisture *Dry* *Average* *Saturated* *other* _____

Soil temperature _____

Site use history _____

Land management description (burned, tilled, fertilizer use, etc) _____

_____

Adjacent land use (wooded, grassland, agricultural, urban, etc) _____

_____

Weather:

Air temperature ___ Daily high/low _____

Cloud cover? *None* *mostly sunny* *mostly cloudy* *complete cover*

Wind speed _____

Precipitation at time of sampling _____

Precipitation in last 24 hours _____

Site map and other relevant observations:

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Field Instructions: Biomass Yield

Objective
To investigate plant growth above ground in a given period of time. This provides information on the potential yield.

Sample Questions
What is the yield of a corn field compared to a prairie?
How does fertilizer affect the yield of this switchgrass?
Should perennial grasses be harvested once or twice a year to maximize yield?

Materials

- 1-2 pairs of scissors or shears
- Quadrat – 30 cm x 30 cm squares can be constructed with rulers (small hoola-hoops work well)
- Pan(s) for collecting and drying
- Oven for drying
- Optional: garden gloves

1. Locate sample field.
2. Randomly toss quadrats into field site.
3. Clip and collect all above-ground portions of plants rooted within the quadrat.
4. Dry this material in an oven for 24 hours if possible (at least overnight) at 105 ºC (225 ºF).
5. Mass the dry material the following day.
6. If an oven is not available, use a microwave to do the drying:
    a. Create a donut ring of biomass—mass starting weight.
    b. Place a glass jar half-full of water in the microwave (to protect microwave).
    c. Microwave for one minute—mass again.
    d. Repeat until mass doesn't change more than 1/10 g.
7. Average your results and compare to other fields.

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Field Instructions: Root Growth Rate

Objective
To investigate root growth and carbon sequestration potential of different crops over a give period of time.

Sample Questions
How much root growth occurs over the summer in a prairie compared to an abandoned field?
Does tilling the soil allow for more root production?

Materials

- #5 plastic mesh plastic canvas sheets
- E6000 Adhesive or similar product
- Utility knife or scissors
- 2" knockout test cap
- Masking Tape
- Stapler and staples
- 1-4 pair of tweezers
- Tray(s) for separating root mass
- Bulb planter, 2" dia. soil probe or 2" dia. soil sampling tube
- Marker flags for each core
- Shovel
- Ruler
- Optional: garden gloves

Constructing the core screens

1. Cut the #5 plastic canvas to the desired height and width. The standard height of an in-growth core is 15 cm. The width is determined by the size of the knockout cap. Check to be sure the canvas rolls up (without gaps) and fits snugly in the knockout cap with ½-1 inch overlap.
2. Use this sheet as your template and cut addition pieces if you will be making more than one corer.
3. Staple the end of the core screen and glue it to the test cap with E6000 adhesive. Be sure to do this (and allow it to cure) in a well-ventilated area.
4. Staple along the long axis of the column. These staples may not stay in place well, but they will function as a semi-permanent clamp.

5. Reinforce the staples with tape on the outside of the screen if necessary to hold it together.
6. Apply adhesive along the seam in the column and allow to cure (~24 hours).
7. Place upright. Allow to dry overnight.
8. Remove the tape after the adhesive has dried and check to be sure the core screen will not easily pull apart.

Installing an in-growth root core

9. Define your study area. All cores should be dug at least one meter from the edges of plots and one meter away from other holes. Select a day to install the core screens when it has not recently rained.
10. Mark each site with a marker flag.
11. Using the long-handle bulb planter, extract a core of soil 15 cm deep. Try not to make the hole any wider than the core screen. If you dig too deep, replace some of the soil, but don't pack it down too much. Be careful to preserve the soil core you remove.
12. Working over a tray, begin to remove the roots from the soil core by carefully breaking it apart and by using the tweezers. The roots can be discarded, but save the soil.
13. Once the roots have been removed, pour the soil into the core screen. It may be helpful to work over another pan so that if soil misses the core screen, it can still be used.
14. It is okay to lightly press the soil into the screen, but pressing hard can change the consistency of the soil.
15. Place the loaded core screen into the hole you dug.
16. You may wish to create a map of your flag locations.

Removing an in-growth root core (to be completed by students)

1. At the end of the growing season or the desired interval of time, locate your flag.
2. Dig up the core using a shovel. Remove the core and some soil around it.
3. Carefully scrape off the excess soil (try not to pull exposed roots from the core) from around the core and cut the roots that are outside of the core.
4. Empty a core into the pan.
5. Separate out the roots from the soil using tweezers and by breaking the soil apart.
6. Mass the total root matter.
7. Place the roots in an oven-safe container and dry for 24 hours if possible (at least overnight) at 105 deg C (225 deg F).
8. Mass the total root matter again.
9. Average your results and compare to other fields.

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Data Analysis and Discussion

1. After you analyze the results of your experiment as indicated by your teacher, summarize the evidence you collected in the space below and describe whether or not your hypothesis was supported.

2. Describe any unexpected events or problems that occurred that may have affected the results of your experiment. Are there any ways to avoid those issues and improve your methods?

3. Draw a diagram which demonstrates how carbon moves through your study site. Include the plants, roots, soil organisms with linking verbs describing the processes that are occurring.

4. Using what you have learned from your readings and evidence gained from this activity, explain why burning fuel in our cars that was made from plants might reduce greenhouse gas emissions more than burning fossil fuels. Provide one or two pieces of advice for a farmer who is trying to decide what to grow or how to grow crops to be used for biofuels if they want to reduce overall emissions from their field.