Phenology and Climate Change: Lesson 1

Insect Activity and Migration Timing

Grade Level	9th – 12th Grade
Subject	Science
Course	Biology I, Biology II, Environmental Science

Essential Question

How do insect activity and migration change seasonally? Why is the timing of seasonal insect activity and migration important?

Summary

In this lesson students will learn about phenology (the timing of biological events) by exploring a variety of insect data sets. Through scaffolded analysis of graphical data, the use of an interactive digital model, and life history descriptions, students will develop an understanding of (1) how temperature affects insect activity and migration and (2) how this has changed over time. From these activities they will draw conclusions and make predictions about the biological significance of the data sets. Additionally, the will learn about how scientists collected the data used in the lesson.

Snapshot

Engage

Students listen to an NPR story about the “insect highway” and generate questions.

Explore

Students create and interpret graphs of seasonal insect activity data and begin generating “big science ideas”.

Explain

Students revisit their initial questions, and learn about phenology and the source of the Explore data.

Extend

Students explore a model of insect migration data and identify patterns in insect arrival over time.

Evaluate

Students determine what information they still need to answer their remaining questions and create a Six-Word Memoir summarizing their learning.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-LS2-2: Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Attachments

- Daily Insect Density Figure—Phenology and Climate Change Lesson 1.jpg
- Leafhopper Data Ranges—Phenology and Climate Change.png
- Leafhopper Migration Guide—Phenology and Climate Change Lesson 1.docx
- Leafhopper Migration Guide—Phenology and Climate Change Lesson 1.pdf
- Lesson 1 Evaluate.docx
- Lesson 1 Evaluate.pdf
- Lesson 1 Explore data.xlsx
- Lesson 1 Explore_Data.pdf
- Lesson 1 Explore_WIS-WIM.docx
- Lesson 1 Explore_WIS-WIM.pdf
- Lesson 1 Extend.docx
- Lesson 1 Extend.pdf
- Lesson Slides—Phenology and Climate Change Lesson 1.pptx

Materials

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Engage

Begin the lesson by going to **slide 5** and introducing students to the NPR *Look Up! The Billion-Bug Highway You Can't See* story. Play the "5 Minute Listen" version of the story. After listening once, play the story a second time. During this second play, provide students with sticky notes and ask them to come up with questions about the story as they listen. If you will be using a Driving Question Board (see paragraph below Teacher's Note: Media), have them write each question on its own sticky note.

Teacher's Note: Media

If your internet bandwidth will not support audio streaming, the 5 Minute Listen player has a download option so you can save the audio file ahead of time and play it from your device. There is also a transcript of the recording available for students who might benefit from reading along while they listen.

You might consider also having students read the associated article which provides the same information in a different format.

Go to **slide 6**. Using the Stand Up, Sit Down strategy, have students share out their questions one at a time and create a class list from the responses. Use these questions to begin a class Driving Question Board. If a driving question board is not a feasible option for your class(es), questions can also be recorded in another public place (e.g., poster paper, Google Doc, etc.); just make sure the information can be referred back to at a later time.

Teacher's Note: Question Themes

While it is an optional step, it can be helpful to have students group their questions into themes/big ideas as they share out. A simple way to do this is for a student to determine whether their question is similar to questions that have already been posed or whether it should be in a category of its own.

For example, a student might decide their question about food sources would fit with one about territory availability because they are both about resources, while another student might decide that their question about responding to weather belongs in its own group.

Explore

Teacher's Note: Graph Prep

Before beginning this activity, create a large graph on a piece of poster paper or whiteboard. The x-axis should be the day of the year, numbered from 100-250 in intervals of 5 days. It will also be helpful to indicate the months. A day of year to month table is provided in the **Lesson 1 Explore Data** handout, which can be printed as strips for students. The y-axis should be percent insect arrival, numbered from 0-100 in intervals of 5%. Graph the data for 2013, and draw a line connecting the points. This line is to help distinguish the 2013 data points from those the students will plot and does not indicate any mathematical meaning.

If you do not have large enough poster paper, this can also be drawn on a white board or a piece of graph paper displayed with a document camera.

Break students into 8 groups. Provide each group one year of the % insect arrival data (10, 25, 50, 75, 90% arrival). While working on the following activity, have a volunteer from each group, one at a time, add their data on the large class graph. They will look at this as a class later.

Hand out a copy of the **Daily Insect Density Figure** to each of the groups. Go to **slide 7**. Using the WIS-WIM strategy, ask students to identify features of the graph(s), determine the meaning of those specific observations, and interpret the entire figure. When all groups have finished, go to **slide 8** and ask a few volunteers to share their conclusions with the class.

Teacher's Note: Big Ideas Anchor Chart

Before having students interpret the class insect arrival graph, create a poster or virtual document to record students' big science ideas. You will revisit this throughout the entire lesson series.

Next, return to the whole-class graph of insect arrival data. Use the WIS-WIM strategy here too, but ask the class to develop the ideas together as a group. Whether you choose to record students' WIS-WIM information on the figure is up to you. Guide students to explain the meaning of the graph in one to two sentences and record their final conclusion(s) on the Big Ideas anchor chart. Finally, show students **slide 9** to help them understand the relationship between the two graphs. If they are struggling to interpret the graph adequately, you could show this slide first to scaffold their understanding.

Teacher's Note: Big Ideas

Students may draw other conclusions, but the most important conclusion they should draw is that insect abundance increases earlier in the season since 2013. They may also note that this is most dramatic earliest in the season, and that insect activity maxes out earlier in the season as well (e.g., 90% of the insects appear in the data earlier since 2013).

