Root Depth Model

In this activity, raffia ribbon is used to create a visual representation of the differing root depths in biofuel crops and prairie plants. The wall hanging can be used to promote discussion about plants' ability to sequester carbon and soil carbon.

Supplies:

- Paper/Cardstock, Paper Cutter (optional), Scissors, Tape, Raffia Ribbon

Directions:

1. Print the 8.5x11 banner pages for the Prairie Plants and/or Biofuel Crops. For a stronger banner, print on heavy paper or cardstock.
2. Cut the banner pages so that they overlap, using a paper cutter for more precise lines. Tape them together.
3. Cut a piece of raffia the length of the banner. Place it underneath the arrows to create a soil line.
4. Cut pieces of raffia the length of each of the roots depths.
5. Attach the raffia to the banner by tying the pieces to the soil line, or taping them directly to the banner.
6. Attach the soil line to the banner by placing tape in between each of the roots.

Root Depths of Biomass Crops:

Corn - 3'
Soybean -6'
Canola - 5'
Hybrid Poplar - 4.5'
Miscanthus - 8'
Switchgrass - 11'
Sugar Cane - 6'

The third page of this document contains the root depths of the prairie plants.

Discussion:

<u>How do plants sequester carbon in the soil? What causes this carbon to be released back into the atmosphere?</u>

- Plants put carbon underground via their roots. Carbon dioxide is taken up during photosynthesis, reassembled to form glucose and then again transformed into root material. When roots die they do one of two things: break off and remain in the soil, contributing to soil organic carbon, or they decompose, releasing carbon into the atmosphere in the form of carbon dioxide.
- Soil microbes are responsible for decomposition. Decomposition occurs more quickly in places where root material dies in moist, oxygenated soils with a healthy population of soil microbes.

<u>What does this model demonstrate about the ability of plants to sequester carbon?</u>

- There is a great deal of plant material underground. Plants with longer roots, such as cylindric blazing star or compass plant, are putting their carbon matter much further down into the soil than species like Kentucky blue grass.

What factors are not shown in this model that influence the amount of carbon that moves into and out of the soil?

- This model only shows root length, not root biomass. (See the table on page 4 for data on root mass). Perennials create more root biomass than annuals and therefore have the potential to sequester more carbon.
- This model does not distinguish between perennial and annual crops. Crops that need to be replanted every year cause more soil disturbance and lead to increased decomposition of dead plant material. Soil disturbance improves conditions for decomposers in the soil, providing oxygen and additional root biomass as food. Carbon from the roots does not stay underground but rather is returned to the atmosphere in the form of carbon dioxide.
- Certain agricultural practices also cause more soil disturbance and a greater loss of stored carbon. Tilling will cause a greater loss of carbon because root matter will be able to decompose when it comes into contact with microbes. No-till practices are better for carbon sequestration.
- Dead roots that are buried deep into the soil are less likely to decompose.

Extensions and Variations:

1. As a warm-up or follow-up activity play the Fields of Fuel video game or Bioenergy Farm board game so students can grapple with the economic- environmental tradeoffs associated with farming in a realistic multiplayer simulation.
2. Before this activity, have students read and discuss the short Science of Farming research story for an in-depth look at the scientists working on this experiment.
3. Before this activity, have students complete the Growing Energy Data Dive comparing biomass yields between different crops.
4. Have students conduct their own investigations using the Field Investigations: Biomass Yield and Root Growth in Crops to strengthen their understanding of the ability of plants to sequester carbon above and below ground.

References:

Cahill, K.N., Kucharik, C.J., & Foley, J.A. 2009. Prairie restoration and carbon sequestration: difficulties quantifying c sources and sinks using a biometric approach. Ecological Application, 19(8), 2185-2201.

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Friend, A.L, Scarascia, Mugnozza, Isebrands, J.G., & Heilman, P.E. 1990. Quantification of two-year-old hybrid poplar root systems: morphology, biomass,and c distribution. *Tree Physiology*, 8, 109-119.

Natura, Heidi. "Root Systems of Prairie Plants." 1995. Conservation Research Institute.

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Neukirchen, D., Himken, M., Lammel, J., Czypionka-Krause, U., & Olfs, H.W. 1999. Spatial and temporal distribution of the root system and root nutrient content of an established miscanthus crop. *European Journal of Agronomy*, 11(199), 301-309.

Smith, D.M, Inman-Bamber, N.G., & Thorburn, P.J. 2005. Growth and function of the sugarcane root system. *Field Crops Research,* 92(2-3), 169-183.

"Soybean Growth and Management Quick Guide." 2004. *NDSU* Agriculture. North Dakota State University.

Standards

Next Generation Science Standards (2013)

Performance Expectations

Elementary School:

- **4-LS1-1**. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Middle School:

- **MS-LS2-3**. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

Scientific and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and using models Constructing explanations and designing solutions Engaging in argument from evidence	**LS1**: From molecules to organisms: Structures and processes **LS2**: Ecosystems: Interactions, energy, and dynamics	Scale, proportion, and quantity Structure and function

Root Biomass Data:

Belowground, in *g/m2*:	**Perennial C3 dominated** - ex. smooth brome grass, alfalfa...	**Perennial C4 dominated** - ex. Switchgrass, blue stem grass, Indiangrass...	**Annual Crop** - corn and soybean rotation
Live Root Biomass (avg.)	315[a] ± 24	525[b] ± 116	32[c] ± 5
Dead Root Biomass (avg.)	165[a] ± 37	139[a] ± 19	40[b] ± 11
Total Root Biomass (avg.)	480[a] ± 42	664[a] ± 114	71[b] ± 10
Root Biomass Range	314 - 611	367 - 1188	23 - 114
Total live roots in the top 10 cm (%)	61	65	59
Total root biomass in the top 30 cm (%)	85	78	80

	Perennial C3 dominated - ex. smooth brome grass, alfalfa...	**Perennial C4 dominated** - ex. Switchgrass, blue stem grass, Indiangrass...	**Annual Crop** - corn and soybean rotation
Total aboveground biomass in g/m^2:	593[a] ± 88	786[b] ± 167	364[c] ± 67
Total root biomass in g/m^2:	480[a] ± 42	664[a] ± 114	71[b] ± 10

Cahill, et al. 2009.