nature's notebook
A project of the USA-NPN

Monarchs and Milkweed - Looking at the Numbers


Photo: USFWS Mountain Prairie

Grade Levels
9-12

Overview
Students will work with a small dataset taken from the USA-National Phenology Network database. The data show the timing of observations by Maine volunteers of milkweed plants and monarch butterflies in 2011. The students will learn the proper way to graph data so they can make comparisons between groups: such as monarch vs. milkweed life phases, and coastal vs. inland timing. They will be asked to make predictions based on what they know about the species and about climate conditions. They will also learn to think about and graph variability, an important concept in statistics and data literacy.

Background
Phenology is the study of the timing of life cycle events, done mostly through personal observations.

Real-world Connection
Monarch populations have been declining in recent years, with a major cause being habitat loss. Volunteer observers can helps scientists learn more by submitting their observations through citizen science programs such as *Nature's Notebook*.

Citizen Science Connection
This activity can be completed with or without a *Nature's Notebook* account. Completing it with an account can provide an opportunity to teach students about the importance of citizen science, and how their contributions help us to better understand the word around us.

Estimated Time

One or two 40-minute class periods for scaffolding students on the topics of "Julian Days;" monarch and milkweed life stages; and the basic relationship between monarchs and milkweed
One 30-minute class period for discussing how to graph the data and to let students give their predictions and explanations.
Two 30- to 40-minute class periods for students to hand-draw their graphs and discuss as a group the stories that the graphs tell

Learning Objectives

Participants will be able to:

- learn how to create graphs showing comparisons between two or more groups
- learn to evaluate variability of data
- understand that the timing of phenological events can vary
- practice making predictions, engaging in inference and speculation, and interpreting information contained in graphs
- learn that monarch butterflies are dependent on milkweed for survival because monarch caterpillars feed exclusively on milkweed plants
- learn about climate and ecological principles affecting species, i.e., that the timing of phenological events may vary according to geography, microclimate, or climate change

Next Generation Science Standards

LS: Life Science			
	Grades 9-12		Grades 6-8
HS-LS2-2	Use mathematical representations to support explanations of factors affecting biodiversity and populations in ecosystems at different scales	MS-LS2-2	Construct an explanation that predicts patterns of interactions among organisms along multiple ecosystems.

Conducting the Activity

Materials

Resources needed

- This lesson plan and dataset
- Pen and paper for drawing graphs
- Optional: laptops with spreadsheet software and internet access

Engage

Connect to prior knowledge

- Prior to data collection, organize students into small groups (2 or 3 students per group, maximum). Discuss as a class the seasonal changes that affect the timing of bird migration (temperature, snowmelt, weather, availability of food, etc.). Make a list of these things on the blackboard or whiteboard.
- Ask the students in each group to use bird identification guides and/or consult online resources to figure out which species are commonly seen in their community, and then ask the students to make predictions about which birds they might expect to find at their feeder (based on the type of food you're providing, surrounding habitat, time of year, etc.), and when they might start to arrive or disappear for the season. Ask the students to record their predictions in their science notebooks.
- [Note: To convert to Julian Days, January 1st = Julian Day 1 and the count goes up from there for a total of 365 Julian Days in a non-Leap Year and 366 days in a Leap Year.]

RESOURCES
Adapted from:

Signs of the Seasons: A New England Phenology Program

Monarch and Milkweed — Looking at the Numbers
Authors: Medea Steinman, Molly Schauffler, Esperanza Stancioff, Beth Bisson

NOTES ON ACTIVITY

Conducting the Activity

Explore

Hands-on learning

Volunteers around Maine have been recording dates for different stages of Monarch butterflies and Milkweed plants. Below are the earliest sightings by observers in a number of different towns in 2011.

