Hubbard Brook Environmental Literacy Program
Data Inquiry Activities

Sugar Babies	
Summary	Students develop science process skills as they work with data from the Hubbard Brook Experimental Forest to answer the question, "What influences the survival of sugar maple seedlings?"
Subject areas	Biology, ecology, environmental science
Skill level	Advanced
Objectives	• List factors important to the survival of a tree seedling. • Represent data in graphical form. • Analyze and evaluate seedling survival data. • Propose a relationship between seedling survival and seedling density. • Modify conclusions based on additional information.
NH Science Framework Standards	• SPS1:11:1.1- Making observations and asking questions • SPS1:11:2.2- Designing scientific investigations • SPS1:11:4.1- Representing and understanding results of investigations • SPS1:11:5.1- Evaluating scientific explanations
Time	Two hours, including teacher introduction and post activity discussion
Materials	• Excell file Sugar Babies.xls (link on website) • Student handout
Assessment	Student handout plus graph. Answer key included.

Note to teachers:

This exercise not only asks students to graph data in a scatter plot but also to analyze and evaluate the results. Part of the analysis has students use Excel to fit a trend line and calculate an R^2 value for the data. When data points are scattered over a graph, a trend line can be helpful in identifying whether any trend exists. An R^2 value tells how well the trend line describes the data. It is a descriptive value between 0 and 1; the closer an R^2 value is to 1, the better the trend line fits the data points. Please note that R^2 does not denote whether a relationship is *significant*. Significance is a statistical term that goes beyond the scope of this lesson.

To learn more about trend lines and R^2 values, we recommend the following resource:
http://www.ncsu.edu/labwrite/res/gh/gh-linegraph.html

Many thanks to teacher Sarah Thorne, who developed this lesson for her Prospect Mountain High School Ecology class.

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Sugar Babies

What influences sugar maple seedling survival?

Sugar maples are an important component of the forests in Northeastern and North Central United States. They are valued by people for their foliage, beauty, and sweet sap. At Hubbard Brook Experimental Forest in the White Mountains of New Hampshire, scientists are gathering data to find out what influences the survival of sugar maple seedlings. The research described in this lesson was supported by a grant through the US Dept. of Agriculture National Research Initiative. Thank you to Dr. Natalie Cleavitt for sharing her data with us.

1. On your own, make a list of 5 factors that you think might affect whether a sugar maple seedling in the middle of a forest will live through its first year of life. Then discuss your ideas with your partner.

Factor	How will it affect the plant?

2. Discuss: do you think that the location in a forest could play a role in seedling survival? How?

In one study, Dr. Natalie Cleavitt planted seedlings in nine plots and followed them during their first year of life in two different sub-watersheds of the forest, Watershed 1 and Watershed 3. Here is her data, below.

% Sugar Maples Emerged		
Plot #	**Watershed 1**	**Watershed 3**
1	71.43	36.36
2	60.00	35.71
3	37.50	16.67
4	33.33	47.73
5	25.00	31.51
6	31.58	43.18
7	33.33	43.86
8	37.50	8.70
9	38.89	42.22

3. What percentage of the sugar maple seeds emerged as seedlings

   a. in plot 1 in Watershed 1? ____

   b. in plot 9 in Watershed 3? _____

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4. Calculate the average percentage of sugar maples that emerged for each watershed.

	Watershed 1	**Watershed 3**
Average		

5. What conclusions, if any, can you draw from this data? Explain how you arrived at your answer.

6. It might interest you to know that Watershed 1 had calcium silicate applied to its soils in 1999 and Watershed 3 did not. Explain how this might have influenced the growth of the seedlings.

7. Look at the data in the table below. It records the percent of sugar maples that survived their first summer and the seedling density for each square meter plot. What question do you think Nat was asking when she set up this study?

plot #	density (# seedlings per square meter)	% surviving
2	4.53	66.67
4	17.57	45.28
5	5.77	74.03
1	3.8	36.36
36	5.47	68.12
11	3.4	66.67
12	12.97	51.79
13	1.87	43.64
188	7.03	65.31
189	11	41.51
190	3.8	66.67
192	8.63	64.41
196	2.37	65.15
262	4.97	76.79
315	1.67	73.86
331	1.47	76.92
332	1.8	90.11
334	3.17	88.64
335	4.2	72.97
24	8.9	64.91
34	3.7	86.84
35	2.87	70.42
31	6.07	59.52

(Partners will now share their findings with the rest of the class.)

Finish this assignment in the Computer Lab.

