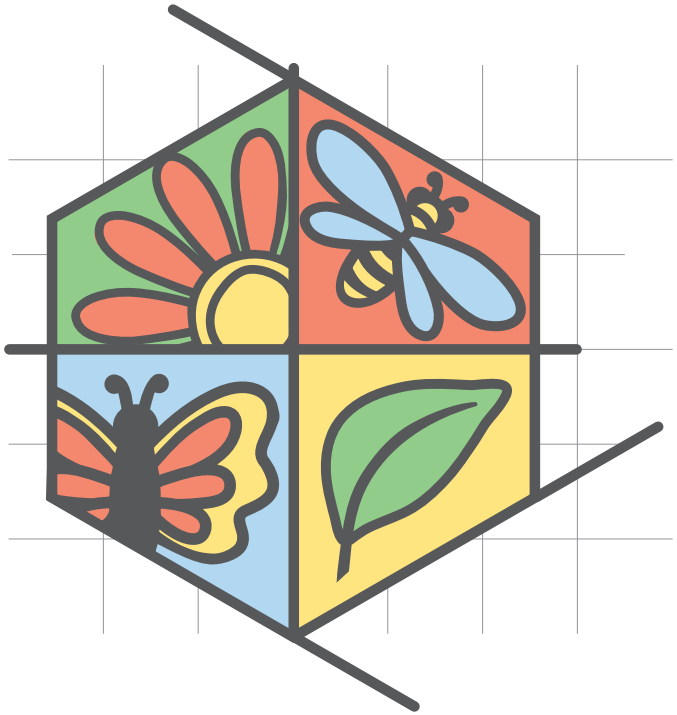

Populations & Ecosystems

Middle School NGSS Storyline

STEM

10.29.18

ATTRIBUTION

This unit storyline was written by Pranjali Upadhyay, Integrated Curriculum Specialist, with support from Stacy Meyer, Regional Science Coordinator, and Vickei Hrdina, Director of STEM Initiatives, Educational Service District 112. The unit, logos and graphics were designed by ESD 112's Design Services, led by Creative Director Heidi Barnes. Instructional materials are developed to support the following science kit:

- FOSS: Populations and Ecosystems

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A digital copy of this document is available on the STEM Materials Center website at: https://www.stemmaterials.org/populations_and_ecosystems/

A Note of Thanks

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STEM
Science
Technology
Engineering
Math

Background on the Core Scientific Ideas in this Unit

WHAT WILL STUDENTS KNOW AT THE END OF THIS UNIT?

This Middle School OER Unit presents two MS NGSS Life Science topic bundles (MS-LS1-6, MS-LS1-7, MS-LS2-1, MS-LS2-3, MS-LS2-4, MS-LS2-2, MS-LS2-5) using the context of Bee Colony Collapse Disorder as an anchoring phenomenon. Students explore the global issue of dying honey bees and develop a plan to help preserve the honey bee population. Through various investigative phenomenon such as the eruption at Mt Saint Helens and the reintroduction of wolves in Yellowstone, students study the foundations and interactions existing within and across ecosystems. Students apply their understanding of these phenomena to deepen their study of ecosystems using various FOSS investigations. Learning is constantly tied back to the anchoring phenomenon as students gather data, evidence, and develop a solution that will help preserve the honey bee and wild bee populations who live in their community. Finally, students create and share a public product which strives to educate and mobilize their community towards bee preservation and appreciation for ecosystem services.

UNIT OVERVIEW

Lesson No.	Duration	Standards	Materials Needed	Focus	Assessment Options
1 **page 6**	1-2 days	3-PS2-1	Computers with internet access	• Engage and explore bee colony collapse using videos and articles. • Research colony collapse disorder. • Brainstorm ways that humans can preserve the honey bees. • Study "where do bees come from?" • Create a quick sketch of the relationship between honey bees and humans. • Create a know/need-to-know chart • Choose one solution to focus on and develop throughout the Unit.	Initial drawing of relationship between honey bees and humans, know/need-to-know chart
2 **page 8**	4-5 days	3-PS2-2	Computers with internet access, FOSS Investigation 1 (Pops and Ecosystems)	• Watch videos of Mt. St Helens Eruption • Explore simulations and study post-eruption devastation on the ecosystem. • Read about the effects of the eruption on life. • Write a CER argument describing the effect of the eruption on life. • Study milkweed bugs and create a model showing how milkweed bugs interact with their environment to survive. • Explore a photosynthesis simulation. • Connect to the storyline through discussing habitat destruction and climate change and the effect on honey bees.	CER argument Model of Milkweed Habitat

UNIT OVERVIEW (cont.)

