Japanese Knotweed & Bug Biodiversity
Vital Signs Data Investigation

Overview of this Unit

Through this unit, students will develop their ecosystem understandings along with their confidence engaging in authentic science investigations. They will explore the impact of invasive species on bug communities in local habitats while they develop their skills in working with real data and connect to a community of scientists.

Research Question: Does Japanese knotweed impact bug biodiversity?

To answer this question, students will:

- Hone their scientific observation, data collection, and data collection skills.
- Use skills in the field to collect species, biodiversity, and habitat information.
- Contribute data to the Vital Signs database.
- Analyze findings to better understand biodiversity, ecology, and invasive species.

Before you begin- Locate an area with large amounts of Japanese knotweed. Students will need to collect data in multiple sites both in and out of a Japanese knotweed patch. If you don't have Japanese knotweed nearby, consider conducting the same investigation with a different invasive plant.

Students will be organized into both **fieldwork teams** and **expert groups.** Fieldwork teams will work together to collect data from the field sites. Each team will be comprised of 3 to 4 *different* experts that will have specific tasks within the group. Throughout the investigation, students will shift between working with fieldwork teams and expert groups.

Expert groups include:

- **Japanese knotweed experts:** responsible for identifying Japanese knotweed and measuring Japanese knotweed patches.
- **Control experts:** responsible for identifying a patch that has NO Japanese knotweed to serve as a control.
- **Habitat experts:** responsible for collecting data on habitat conditions and advising Japanese knotweed group 2 on finding a patch with similar conditions as the knotweed patch.
- **Bug experts:** Responsible for setting and collecting bug traps and counting bug biodiversity. Note: Bug experts do NOT need to accurately identify each species of big. They should do their best to determine the number of species, knowing that the counts will be approximate.

Fieldwork teams are identified by the class name and numbered one through four. Each fieldwork team will set two bug traps, one in a knotweed patch and one in a control area, and compare the diversity of insects in each site. They will use their data to submit two observations to Vital Signs (one Japanese knotweed "FOUND" and one Japanese knotweed "NOT FOUND"). Thus, each class will set 8 traps and submit 8 observations.

Set up a Vital Signs investigation and with team names and password for each fieldwork team. Use this guide to help: http://vitalsignsme.org/how-teachers-set-investigations-their-students

Fieldwork teams will record notes on their investigation on the Vee diagram, which can also serve as an assessment for the investigation. This diagram is meant to track progress through the investigation process. The diagram is intentionally designed to be non-linear to encourage students to add to or revise different sections at any time. The research question is positioned at the top as a reminder of the purpose of the investigation.

Outline
*Estimates of class time needed are based on 50-60 minute periods.

Part 1: Build background knowledge

Activity 1: Oh Deer! with invasive species modifications (1 class period)
Activity 2: Biodiversity Jenga with data analysis (1 class period)
Activity 3: Frame the Investigation (1 class period)

Part 2: Collect data

Activity 4: Fieldwork Skills Stations (1 class period)
Extension: The Purpose of a Control Group (1 class period)
Activity 5: Collect Data—Part 1 (1 class period)
Activity 6: Collect data--Part 2 (1 class period)

Part 3: Analyze data

Activity 7: Analyze Data (1 class period)
Extension: Explore Statewide Data (1 class period)

Part 4: Interpret and share results

Activity 8: Draw conclusions (1 class period)
Extension: Create a final artifact to show your work (varies according to project)

Full Materials List:

laptops/ipads – one per 4 to 5 students
Student notebook printouts- one for each student
Vee diagram- one for each student (included at the end of the lesson plans)
Project rubric- one for each student (included at the end of the lesson plans)
Cones to mark field for Oh deer
Chart paper with sticky top strip for creating graphs
Jenga – 1 set per 4to 5 students (optional)
Species ID cards – Japanese knotweed, Giant knotweed (print from Vital Signs website)
Species in focus card set for fieldwork skills stations (print from Vital Signs website)
Insect photos (print from Vital Signs website)
Habitat photos and habitat descriptors (print from curriculum bank post)
Vital Signs data sheets (print Curriculum bank post)

GPS (1)
Cameras or ipads (one per 4 to 5 students)
Camera cords to connect camera to computers
Extra batteries
Rulers
Plastic cups (2 per 4 to 5 students)
Container of dish soap
Water bottle (1)
Permanent markers (1 per 4 to 5 students)
Post-it notes square (3 different colors
Metal spoon or other instrument to dig in the ground
How to post data guide (print from Vital Signs website)
Ice cube tray (1 per 4 to 5 students)
Tweezers (1 per 4 to 5 students)
(Optional) Hand held magnifiers (1 per 4 to 5 students)
(Optional) M&Ms one large bag per class

***Vital Signs* Investigation Curriculum Standards**
This curriculum was designed for grades 6-8. The following are the standards and learning outcomes that students work toward through this curriculum.

NGSS performance expectations:

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.

MS-LS2-2: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.

MS-LS2-3: Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

Common Core Standards: Math

CCSS.MATH.CONTENT.6.SP.A.2Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

CCSS.MATH.CONTENT.6.SP.B.4: Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

CCSS.MATH.CONTENT.7.SP.A.1: Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid references.