8. a. With your partner, open up Sugar Babies Data.xls and create a scatter plot chart from the middle and right columns of data to help Nat answer her question. Remember to include a title and X and Y axis labels.

   b. Do you see a pattern (or relationship) between these two variables? Can you draw a conclusion from the scatter plot? If so, what is it?

   c. Does this seem to answer the question that Natalie was asking (question 7)?

9. Now, add a trendline by right clicking on a data point and choosing *Add Trendline*. In the Trendline box, select *Linear* and Excel will fit a line to the data points. We can find out how well this line describes the data by asking the computer to calculate the R^2 value for the line. To do this, again right click on a data point, choose *Add Trendline*, and at the bottom of the Trendline box, click in the box next to *Display R-squared value on chart*. The highest an R^2 value can be is 1; and the higher the R^2 value, the better the response variable (% surviving) is described by the predictor variable (density).

   What is the R^2 value?

10. How does knowledge of the R^2 value expand your answer to Question 8b? Rewrite your conclusion.

11. Since the R^2 value seems to imply that some, but not all, of the percent of seedlings surviving can be described by seedling density, what others factors besides density do you think might also influence seedling survival? Make a list.

12. What factors might cause or explain the relationship between seedling density and seedling survival through the first summer?

13. Print out your chart and staple it to your worksheet. (Results will be shared with the class and discussed.)

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Sugar Babies

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1. On your own, make a list of 5 factors that you think might affect whether a sugar maple seedling in the middle of a forest will live through its first year of life. Then discuss your ideas with your partner.

Factor	How will it affect the plant?
Soil substrate	*Soil substrate is extremely important to seedling survival, as it is what provides nutrients, moisture, and a place for roots to grow and anchor the plant.*
Light availability	*Different plant species require different amounts of light. Though sugar maple is a shade tolerant species, it still requires sunlight for photosynthesis.*
Nutrient availability	*Plants require nutrients for growth. A nutrient-poor substrate can inhibit growth.*
Moisture availability	*Different plants species have different moisture requirements. Seedlings are particularly sensitive to a lack or an excess of moisture.*
Competition	*Competition among seedling for the above factors can limit growth and survival.*
Pathogens/disease	*Pathogens, especially fungi, often kill seedlings.*
Predation	*Animals, particularly slugs, eat seedlings.*
Extreme events	*Wind storms might potential drop trees onto seedlings.*

2. Discuss: do you think that the location in a forest could play a role in seedling survival? How?
   Yes, the location in a forest certainly plays a role in seedling survival. There is much variation in many of the factors listed in Q1 across the forest. There can even be a lot of variation within a very small area ("microtopography").

In one study, Dr. Natalie Cleavitt planted seedlings in nine plots and followed them during their first year of life in two different sub-watersheds of the forest, Watershed 1 and Watershed 3. Here is her data, below.

% Sugar Maples Emerged		
Plot #	**Watershed 1**	**Watershed 3**
1	71.43	36.36
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5	25.00	31.51
6	31.58	43.18
7	33.33	43.86
8	37.50	8.70
9	38.89	42.22

3. What percentage of the sugar maple seeds emerged as seedlings

   a. in plot 1 in Watershed 1? ____ 71.43 %

   b. in plot 9 in Watershed 3? _____ 42.22 %

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4. Calculate the average percentage of sugar maples that emerged for each watershed.

	Watershed 1	**Watershed 3**
Average	40.95	33.99

5. What conclusions, if any, can you draw from this data? Explain how you arrived at your answer.
   A higher percentage of sugar maple seedlings survived in Watershed 1 than did in Watershed 3. We know this because the percentage of seedlings surviving in Watershed 1 was about 41%, while survival in Watershed 3 was about 34%.

6. It might interest you to know that Watershed 1 had calcium silicate applied to its soils in 1999 and Watershed 3 did not. Explain how this might have influenced the growth of the seedlings.

   Students can be expected to surmise that the addition of calcium, silica, or both was beneficial for the growth of seedlings. Perhaps students may suggest that calcium and/or silica were limiting nutrients in Watershed 3. In fact, about 50% of the calcium present in the soils at Hubbard Brook prior to the Industrial Revolution has been lost, as acid rain has leached it and other nutrients (base cations) from the soil. This was the basis for the experimental 1999 calcium silicate application in Watershed 1.

7. Look at the data in the table below. It records the percent of sugar maples that survived their first summer and the seedling density for each square meter plot. What question do you think Nat was asking when she set up this study?

