Hubbard Brook Environmental Literacy Program
Data Inquiry Activities

Colder Soils in a Warmer World?	
Summary	Students graph and analyze snow depth and soil frost data to explore how a decrease in snowpack might affect forest floor dynamics.
Subject areas	Ecology, environmental science *Assumes students have some prior, basic knowledge of ecosystem processes within the forest floor.*
Skill level	Advanced
Objectives	• Use Excel to calculate averages and percentages. • Use Excel to create a line graph with four lines. • Analyze graph to interpret data and determine trends. • State a possible relationship between snow depth and soil frost. • Predict potential measurable impacts of reduced snowpack on forests.
NH Science Framework Standards	• SPS1:11:1.1- Making observations and asking questions • SPS1:11:4.1- Representing and understanding results of investigations • SPS1:11:5.2- Evaluating scientific explanations • SPS3:11:1.2- Scientific endeavors • SPS3:11:3.1- Science and technology
Time	90 minutes
Materials	• Optional slideshow ColderSoilsWarmerWorld.pdf • Excel file ColderSoilsWarmerWorld.xlsx • Student handout
Assessment	Student handout plus graph. Answer key and answer spreadsheet (ColderSoilsWarmerWorld_ANSWERS) included.

Notes to teachers:

- An optional, brief slideshow accompanies this lesson and may be helpful in introducing the concepts of soil frost, snowpack and the study from which the data was collected to students.

- The Excel spreadsheet has been locked so that users are not able to make changes or perform any functions directly to it. Before having your students do this lesson, the teacher needs to copy, paste

and save the spreadsheet into a new Excel file. Have students work from this new file and they will be able to make changes and manipulate data.

Acknowledgments: This research was conducted by Annie Socci and made possible by grants to Pamela Templer (Boston University) provided by the Andrew W. Mellon Foundation and the National Science Foundation, "STATS4STEM.ORG: Enriching STEM education through real-world data sets, computing and statistical analysis.

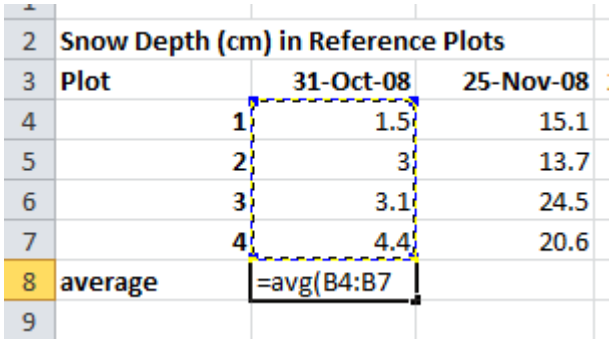
Reference: Hayhoe, K, CP Wake, TG Huntington, L Luo, MD Schwartz, J Sheffield, E Wood, B Anderson, J Bradbury, A DeGaetano, T Troy, and D Wolfe. 2007. Past and future changes in climate and hydrological indicators in the US Northeast. *Climate Dynamics* 28: 381-40.

Winter Climate Change: Colder Soils in a Warmer World?

Imagine that you are a forest ecologist interested in understanding how climate change, a global phenomenon, might impact forests here in New Hampshire during the winter. Climate scientists predict that in the future there will be less snowfall on average, and a later onset of the winter "snowpack". Knowing that snow is a natural insulator, **you have been researching how less snow might affect life on the forest floor.** To answer this question, you and your team monitored snow and ice at designated plots throughout Hubbard Brook Experimental Forest. On half of your plots, you shoveled snow off of the forest floor for the first six weeks of winter to mimic a decrease in the snowpack and create a future climate scenario. Now it is time for you and your team to analyze your data.

1. Open up the Excel spreadsheet ColderSoilsWarmerWorld.xlsx. Click on the "snow depth data" tab. The first set of data are for the four "reference" plots, which had a natural snowpack. The second set of data are for the four "snow removal" plots, which had snow shoveled off after each snowfall event during the first six weeks of winter, after which snow was allowed to accumulate for the rest of winter.

2. For each treatment (reference and snow removal), find the average snow depth for the four plots for each date. To do in Excel:
   a. Click in the cell where the answer will be placed (beneath each column of data).
   b. Type " =average (" and then highlight the four values above this cell, as shown below:



2	Snow Depth (cm) in Reference Plots		
3	Plot	31-Oct-08	25-Nov-08
4	1	1.5	15.1
5	2	3	13.7
6	3	3.1	24.5
7	4	4.4	20.6
8	average	=avg(B4:B7	
9			

   c. Press "Enter" to calculate the average snow depth for that date.