CCSS.MATH.CONTENT.7.SP.A.2: Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

Common Core Standards: ELA

CCSS.ELA-LITERACY.RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

CCSS.ELA-LITERACY.RST.6-8.9: Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

CCSS.ELA-LITERACY.WHST.6-8.1: Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA-LITERACY.WHST.6-8.6: Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

CCSS.ELA-LITERACY.WHST.6-8.7: Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Maine Learning Results

A1 – Unifying Themes – Systems: Describe and apply principles of systems in man-made things, natural things, and processes.

A2 – Unifying Themes – Models: Models: Use models to examine a variety of real-world phenomena from the physical setting, the living environment, and the technological world and compare advantages and disadvantages of various models.

B1 – The Skills and Traits of Scientific Inquiry: Students plan, conduct, analyze data from, and communicate results of investigations, including simple experiments.

C1 – The Scientific and Technological Enterprise – Understanding of Inquiry: Describe how scientists use varied and systematic approaches to investigations that may lead to further investigations.

E2 – The Living Environment – Ecosystems: Examine how the characteristics of the physical, non-living (abiotic) environment, the types and behaviors of living (biotic) organisms, and the flow of matter and energy affect organisms and the ecosystem of which they are part.

Part 1: Build background knowledge

Activity 1 Oh Deer with invasive species modifications (one class period)
(Adapted originally from a Project WILD activity and Vital Signs Oh Deer: Invasive species style - http://vitalsignsme.org/oh-deer-invasive-species-style)

In this active and competitive game, students build background knowledge by experiencing how a community of native animals and plants changes in response to resource availability in their habitat. Students collect data during the game and then graph and analyze their data to answer the driving question, "How does the introduction of an invasive species to a habitat affect native species populations?"

Learning Outcomes: Students will be able to...

- Explain how invasive, native, and non-native species compete for resources within a model ecosystem.
- Determine the resources necessary for species survival within an ecosystem.

Materials

Clip boards (1 per class)
Data sheet – included at the end of the lesson plan (1 per class)
Student notebook pages (1 per student)

Teacher preparation

Review the full instructions on how to play in the student activity description below. Watch this video to see the game in action - https://youtu.be/sLGNeWQztQE

Instructions:

Introduction to the Game – In the classroom, facilitated by teachers

1. Explain to students that in the next three days, they are going to be conducting an investigation around the impact of invasive species on other species in our area.

If students do not have background knowledge of invasives, that's ok! They are going to play a game that shows the potential impacts of these species.

Introduce the driving question for this activity: "How does the introduction of an invasive species to a habitat affect native species populations?"

Explain that in this game, students will experience how the populations of a community of bluebirds and changes over time in response to resource availability and other species in their habitat.

2. Explain to students that they will play the roles of "habitat resource" and "native species" to see how populations change in response to available resources. Each "native species" will need to find a particular "habitat resource" in order to survive. As the game progresses, these roles will change as the ecosystem changes. Introduce the signals for the habitat resources:

- Food: Put hands over stomach
- Water: Put hands over mouth
- Shelter: Put hands over head
- Space: Put arms out to sides

3. Head to the site where you have set up the game.

Modeling a Healthy Ecosystem- at the field, facilitated by GMRI staff

1. Have the students count off by four.

2. Have the 1's go to one end of the field and stand in a line about shoulder-width apart, facing away from the rest of the class. This group is the **bluebirds** (native species)**.**

3. Have the 2's, 3's, and 4's line up at the opposite end of the playing field, facing away from the native species. This group is the **habitat resources.**

4. Tell the students that before each round you will count the population of **bluebirds** and **habitat resources** and record this number on the data table (remember to record each class's data in a different table).

Modifications*:*
Students who are not able to participate in an active game may take on modified roles, such as a species that does not move (i.e, part of the ecosystem), reporters that record a running commentary or play-by-play of the game, or data collectors.

5. Explain that at the beginning of each round, while their backs are turned, each **bluebirds** will decide to look for any one of its four basic resources. Review the signals introduced in class. A native species may *not* change what it is looking for until the next round.

6. At the same time, while their backs are turned towards the native species, each student that represents **habitat resources** will decide which habitat resource he or she wishes to represent and will indicate their choice using the same signals. Like the native species, the habitat students may *not* change within the round, but can change the following round.

7. Make sure the two groups (bluebirds and habitat resources) keep their backs turned from each other until the start of each round. Tell each student to make their signal.

8. Give the directions for each round/year:

    a. When you say, "Go," students will all turn around and face each other while continuing to hold their signals.

    b. **Bluebirds** should walk/run toward the habitat resource that matches what they are looking for. The **habitat resource** students should stay in their places.

c. Any **bluebirds** that finds the resources they need will survive and reproduce. They will take their habitat resource back to the starting place to become a native species.

d. **Bluebirds** that do not find the resource they need, die and become part of the habitat (representing natural population flux).

e. If more than one native species tries to get the same habitat component, the one to get there first survives.

9. Go through one round/year with the students. Explain that this represented one year in the life of this native species population and discuss what happened. Most of the native species should have found what they needed and successfully reproduced. This would result in an increase in the native species population.