Milkweed leaves			
Julian Days	City/Town	County	Geography
141	Bangor	Penobscot	Inland
166	Eustis	Franklin	Inland
153	Kingfield	Franklin	Inland
146	Bristol	Lincoln	Coastal
90	Camden	Knox	Coastal
141	Cape Elizabeth	Cumberland	Coastal
260	Falmouth	Cumberland	Coastal
208	Portland	Cumberland	Coastal
181	Waldoboro	Lincoln	Coastal

Monarch adults			
Julian Days	City/Town	County	Geography
206	Eustis	Franklin	Inland
221	Kingfield	Franklin	Inland
164	Livermore	Androscoggin	Inland
203	Bristol	Lincoln	Coastal
186	Cape Elizabeth	Cumberland	Coastal
233	Cherryfield	Washington	Coastal
216	Portland	Cumberland	Coastal

Milkweed flowers			
Julian Days	City/Town	County	Geography
183	Bangor	Penobscot	Inland
166	Eustis	Franklin	Inland
196	Bristol	Lincoln	Coastal
203	Cape Elizabeth	Cumberland	Coastal
181	Waldoboro	Lincoln	Coastal

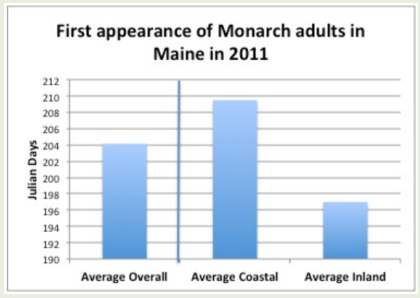
The following are suggested lines of inquiry for teachers to explore with their students. We recommend that teachers work with the data first and think about where their students might stumble so that they can be prepared to lead them through the discussion. You may have other questions and activities you would like to add.

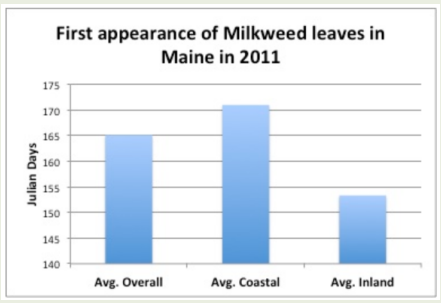
We suggest you first broach this as a full class discussion. Then you may wish to break students into small groups to think about this and help each other decide how to go about graphing the data to answer the questions. Remind students to stay focused on the question as they think about the graph.

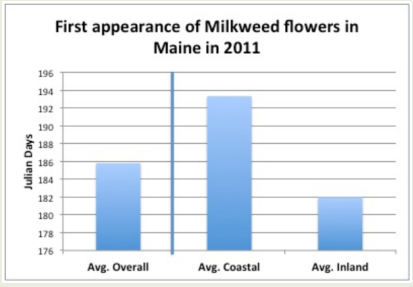
If you wanted to compare coastal and inland timing for the different stages of monarchs and milkweed, how would you graph these data?
What do you think you would see first? Monarch adults, milkweed leaves or milkweed flowers? Why?
What would you expect to see if you compared coastal and inland Maine? Do you think you would see signs of Monarchs and Milkweed on the coast first or inland first? Why?
Acceptable graphs (by hand or computer):

When and where did Monarchs and Milkweed first appear in Maine in 2011?

The graphs can be plotted individually, as follows:

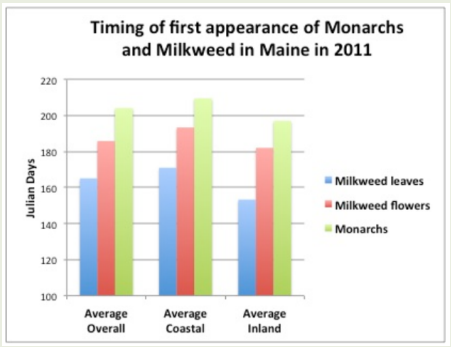


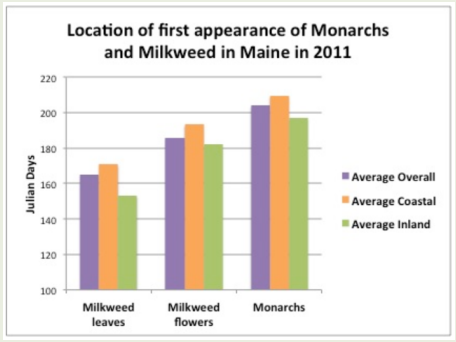




Conducting the Activity (continued)

