Welcome to Miller & Levine Biology Explorer’s Journal: Problem-Based Learning Workbook! This is the ultimate student tool for navigating Problem-Based Learning activities. Students will be able to:

- Engage in real-world science research reflecting the needs of their community.
- Enhance their science and engineering skills to devise new solutions.
- Record notes, gather and analyze data, monitor their progress, evaluate their work, and collaborate with classmates.
- Participate in a variety of tasks including STEM projects, hands-on labs, and authentic readings as they explore solutions to the problems.

**Problem Launch**

Students complete a path of activities as they develop a solution to a local problem. They investigate and take ownership of their research—increasing their interest and engagement. Students apply science and engineering practices as they record their findings and describe their solutions.
Get Started

Thought-provoking questions encourage students to think carefully and critically about the upcoming project. The journal includes suggestions and resources for developing their project.

Bounce Video

The unit begins with a video to launch the project. Students watch and analyze the information as it relates to the problem situation. They take notes, answer questions, and brainstorm potential solutions.

Guiding Questions

Analytical, guided questions lead students to make discoveries.

GET STARTED

To solve this problem, begin by choosing a local invasive to focus on. Choose carefully, because the invasive species you choose in this activity will be the species you focus on for the whole unit.

THINGS TO KNOW ABOUT

- Be sure to choose an invasive species. Not all non-native species are invasive. An invasive species is a non-native species that is threatening the biodiversity of an ecosystem.
- Choose a species for which you can design a solution. In later activities, you will be designing a solution to reduce the impact of your chosen invasive on your local ecosystem. Your teacher might even have you build your design. So, be sure to choose a species for which you can execute a good solution. For example, do not choose an organism that is inactive during that time of year.
- Choose a species that you can successfully research from several reliable sources.
- Pick a species that is interesting to you!

FIND A SPECIES

One way to find out which species might be invading your area is to visit the National Invasive Species Information Center website.

- Go to the National Invasive Species Information

ANALYZE AND CONCLUDE

4. Briefly describe characteristics of your local area, including information about climate, vegetation, and geography.

5. What human activities have helped cause the spread of the invasive species?

6. Describe any effects the invasive species has had on your local ecosystem. Be sure to support your description with evidence you have gathered from your research.
**INTERACTIVITY**

**Food Webs and Invasives**

*How do invasive species affect an ecosystem?*

**Timing** Chapter 4, Lesson 2

**RECORD OBSERVATIONS AND DATA**

Part 1

1. Which organisms in this ecosystem are producers, herbivores, carnivores, and omnivores? Record your answers in the table.

<table>
<thead>
<tr>
<th>Type</th>
<th>Feeds On/Energy Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae or other Phytoplankton</td>
<td>Producer &amp; Uses sunlight to carry out photosynthesis</td>
</tr>
<tr>
<td>Bluegill</td>
<td>Omnivore &amp; Zeoplankton, algae, animals such as snails and crayfish</td>
</tr>
<tr>
<td>Catfish</td>
<td>Producer &amp; Uses sunlight to carry out photosynthesis</td>
</tr>
<tr>
<td>Crayfish</td>
<td>Omnivore/Deintrinsic &amp; Algae, animals such as snails, detritus</td>
</tr>
<tr>
<td>Pumpkinseed Snail</td>
<td>Herbivore</td>
</tr>
<tr>
<td>Largemouth Bass</td>
<td>Carnivore</td>
</tr>
<tr>
<td>Muskrat</td>
<td>Omnivore</td>
</tr>
<tr>
<td>Western Pond Turtle</td>
<td>Omnivore</td>
</tr>
<tr>
<td>Zooplankton</td>
<td>Herbivore</td>
</tr>
<tr>
<td>Bacteria and fungi</td>
<td>Decomposers</td>
</tr>
</tbody>
</table>

Part 2

The notebook in the Interactivity and the data table below both describe how each organism obtains energy in this environment. Use the table to help you complete the food web.

**Analyze & Conclude**

Just like professional biologists, students will:

- examine their findings.
- analyze and interpret the data.
- develop conclusions.
- construct their explanations.
- develop supporting models.
- evaluate their solutions.

**Record Data & Observations**

Students practice the habits of real-world scientists. Students will:

- complete their activities.
- record their observations.
- organize data.
- make decisions.
- develop important research skills.

**ANALYZE AND CONCLUDE**

Refer to the completed food web from Part 2 to answer the following question.

4. **Construct an Explanation** List any organisms that appear in more than one trophic level. How is it that an organism can be in more than one trophic level in an ecosystem? Include an example in your explanation.

Refer to the completed food web from Part 3 to answer the following question.

5. **Develop Models** Draw two food chains from the food web that involve the eutida.

6. **Analyze** How can the introduction of nutria affect a pond ecosystem food web?
Connect to the Unit Problem
Students consider similarities and differences between the unit activity and their problem. The questions they answer will guide them as they make connections and develop a solution.

PROBLEM WRAP-UP

Invasives in Your Neighborhood

PROBLEM: HOW CAN YOU REDUCE THE IMPACT OF AN INVASIVE SPECIES ON YOUR LOCAL ECOSYSTEM?