Lesson No.	Duration	Standards	Materials Needed	Focus	Assessment Options
3 page 11	8-10 days	3-PS2-1 3-PS2-2	FOSS Investigation 3 materials, computer with internet access, Yellowstone animal sort cards	• Engage in phenomenon of Wolves of Yellowstone by studying articles showing the contrast before and after the wolves were reintroduced. • Engage in a debate about whether or not wolves should have been introduced. • Write a CER argument to defend their stance. • Create a Yellowstone food web to show transfer of energy. • Create a mini-ecosystem and explain the interactions between biotic and abiotic factors in the mini-ecosystem. • Connect to the storyline and create a model showing the relationship between bees and their ecosystem. • Engineer an artificial pollinator.	Model of mini-ecosystem, CER argument, model of bees in their ecosystem
4 page 16	2-3 days	3-PS2-1 3-5-ETS1-1	FOSS Investigation 6 materials, computer with internet access	• Investigate rise and fall of milkweed bug population. • Discuss the impact of resources availability on bee populations in the Pacific Northwest.	Check-in with project updates
5 page 18	4-5 days	3-PS2-3 3-PS2-4	Computer with internet access Video or phone camera Misc supplies for creating final product (ex. posters, markers, paints, props	• Collaborate with team members based on specialization of solution. • Plan and create final product. • Craft CER argument to accompany product • Peer review and provide feedback to peers • Improve and present final public product.	Final Public Product and CER Argument

LESSON 1: Save the Bees!

Strategy: Engage

Engage students by presenting a driving question that connects to real-life phenomenon.

Materials Needed

- Computers with Internet Access
- Chart paper and Markers

Throughout this Unit, students will expand their understanding of ecosystem dynamics and study how organisms interact with each other and other non-living parts of the ecosystem. Students will study the anchoring phenomenon of Colony Collapse Disorder and will explore the relationship between honey bees and humans. After each lesson, students will connect their findings to the problem of colony collapse disorder and its potential impact on humans. Students may also chose to focus their attention on wild native bees if they are interested in preserving that population. The intent for using an anchoring phenomenon is to provide students with a larger context in which to tie together different DCIs and CCCs through the use of various SEPs. Please read this STEM teaching tool about using phenomenon-driven instruction if you would like more information about using phenomena to teach science.

Driving Question: What can we do in our community to preserve the honey bee population?

Entry Event: Introduce students to the anchoring phenomenon of honey bee colony collapse that is happening throughout the United States and around the world using one or more of these entrance videos:

- Why are all the honey bees dying!
- What's Happening to Honey Bees?
- Why are the bees dying?

This lesson developed by the NYT Learning Network can also be used as an entry event to introduce the topic and engage students with the driving question.

Articles to develop background knowledge (ELA integration)

Have students read these following articles and identify several possible causes for the honey bee population dying out. What is the role of humans in causing bee populations to die out? Since this is a lot of reading, students will need some additional support and scaffolding to be successful. Use your preferred strategies or protocols to help students process the texts. For example, you may choose to use a jigsaw protocol and have students each read one article and share

LESSON 1 (cont.)

out their new learning with a small group. Also read this timeline of honeybee history together so students understand the background of honey bees. Contrary to common misconceptions, honey bees are not native to the United States (or the western world) and have been domesticated by humans thousands of years ago for their honey and for their assistance in pollinating our agricultural crops. There are points throughout the unit where students can shift focus to the native bees in the Pacific Northwest and the services that they provide to their ecosystem.

- No Bees No Food
- Good news for Honeybees: 2016 Population Results are not 'Horrible'
- Want to eat?
- Study: One Pesticide doesn't harm bees, but two do
- Zombie bees found in Washington State

Need-to-know chart (N2K chart): After students have spent some time researching and becoming familiar with problem of bee colony collapse, ask students to come up with know/need-to-know chart (N2K chart). Here, students can write the information that they already know about the problem, and information that they need-to-know in order to solve the problem.

- Make sure that the N2K is *visible and accessible to students*. They will revisit the chart and add to it throughout the course of the Unit.
- Remind them about their driving question: What can we do in our community to preserve the honey bees? Ask students to begin to think about what aspect of the problem they would like to focus on (ex. pesticides/insecticides, parasites, habitat destruction, malnutrition, etc.).
- Students may need teacher guidance to craft questions. This is where the teacher can emphasize the relevance of the content that will be taught in the Unit and give students a reason behind the learning.

Creating an initial model and forming 'expert groups:' Ask students to draw a quick sketch/drawing that illustrates the relationship between bees and humans. They can use arrows and captions to help represent their thinking. Please use STEM Practice Brief #8 to access resources to support scientific modeling in the classroom. Ask students to think about which part of the problem they would like to focus their research on (habitat destruction, pesticides, and commercial agriculture leading to poor nutrition, parasites, contaminated water, and migratory stress). Why is this particular cause of interest to them? Encourage students to choose a topic that they genuinely find interesting, as they will be studying this cause more deeply and will be coming up with a solution to mitigate its effects on bees. The teacher can start to organize students into "expert groups" based on the particular type of solution they'd like to focus on (ex. group addressing use of pesticides, invasive species, habitat destruction, climate change, etc.).