Or combined into one bar graph:



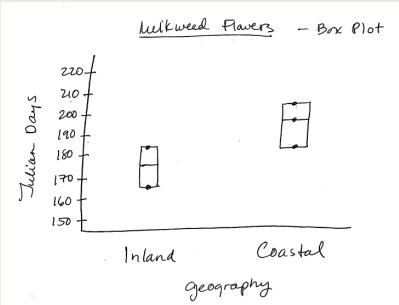


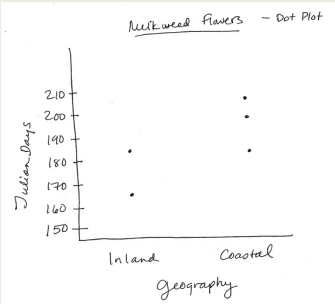
Interpretation of graphs:

How many days, on average, are there between the first coastal and the first inland sightings?How different is the timing between the different stages? It could be interesting to watch the timing of these stages over the years. Given the evidence for climate change and increasing temperatures in Maine, how would you expect these dates to change over the next 50 years in our state?

Variability is an important concept in data analysis and in science, yet it is often overlooked or misunderstood by students. For example, one common misconception is that "outliers" should always be disregarded or discarded. Sometimes this is true but not always. This simple data set can be used to help your students think about the inevitable variability that exists among data. Here are two questions about this dataset that can be used to open the discussion and to teach about graphs and plots that can illustrate variability.

Overall, how variable is the timing for first monarch sightings in Maine in 2011?
How about for first milkweed leaves or flowers?
The graph illustrating an answer to either of these questions can be accomplished through a frequency plot, such as a box plot or a dot plot. A box or dot plot will display the median value, as well as the high and low values. A box or dot plot can be created in Google Sheets, or, they can create hand-drawn plots.





Explain

Listening and communicating understanding

Ask students to interpret the graphs and explain what they show. Engage them in speculation about whether the graphs' assertions might be true or not. Talk about any other questions the graphs raise for you and the students. Point out to them the value of engaging in these kinds of speculations and inquiry and how this process is central to the experience of "doing" science. For any questions that you can't answer now, how might you find the answers? And if the students agree that the data are not developed enough, ask them how the dataset could be improved. Often, it is essential to come up with recommendations for further research or enquiry.

Extend

Group projects, real world connections

Study the life history and requirements of monarchs and milkweed. Learn about the monarch's migration and its dependence on milkweed. Visit the library or use the Internet to research the conservation status of monarchs, and of milkweed as monarch habitat. If your school has a garden, consider planting milkweed to create monarch habitat and establish a citizen science monitoring schedule for these two species using *Nature's Notebook*.

Also visit the USA-National Phenology Website and try out the Phenology Visualization Tool. Here you can download and visualize data, view the map gallery and view historic data sets. We recommend that you complete the Tutorial to learn how to make full use of the visualization features.

Evaluate

Summarize, Check for Understanding, Assess

Ask students to interpret the graphs and explain what they show. Engage them in speculation about whether the graphs' assertions might be true or not. Talk about any other questions the graphs raise for you and the students. Point out to them the value of engaging in these kinds of speculations and inquiry and how this process is central to the experience of "doing" science. For any questions that you can't answer now, how might you find the answers? And if the students agree that the data are not developed enough, ask them how the dataset could be improved. Often, it is essential to come up with recommendations for further research or enquiry.

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