Timing: End of Unit 2

Solve It
If you did not complete the STEM Project, Controlling Local Invasives take a few moments to consider some potential solutions to reduce the impact of your local invasive species. Record your thoughts below.

Problem Wrap Up
Students demonstrate their acquired scientific knowledge as they present and share their findings with their teacher and classmates. An important part of the presentation process is reviewing and critiquing their classmates' work. Students listen to their peers, evaluate their presentations, and provide suggestions for improvement.

Problem Rubric
This resource provides guidance for students to self-monitor and assess their own progress. It allows them to engage in peer review and evaluate the work of others.
Explorer’s Journal: Problem-Based Learning Workbook

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Interactivity: Explore invasive species’ effects with an interactive food web.
Virtual Activity: Conduct a virtual investigation on how Burmese pythons effect the Everglades ecosystem.
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Unit 3 Cells
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PROBLEM: How can you develop a species recovery plan?
Bounce Video
Problem Launch
Interactivity
Lab
Authentic Reading
STEM Project
Interactivity
Problem Wrap-Up

Unit 2 Sampled on the following pages
It’s a snake big enough to eat an alligator, and it’s wreaking havoc in the Florida Everglades! Native to Southeast Asia, Burmese pythons in Florida have no natural predators and a steady supply of food. As a result, the population has exploded. But, there’s hope for the Everglades. Using radio tracking technology, researchers have been able to investigate the habits of the pythons, including where they live, how far they travel, what they eat, and how often they reproduce. This information has made it possible to locate, trap, and remove pythons, and to destroy nesting sites. The success may be a model for the control of invasive species in other ecosystems. However, Burmese pythons have not been entirely eliminated, and work to control the population is ongoing.

How can you reduce the impact of an invasive species on your local ecosystem? Get ready to investigate and devise a way to remedy the problems they cause.
PROBLEM  How can you reduce the impact of an invasive species on your local ecosystem?

To solve this problem, perform these activities as they come up in the unit, and record your findings in this journal.

Chapter 4  Lesson 2

Chapter 5  Lesson 2
Chapter 5 Lesson 2

STEM PROJECT
Controlling Local Invasives
Design a solution to help control the local invasive species you chose.

Check when complete

Chapter 6 Lesson 1

AUTHENTIC READING
To Tame a 'Wave' of Invasive Bugs, Park Service Introduces Predator Beetles
Read about how an invasive species is changing hemlock forests in the Smoky Mountains.

Check when complete

Chapter 7 Lesson 4

INTERACTIVITY
Controlling Invasives
Test strategies for controlling an invasive frog in the American southwest.

Check when complete

PROBLEM WRAP-UP
INVASIVES IN YOUR NEIGHBORHOOD
Present your findings, and propose a solution for controlling an invasive species in your ecosystem.

Check when complete

End Unit 2

Unit 2 Ecology | Introduction

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**Solve the Problem**

Each activity in this unit brings you one step closer to solving the problem. Track your progress as you complete each activity.

<table>
<thead>
<tr>
<th>Activity</th>
<th>What I learned.</th>
<th>How it helped me solve the problem.</th>
<th>Questions I still have.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VIDEO INVASIVE TOADS</td>
<td></td>
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<tr>
<td>Beginning of Unit 2</td>
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<tr>
<td>PROBLEM LAUNCH INVASIVES IN YOUR NEIGHBORHOOD</td>
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<tr>
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<tr>
<td>INTERACTIVITY FOOD WEBS AND INVASIVES</td>
<td></td>
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<tr>
<td>Chapter 4, Lesson 2</td>
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<tr>
<td>INTERACTIVITY PYTHONS IN THE EVERGLADES</td>
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<tr>
<td>Activity</td>
<td>What I learned.</td>
<td>How it helped me solve the problem.</td>
<td>Questions I still have.</td>
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<tr>
<td>STEM PROJECT</td>
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<tr>
<td>CONTROLLING LOCAL INVASIVES</td>
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<tr>
<td>Chapter 5, Lesson 2</td>
<td></td>
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<tr>
<td>AUTHENTIC READING</td>
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<tr>
<td>To Tame a 'Wave' of Invasive Bugs, Park Service Introduces Predator Beetles</td>
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<tr>
<td>Chapter 6, Lesson 1</td>
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<tr>
<td>INTERACTIVITY</td>
<td></td>
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<tr>
<td>CONTROLLING INVASIVES</td>
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<tr>
<td>Chapter 7, Lesson 4</td>
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<tr>
<td>PROBLEM WRAP-UP</td>
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<tr>
<td>INVASIVES IN YOUR NEIGHBORHOOD</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>End of Unit 2</td>
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</tbody>
</table>
Invasive Toads

Watch a video about Australia’s battle with invasive cane toads.

Timing Beginning of Unit 2

1. Take notes as you watch the video.

   - Cane toads are not native to Australia. They were introduced to Australia to control the greyback cane beetle population that was destroying sugar cane crops.
   - Cane toads are invasive to Australia.
   - Cane toads reproduce rapidly, and they take over nesting sites normally used by native species.