LESSON 2: Recovering from a Disturbance

Strategy: Explore

In this Lesson, students will be exploring a few different phenomena and answer the investigative question: How can we plan to help an ecosystem recover after a serious disturbance? They will be studying the Mount St. Helens eruption throughout most of the lesson and will engage in embedded FOSS investigations. Students will then tie their learning to the anchoring phenomenon of the bees and colony collapse disorder.

Engage students in this lesson by asking students if they have visited or heard about Mount St. Helens and what happened in May of 1980. Show students some videos the catastrophic event: Mount St. Helens Video.

1. Have students discuss: What types of organisms were living in this area before? What might have happened to them after the eruption? Provide students with this chart to take notes/observations before, during, and after the event:
2. Students can view this slideshow from National Geographic to make observations.
3. Students can also read this article to study how the organisms in Spirit Lake were affected.
4. Have students explore the Mount St. Helens Science and Learning Center Interactive which describes the types of devastation caused by the eruption, ask them to log their observations in the B/D/A charts.

Creating a CER (Claims Evidence Reasoning) Argument: Ask students to imagine they are talking to their friend from Arizona who doesn't know about the Mt. Saint Helens eruption. When it is mentioned, their friend says, "Well, why was the eruption that big of a deal? How did the eruption even affect the living things in the area?" Students can create a claim to answer the question use pieces of evidence they have found throughout their research to back up their claims. This template can be used to help scaffold students' arguments. Please see this sample CER argument for the teacher's reference. Remind students that their reasoning is important because it will help their friend see how important their evidence is in supporting the claim. Students may also want to revisit and revise the "reasoning" column of their argument after the milkweed bug discussion in the next part of the lesson.

FOSS Investigation 1: Milkweed bugs. In order to understand why much of the life in and around the Mt Saint Helens Eruption and Spirit Lake died after the eruption, we will first study the question: What does a living organism need in order to survive and reproduce? Reframe the context of this investigation to focus on the things that the milkweed

Materials Needed

Computers with Internet Access (one per student or pair)

Clipboards for Field STEM activity

Materials for FOSS Investigation 1: Milkweed Bugs

- Petri Dishes
- Milkweed bugs
- Hand lenses
- Notebooks
- Zip Bags
- Vials with caps
- Paper towels
- Sunflower seeds
- Pieces of netting
- Rubber bands
- Paper clips
- Pushpin
- Large dowel with pointed end
- Cardboard piece (15 cm x 30 cm)*
- Hole punch
- Transparent tape*
- Overhead Projector

*Not included in kit

LESSON 2 (cont.)

bugs will need in order to survive and reproduce (instead of focusing just on reproduction of bugs). Students can read pages 3-5 from the FOSS reader for more information about the milkweed bugs.

Ask students to think about the following prompts:

- What do animals need in order to survive and reproduce?
- Where will the milkweed bugs get their energy?
  - Where do the sunflower seeds come from?
  - Where do the sunflower plants get their energy?
- How are the milkweed bugs using the food they eat?
- What do they need energy for?
- What happens to the food after it is eaten?
- What is the purpose of each part of the habitat?
- What else, besides food, do the milkweed bugs need in order to survive?
- What are the milkweed bugs releasing into their habitat?

Have students **create a model** showing how their milkweed habitat provides the bugs with the components necessary for survival. Students can create "zoom-in" boxes to show how different parts of the habitat (food, air, etc.) is used by the organism to survive. Students can play this digestion game that guides them through the different parts human digestive system. Ask students to address the following prompts: What happens to the food once it's eaten? What else does the milkweed bug use and why? Present students with a checklist of words to include in their model (food, breaking down, oxygen, energy, carbon dioxide, waste).

Field STEM opportunity: Pick a day where the weather is agreeable to some field observations. Walk students through a field investigation using Lesson 2 in this Field Investigations Guide created by the Pacific Education Institute. Have students focus on the question: What plants and animals use the schoolyard habitat? Have students log their drawings and observations in their Science notebooks.

Introducing Photosynthesis: Expand students' thinking by asking: how is the sunflower plant able to produce food for the milkweed bugs? Use this interactive simulation (use Google Chrome browser) from Concord Consortium for students to explore the process of photosynthesis and to make observations about the products and reactants involved in the process of plants making food. Before diving into the simulation, have students study the key which shows how each component is represented in the simulation. Also, encourage students to slow down the process and to increase the amount of sunlight in the simulation. Ask students to log their group's findings. Have students revisit their model of the milkweed habitat and add refine and improve their model using the information they found from the simulation.

Discussion questions connecting back to the Mt Saint Helens: How did the ecosystem change after the eruption at Mount St. Helens and how did these changes make it harder for living things to survive? What necessities of life did plants not have anymore? After studying what the milkweed bugs need to survive, how do you think the loss of plant life affected other organisms' ability to survive? Allow students to revisit their CER argument and add any pieces of evidence or reasoning that they feel would strengthen their argument. STEM teaching tool #48 is a helpful resource for guiding conversations in the classroom.

