HARVARD FOREST HARVARD UNIVERSITY
Established 1907 Long Term Ecological Research Site since 1988

LTER Schoolyard Ecology Program

Teacher Developed Lessons and Documents that integrate Harvard Forest Schoolyard Ecology Themes into curriculum.

- **Title:** How to Make Awesome Graphs
- **Teacher/Author:** Nora Murphy
- **School:** Concord Carslisle High School
- **Date:** March 30, 2017

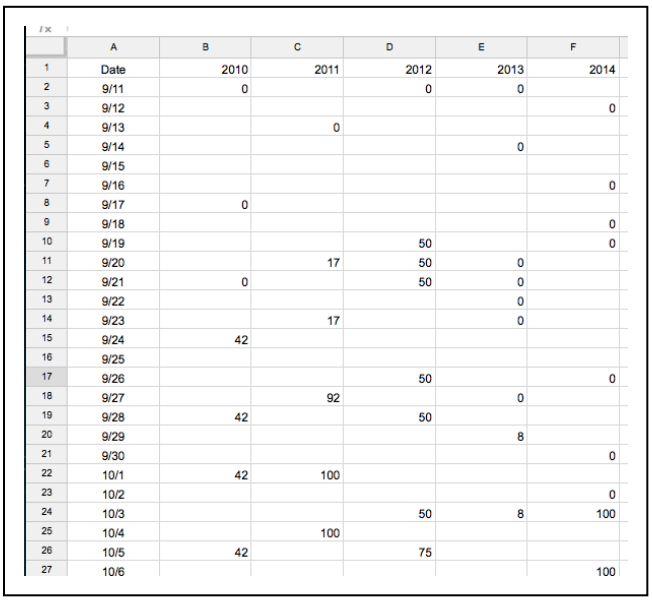
Name _____ Block _____ Date _____

How to Make Awesome Graphs

Note, Microsoft Excel is a more powerful graphing program than Google Docs Spreadsheets. Since not all students have Excel, we will accept the limitations of Google Docs Spreadsheets so that you can easily work on your graphs on any computer at home and at school.

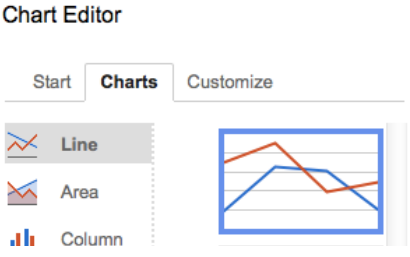
Does a tree drop leaves at the same time each year?

Open the class Google data. Save a copy to edit. Practice building a graph by analyzing whether one of the trees you studied dropped leaves at the same time each year.



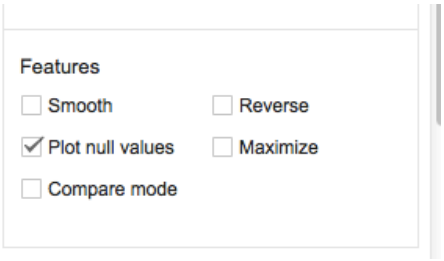
	A	B	C	D	E	F
1	Date	2010	2011	2012	2013	2014
2	9/11	0		0	0	
3	9/12					0
4	9/13		0			
5	9/14				0	
6	9/15					
7	9/16					0
8	9/17	0				
9	9/18					0
10	9/19			50		0
11	9/20		17	50	0	
12	9/21	0		50	0	
13	9/22				0	
14	9/23		17		0	
15	9/24	42				
16	9/25					
17	9/26			50		0
18	9/27		92		0	
19	9/28	42		50		
20	9/29				8	
21	9/30					0
22	10/1	42	100			
23	10/2					0
24	10/3			50	8	100
25	10/4		100			
26	10/5	42		75		
27	10/6					100