10. Count the number of **bluebirds** and **habitat resources** and record it in the table.

11. Continue with 3 to 5 more rounds. As the population changes, invite students to share reasons behind the changes. Begin using the term “fluctuation” to describe these natural ups and downs and “competition” over resources.

Modelling the Introduction of an Invasive Species- in the field, modified by GMRI Staff

1. Once students get the hang of the activity, introduce **sparrows** (invasive species).
    a. If students are not familiar with invasive species, explain that a new species has been brought into the ecosystem that has an advantage (maybe it is faster or lives closer to the resources).

    b. Make sure you note when a new species is introduced on the chart. This will help students interpret their data in the next lesson.

    c. Identify 3 to 4 students as **sparrows**.

    d. Instead of starting in line with bluebirds, have the **sparrows** start half the distance to the line of habitat resources, (mimicking their ecological advantage).

    e. When the **sparrows** get their habitat resources, have those resources go back and join the invasive group at the halfway line (just as they would go back with the native species in previous rounds).

2. Continue going through a total of at least 10 rounds, recording the number of **bluebirds**

3. Bring students back inside to debrief the activity.

Oh Deer! Debrief- in the classroom, facilitated by teachers

1. Gather initial observations of the game. Use the following questions to prompt discussion:

- In what years does the bluebird population increase/decrease most dramatically?
- Why do you think the population crashed in Year ___?
- How would you describe the amount of resources leading up to that year?
- What was the population of the sparrows in that year?
- How does the population of the native species relate to the amount of habitat resources?
- How does the population of the native species relate to the population of the invasive?
- How do you think the game compares to what happens to species populations in nature?
- Why did the invasive start closer to the habitat resources? What did that represent?
- Why do you think we call invasive species "invasive"?

2. Invite students to share examples of invasive species that they have heard of and challenge students to use their experience to define invasive species. A strong definition includes:

- species that has been brought into a new environment
- a species that has some advantage that allows it to take over the ecosystem

3. Return to the original question of "How does the introduction of an invasive species to a habitat affect native species populations?" Challenge students to answer the question using specific examples from the game.

4. Optional: as a group, use the experience to construct an analogy map (in the student notebook)

a. In the first column = something that happened in the game.

b. In the second column = something that happens in the real world that is like the game.

c. The last column = explain how the part of the game listed in column one is supposed to represent the part of the real world listed in column two.

Oh deer! data sheet

Game 1:

Year (round)	Number of habitat resources	Number of natives	Number of invasives
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

Game 2 (optional):

Year (round)	Number of habitat resources	Number of natives	Number of invasives
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

Activity 2: Biodiversity Jenga (one class period)

Through this hands-on modeling activity, students will learn about the importance of biodiversity and develop skills in using a dot plot, which will prepare them for analysis of data from the class investigation.

Learning Outcomes: Students will be able to…

- Explain the importance of biodiversity in an ecosystem, using their own words
- Organize data into a dot plot

Materials:

4 Jenga games per class
Chart paper
Markers
Projector with sound

Teacher preparation:

1. Make sure you can access the following video of Bill Nye: Biodiversity. You can play the first 4 minutes and 30 seconds for students or play the entire 22 minutes, depending on time constraints. The video can be found here: https://www.schooltube.com/video/8e1097409b914b60be69/Bill%20Nye%20Biodiversity.

2. If you are unfamiliar with constructing dot plots, watch this Khan academy video: https://www.khanacademy.org/math/cc-sixth-grade-math/cc-6th-data-statistics/dot-plot/v/frequency-tables-and-dot-plots

3. Set up a graph on chart paper on which students can plot their data (see the examples below in the activity directions).

Title "Final Biodiversity Count"
y-axis: "Number of Games Reporting" on both graphs and space out units from 1 to 10
x-axis: "Final Biodiversity Count before Collapse" and space out units from 1 to 35.

Instructions:

1. Have students recap their learning from day one.

2. Revisit the investigation question: "Does Japanese knotweed affect bug *biodiversity*?" The next activity is meant to explore what we mean by biodiversity and why it is important.

3. Play at least the first 4 minutes and 30 seconds of Bill Nye: Biodiversity.

4. Explain to students that they are going to play their own Biodiversity Jenga, but they are going to collect and analyze the data from the game. This practice will help with the class investigation. Explain that unlike Bill Nye's Jenga game, their ecosystem will have an invasive species, like Japanese knotweed.

5. Have students turn to the student notebook and read through the rules of the game. Invite volunteers to come up to the front and help you model each step. As you model the game:

a. Use specific examples of species that may be present at your field site, like grass, other native plants, native birds, and bugs. Use the example of Japanese knotweed for the invasive blocks. Invite students to add their own examples.

b. Come up with examples of why species might be removed from the ecosystem, and invite students to generate their own (for example, not enough light, food, human disturbance).