2. Explain why cane toads have thrived in Australia and now are considered invasive.
   There are several reasons why cane toads are considered invasive in Australia. Cane toads are highly adaptive to different environments and reproduce rapidly. They eat more than just greyback beetles. So, they disrupt ecosystems by eating native species or the food supply of native species. Cane toads are also highly poisonous, and the predators of Australia have not learned to avoid them. The cane toads are poisoning the native predators that catch and eat them.

3. At the end of the video, the narrator mentions that scientists may need to help nature to restore balance in the ecosystem. Brainstorm some ways they might try to control the cane toad population. Answers will vary. Check that students have brainstormed several reasonable suggestions for controlling the cane toad population.
PROBLEM LAUNCH

Invasives in Your Neighborhood

Conduct research to identify an invasive species in your local ecosystem.

Timing Beginning of Unit 2

PROBLEM HOW CAN YOU REDUCE THE IMPACT OF AN INVASIVE SPECIES ON YOUR LOCAL ECOSYSTEM?

1. What is this problem asking you to solve?

   The problem asks me to identify the invasive species in my region, determine any damage it is causing, and then find a way to remove the species or reduce its impact.

WHAT DO I NEED TO KNOW?

2. What questions do I need to answer to solve this problem?

   Sample answers: What is a significant invasive species in my region? How was the invasive species introduced to the region? How does the invasive species reproduce? In what environment or habitat does the invasive species thrive? What foods does the invasive species eat? How does the invasive species affect native plants and animals, or farms, crops, and livestock? How does the invasive species affect the physical environment?
GET STARTED

To solve this problem, begin by choosing a local invasive to focus on. Choose carefully, because the invasive species you choose in this activity will be the species you focus on for the whole unit.

THINGS TO THINK ABOUT

- **Be sure to choose an invasive species.** Not all non-native species are invasive. An invasive species is a non-native species that is threatening the biodiversity of an ecosystem.

- **Choose a species for which you can design a solution.** In later activities, you will be designing a solution to reduce the impact of your chosen invasive on your local ecosystem. Your teacher might even have you build your design. So, be sure to choose a species for which you can execute a good solution. For example, do not choose an organism that bites or is toxic. Consider the time of year you are working on the problem. Do not choose an organism that is inactive during that time of year.

- **Choose a species that you can successfully research from several reliable sources.**

- **Pick a species that is interesting to you!**

PICK A SPECIES

One way to find out which species might be invading your area is to visit the National Invasive Species Information Center website.

- **Go to** the National Invasive Species Information Center Website.

- **Under Browse by Geography,** click on United States.

- **Find State Resources,** and click on More to open up a map of the United States.

- **Click on your state.** Use the links provided on this page to learn about different invasives in your state. In particular, you might want to look at the Early Detection & Distribution Mapping System which allows you to filter a list of invasives by state and organism category.

As you research, write down a list of any invasive species you are considering. Be sure to list both the common name and the scientific name of the organism.
1. Choose one invasive species that has thrived in your local ecosystem to focus on. Be sure to list both the common name and the scientific name.
   Sample answer: Eurasian milfoil, Myriophyllum spicatum

2. Describe your organism. Traits could include qualities such as what type of organism it is (plant, animal, fungus, etc); size; color(s); identifying characteristics; life cycle; and so on.
   Sample answer: A floating plant that has about 12 to 20 pairs of tiny leaves attached to long, thin stems. It can form tangled mats of leaves and stems near the surface of the water. It can reproduce asexually from very small parts, such as a single cut stem.

3. Sketch your organism. Label any important characteristics.

Sketch should match physical description in Item 2 above, and accurately depict the chosen organism.
NATURAL HISTORY OF YOUR INVASIVE

FOOD
(what it eats/how it obtains energy)
Sample answer: Sunlight, oxygen, nutrients

HABITAT DESCRIPTION
(where it lives)
Sample answer: Thrives in nutrient-rich fresh water, especially without other plants in the habitat.

NATIVE RANGE
(where it is from)
Sample answer: Bodies of fresh water in Europe and Asia

INVASIVE RANGE IN THE U.S.
(where it is invading. If possible, shade in this range on the map.)

Check that students have accurately shaded the range of their chosen invasive species on this map.
ANALYZE AND CONCLUDE

4. Briefly describe characteristics of your local area, including information about climate, vegetation, and geography.
   Sample answer: Our region has large rivers linked to the Great Lakes, and our town has hundreds of ponds. We have a temperate climate with deciduous forests and some farming.

5. What human activities have helped cause the spread of the invasive species?
   Sample answer: Boaters have accidentally spread milfoil from lake to lake. Milfoil stems stick to hulls, motors, and oars. When people move the boat to a new lake, the milfoil moves there, too. Removing native water plants also increases the spread and growth of milfoil.

6. Describe any effects the invasive species has had on your local ecosystem. Be sure to support your description with evidence you have gathered from your research.
   Sample answer: Milfoil has choked the surface of several lakes, crowded out the native plants, and reduced the populations of certain fish that eat the native plants. These fish do not eat milfoil.