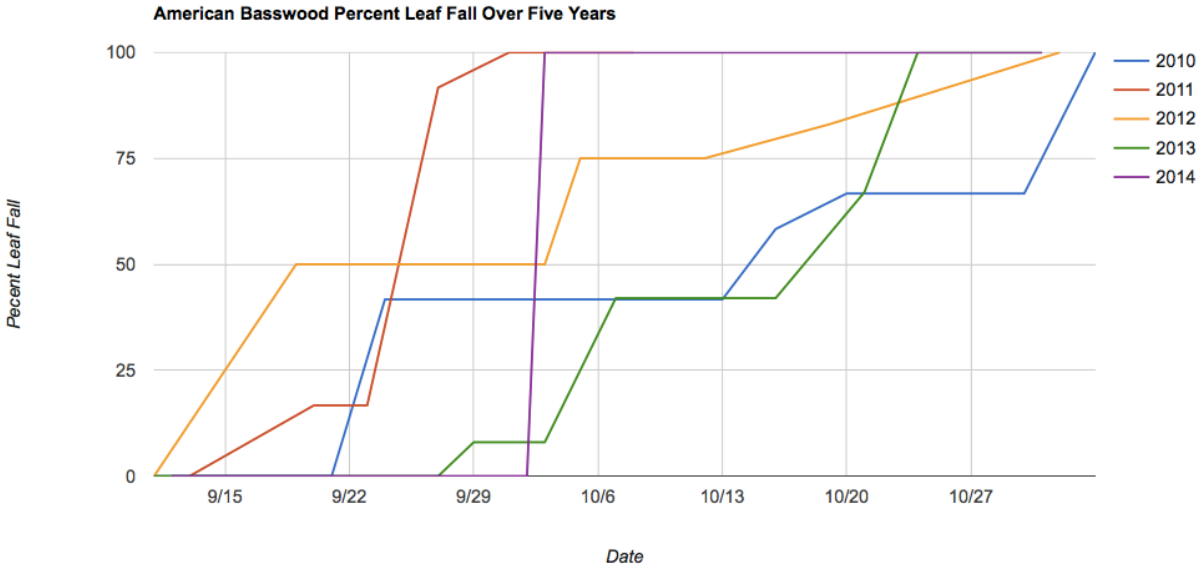
- You may create a new spreadsheet for each data set and graph or you may choose to keep all of your data on one spreadsheet and simply move each graph to its own page.
- Google requires graphed data to be in adjacent columns. Create a column for date. You can copy the dates for one year, then reformat this column by choosing Format – Number – More Formats – More Date and Time Formats then selecting a date format that omits year. Make sure to click Apply.
- Create columns for each year of your tree data. Fall 2009 data is included for your interest, but should not be analyzed. This study included courtyard trees from the old school. The next spring, we began studying mostly native trees in the current field sites.
- Note that data collection started on different dates each year. Make sure to paste each year's data correctly. You may choose to edit the data at the start or end of the season if there is no additional information added. For example, I eliminated some early dates of data for two years since all leaves were still present. This improves overall graph design.
- Highlight the columns you wish to graph, including the headings.
- With the data still highlighted, choose the Charts icon and, in the Chart Editor, choose Charts – Line and select the top example provided (see box). Make sure to click Use Row 1 As Headers in this window!
- Once you have created the graph, choose the editing tool in the upper right hand corner to find the option to insert the graph onto its own page.



Used Advanced Edit to format your graph clearly.

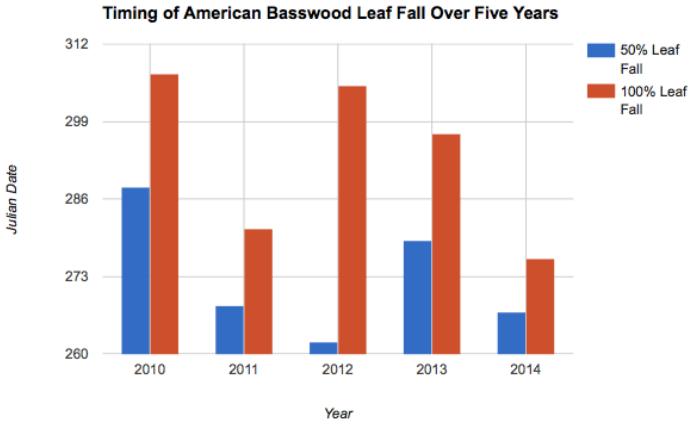
- First, scroll down to Features and choose Plot null values so that Google will fill in the missing data points, creating a continuous line.
- Give your graph a clear and specific title by typing it into the appropriate space in the edit window. Learn the scientific name of your tree and include it with the common name.
- Add clear and specific titles to the X and Y-axes. Google provides a toggle button to choose one or the other in the editing menu. A frustrating limitation is that, while Google allows you to rescale Y-axes, you cannot rescale the X-axis.