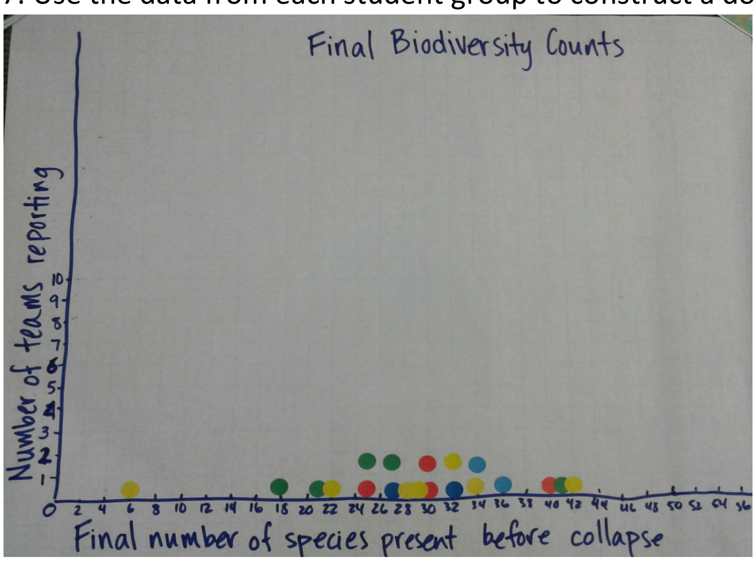
c. Collect data in a table like the one in the student journals. Keep track of the number of species present (biodiversity) and the number of individuals in the invasive species population that have been introduced (number of blocks placed on top). Students do NOT need to record this data as they will record data from their own game shortly.

Note: Biodiversity should NOT change in the first turn (the first invasive is added is a new species which counters the loss of the native species from the ecosystem). The biodiversity count will decrease by one after each subsequent year, as species are removed from the ecosystem but no new species are added.

d. Emphasize that this Jenga game represents a model ecosystem. The model may or may not predict what will happen in the class investigation. We don't actually know what will happen in our investigation!

6. Have students follow the same procedure to play and record data for 15 to 20 minutes in **fieldwork teams**. If the ecosystem collapses, they should begin a new game. The data table is designed for two full Jenga games. They can keep going if they have time and collect data on a new sheet of paper.

7. Use the data from each student group to construct a dot plot (see the example below).



a. Use the data from the class demonstration to show how to add to each of the dot plots. Write a dot over the place on the X-axis that represents the final biodiversity count and the final invasive count before collapse.

b. One group at a time, have students come up to the chart and add a dot over the final counts for each Jenga game that they played.

c. If you have multiple classes, collect data from each class on one graph so that you have more data to analyze. If you can, save your data year after year for a robust database!

8. Once the graphs have been constructed, model how to interpret the results.

a. Point out a tower that had a low biodiversity when it fell and one that had a high biodiversity. Ask students why all the towers didn't fall at the same time. Example responses include shaky hands, depends on the blocks you choose etc.

b. Explain that all ecosystems are different, but sometimes we can find patterns by looking at the data all together. Point out a part of the graph with a lot of data points. "From the data, you can say that a lot of ecosystems collapse when the biodiversity gets down to around ___"

9. Explain that by looking carefully at the data, you can find out a lot about what happened in the games. Have the students work with their team to annotate their graph according to the instructions in the notebook. When they are finished, they should choose one question at the bottom of the page to discuss with their team.

10. Have students share their discussions of the questions. Key points are italicized.

- What happened to the tower as biodiversity got lower and the number of invasives increased?
  The tower was less stable, more wobbly as the number of invasives increased.

- What was the biodiversity when most of the games collapsed? *This will depend on the data from the group. Look for statements like "most of the towers collapsed between biodiversity of __ and __. "*

- What does this game have to do with our investigation about Japanese knotweed and bugs?
  Because Japanese knotweed crowds out other plants and takes up lots of sunlight, it affects other living things around it. More Japanese knotweed might result in less bug biodiversity, just like in the Jenga games, but we don't actually know yet.

Activity 3: Frame the Investigation (one class period)

In this activity, students will choose roles in the investigation and then collect background information that connects to their particular role.

Learning Outcomes: Students will be able to...

- describe the purpose of their investigation and its real-world significance

Materials

ipads/computers

Vee diagram (1 per fieldwork team)

Teacher preparation:

Create **fieldwork teams** of 3 to 5 students (4 being the ideal number). Give each group a number.

Instructions:

1. Explain to students they the investigation that they are conducting has to do with the invasive plant Japanese knotweed. This is a plant that is found all over the state of Maine. Invite students to share whether or not they have heard of the plant.

2. Have students brainstorm how an invasive *plant* might affect other species around it. Encourage students to think about:

- crowding out other plant species that might be food to other parts of the ecosystem
- blocking out light
- using water

3. Explain that one thing that scientists *don't* know, since not many people have studied it, is how invasive plants impact bugs. Students are going to investigate whether Japanese knotweed affects bug diversity (or the number of *different* bugs) around it. Emphasize that this is an authentic investigation—no one knows what the students will find. Students will be adding new information about Japanese knotweed and its impacts.

4. Divide students into their **fieldwork teams.** Tell each team their number or encourage them to come up with a team name.

5. Explain that within each team, each student will have a special role. Explain the roles listed in the student notebook:

- **Japanese expert:** You are responsible for identifying Japanese knotweed. You will gather photo and written evidence showing where Japanese knotweed is found. You will also measure and count the Japanese knotweed.
- **Control expert:** You are responsible for finding a site where Japanese knotweed is NOT FOUND. You will gather photo and written evidence showing there is no Japanese knotweed at your location.