Explain

Go to **slides 10-14** and review the information with students. They cover insect migration and reasons why organisms would migrate, followed by a brief overview of phenology. **Slides 15-17** cover how radar is used to detect organisms and example radar images. Detailed notes are provided in the notes section of these slides.

Teacher's Note: Taking Notes

Have students take notes at your discretion, but keep in mind migration, phenology, and degree days are all concepts that will be relevant for the rest of the lesson series. To help avoid students' tendency to write down everything on the slides, you might pause between sections and ask the class to summarize in their own words what information is important to write down for reference later.

Teacher's Note: Guiding Questions

Some questions you might ask students throughout the lecture slides:

- How could "degree days" explain the patterns we saw in the insect arrival data?

Go to **slide 18**. At this point, the class should return their attention to the questions they generated in the Engage. Determine whether they can answer any at this point, and if so, whether the answers belong on the Big Ideas list. After that, solicit any new questions students have after their Explore activities. If the questions were grouped by theme, this is also a good point to re-evaluate the themes to determine if there are better ways to group the questions. **Go to slide 19**. Also ask students to add any other big ideas they've taken away from the notes they've taken throughout the Explain.

Go to slides 20-21 to provide students some life history information about potato leaf hoppers, which are the focal organism in the Extend activity.

Teacher's Note

An important detail to note for later when students are comparing birds to insects, is that seasonal leaf hopper migration occurs over multiple generations. Rather than a single individual moving the entire distance of the range over the course of a season, offspring of each subsequent generation move a little further north than their parents did (**slide 21**).

Extend

Teacher's Note: Site Access

Be sure to check with your school and/or district to make sure that the Shiny App website is unblocked and accessible by student devices. This page will be used for the entirety of this lesson series.

Now that students have examined the seasonal activity of resident insects (i.e., from Oklahoma), next they will explore insect migration timing using potato leafhopper data. Go to **slide 22**. Direct students to the "Leafhopper Migration" page of the Shiny app and show them how to change the model's variables. See the **Leafhopper Migration Guide** for details on how to help students navigate the model. Provide students with a copy of the **Lesson 1 Extend handout**.

Teacher's Note: Presence/Absence Consistency

Due to the nature of the data set used in the leafhopper model, the quantity of data will vary from year to year. Some years have no data (1968-1979) and others will have data from most sites. Bold circles on the maps indicate that someone physically went to the location and collected data during a given year. Thin circles mean no one went to the location to collect any data that year.

Direct students to select years with more bold circles to increase the amount of data available to analyze. A table of states with the most complete data sets and the years with the most states sampled is provided in the **Leafhopper Data Ranges** attachment and in the **Leafhopper Migration Guide**.

Have students focus on map 1 to begin. They should pick a year early in the time series and move the days of the year slider to look for patterns in insect arrival. Next, they should select a different year for map 2 and repeat the process, looking for patterns in insect arrival for that year specifically. Finally, have them compare the side by side maps to identify trends between the years. Direct their attention to the horizontal latitude line as part of their analysis. This shows an approximate average of the range over which the insects have migrated (e.g., as insects are detected in more northern states, the line will shift north).

Bring students together as a class to discuss their results. Go to **slide 23** and ask volunteers to share their findings. Continue the conversation by going to **slide 24** and having students discuss the questions.

Teacher's Note: Possible Discussion Questions

Results

- What patterns or trends did you observe in leafhopper appearance within a single year? (Example: insects arrive later in the season the farther north you go on the maps)
- What patterns or trends did you observe between the two years/two states you compared? (Example: insects arrived earlier in the season in more recent years than in the past)

Significance

- Are leafhoppers altering their migration phenology? How do you know?
- Do they always migrate strictly from north to south?
- Why might one location not have leafhoppers observed until later in the year, when a further north location already has them? *(Note: students may give answers about study design or that a farmer didn't notice the insects, but there are more relevant biological reasons. For example local weather was cooler that year/field, the winds that brought in migrants happened to bypass that location, or maybe they planted a different, less attractive crop that year).*
- How might insect life history drive these patterns?
- Why might scientists be interested in/care about insect seasonal activity and migration data?

Evaluate

Go to **slides 25**. Return one more time to the list of student questions to determine whether any can be answered and whether any should be removed (e.g., can't be answered, are no longer interesting, etc.). Give students a few minutes to think about what other information they might need to answer their existing questions. From these ideas, encourage them to generate questions that would help them collect the missing information they need (what question could we ask to generate/find the information we need?). Add these to the question list. Next, go to **slide 26** and ask students whether there are any new Big Ideas to add to their list at this point.

Go to **slide 27**. To wrap up the lesson ask students to create a Six-Word Memoir to summarize the most scientifically meaningful thing they learned about insect phenology (i.e., a cool fact about leafhoppers wouldn't be meaningful in this case).

Resources

- NPR Look Up! The Billion-Bug Highway You Can't See https://www.npr.org/sections/krulwich/2011/06/01/128389587/look-up-the-billion-bug-highway-you-cant-see
- Stand Up, Sit Down https://learn.k20center.ou.edu/strategy/1771
- Driving Question Board https://learn.k20center.ou.edu/strategy/1511?rev=24475
- WIS-WIM https://learn.k20center.ou.edu/strategy/1201
- Anchor Chart https://learn.k20center.ou.edu/strategy/58
- Six-Word Memoir https://learn.k20center.ou.edu/strategy/75