You can also represent timing of leaf fall over five years through a bar graph showing specific data points from the season. Below is an example of a data table and the resulting chart produced by selecting Graph – Column. Note that you must use Julian dates to make this graph. The phenology analysis instructions explain how to estimate timing of 50% leaf fall. A Julian date calendar like those at <http://landweb.nascom.nasa.gov/browse/calendar.html> will help you convert dates

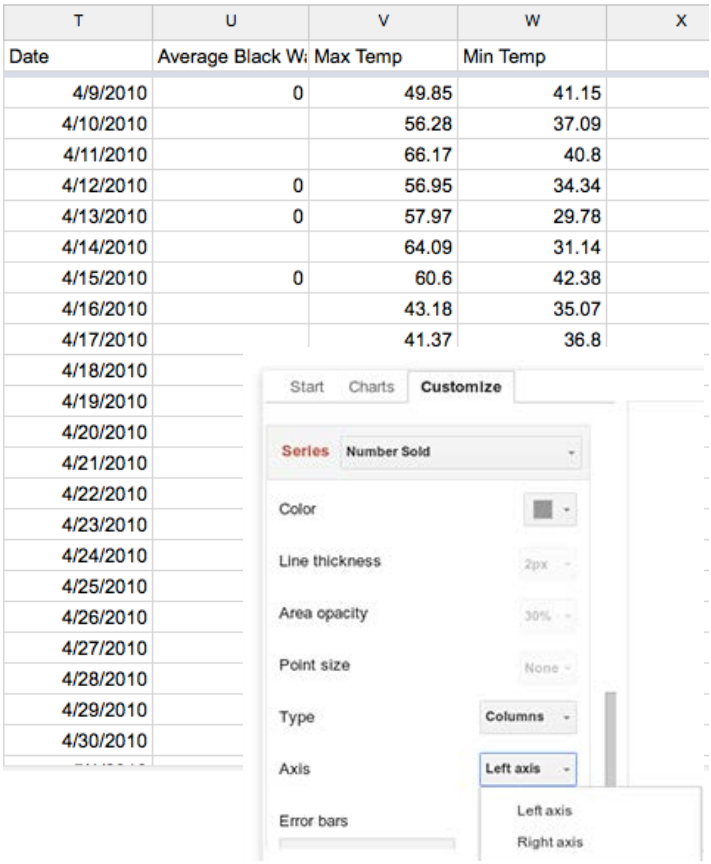
	A	B	C
1	Year	50% Leaf Fall	100% Leaf Fall
2	2010	288	307
3	2011	268	281
4	2012	262	305
5	2013	279	297
6	2014	267	276
7			



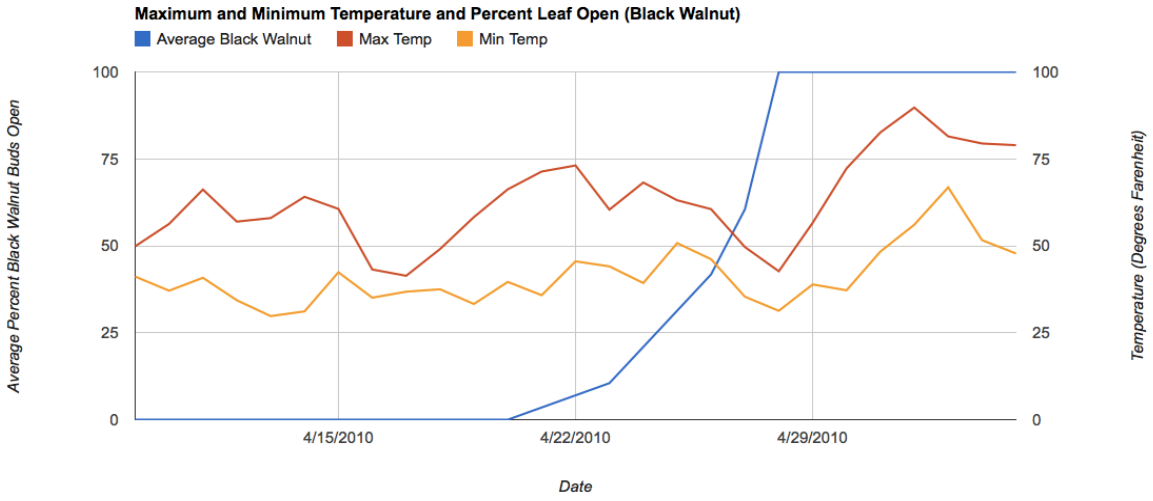
How do weather variables affect timing of leaf fall?

Some of you will likely choose to study the effect of weather variables using data from the CCHS weather station. Here are some additional instructions to help you in graphing this data. Open the class Google data. Save a copy to edit. Note that the weather data is stored by year and is separate from the tree data. You will need to create your own spreadsheet combining these.