   Does the density of seedlings affect the survival of seedlings?
   How does the density of seedlings affect the survival of seedling?

plot #	density (# seedlings per square meter)	% surviving
2	4.53	66.67
4	17.57	45.28
5	5.77	74.03
1	3.8	36.36
36	5.47	68.12
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(Partners will now share their findings with the rest of the class.)

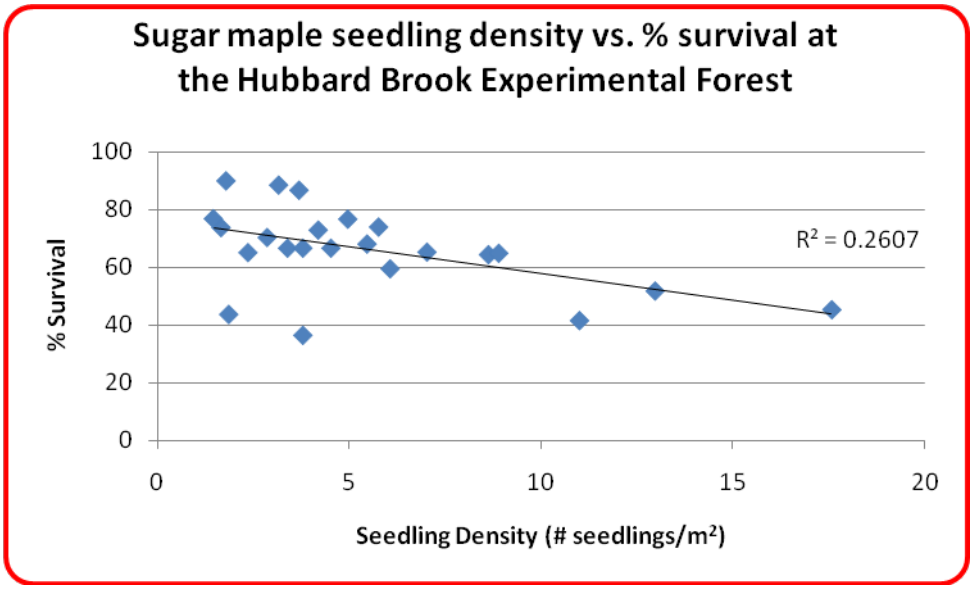
Finish this assignment in the Computer Lab.

8. a. With your partner, open up Sugar Babies Data.xls and create a scatter plot chart from the middle and right columns of data to help Nat answer her question. Remember to include a title and X and Y axis labels.
Graph is below.

b. Do you see a pattern (or relationship) between these two variables? Can you draw a conclusion from the scatter plot? If so, what is it?
Thought most of the data points fall under 10 seedlings per square meter, and the survival rate among these seedlings varies from between 36-90 %, there does appear to be a relationship between density and survival. It appears that when seedling density is greater, a smaller percentage of seedlings survive.

c. Does this seem to answer the question that Natalie was asking (question 7)?
Answers will vary. Some students will say that yes, it does answer the question. Others might say that density seems to play a part, but that there must be other factors (variables) involved.

9. Now, add a trendline by right clicking on a data point and choosing *Add Trendline*. In the Trendline box, select *Linear* and Excel will fit a line to the data points. We can find out how well this line describes the data by asking the computer to calculate the R^2 value for the line. To do this, again right click on a data point, choose *Add Trendline*, and at the bottom of the Trendline box, click in the box next to *Display R-squared value on chart*. The highest an R^2 value can be is 1; and the higher the R^2 value, the better the response variable (% surviving) is described by the predictor variable (density). What is the R^2 value?
$R^2 = 0.2607$



10. How does knowledge of the R^2 value expand your answer to Question 8b? Rewrite your conclusion.

Since the R^2 value is relatively low (closer to 0 than to 1), we know that the predictor variable (density) does not completely describe the response variable (% surviving). Density does seem to affect seedling survival, but there must be other variables that also affect survival.

11. Since the R^2 value seems to imply that some, but not all, of the percent of seedlings surviving can be described by seedling density, what others factors besides density do you think might also influence seedling survival? Make a list.

Almost all of the factors included in the list in Q1 are appropriate to list here.

12. What factors might cause or explain the relationship between seedling density and seedling survival through the first summer?

Seedlings in an area of greater density will likely experience greater competition for light, nutrients and moisture. Pathogens and disease are more easily spread among seedlings growing closely together.

13. Print out your chart and staple it to your worksheet. (Results will be shared with the class and discussed.)