3. Enter these average values into the blank data table below the first two, titled "Average Snow Depth for Reference and Snow Removal Plots." If using the copy function, be sure to select **paste values**, not formulas. Do so by placing the cursor in the cell where you want to place the value, right clicking, and choosing "values" as the paste option.

4. Now plot only the **average data** on a line graph using Excel.
   a. Highlight the data you wish to graph (the entire data table "Average Snow Depth for Reference and Snow Removal Plots").

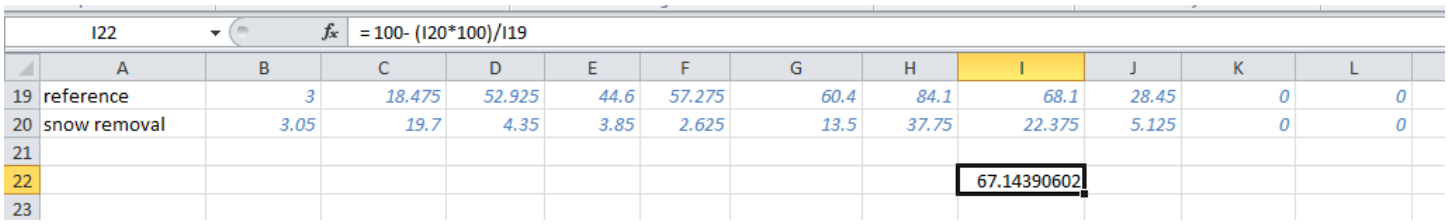
b. Click on the Insert tab and select Line. Your graph should automatically appear.
c. Give your graph a title and label the X- and Y- axes. Do so by clicking on the graph, which will make the Chart Tools tab appear. Choose Layout, and then Chart Title to create a title, or Axis Titles, to label the axes. (Choose horizontal axis for the X, and vertical → rotated vertical for the Y.)

5. Print out your data table and graph on **one sheet** of paper, and attach to this handout.

6. In a paragraph, explain what the data show about the natural snowpack in the forests of New Hampshire in winter 2008-2009. Using the average values from your reference plots, for about how many days did the snowpack cover New Hampshire that year? Notice the times in the winter when the snowpack depth actually went down. What do you think caused this?

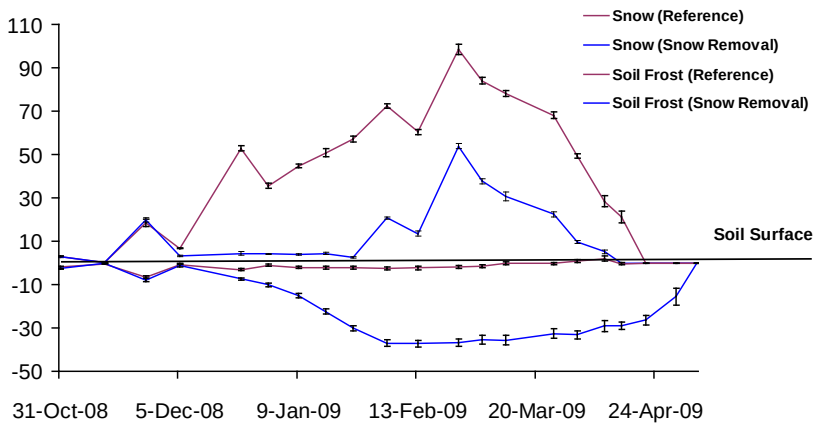
7. Compare the average snow depth on March 25, 2009 between the "Reference" and "Snow Removal" plots. By what percentage was the snowpack in the "Snow Removal" plots less than the snowpack in the "Reference" plots?

   *If you would like to do this calculation in Excel, first write out the entire calculation. Then click in the cell where you'd like the answer to be placed. Type " = 100- (I20*100)/I19 " as shown below:*