7. Have there been any efforts to control this species in your state’s ecosystem? If yes, briefly describe each effort and how successful it was, using evidence from your research.
   Sample answer: The state has tried to educate people about milfoil and encourage boaters to clean their boats when they remove them from the water. At some lakes, machines are used to clean up milfoil mats. However, these efforts do not seem to have slowed the spread of milfoil.
   Milfoil does not grow so abundantly in its native waters. Other water plants keep its population in check, and native insects feed on it. Research suggests that introducing milfoil eating insects to North America might help control the milfoil population.
Food Webs and Invasives

How do invasive species affect an ecosystem?

Timing Chapter 4, Lesson 2

RECORD OBSERVATIONS AND DATA

Part 1
1. Which organisms in this ecosystem are producers, herbivores, carnivores, and omnivores? Record your answers in the table.

<table>
<thead>
<tr>
<th>Producers</th>
<th>cattails, phytoplankton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbivores</td>
<td>zooplankton</td>
</tr>
<tr>
<td>Carnivores</td>
<td>large mouth bass</td>
</tr>
<tr>
<td>Omnivores</td>
<td>muskrat, fresh water snail, pond turtle, crayfish, bluegill</td>
</tr>
</tbody>
</table>

Part 2
The notebook in the Interactivity and the data table below both describe how each organism obtains energy in this environment. Use the table to help you complete the food web.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Type</th>
<th>Feeds On/Energy Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algae or other Phytoplankton</td>
<td>Producers</td>
<td>Uses sunlight to carry out photosynthesis</td>
</tr>
<tr>
<td>Bluegill</td>
<td>Omnivore</td>
<td>Zooplankton, algae, animals such as snails and crayfish</td>
</tr>
<tr>
<td>Cattail</td>
<td>Producer</td>
<td>Uses sunlight to carry out photosynthesis</td>
</tr>
<tr>
<td>Crayfish</td>
<td>Omnivore/Detritivore</td>
<td>Algae, animals such as snails, detritus</td>
</tr>
<tr>
<td>Freshwater Snail</td>
<td>Herbivore/Detritivore</td>
<td>Plants such as cattails, algae, detritus</td>
</tr>
<tr>
<td>Largemouth Bass</td>
<td>Carnivore</td>
<td>Animals such as crayfish, snails, bluegill, turtles</td>
</tr>
<tr>
<td>Muskrat</td>
<td>Omnivore</td>
<td>Plants such as cattails, animals such as bluegill, crayfish, and snails</td>
</tr>
<tr>
<td>Western Pond Turtle</td>
<td>Omnivore</td>
<td>Animals such as snails, and carrion</td>
</tr>
<tr>
<td>Zooplankton</td>
<td>Herbivore</td>
<td>Phytoplankton</td>
</tr>
<tr>
<td>Bacteria and fungi</td>
<td>Decomposers</td>
<td>Breaks down other organisms and releases nutrients</td>
</tr>
</tbody>
</table>
2. Save an image of the completed food web for Part 2. Print it and attach it to this worksheet or use the space provided to draw the food web for this pond ecosystem.

Part 3
3. Save an image of the food web with the addition of the nutria, print it, and attach it to this worksheet. If you drew the food web in the space provided, add the nutria to your drawing and show what it feeds on.
ANALYZE AND CONCLUDE

Refer to the completed food web from Part 2 to answer the following question.

4. Construct an Explanation List any organisms that appear in more than one trophic level. How is it that an organism can be in more than one trophic level in an ecosystem? Include an example in your explanation.

An organism may be a part of more than one trophic level when it eats a variety of foods, such as plants and animals.

The muskrat is a first-level consumer when it eats cattails, and a second-level consumer when it eats crayfish.

Refer to the completed food web from Part 3 to answer the following question.

5. Develop Models Draw two food chains from the food web that involve the nutria.

Students should identify two of the following food chains: cattails → nutria; phytoplankton → freshwater snail → nutria; cattails → freshwater snail → nutria; bacteria and associated fungi → freshwater snail → nutria;

6. Analyze How can the introduction of nutria affect a pond ecosystem food web?

Sample answer: Even though nutria consume insects and snails occasionally, they affect the food web primarily by eating huge amounts of vegetation. This leads to habitat loss for native species. They also compete with the muskrat for food.

CONNECT TO THE UNIT PROBLEM

7. Think about the invasive species you chose to research in the Problem Launch. What is the role of this species in your local food web? Is it a producer? herbivore? carnivore? Find out about a few other species in your local ecosystem. Populate the chart by listing your invasive species in the first row, its food or energy source and its role in the ecosystem. Then fill out rows for four other populations in your local ecosystem. Sample answers provided.

<table>
<thead>
<tr>
<th>Population</th>
<th>Food or Energy Source</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurasian Milfoil</td>
<td>Sunlight</td>
<td>Producer</td>
</tr>
<tr>
<td>Bulrushes</td>
<td>Sunlight</td>
<td>Producer</td>
</tr>
<tr>
<td>Trout</td>
<td>Insects (larval stage to adult)</td>
<td>Carnivore</td>
</tr>
<tr>
<td>Wood duck</td>
<td>Duckweed, water lilies, other plants and plant parts (including fruits and nuts), insects</td>
<td>Omnivore</td>
</tr>
<tr>
<td>Moose</td>
<td>Plants (including water lilies and cattails)</td>
<td>Herbivore</td>
</tr>
</tbody>
</table>

8. How might your invasive species be affecting the native species in your local food web? What resources might it be using in order to thrive?