LESSON 2 (cont.)

Connect with the storyline (project time): Think about the Colombia River Gorge fires that happened in the summer of 2017 and facilitate a discussion using these prompts:

- How might the Gorge fires have created a disruption similar to the Mount St. Helens eruption?
- How were the honey bees or wild bees in the area affected by the fires?
- What do bees need to survive?
- What are some of the changes in the environment that may affect the honey bee's chance for survival?

Students can read these articles about how bee habitat destruction and climate change are causing bees to die. This article also talks about how native bees are being affected by habitat destruction. You can also show students this video about humans and our view of climate change. Students can begin to research possible solutions to habitat destruction. How have humans caused habitat destruction that has impacted the bees? What can we do to help provide bees with the things they need to survive? Have students research some of the possible solutions to these problems and consider their potential to answer the driving question. How do these concepts relate to or differ from the solution that you are focusing on for the Unit?

Career connections: Present students with the career of a **Conservation Scientist.** Use this video to introduce students to the field of Conservation Biology and the career of a Conservation Biologist. A Conservation Scientist strives to conserve biodiversity by preserving different ecosystems on the earth. Talk through this article with students and talk about the various advantages that biodiversity brings. Ask students to think from the perspective of a Conservation Scientist, what recommendations would they make to people in their community to help protect the bees and the organisms they are connected to?

LESSON 3: Interactions within an Ecosystem

Strategy: Explain

In this lesson, which will span over a few weeks, students will explore and explain how species are interconnected and how energy flows from one organism to another in an ecosystem.

Days 1-3

Introduction for students: Introduce students to this concept of interconnectedness by introducing the investigative phenomenon of the Wolves of Yellowstone. Give students background knowledge about why the wolves died out in the first place using first section of this article. Ask students to share their thoughts in a discussion using the following prompts:

- Why was it or why wasn't it ok for the ranchers and farmers to kill all the wolves?
- What do you think happened once the wolves were eliminated?
- Show students one or more before/after photos and ask them to write down their observations. Then have students share and log observations together as a class.

Please note that based on the backgrounds of students in your classroom, multiple perspectives may be brought up by students. Attend to equity by allowing students to share their perspectives in a safe place. Validate students' ideas and provide multiple perspectives when discussing the consequences of hunting the wolves. Use STEM Teaching Tool #54 to access resources that will help you implement equity-based practices in your classroom.

Reintroducing the Wolves: Then show students this video about the effects of reintroducing the wolves. Ask students to watch the video and then think about the following questions: How did the wolves cause a cascade of changes in Yellowstone? What surprised you or stood out to you? How did the biotic (living) factors change once the wolves were introduced? How did the abiotic (nonliving) factors (such as streams, rivers, ponds, etc.) change once the wolves were introduced? In this series of lessons created by The Nature Conservancy, students analyze and interpret data about the fall and rise of various populations in the Yellowstone area (part 1), evaluate the pros and cons of both sides of the argument by role-playing as involved stakeholders (to introduce wolves or not to introduce wolves) (part 2). For Part 1, tie in the CCC of Patterns by encouraging students to look at the data and identify any patterns they notice. Ask groups to share their findings and implications. After at least the first two parts, have students write a CER argument to answer the question: Should wolves have been re-introduced to Yellowstone, and why or why not?

Materials

- Computer with internet access (one per student or pair)
- Materials for Nature Conservancy Lesson (handouts that need to be printed)
- Materials for Carbon Cycle Game (not provided in STEM kit)
- Materials for FOSS Investigation 3: Mini-ecosystems.
- Materials for FOSS Investigation 2: Sorting out life
- Engineering Artificial Pollinators Activity: markers, colored pencils, graph paper, chart paper, post-its

LESSON 3 (cont.)

Days 4-5

Making a Yellowstone Food Web (note: this lesson is replacing FOSS Investigation 4 in order to maintain coherence with the storyline): Now that students have been studying the interactions and interdependence amongst organisms in the Yellowstone ecosystem, they will create a food web showing the transfer of energy from one organism to another.

- This lesson from PBS.org can be used to engage students in a modeling activity where they create a large food web showing the interactions amongst organisms. This page on the website can be used to get information on "spotlighted" animals in the Yellowstone food web. These animal cards can be printed and students can use the back of each card to write information about each organism.
- Use these key questions to help students think about the relationships between the organisms and to make expectations clear about the assignment.
  - Which organisms are producers?
  - Where do the producers get their energy?
  - Which organisms are consumers?
  - Where do consumers get their energy?
  - What happens to organisms after they die?
  - Why are the decomposers important?
  - Can you use arrows to show the flow of energy from one organism to another?
- Ask students to include explanations in each part of their model to show how the ecosystem works. Show students the trophic pyramid (or energy pyramid) of an ecosystem. Students can also read pages 17-21 in the FOSS reader to obtain more information about ecosystems. These prompting questions may be used to facilitate discussion:
  - What is this model trying to show?
  - What do they like about this model of an ecosystem?
  - How does this model give us more information about the ecosystem than a food web does?