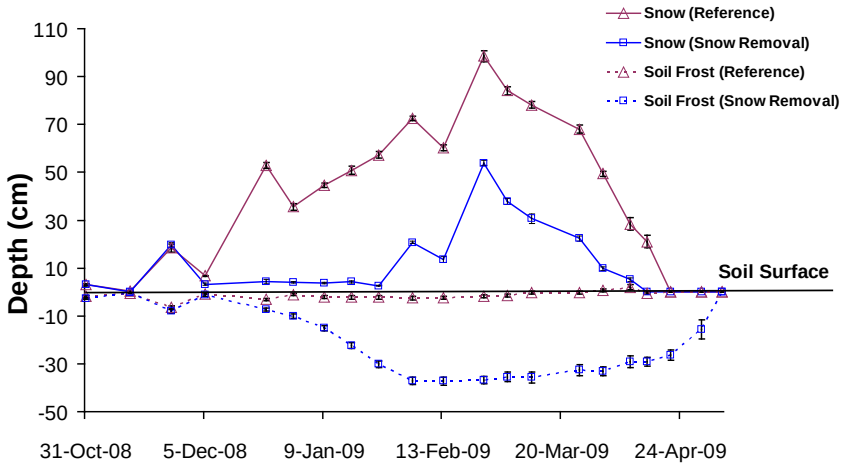


8. Now your team is interested in understanding **how snow depth affects soil freezing** belowground. On the next page, circle the letter of the figure that best allows you to compare this relationship.

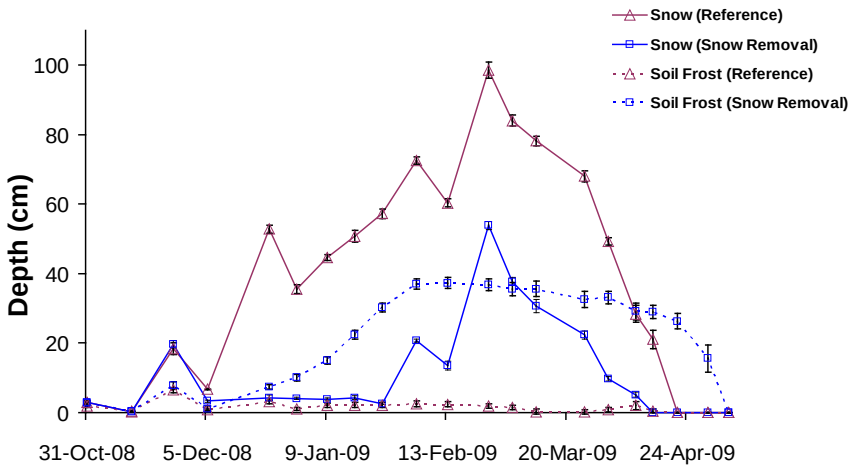
a.



b.



c.



9. Of the figures that you did *not* select, identify one characteristic of each of them that makes it difficult to interpret your data.

Figure (letter)	The figure is difficult to interpret because:

10. In a paragraph, what can your team conclude from these data about the relationship between snow depth and soil frost depth? How does early winter snowfall in particular affect forest soils?

11. Winter climate can actually have a significant effect on forests during the following growing season (spring and summer). For example, soil freezing in the winter has been shown to lower arthropod diversity in the forest floor during the following growing season, since some species that overwinter there are not adapted to freezing temperatures in the soil. In the future, how might predicted changes in winter climate affect other forest organisms (both plant and animal) during the following growing season? Brainstorm with your team four **potential impacts of a reduced snowpack** on forests in New Hampshire, and what data sets you would use to test these impacts over time. Complete the table on the following page with your ideas.

Potential Impacts of Winter Climate Change on Forests:	What types of data would you need to collect in order to test for this?

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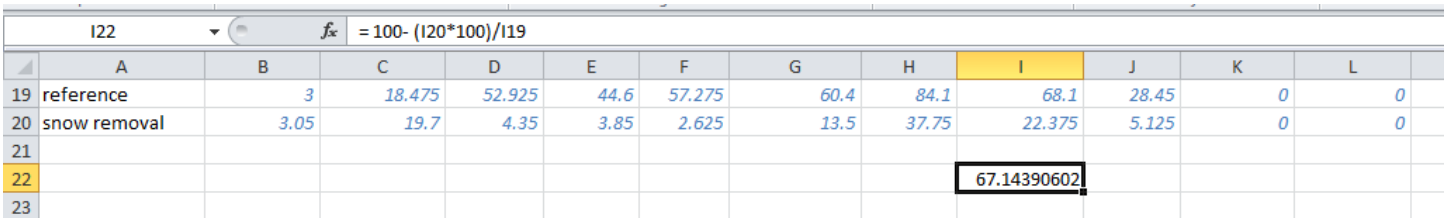
Winter Climate Change: Colder Soils in a Warmer World?
Answer Key

Questions 1- 5: Answers are contained in Excel file ColderSoilsWarmerWorld_ANSWERS.xlsx.