Sample answer: Eurasian milfoil is a producer that is not a significant food source for any native consumer. It uses resources such as space and sunlight and can crowd out native producers. Reducing populations of native producers may result in reduced food sources for consumers that feed on native producers.
Pythons in the Everglades

What is an effect of the introduced Burmese python on the Everglades ecosystem?

Timing Chapter 5, Lesson 2

RECORD DATA AND OBSERVATIONS

Parts 1–3

1. You will release and monitor radio-collared marsh rabbits in two different study areas located in south Florida—the Fakahatchee Strand and Everglades National Park. When you have finished releasing your rabbits, save a copy of your map. Quickly redraw the number of rabbits you released on the map below, or print the image and attach it to this worksheet.

Maps should show the numbers of the rabbits that were released in Fakahatchee Strand and Everglades National Park.

Radio-Collared Rabbits: 50

Fakahatchee Total: ___ 25 ___

Everglades Total: ___ 25 ___
2. Open your notebook to view the data you collected during your study. Save the table showing your results. You may insert the table at the end of this file, print it and attach it to the end of this sheet, or copy the information from the lab notebook by hand into the table below.

Sample data:

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Rabbits Released</th>
<th>Rabbit Deaths Due to Predation by:</th>
<th>Lost Rabbits</th>
<th>Surviving Rabbits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pythons</td>
<td>Birds</td>
<td>Mammals</td>
</tr>
<tr>
<td>Fakahatchee Strand</td>
<td>25</td>
<td>0</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Everglades National Park</td>
<td>25</td>
<td>18</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

3. Repeat your study, this time placing a different number of rabbits in each site. Record your data. Compare your data to the data you collected during your previous yearlong monitoring. In what ways is it similar? In what ways is it different?

Sample answer: The initial number of rabbits in each site was different than before, but the numbers changed in a similar pattern. Pythons killed most of the rabbits in the Everglades, and other animals killed them in Fakahatchee Strand.

4. In which study site—Fakahatchee Strand or Everglades National Park—is a marsh rabbit most likely to be killed by a mammal? Use your data to explain your answer.

The data show that a mammal is about 3 to 4 times more likely to kill a rabbit in Fakahatchee Strand, where pythons are not common.

5. According to your data, which study site—Fakahatchee Strand or Everglades National Park—is most likely to have at least one or more surviving rabbits at the end of a year of monitoring? Explain your answer using evidence.

Rabbits are more likely to survive in Fakahatchee Strand. In all of the simulations that were conducted, no rabbits survived in the Everglades, but sometimes one or two rabbits survived in Fakahatchee.
ANALYZE AND CONCLUDE

6. **Evaluate Solutions** How did the use of radio telemetry make it possible for you to discover how the Burmese python is affecting the Everglades ecosystem?

The radio collars on the rabbits allowed us to track them and find their remains. Examining the remains allowed us to identify the cause of death, which typically was a predator such as a python. The data show the extent that pythons have spread through the Everglades and succeeded as predators there.

7. **Analyze and Interpret Data** Some species of birds, mammals, and reptiles found in the Everglades are too large or too fast to be eaten by Burmese pythons. Based on your data, how do you think the presence of the Burmese python in the Everglades National Park could nevertheless affect these species?

The data show that pythons are more successful at hunting rabbits than birds, mammals, and other reptiles. Most likely the pythons are outcompeting other species at catching many small prey. In this way, the pythons are reducing the food supply for other animals.

CONNECT TO THE UNIT PROBLEM

8. **Connect to Society** Think about the invasive species you chose in the Problem Launch. Consider how scientists studied the effects of Burmese pythons on the Everglades ecosystem. Suggest some ways scientists might study the impact of your invasive species on your local ecosystem.

Sample answer: Perhaps we could label a sample of Eurasian milfoil in a lake to study how quickly it grows and spreads. The label would need to be at the molecular or genetic level, so that we could identify a plant’s growth and offspring. We could also label native plants in lakes with and without milfoil, and then compare their lifespans and growth.
Controlling Local Invasives

Controlling invasives requires both diligence and creativity, but thankfully there are many success stories both in the U.S. and throughout the world. What can you do to make a success story in your ecosystem?

Timing Chapter 5, Lesson 2

**DEFINE THE PROBLEM** HOW CAN YOU REDUCE THE IMPACT OF AN INVASIVE SPECIES ON YOUR LOCAL ECOSYSTEM.

1. List your chosen invasive species and summarize its effects on your local ecosystem.

   Sample answer: Eurasian milfoil spreads widely among lakes and streams in our region. The milfoil changes the ecosystem because of how it grows. For example, it grows in thick mats on a lake’s surface that can crowd out other plants.

**BRAINSTORM SOLUTIONS**

2. With your partners, brainstorm a list of possible methods for controlling the invasive species. Include methods that have been tried elsewhere and possible revisions to these methods.