- Create your own spreadsheet combining weather and tree data. An example is shown at right. Google requires graphed data to be in adjacent columns. Include date, weather variables of interest to you and tree data. Make sure that you align both weather and tree data with the appropriate dates.
- Again, highlight data as you did before, including titles. Choose a line graph as you did before.
- This graph will be clearer if you have two Y-axes. Add a second Y-axis by going to the Customize tab in the Chart Editor. Scroll down to Series. In the drop-down menu, select the name of the data series you would like to scale on the right axis, then choose Right axis from the drop-down menu next to Axis.
- Your graph will look something like the one shown below.

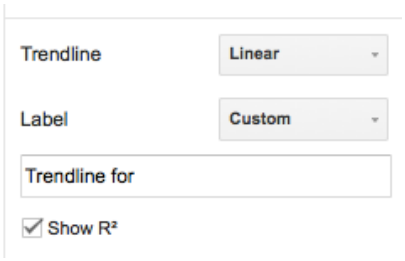


T	U	V	W	X
Date	Average Black W:	Max Temp	Min Temp	
4/9/2010	0	49.85	41.15	
4/10/2010		56.28	37.09	
4/11/2010		66.17	40.8	
4/12/2010	0	56.95	34.34	
4/13/2010	0	57.97	29.78	
4/14/2010		64.09	31.14	
4/15/2010	0	60.6	42.38	
4/16/2010		43.18	35.07	
4/17/2010		41.37	36.8	
4/18/2010				
4/19/2010				
4/20/2010				
4/21/2010				
4/22/2010				
4/23/2010				
4/24/2010				
4/25/2010				
4/26/2010				
4/27/2010				
4/28/2010				
4/29/2010				
4/30/2010				

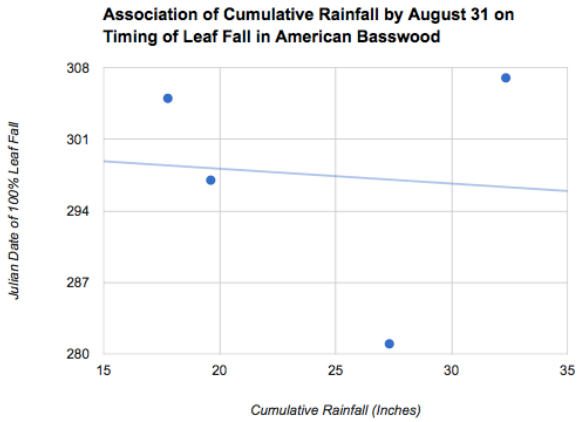


An alternative way to examine the effect of weather data on timing of leaf fall is to create a scatter plot of discrete variables. Select only two columns. Both must include numerical data only, so Julian dates are required. Choose a Scatter Plot. Google provides the option of selecting different trend lines.

A	B	C
Year	Cumulative Rainfall by August 31	100% Leaf Fall
2010	32.34	307
2011	27.32	281
2012	17.77	305
2013	19.62	297
2014		276



Is a linear trend line is appropriate for this graph?



The trend line graphs a best-fit line for these points—it summarizes all the points into a single linear (or other) equation. If you believe there is a linear relationship, Google can perform a regression analysis as a measure of how two variables relate. A linear trend line is created by calculating how far each point is from the mean (average) *x* and mean *y* values. An *r*-value estimates the correlation between the variables, with 1 signifying a positive 1:1 correlation, -1 a negative correlation, and 0 no correlation. This does *not* mean that there is causation, but a strong association can provide the basis for future experiments to test causation. For example, if amount of rainfall appeared to influence timing of leaf fall, a field or greenhouse experiment controlling the amount of water received by trees could be used to test this hypothesis.

The *r*-value can be used to calculate R^2, which provides an estimate of the contribution of a variable on the effects observed. For example an *r*-value of 0.25 equals R^2 of 0.064 suggesting that only about 6.4% of variation in *y* values can be explained by changes in *x* values. Google displays R^2 unclearly on the graph. If you choose to look at R^2 values, have Google calculate them, then eliminate the legend, instead presenting these values clearly in graph captions.

If you had been interested in exploring how rainfall affects leaf fall, do not be discouraged by this analysis of a single American basswood tree over four years. Other species may be affected differently and a larger sample size may provide more evidence about whether rainfall has an effect.

Additional information to help you graph your data can be found at Doc Editors Help – Editing and formatting your chart: <https://support.google.com/docs/answer/63824?hl=en>

Information on r*-values and* R^2 *adapted from the College Board's AP Biology Quantitative Skills Guide for Teachers. 2nd Printing. (2012.)*