- **Bug expert:** You will be responsible for collecting data on bugs. You will make bug traps, set them, remove them, and count the number of different kinds of bugs in the traps. Caution: you will need to handle dead bugs.
- **Habitat expert:** You will be responsible for recording the habitat conditions where the Japanese knotweed is found and where it is not found. You will choose two sites with similar conditions to place the two bug traps.

6. Give students time to read over the expert roles in the student notebook and decide who will take on each role. Let students know they will keep these roles throughout their investigation.

If students have trouble deciding their roles, encourage them to write the names of the roles on a slip of paper, shuffle the papers, and choose blindly. Disputes can also be resolved using "rock, paper, scissors."

Note: if a fieldwork team has 3 people, one person will need to take on two expert roles. If a team has 5, two people can have the same role.

7. Next students will conduct background research on their investigation. Each expert will focus on a different question. Preview the four questions, and make sure that each student knows the ONE question that they are researching.

8. Have students get into their **expert groups** to conduct their research. Allow expert groups to work together, share sources, and share what they find.

9. After 15-20 minutes, have students get back into their **fieldwork teams.**

10. Each expert should share what he or she found.

11. Using all the information students have gathered, each fieldwork team should work together to complete boxes 1 through 3 of their Vee diagram.

12. Once students are finished, give them time to complete the Part 1 reflection.

Part 2: Collect data

Activity 4: Fieldwork Skills Stations (one class period)

Students will prepare for field work through these interactive stations. Before heading out to the field, they will develop skills in making high quality observations in these in-class skills stations.

Learning Outcomes: Students will be able to…

- Describe the characteristics of high-quality scientific observation.
- Identify high quality scientific observations.

Materials/teacher prep:

Set four stations at different parts of the room. Label each station clearly:

Spot the difference:

- Japanese knotweed species ID card http://vitalsignsme.org/sites/default/files/content/ui_fallopia_japonica_062912.pdf
- Giant knotweed species ID card http://vitalsignsme.org/sites/default/files/content/ui_fallopia_sachalinensis_071012_0.pdf

Species in focus:
print photos from here: http://vitalsignsme.org/species-focus-photo-critique-activity
spread the photos out around the table/desk

How many species are there? Spread out the bug photos (print from curriculum bank post)

Describing a habitat: Spread out habitat photos and terms (print from curriculum bank post)

Instructions:

1. Show the Vital Signs website. Let students know that students from across the state have been investigating invasive species and posting what they find out on this site. Researchers and research managers go review the information in order to find out more about these species and know where in the state the invasives are. Tell students that they will be posting their information to this site, too.

2. Show students how to search the Vital Signs database for Japanese knotweed (instructions are in the student notebook). Click on a few different observations and have students point out some similarities and differences. Which observations have the best photos? What makes them the best? Which have the best written observations?

3. Give students time to explore the data on their own and find examples of great and “okay” observations.

4. Next, point out the station names and the activity instructions at each station. Explain that students will work in stations to practice skills that will help them make great observations.

5. Assign each **Fieldwork team** to a station. Give students 6 minutes complete the tasks at the station. Students should take notes in their notebooks. After time is up, they should rotate to the next one.

6. After students have gone through the stations, work as a group to generate at least three important tips for going out to collect data.

Extension: What is a Control Group?

Students may not understand the purpose of collecting data where there is no Japanese knotweed found. If this comes up, try this simple activity.

Learning Outcomes: Students will be able to…

- Explain the purpose of a control in an experiment

Materials

Three bags of M&Ms
8 cups
spoon

Teacher preparation:

Set up one bowl of M&Ms by the window. Keep one package of the M&Ms unopened.

Note: If students have allergies or are not able to eat M&Ms, substitute with a different snack.

Instructions:

1. Explain to students that you have heard that leaving M&Ms out in the sun will affect the taste of the M&Ms. Together, you are going to conduct an investigation to find out if it is true.

2. Show the bowl of M&Ms by the window. Explain that each student will taste one M&M and then decide whether or not the taste was affected by being out in the sun. Then you will tally up all the yes and no answers to come to a conclusion.

3. Spoon out one M&M for each student.

4. Have each student taste the M&M at the same time to decide whether or not the sun affected the taste.

5. Give students a minute to make their decision, then have all students that think "yes" go to one corner of the room, "no" to a different corner, and "not sure" stay in the middle.

6. Ask a student volunteer to tally up the responses then have students return to their seats.

7. Ask students what they thought of the experiment. Were they sure of their answer? Was it difficult to decide if the sun affected the taste? Students are likely to share that they don't know how the sun affected the taste because they had nothing to compare the taste to.

8. Define a "control group" as a part of an experiment that is used to compare against the part that you have a question about. Explain that the experiment lacked a control group.

8. Challenge students to come up with a way to improve the experiment to answer the question "Does sunlight affect the taste of M&Ms?" Have students get into their **fieldwork teams.** Give the teams 10 minutes to come up with a better experiment. Give each team a handful of M&Ms to work with.

9. After ten minutes, have students share their ideas with the class. As students share, look for opportunities to reiterate that control groups help with comparison, especially when conditions are similar for the control and experimental groups.