   Sample answers: Introduce insects that eat milfoil, harvest milfoil mats regularly, as done in very popular lakes, encourage people to clean milfoil from boats (already underway), add more native plants to lakes, try feeding milfoil to farm animals.


**CHOOSE A SOLUTION**

3. Decide on one of the methods that you identified. Explain the reasons for your choice and how you think it will address the problem.

   Sample answer: We propose to encourage people to clear milfoil from their boats. We could make these encouragements by creating a social media blog. We also propose to coordinate a native plant project to help combat the growth of milfoil.

**DESIGN A SOLUTION**

4. Plan how you will put your solution into action. What materials do you need?

   Sample answer: First we could get the contact information for our state’s Department of Natural Resources. We can volunteer to help with the removal of Eurasian milfoil. Next, we could provide a link to the state’s website on our social media page. Also, under the supervision of the Department of Natural Resources, we could coordinate a native plant project where we and members of the community could participate in the project.

5. Do you need permission or cooperation from others? What sort?

   Sample answer: We need permission from the local and state government/Department of Natural Resources to participate in any native plant project or link to our social media site.

6. How will you measure the success of the solution?

   Sample answer: We can schedule routine observations to see if there is a reduction in the Eurasian milfoil. Also, we can develop charts and maps to record our observations of the milfoil reduction.
7. Use the space below to design your solution. If possible, draw a detailed, labeled sketch of your solution.

Check that drawings accurately represent students’ choice of a plan and have detailed action steps and labels.
COMMUNICATE RESULTS

8. Prepare a brief presentation to share your solution with the class. Include any visuals or drawings you think would be helpful. Remember, that your solution is a work-in-progress right now and that you are asking the class for improvement suggestions. Present what you have and listen carefully for feedback. Use the lines below to briefly outline what you will cover in your presentation.

Sample answer:
Beth: Introduction and overview
Jamal: The problems caused by milfoil
Honoria: Research and brainstorming ideas
Oscar: Testing the plan, and the results
Beth: Conclusions and recommendations

9. Your classmates will also be presenting their solutions. Answer the following questions for each presentation.

• What features of the solution do you think are useful?
Sample answer: Easy and inexpensive to implement; potential for success, and on-going education for boaters.

• What limitations do you see with the solution?
Sample answer: We can educate boaters on cleaning milfoil, but boaters must keep cleaning their boats regularly to ensure they don’t transfer the milfoil.

• What ideas do you think would improve the solution?
Sample answer: In performing research, we could encourage the Department of Natural Resources to use herbicides.

• What questions, if any, do you have that were not addressed in the presentation?
Sample answer: If there is a switch to herbicides, how would that affect the ecosystem? Also, how might the introduction of an insect that eats milfoil affect the ecosystem?
EVALUATE AND REDESIGN

10. Evaluate any suggestions you received from other students. Sketch or describe features of the solution that you think can be improved.

Sample answer: Perhaps with the cooperation of the Department of Natural Resources, we as students and the community can volunteer in manually removing the Eurasian milfoil, while the Department can handle the introduction of insects that eat the milfoil mats.
To Tame A ‘Wave’ Of Invasive Bugs, Park Service Introduces Predator Beetles

by Nathan Rott

Timing Chapter 6, Lesson 1

The female wooly adelgid is miniscule, attaching herself to the hemlock’s needle after creating her ova sack, as shown above.

The forest at Great Smoky Mountains National Park is sick, infected by invasive bugs and plants. Matt Moore, Kaleb Lique Naitove and Emily Baird of the National Park Service are some of the field medics trying to keep it alive.

... The forest they walk through is mesmerizing. The trees glow green in the Tennessee sun. There are a lot of tree species in this forest, but the one they’re looking to treat is an Eastern hemlock, an evergreen conifer that ranges from Canada to northern Mississippi. Hemlocks make up a significant portion of a lot of forests in the eastern U.S., but particularly so in Great Smoky Mountains National Park.

... ‘A Tsunami Wave’ Of Adelgids

After about 20 minutes of hiking off-trail in the park, Moore and company reach the tree they’ve been looking for. It’s tall, but not particularly big. You could wrap your arms around its trunk and still clasp your hands. By all outward appearances, it’s healthy.

It’s time for the crew to start helping the tree by injecting it with pesticide. Moore drills holes around the tree’s base and then Lique Naitove and Baird attach tubing. A bicycle pump connected to the tube system begins to fill it and then the base of the tree with the red pesticide.
It’s called a tree injection system. “We call them IVs,” Webster says. “They’re out doing a tree IV.”

It’s like a flu shot that will help the tree ward off invasive bugs. Most of the trees Webster’s crew treat just get sprayed with pesticides that have the same effect. This one’s different because it’s near a stream and the crew doesn’t want pesticides getting in the water.

They can’t do it for all of the trees they treat because there are just too many. The vegetation crew here has treated more than a quarter million trees in the Great Smoky Mountains. The treated ones, like the one they hiked to, are easy to spot because they look healthy and are alive. The trees that weren’t treated are probably dead “or they’re close or on the way out very soon,” Webster says. “Probably in the next 10 years.”