6. In a paragraph, explain what the data show about the natural snowpack in the forests of New Hampshire in winter 2008-2009. Using the average values from your reference plots, for about how many days did the snowpack cover New Hampshire that year? Notice the times in the winter when the snowpack depth actually went down. What do you think caused this?
   The data show that for the winter of 2008-9, snow began to cover the ground as early as October 31, and the snow reached a maximum depth on March 24. It is hard to tell if snow fell after this date, but it appears that snow started to melt, as snow depth decreased from March 24 until it was completely gone, by April 21, 2009. The decrease in snow depth between December 23, 2008 and January 25, 2009 indicates that temperatures warmed up, creating melting within the snowpack and thus, a snowpack with greater density. This is what some people call the "January thaw," which is common during northern New England winters.

7. Compare the average snow depth on March 25, 2009 between the "Reference" and "Snow Removal" plots. By what percentage was the snowpack in the "Snow Removal" plots less than the snowpack in the "Reference" plots?
   *If you would like to do this calculation in Excel, first write out the entire calculation. Then click in the cell where you'd like the answer to be placed. Type " = 100- (I20*100)/I19 " as shown below:*



	A	B	C	D	E	F	G	H	I	J	K	L
19	reference	3	18.475	52.925	44.6	57.275	60.4	84.1	68.1	28.45	0	0
20	snow removal	3.05	19.7	4.35	3.85	2.625	13.5	37.75	22.375	5.125	0	0
21												
22									67.14390602			
23												

Reference= 68.1 cm
Snow removal= 22.375 cm
*(22.375 * 100) / 68.1 = 32.85 %*
100% - 32.85% = 67.15%

8. Now your team is interested in understanding **how snow depth affects soil freezing** belowground. Circle the letter of the figure that best allows you to compare this relationship.
   B

9. Examining the figures that you did *not* select, identify one characteristic of each of them that makes it difficult to interpret your data.

Figure (letter)	The figure is difficult to interpret because:
A	*The Y-axis is not labeled.* *The same color scheme denotes both snow and frost on the snow removal or reference plots, so it is unclear which line represents which.*
C	*This graph is not incorrect, but it is not as easy to see the relationship between snow depth and soil frost as in graph B. By inverting the soil frost data to represent its depth belowground, it is easier to understand the relationship between snow and soil frost.*

10. In a paragraph, what can your team conclude from these data about the relationship between snow depth and soil frost depth? How does early winter snowfall in particular affect forest soils?
    When snow depth is greater, it effectively insulates the ground from freezing temperatures, thus soil frost cannot form. This relationship seems particularly critical in early winter. If soil is insulated by snow around the same time that freezing winter temperatures set in, the heat remaining in the soil from the growing season is preserved. Alternatively, if freezing temperatures set in during November or December without a snowpack on the ground, then soils will freeze and a later snowpack will simply maintain the soil as frozen, much like a cooler keeps a previously refrigerated beverage cold.

11. Winter climate can actually have a significant effect on forests during the following growing season (spring and summer). For example, soil freezing in the winter has been shown to lower arthropod diversity in the forest floor during the following growing season, since some species that overwinter there are not adapted to freezing temperatures in the soil. In the future, how might predicted changes in winter climate affect other forest organisms (both plant and animal) during the following growing season? Brainstorm with your team four **potential impacts of a reduced snowpack** on forests in New Hampshire, and what data sets you would use to test these impacts over time.

Potential Impacts of Winter Climate Change on Forests:	What types of data would you need to collect in order to test for this?
1. It is predicted that forests will receive more precipitation in the winter under climate change, but it will be in the form of rain rather than as snow. Less snowpack will mean less water released into ecosystem during snowmelt, a time when plants start to take up water.	*Stream flow* *Soil moisture*
2. Less snowpack and greater soil freezing might damage roots, impairing plants' ability to take up water and nutrients.	*Plant water uptake (sap water uptake)* *Root nutrient uptake*
3. Less snowpack might make it easier for some animals, such as moose and deer, to travel and find food to eat.	*Remote sensing of animal migration* *Radio telemetry (collars) of individual animals* *Field observations and tracking*
4. Less snowpack might make it harder for tunneling animals, as without tunnels they will be more obvious to predators.	*Small mammal abundance and diversity in the spring*
5. Less snowpack might make it harder for any organisms that rely on snow as insulation (i.e., caterpillars and larvae that lie beneath the snow).	*Arthropod abundance and diversity (by collecting leaf litter samples)*
6. Increased soil frost might affect the rate of microbial processes, which could affect decay rates, nutrient cycling, etc.	*Measure soil respiration* *Measure decomposition rates* *Nutrient transformations in soil*
Other?	

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