10. Let students know that the real purpose of the activity was to explore ideas about a control group and how it can be helpful. Challenge students to draw connections between this investigation and the ongoing Japanese knotweed and bug biodiversity investigation. Give students three minutes to discuss any similarities in their groups.

11. Have students share. Guide them towards identifying the patch that has NO Japanese knotweed as a control group. They will compare the number of bugs in this group to the number of bugs in the Japanese knotweed patch to see if the Japanese knotweed makes a difference.

Activity 5: Collecting Data—Part 1 (one to two class periods)

Learning Outcomes: students will be able to…

- Collect clear and accurate data

Materials:

For each fieldwork team:

2 shallow bowls
2 Japanese knotweed species ID cards-
http://vitalsignsme.org/sites/default/files/content/ui_fallopia_japonica_062912.pdf
2 adapted Vital Signs data sheets (included in the curriculum bank post)
2 Clipboards
Ruler
Camera/ipad

For the class:

GPS
Permanent markers
Dish soap
Bottle of water
Extra pencils
Extra
1 spoon or small tool to dig holes with

Teacher preparation:

Identify sites where each fieldwork team can collect data—one in a Japanese knotweed patch, and one outside of the patch.

Make sure you have your investigation set up in Vital Signs with a team name and password for each fieldwork team. Use this guide to help. Use this guide to help: http://vitalsignsme.org/how-teachers-set-investigations-their-students

Gather materials for fieldwork.

Instructions:

1. Explain to students that they are going to go out to the field to collect data shortly, and they need to know exactly what they will be responsible for in the field.

2. Divide students into their **expert groups**.

3. Have expert groups read over their roles and look over their materials. Let students know that they will need to explain what they will be doing to their fieldwork team.

4. Check in with each expert group to see if they have any questions and if they understand what they need to do.

5. Move students into their **fieldwork teams.**

6. Have students explain their jobs to their team. Once they have shared, students should summarize the data collection plan in box 4 of the Vee diagram.

7. Check in with each team before heading out into the field, making sure they have materials and know what to do.

**Consider bringing students out to see their field site and do a trial run of their procedure to make sure they are comfortable to completing all of their tasks before they need to set traps and collect data. **

8. Walk students to the field site.

9. Help students identify the Japanese knotweed patch.

10. Check the fieldworks teams' datasheets before coming back to the classroom (each team should have 2—one for the knotweed patch and one for the control area).

11. Back in the classroom, have students share about anything that came up during their fieldwork. Did they miss anything? Did anything happen that was unexpected? If did not complete any part of the data sheet, they can fill in the data in part 2 of data collection.

Activity 6: Collect Data—Part 2

Students will return to the field to collect bug traps and fill in any missing parts of their observations. Then, they will enter, quality check, and publish data to the *Vital Signs* database. Published observations are shared with an online community of students, teachers, citizen scientists, and professional scientists.

Learning Outcomes: Students will be able to…

- Assess the quality of data collected during field work
- Revise, edit, and organize work for publication

Materials

Data sheets from field work
Cameras with the photographs taken during fieldwork
Cord for connecting cameras to the computers/ipads
Access to the internet
How-to guide for posting to Vital Signs:
http://vitalsignsme.org/how-students-put-their-data-website
Tweezers
Paper towels
Ice cube trays
Magnifying glasses

Teacher preparation:
Make sure that students have their datasheets from Activity 6

Lay out tweezers, magnifying glasses, paper towels, and ice cube trays for bug experts to use for sorting bug species.

Instructions:
1. Have students get together with their **fieldwork team.** Students should go through the datasheet together to make sure they have completed all the required sections (indicated with a *) If any sections of these sections are blank, they can fill them in at the field site.

2. When students are ready, take them back to the field site to collect the traps. Make sure that bug experts carry the traps carefully so that no bugs are lost as they walk back to the classroom.

3. Inside the classroom, have students work in their **expert groups** to collect and post all the data.

Japanese knotweed experts: post “Japanese knotweed FOUND” observations to vital signs.

Control experts: post “Japanese knotweed NOT FOUND” observations to vital Signs

Give students the “How-to” guide to help with posting.

Habitat experts: help with posting. Conduct the Quality Assurance check in the student notebook.

Bug experts: Count and record the number of species of bugs in each trap.

Students can sort species by placing different species in each section of the ice cube tray. Have students use tweezers for the smaller bugs.

Make sure that students sort species from one tray at a time and record the data right away so that they do not confuse the data from different traps.

Note: Students do not need advanced identification skills for this task. Sorting bugs into groups like "ant" "small fly" "big fly" "spider" etc. is fine for the purpose of this investigation.

Report these numbers to the knotweed groups to be entered into the "Field Notes" section of the observations. Make sure the bug traps in the knotweed patches should be posted with the FOUND observations. The data from the traps from the control area should be added to NOT FOUND observations.

4. Once students have published their data, they should get a response from the species expert. They can look at each other's observations by going to the "explore data" tab on the Vital Signs website: http://vitalsignsme.org/explore/search

5. While students are waiting for responses, they should complete their part 2 reflection.

Part 3: Analyze data

Activity 7: Analyze Data (one class period)

Students will combine their data, first as a class and then with other groups. They will compare the number of bug species in the knotweed traps versus the number of species in the control area to draw conclusions.