The reason for this die-off is the hemlock woolly adelgid, which is native to Asia. Scientists believe that the specific kind killing the Eastern hemlock is from southern Japan.

Adelgids were first discovered in the U.S. in the 1920s. They were transported overseas by humans and continue to be spread with human help, mostly through the purchasing, selling and transporting of firewood. Today, the hemlock woolly adelgid is established in 16 states, from Maine to Georgia.

The trees at Great Smoky Mountains National Park have been infested with adelgids for longer than a decade. With no natural predators and no evolved defenses, the adelgids swept through the hemlocks at the park like “a tsunami wave,” Webster says. Many of the park’s hemlocks died quickly; others are dying more slowly.

A Predator-Prey Balance

The pesticide treatment that the park’s vegetation crew uses doesn’t get rid of the hemlock woolly adelgid. It protects the tree that gets it and only lasts five to seven years. “It’s a stopgap solution,” Webster says.

Because of that, the National Park Service and scientists have been trying a longer-lasting one: predator beetles. The hemlock woolly adelgid, like most invasive species, thrives in its new environment because it doesn’t have any natural predators. To change that dynamic, Great Smoky Mountains National Park has brought in a few species of predator beetles from Asia that they’re raising at insectaries, or nurseries for bugs.

Predator beetles will never eradicate the hemlock woolly adelgid. They’re here to stay. The hope of the Park Service is that by creating that balance between predator and prey and by educating people to not move firewood from one location to another, they can slow the spread of the adelgid enough to give the remaining Eastern hemlocks a chance to survive and adapt.

©2016 National Public Radio, Inc. Excerpts from NPR news report “To Tame A ‘Wave’ Of Invasive Bugs, Park Service Introduces Predator Beetles” as originally broadcast on NPR’s Morning Edition on June 2, 2016 and is used with the permission of NPR. Any unauthorized duplication is strictly prohibited.
READING COMPREHENSION

1. About when were the wooly adelgids introduced to the US and how are they spreading?
   The wooly adelgids were first discovered in the US in the 1920s. They continue to spread as humans buy, sell, and transport firewood.

2. Describe how the introduction of a predator beetle from Asia might affect the wooly adelgid population.
   The predator beetles will hopefully feed on the wooly adelgids and decrease the adelgid population in the Great Smoky Mountain National Park ecosystem.

3. Describe why the hemlock wooly adelgid was able to sweep through the hemlocks of Great Smoky Mountain National Park.
   Because the adelgid has no natural predators in the Smoky Mountains and the hemlock trees have no natural defenses, the wooly hemlock adelgid has flourished as an invasive species.

4. Why did the vegetation crew decide to treat the hemlock in the article with a tree IV, instead of using pesticides as they did for other hemlocks?
   The vegetation crew used a tree IV because the hemlock in the article is near a stream, and they did not want pesticides getting in the water.

CONNECT TO THE UNIT PROBLEM

5. In what ways is the impact of wooly adelgids on the Eastern Hemlocks in the Great Smoky Mountains National Park similar to the impact of the local invasive species you chose in the Problem Launch? How is it different?

<table>
<thead>
<tr>
<th>Similar</th>
<th>Different</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample answer: The population of the wooly adelgid grows rapidly in a new habitat where it has no native enemies, much like the Eurasian milfoil grows in lakes and streams at rapid pace—much faster than the native plants. Also, the wooly adelgid is causing problems with the ecosystem in the Smoky Mountains because of its destruction of the hemlocks, much like the Eurasian milfoil growing in matslike structures is altering the ecosystem in my region.</td>
<td>Sample answer: The adelgid is an animal, consuming the sap of trees, and milfoil is a plant, so it is a producer, not a consumer. The wooly adelgid is directly feeding on and destroying the hemlock trees in the forest. The milfoil, on the other hand, forms thick mats at the surface of a water body that prevents the growth of native plants in the water.</td>
</tr>
</tbody>
</table>

6. What methods of reducing the impact of your local invasive species might you suggest based on methods used to control adelgids?
   Introducing natural predators can be one method of controlling the damage caused by an invasive species. I might consider adding an organism that feeds on Eurasian milfoil to help reduce its population in my local ecosystem.
Controlling Invasives

What are ways to control invasives in an ecosystem?

Timing Chapter 7, Lesson 4

Part 1

1. After reading about the habitat, diet, and life cycle of the two frog populations, compare and contrast the two different frogs. Are there any differences that you might be able to use to control the American bullfrog population?

Sample answer: the leopard frog on average lays fewer eggs than the bullfrog; the Leopard frog eats less types of food than the bullfrog; the bullfrog has no predators except other bullfrogs.

Part 2

2. The handbook in the interactivity and the table below list possible control methods for the bullfrog in Buenos Aires National Wildlife Refuge. List the advantages and disadvantages for each method.