Days 6-7

FOSS Investigation 3: Now that students have begun to study ecosystem dynamics by looking at the interdependence of organisms in Yellowstone and begun to describe the transfer of energy from one organism to another, they can use this lens to construct their own mini ecosystem for FOSS Investigation 3. Use the CCCs of Energy and Matter and frame the context of this investigation.

- Ask students to think about how energy will flow throughout their mini ecosystem:
  - What types of organisms will they have at each trophic level and how will these organisms interact?
  - What nonliving, or abiotic factors will play a role?
- **Creating an ecosystem model:** Ask students to create an initial model of their mini ecosystem even before starting the building process. In their model, students

should include arrows to show the transfer of energy from one organism to another. Also, ask students to be aware of energy that may be entering or leaving their ecosystem from the outside. Throughout their study of the mini ecosystem, have students continuously update their model with changes they've noticed, and phenomena that they believe may have a cause and effect relationship (ex. Why are some organisms thriving and some not?).

The Carbon Cycle game: Students will now engage in modeling the cycling of matter in both living and non-living parts of the ecosystem (LS2-3). Engage students in this Carbon Cycling Game where students use a human model is used to show the cycling of matter (in this case, Carbon) in an ecosystem. Links to reusable printable are embedded within the pdf, but please note that the beads (10 different colors) and string are not provided in the STEM Materials kit.

- Students can also use this online activity to model the same process and learn more about the details of each step in the process. Teacher resource on Carbon Cycle.
- **Revising their ecosystem model:** Have students reconnect with their models from FOSS Investigation 3 and to add details about the various processes to their model. Ask students to include the processes of photosynthesis and cellular respiration in their model. Suggest that students use "zoom-in" boxes to show what is happening at a cellular level if they want to show more detail.

Day 8

FOSS Investigation 2 (optional Formative Assessment): Ecosystems Card Sort. This investigation asks students to sort cards into different categories. In order to better align with NGSS DCI 2.A (interdependent Relationships in Ecosystems) and 2.B (Cycle of Matter and Energy transfer in Ecosystems), have students first separate the cards into biotic and abiotic factors. Then, ask students to create a food web showing the interactions between the organisms in the ecosystem. If there isn't space in the class for students to have their food webs on a large poster or wall, have students map out the food web using the Ecosystem cards and use arrows to represent a transfer of energy. Students can also include connections between abiotic factors if they are an important part of that ecosystem (ex. The Sun should definitely be included in the model as an energy source for the producers).

Symbiotic Relationships and Ecologists: Now that students hopefully understand the importance of solar fueled producers in an ecosystem, have students think more about how predators can keep an ecosystem healthy. This video is about how important keystone species are in maintaining balance and biodiversity in an ecosystem. Ask students to identify interdependent relationships as they watch the video. Why was the relationship important? What patterns did the scientists notice? How did the absence of one species affect the populations of other organisms in the ecosystem? How did you see similarities between these cases and the wolves of Yellowstone? Extend by connecting to the scientists featured in the video: how did the ecologists learn about the relationships between the organisms in the ecosystem? How can we use this information to understand the ecosystems around us?

Day 9-10

Connect with the storyline and create a model (Formative Assessment): Have students think back to their driving question about the honey bees. Students will create a model showing the interactions that honey bees have with humans. Students may want to research and see which organisms the honey bees locally depend on for survival (in Washington) and which organisms the bees are helping with their ecosystem services. Students can create a food-web-like model

to show the interactions between the producers and consumers in the ecosystem. What role do bees play in the ecosystem? What is the difference between wild bees and honey bees? How do bees interact with their surroundings?

Ecological services: Have students take a step-back to think about the ecological services that honey bees provide. Introduce students to the idea of ecosystem services using this TED Ed video. Use the following prompts to facilitate a discussion:

- What services do honey bees provide for humans?
- What would happen if we no longer had honey bees?

Ask students to expand their model to think about the way that the loss of all honey bees would affect humans around the world. What mutually beneficial patterns of interactions (LS2.A Interdependent Relationships in Ecosystems, and CCC-Patterns) would be disturbed if the honey bees were to disappear? **Ask students to represent their thoughts in their model by expanding it to show what the greater impact of honey bees is.** This may also be an appropriate time to highlight the differences between honey bees and wild bees. This article can help students read about the history of different species of bees.

Field STEM opportunity: If the weather permits and depending on time of year, take students on a walk around the school campus and ask them to make observations about the plants in the area that require pollination. How do our local plants depend on pollinators? Do they see any bees buzzing around the plants? What kinds of bees are there? Have students catalog their findings in their Science notebooks. Ask them to draw the different pollinated plants they observe and record the number and types of plants that need pollination. Ask students to be detailed in their diagrams and observations of the structures of the pollinators, as they will be engineering an artificial pollinator in their next activity. Ask students to write down their questions/wonderings and anything they notice.