Learning Outcomes: Students will be able to…

- Compare two distributions of data

Materials

Poster sized paper
Markers

Teacher preparation:

Set up two graphs on the poster paper:

Graph 1:
Title: Bug biodiversity where Japanese knotweed was FOUND
X axis: Bug species count
Y axis: Number of teams reporting

Graph 2:
Title: Bug biodiversity where Japanese knotweed was NOT FOUND
X axis: Bug species count
Y axis: Number of teams reporting

If you have data from previous years or different sections of the same science class, have it ready so it can be combined with your current data OR reach out to Meggie at mharvey@gmri.org for data collected from other schools.

Instructions:

1. Have **fieldwork teams** share their findings from their fieldwork, including the number of bug species found in each trap.

2. Have the **bug expert** from each group add their data to the poster sized graph that you created. As they do, have all other students add to the graphs in their student notebook.

3. Look closely at the class data as a group. Are there any points that stand out? That are questionable? For example, were there any traps that just didn't work? If so, decide as a group whether the data should be removed.

4. Challenge students to explain any of the *differences* in the data. Was one of the traps out in the sun while the others were in the shade? Are there other factors that could have contributed to these differences?

5. See if you can draw any tentative conclusions based on the class data. What was the bug diversity for most of the traps in the knotweed patch? In the control area? Write these numbers down.

6. If possible, have students add data from other classes to the graphs(from years prior or from different science classes participating).

7. Have two student volunteers fill the rest of the data in on the class graph.

8. Have the students look closely again at the data, working in their **fieldwork teams,** following the instructions in the student notebook.

9. Once they have discussed their graphs, following the prompts in the notebook, have them share out. Below are a few key discussion points to draw out:

- Which had higher bug biodiversity, the sites with Japanese knotweed, or the sites without? How do you know?
  Encourage students to refer to the data in the graphs. They should look for most common values, highest values, lowest values, cluster of data to support their answers.

- How reliable is the data that we collected? Is there anything we could have done to collect better data?

  Encourage students to give specific examples of conditions or actions that varied from site to site. Propose some specific factors that may have affected the data, such as trap design, amount of sunlight, surrounding environment, fertilizers, pollution from roads and sidewalks, etc.
- What was the purpose of collecting data in places that had NO Japanese knotweed?
  Remind students that the control area was used to compare against the bug biodiversity in the knotweed patch. Without the control area, they wouldn't know if Japanese knotweed made a difference to the bug community.

10. Have **Fieldwork teams** summarize their data in box 5 of the Vee diagram. They should include values that describe bug biodiversity in each area, such as most common values, highest values, lowest values, biodiversity ranges where there are clusters of data, etc,

Extension: Explore the State Japanese Knotweed Data (one class period)

In this extension, students build their skills in data collection by analyzing the Japanese knotweed and biodiversity data in the Vital Signs database.

Learning Outcomes: Students will be able to…

- Describe two distributions of data
- Compare distributions to form a tentative claim

Materials

Computers/ipads

Teacher preparation

Watch the CODAP "Getting Started" video to get acquainted with the program:
https://codap.concord.org/help/basics/graphs

Instructions:

1. Explain to the class that students from across the state have been collecting data on Japanese knotweed and biodiversity for many years (but you are the first to collect BUG biodiversity counts). The challenge for this class is to look at that data all together to see if Japanese knotweed has an impact on total biodiversity,

2. Click on the following link to access the data: http://bit.ly/jknotweed. A graph should automatically pop up showing biodiversity where Japanese knotweed was FOUND. Another graph is minimized showing the NOT FOUND biodiversity data.

3. Show students how to open both graphs and how to use the pencil icon to annotate them. Challenge students to follow the instructions in the student notebook to look very carefully at the data. After they have looked at each graph one at a time, they will try and decide if biodiversity is higher in areas where Japanese knotweed was found.

Note: There are more data points in one graph than the other, but that doesn't necessarily mean that the biodiversity is higher.

4. Have students share their conclusions and what they saw in the data that led to them. Here are a few things you can point out about the data:

a. In both datasets, 5 is the most common value (or mode). That doesn't really help with a conclusion. So are the highest and lowest values (0 and 50)

b. In the FOUND graph, there are lots of datapoints between 0 and 5. Those are very low values for biodiversity.

c. In the NOT FOUND graph, the greatest cluster of datapoints is between 5 and 10, slightly higher than the FOUND data.

d. In the FOUND graph, by far, the greatest percentage of the datapoints are between 0 and 10. In the NOT FOUND, there is a significant percentage of data between 10 and 20.

Based on the above, you could say that biodiversity was higher where Japanese knotweed was NOT FOUND. It is also really tricky to tell based on this dataset, and it is OK if kids don't get there on their own. They might, instead, come to the conclusion that more NOT FOUND data is needed. That is a great conclusion.

4. Once students have drawn conclusions, challenge them to explore the data on their own by creating their own graphs. Show how to open a graph and drag and drop different attributes to the axes. There are additional questions for students to investigate in the notebook.

Part 4: Interpret and share results

Activity 8: Draw Conclusions (one class period)

In this section, students will apply their data analysis to concepts that they have learned about relationships in ecosystems in order to draw conclusions. Students should be able to work with some independence, building on the work already done in this unit.