Day 11-12

Engineering Artificial Pollinators Activity: If the honey bees were to disappear, how would humans continue to pollinate their crops? What is a possible solution if the honey bees disappear and we no longer have them to pollinate our crops? Engage students in an engineering design challenge where they are creating a device that can be used to pollinate crops in a world without bees. This article can help support students' understanding of why bees are important.

- **Ask:** What is the problem that we are trying to solve? What structures does a pollinator like a bee have that help them perform the function of pollination? What more do we need to know about these structures to be able to design one?
- **Imagine:** Have students brainstorm. What type of a device would you like to make? Will it be a device that has to be worn or something that will function on its own? No idea is crazy during this phase of the process.
- **Plan:** What materials would be best? What structure would be appropriate? How will each part of the device be connected? What are potential concerns that need to be addressed? Is the product durable? How much will it cost?
- **Create:** Have students create the detailed blueprints for their pollinator and to showcase their creations in a gallery walk. Ask students to calculate the cost of producing and using the device.

LESSON 3 (cont.)

- **Gallery Walk:** Have students share their devices with the class and to provide each other meaningful feedback which can aid in the improvement of the devices.
- **Improve: Give teams time to improve their device and to catalog their improvements.**
- **Wrapping up:** Have students read this article about drones that have been developed by scientists to pollinate plants. Ask students discuss the following questions: How can this innovation be helpful in the future? Why isn't it a replacement for bees? Why can't we just replace bees? What are some other potential solutions in case the bees die out? Provide students with the option of further exploring and specializing on this topic for their final project.

Career connections: **Engineer.** Ask students what an engineer does. Write their ideas on the board. An engineer designs solutions to problems. There are many different types of engineers and they work on issues ranging from microscopic and cellular problems, to problems on a global scale. This website created by the National Academy of Engineering has lots of great information to explore the many career options available in the engineering field.

LESSON 4: Populations and Resources

Strategy: Elaborate

In this Lesson, students will re-connect to the storyline and study how the availability of resources affects population growth.

Materials Needed

Computer with internet access (one per student or pair)

Materials for FOSS Investigation 6: Mini-ecosystems (look in FOSS guide for list of materials).

FOSS Investigation 6: Population Size. In Part 1 of this investigation, students will study the population growth and decline of their milkweed bug population and identify factors that limit growth of a population. After having students analyze their data from the milkweed bug population, refocus their attention to think about the following questions: Why can't the population of milkweed bugs keep growing forever? What are some factors that will limit population growth? Engage students in an inquiry task through this online tuna simulation. Students can manipulate different variables that affect population growth. Ask students to log their data and observe patterns. Students can read pages 22-24 to obtain more information about limiting factors of a population. These questions can be used to frame learning in context of the CCC Patterns:

- How did the population initially change over time?
- What observations did you make about the factors that had an effect on the population size?
- Did you see any patterns that showed a variable that limited the population (or caused it to decline)?
- How does the availability of a resource affect an organism?
- Why do you think this variable would limit a population in nature?

Note: Parts 2 and 3 of this investigation can be substituted with the activities below in order to increase coherence with the storyline.

Population Dynamics Extension-Competition: To extend students' understanding of population dynamics, present this activity from the Concord Consortium. Have students focus on the question, what can plants do to defend themselves against consumers? Follow-up the activity with the questions: why is the health of the population of producers important for the overall health of the ecosystem? What happens if the producers are gone? What will happen to the rabbit population if there are fewer plants available? Present students with the challenge of identifying: which organisms were competing with each other? Have students look at some of the food webs and models they created in the previous lessons. Which animals were competing with each other? What does it mean for animals to compete? What might happen to populations in an ecosystem if there is a lot of competition and a limited number of resources? You can also further extend learning through this lesson called, Oh Deer from the Nature Bridge where students act out the changes in an ecosystem and model the natural fluctuations that occur in populations.

Connect with the storyline (project time): Facilitate a discussion based on the questions provided. Suggested strategy: break students up on groups of 2-3 and ask them to discuss the following prompts using sentence starters and sentence frames from this STEM-y table tent (supports students in explaining their ideas and responding to other people's

LESSON 4 (cont.)

ideas), or this Talk Culture Sheet. You can ask students to focus on at least 4 of the questions (instead of all) and students should be documenting their thoughts. After students are done talking, have teams share the notable points of their discussion with the whole group. Students are encouraged not only to share their ideas but to paraphrase what other people in their team were thinking:

- What are the resources that the honey bee population needs to survive in the Pacific Northwest?
- What are some factors that limit a population of a hive (think back and look back at your work)?
- What are the biotic and abiotic factors that have affected the population of honey bees?
- How have changes in the environment and the honey bee's habitat affected their ability to survive?
- How have humans created factors that have limited bee population growth?
- How would the loss of honey bees affect ecosystems across the planet?
- How would our community be affected? In the next lesson, students will be using the information they collected to craft their campaign. Ask students to take a moment to reflect on why honey bees (and/or wild bees) are a noteworthy cause.
- Why should we even take this seriously?
- Ask students to document their thoughts for the next lesson.

Career connections: **Bee Keeper.** Introduce the career of sustainably keeping bees, which is one way of supporting honey bee communities locally. A beekeeper is a person who takes care of a hive of honey bees by keeping them in a box or a hive. A bee keeper is responsible for preparing bees and equipment, feeding the bees, cleaning and maintaining their hives, raising and replacing queen bees and replacing combs. Supporting local bee keepers is one way to sustainably support bee populations in the area. This is an interesting video showing an organic bee farmer harvesting honey.

LESSON 5: Campaigning for the Bees

Strategy: Evaluate

Now that students have studied how organisms interact and are interdependent within and across ecosystems, student will construct a final explanation and design solution that will help preserve the bee population in their community. Their explanation for the urgency of this cause (through a CER argument) will be presented in conjunction with a specific solution to one aspect of the problem. This lesson has 3 components: 1) CER Argument 2) Design Solution 3) Communication Project.

Career connections: **Social Media Manager.** A social media manager is a person who works for a company or organization and manages the way that they are represented on social media. It is a career did not exist a decade ago, but now, companies are constantly looking for individuals to help create a positive public image that can be widely shared with a public audience. Ask students if they have siblings (or parents) that engage on social media. How do people use social media? Have you seen companies using social media (yes, for advertising)? Some of the skills of a social media manager include: being able to study a population to identify needs and perceptions of the audience, designing, creating and managing promotions, looking at data and adjusting strategies, working with other team members in various departments, developing strategies to get a message out to a large audience. How is their task similar to what a Social Media Manager would do?

Part 1: CER Argument

Crafting a CER (Claims, Evidence, and Reasoning) Argument: What is the problem? Have students revisit the resources they have studied throughout the Unit. Why should something be done to save the bees? Why is the relationship between bees and humans so important? What have humans done to cause the problem? Ask students to look back at their research and find evidence to support their argument.

Additional Articles about the relationship between bees and humans:

- Bee decline could increase malnutrition and disease risk
- Why bees matter so much for humans
- Humans' relationship with bees dates back 9,000 years

Re-convene the 'expert teams:' Remember to have students work in their expert teams based on their topics of interest. By this point, students should have already decided what aspect of the problem they want to focus on and should have been working together during the project working times provided.

Materials

- Computer with internet access (one per student)
- Video or phone camera
- Misc supplies for creating final product (ex. posters, markers, paints, props)

LESSON 5 (cont.)

Part 2: Designing a Solution

Engage students in a [engineering] design process to create a solution for the problem they are focusing on. Present students with the steps on this poster (created by Engineering is Elementary).

Important note for teacher: *Engineering does not require students to create a physical (3D) product. In this specific task, students are designing a solution to their focused problem that is harming the honey bees. Design solutions can take many different forms (e.g. a plan for the community to plant honey bee friendly plants, a plan to convince farmers to use natural methods to control pests instead of pesticides, the development of community bee hives that support the bee population, a method to control the parasites affecting the bees, a device that can help the bees settle and thrive, or the idea for a phone app).*

1. **Ask:** Have students revisit their CER argument. What is the specific problem they are trying to solve? Ask students to research and see if there are solutions that people have been working on to address the problem.
2. **Imagine:** What are some solutions that can solve the problem? What is the most tangible solution that can be developed and presented to the public audience?
3. **Plan+Create:** What kind of a diagram or prototype needs to be created to explain the design solution to a public audience (e.g. a poster, a 3D model)
4. **Improve:** Facilitate a gallery walk or Charrette Protocol (page 32) where students can share their work in progress and give each other meaningful feedback (e.g. on post-its) which can be used to improve the product. This video explains the protocol and purpose of a gallery walk. This peer feedback protocol poster can help set expectations for the process as well. Students can then optimize their design solutions taking peer feedback into account.

Part 3: The Campaign for Honey Bees

Brainstorming the Campaign: What information have we learned and collected that will allow us to create a powerful campaign? Which part of the problem have they focused their solution on throughout the unit? How will they present this information in a way that will mobilize the public?

Planning and Communicating: students will work in teams to create a product that will be presented to the community. The end product can be in the form of a YouTube video, a podcast, a website or blog, a visual illustration, a slide presentation, a series of educational memes for the public, etc. Ask students to reflect on their chosen product and to spend some time researching online about the components of their product (ex. how do you film a good YouTube video or create a podcast?). Who is their audience and which medium of communication will be most impactful (ex. a poster or slide show will not necessarily reach the biggest audience and have the greatest impact).

Provide students with the following checklist of criteria and this single point rubric to think about when creating their product:

LESSON 5 (cont.)