Learning Outcomes: Students will be able to…

- Make claims supported by evidence and reasoning
- Evaluate the strength of their clams

Materials

Charts, graphs, diagrams generated in previous activites
Post it notes (preferably 3 different colors)

Teacher Preparation:

Write the question "Does Japanese knotweed impact bug biodiversity?" at the top of a poster sized paper. Beneath, make two columns, labeled "YES" and "NO." Hang the poster up.

Instructions:

1. Explain to students that it is time to pull together everything they have learned in their investigation to address their question.

2. Give each fieldwork team a post-it note. Let them know that they have 5 minutes to come up with their answer. On the post-it, they should write their answer (yes or no) and one piece of evidence that led to their answer.

3. After 5 minutes, have students stick the post it on the appropriate side of the poster.

4. Give teams two more post-it notes (two different colors). They are going to have 5 more minutes to look over the other teams' responses. On one of the post its, they will write why they agree with other team's response. On the other, they can write why they disagree, or questions that they have. Instructions and examples are given in the student notebook.

5. Point out that the class has gathered all of the important pieces of an argument. The claim (yes or no), evidence to support the claim (on the first pos-it) explanation of the reasoning behind the claims and evidence (post-it 2) and possible reasons for uncertainty or alternative claims (post-it 3).

6. Allow fieldwork teams to use any of the thinking gathered to organize their argument in their Vee diagram. They may need to use the back for extra writing space.

Summative assessment: collect Vee diagrams as a summative assessment. Use the rubric attached at the end of this document for reference.

Extension: Create an artifact to share your findings

Students will create final artifacts to showcase their work. This lesson is designed to be open-ended to accommodate a wide range of student projects.

Learning Outcomes: Students will be able to…

- Revise and edit work using self, peer, and adult reviews
- Produce a final project that showcases their learning

Materials

Materials will vary depending on student projects

Teacher Preparation for Lesson 14:

Review the "Best Projects" from the Vital Signs project bank for examples to show to students: http://vitalsignsme.org/best-projects. Here are some suggestions:

- http://vitalsignsme.org/lady-slipper
- http://vitalsignsme.org/bullies-versus-benefactors-natives-vs-invasives
- http://vitalsignsme.org/there-correlation-between-blue-mussel-population-and-green-crab-population

Lesson Steps:

1. Congratulate students on an in-depth investigation. Encourage students to think about who else might be interested in their findings and how their research impacts the community.

2. Show two to three examples of projects from the Vital Signs Project Bank, and go over the options listed in the student notebook.

3. Review the timeline for the project and your expectations for how students will use their time.

4. Give students time to work on their projects. Check in frequently as students work. Remind them often of the amount of time remaining.

5. Once students' final projects are complete, they should post them to the Vital Signs project bank (directions are listed in the student notebook).

6. Work with students to determine how best to share with the community and get to work spreading the word!

Vee Diagram

Box 1 - Our research question:

Box 2 - What do we know about invasive species and ecosystems? Write down what you know that might be helpful to our investigation.

Box 3 - What will we find? Write your hypothesis.

Box 4 – What sampling methods will we use? Summarize your data collection plan.

Box 5 - What did we observe? Summarize your data and attach your graphs.

Box 6 – What can we learn from our findings?

Claim:

Evidence:

Reasoning:

Level of Certainty:

Japanese knotweed and Bug Biodiversity Investigation Rubric

	Level 1 (Beginning)	Level 2 (Developing)	Level 3 (Meets)	Level 4 (Exceeds)
	I can…	*I can do all of level 1 and…*	*I can do all of level 2 and…*	*I can do all of level 3 and…*
The question NGSS SEP 1: Asking Questions and Defining Problems	State our research question in my own words.	Connect the question to the data collected.	Explain why the question matters to me, my local community, or the scientific community.	Identify how my question adds something new to existing scientific research.
Methods NGSS SEP 3: Designing and Carrying out Investigations	Describe an investigation that addresses my research question.	Describe the data used to address my research question.	Describe how to record the data, including specific measurements and observations to be collected.	Describe the thinking that went into gathering reliable data, including collecting data from multiple sites or multiple times, controlling variables or using a control group.
Results NGSS SEP 4: Analyzing and Interpreting Data	Display the data that I collected to answer the question.	Create a visual representation that makes my data understandable, like a graph, table, or other figure that is scaled, labeled, and accurate.	Choose an appropriate graph, table, or figure that organizes the results in a way that helps address the research question. I can explain the information in that graph, table, or figure.	Identify aspects of the data that help to understand the results, which could include the range, mean, median, mode, the spread of the data, any interesting points or groups of data, or outliers in the data.
Conclusions NGSS SEP 7: Engaging in Argument from Evidence	Use the information that I gathered to make a clear claim about my research question.	Support my claim with evidence from the data and explain why I think the data supports my claim. I can connect my findings to scientific concepts and explain the significance of my claim.	Explain how confident I am in my claim, considering factors that that might have impacted my data, possible sources or error, natural variability in the data, and/or the amount of data collected.	Explain how I ruled out other possible claims. I can pose additional questions for future study to help me investigate further.