- ☐ Does your product hook the audience's attention by showing how this cause is important?
- ☐ Does your product include scientific evidence to support your argument?
- ☐ Does your product include enough evidence to support your argument?
- ☐ Does your product motivate the public to do something?

Feedback and revision: Organize a gallery walk or Charrette Protocol (page 32) where students are able to share their product with their peers to get feedback. A Charrette Protocol is a method that can be effective as it allows student to get focused feedback from their peers on areas they identify as areas where they need help. Allow students time to reflect on the feedback and make adjustments to their product.

Public Presentation: Once students have received feedback and have improved their product, organize the opportunity to share the product with a public audience. Celebrate your hard work and success during this project!

How This Unit Supports Next Generation Science Standards

MS.Matter and Energy in Organisms and Ecosystems
MS.Interdependent Relationships in Ecosystems

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required.

Peformance Expectation	**Connections to Classroom Activity,** *Students:*
MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. 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-LS2-3. 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-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.	• Create a model to explain how photosynthesis allows producers in an ecosystem to create energy which is then channeled throughout the ecosystem. • Create a model of how a milkweed bug uses things in their environment to survive (such a using oxygen and breaking down food to release energy. • Study the population increase of their milkweed bug population and identify factors that limit growth of a population. Students manipulate an interactive tuna population through a simulation and identify factors that cause changes in populations? • Throughout the Unit, students are creating several models that explain the cycling of matter within a particular ecosystem. Models of ecosystems include: Mt St Helens, Yellowstone National Park, bees and their interactions within the community, FOSS mini-ecosystem, and the milkweed bug habitat. • Generate a CER argument explaining how the physical changes caused by the Mt St Helens eruption affected the ecosystem of the area. Students also look at the impact of wolves (biological component) on the ecosystem of Yellowstone. • Explain how the loss of bees affects organisms and interactions across the global ecosystem. • Study, design, and compare various design solutions for maintaining the ecosystem services provided by the bees in their community.

SCIENCE & ENGINEERING PRACTICES	
Developing and Using Models Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Engaging in Argument from Evidence	• Students use models to explain how an ecosystem functions. Students create a model of their milkweed habitat, a Yellowstone ecosystem, their miniecosystem, the cycling of carbon in an ecosystem, the role of bees in the local ecosystem, • Students analyze and interpret data to study the impact of the eruption on the ecosystem surrounding Mt St Helens, the changes associated with wolves in the Yellowstone area, and data (through studying various articles) about colony collapse disorder cause by human impact. • Students construct an explanation for how an ecosystem functions through the use of various models. Students also study, design, and evaluate various design solutions to help preserve the bee population. • Students construct a scientific argument to explain how the eruption at Mt St Helens impacted organisms living in the surrounding ecosystem. Students also create a culminating CER describing why it is important to preserve the bee population and the ecosystem services they provide.
DISCIPLINARY CORE IDEAS	
LS1.C Organization for Matter and Energy Flow in Organisms IS2.A Interdependent Relationships in Ecosystems LS2.B Cycle of Matter and Energy Transfer in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience. PS3.D Energy in Chemical Processes and Everyday Life LS4.D Biodiversity and Humans ETS1.B: Developing Possible Solutions	• Students study the process that producers go through to make energy from light and carbon dioxide from the atmosphere. Students study how food is broken down to provide energy for an organism's survival (through study of milkweed bugs and ecosystem). • Through studying the ecosystem case studies within the Unit, students analyze and explain the complex interactions between living and non-living components of an ecosystem. • Students study how disruption to an ecosystem has a cascading effect which impacts the ecosystem's functioning. • Students study how resource availability affects the interactions between organisms and population size in an ecosystem. • Students describe how each member of the ecosystem plays an important role in the cycling of matter by creating a model to show how energy and mater is transferred in their classroom mini-ecosystem. • Students study the dynamic nature of ecosystems, and that they are constantly changing as a result of physical or biological fluctuations. • Students explore numerous possible solutions to preserving bee populations and the ecosystem services that they provide (ex. habitat preservation, reducing use of insecticides, planting bee friendly trees, engineering artificial pollinators).

CROSSCUTTING CONCEPTS	
Cause and Effect Energy and matter Patterns Stability and Change Influence of Science, Engineering, and Technology on Society and the Natural world	• Cause and Effect is a CCC which is embedded within almost each activity in this Unit. In each case study, students are explaining the changes caused to an ecosystem due to a specific change. Students also take a critical look at the human caused environmental changes that have threatened the global bee population. • Energy and Matter is a CCC that is highlighted while students are creating their ecosystem models to show the transfer of energy and matter between biotic and abiotic factors of their ecosystem (lessons 2 and 3). • Patterns are emphasized when students are looking at population changes in Yellowstone (lesson 3), exploring the photosynthesis simulation to understand the chemical exchanges involved (lesson 2), and using the tuna simulation to understand the growth and decline of a population caused by availability of resources (lesson 4). • Stability and change is also a CCC that is strung throughout the Unit to tie together students' understanding of ecosystems.