Sample answers provided:

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gigging</td>
<td>—Easy to record the quantity of frogs destroyed on given day/night.</td>
<td>—Not efficient as it takes lots of human resources to perform; can only destroy frogs one at a time.</td>
</tr>
<tr>
<td></td>
<td>—Specifically targets the invasive species you want to control.</td>
<td></td>
</tr>
<tr>
<td>Netting</td>
<td>—Traps can catch tadpoles and can be removed daily</td>
<td>—Require workers to empty the traps daily.</td>
</tr>
<tr>
<td></td>
<td>—Since removed tadpoles are euthanized and do not reach adult maturity, they cannot reproduce.</td>
<td></td>
</tr>
<tr>
<td>Pond Draining</td>
<td>—Can separate native organisms from bullfrog eggs, tadpoles, and adults</td>
<td>—Might not be efficient to drain an entire pond.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—Could affect native vegetation when pond is drained (since it is lacking water).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—Bullfrogs could return to the pond after pond is refilled.</td>
</tr>
<tr>
<td>Chemical Sprays</td>
<td>—Effectively eliminate/destroy bullfrogs when the chemicals pass through their skin</td>
<td>—No testing has been done on effects on native species nor what effects occurs on water/drinking water.</td>
</tr>
</tbody>
</table>
Part 3

3. Fill out the table below with the number of fyke nets needed to reduce the American Bullfrog population in each water body to a single bullfrog.

<table>
<thead>
<tr>
<th>Water bodies</th>
<th>Size (m²)</th>
<th>Number of Fyke Nets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Tank</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Small Pond</td>
<td>25</td>
<td>35</td>
</tr>
<tr>
<td>Large Pond</td>
<td>1000</td>
<td>95</td>
</tr>
</tbody>
</table>

Analyse and Conclude

4. Construct an Explanation American alligators, turtles, and belted kingfishers are natural predators of the American bullfrogs. Would you consider introducing any of these predators to the Buenos Aires National Wildlife Refuge to combat the American bullfrog population? Why or why not.

Sample answer: I would not introduce American bullfrog predators to the Buenos Aires ecosystem because it could actually cause another problem with any of those predator populations becoming an invasive species at the wildlife refuge. It can become a potential problem when introducing a species that is not native to an ecosystem especially if there are no current natural predators.

5. Evaluate Solutions Since there are multiple possible solutions to controlling the American bullfrog population at Buenos Aires, would you consider using more than one solution? Use data to support your answer. If you support a blend of solutions, which solutions would you use?

Sample answer: Yes, I would consider using more than one solution to combat the American bullfrog population. I would propose using gigging and netting as two viable solutions. Since resources would be present at ponds where American bullfrogs lay eggs, fyke nets could be set up and while the resources are present, they could destroy adults that are present in the area.

Connect to the unit problem

6. Analyze Think about the possible solutions you have brainstormed for controlling the invasive in the Problem Launch. What advantages and disadvantages does each method have? Organize your methods and advantages and disadvantages for each method you have thought of.

Sample answer: Introducing insects that eat Eurasian milfoil could have long term affects on other native species in the ecosystem. Also, it is not very efficient for my classmates and me to get access and permission to insects that eat Eurasian milfoil. A possible advantage could be that we know that Eurasian milfoil will decline because of insects eating the milfoil.
PROBLEM WRAP-UP

Invasives in Your Neighborhood

PROBLEM: HOW CAN YOU REDUCE THE IMPACT OF AN INVASIVE SPECIES ON YOUR LOCAL ECOSYSTEM?

Timing End of Unit 2

Solve It
If you did not complete the STEM Project, Controlling Local Invasives take a few moments to consider some potential solutions to reduce the impact of your local invasive species. Record your thoughts below.

Solutions could include finding a way to poison the Eurasian milfoil without damaging other species; introducing an animal that feeds on the milfoil but not other species; removing milfoil mats by hand or with a machine; and enforcing laws that prevent the spread of milfoil from lake to lake.

PRESENT YOUR WORK
Decide how you would like to present your information and solution. Choose a method that will best communicate what you learned about the species, how it impacts the local ecosystem, and how your proposed solution will reduce its impact. Here are possible methods.

- Slide presentation
- Public service announcement
- Tri-fold poster
- Blog

Develop the presentation with your group. Make sure the information is clear and easy to follow.
→ **Review Other Solutions**

As you listen to each group, answer the following questions.

1. **What do you like about the presentation?**
   
   Sample answer: The presentation was clear and easy to follow. The solution was interesting and was properly tested.

2. **How could the presentation be improved?**
   
   Sample answer: The speakers could have interacted more, perhaps by asking questions of one another. More photographs or other visuals would have been helpful.

3. **What suggestions do you have for improving the solution? Why do you think they will be effective?**
   
   Sample answer: I suggest finding a way to make the invasive plant useful or valuable. People are more likely to harvest the plant if they have a strong financial incentive.
## Unit 2 Problem Rubric

Use this rubric to help you assess your own solution as well as your classmates’ presentations.

<table>
<thead>
<tr>
<th>EXEMPLARY Score your work 4 if:</th>
<th>ACCOMPLISHED Score your work 3 if:</th>
<th>DEVELOPING Score your work 2 if:</th>
<th>BEGINNING Score your work 1 if:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Define the Problem</strong></td>
<td>Local invasive species is correctly identified and described; impact on the ecosystem is summarized.</td>
<td>Local invasive species is correctly identified and described, but negative impact on ecosystem is not clearly defined.</td>
<td>Invasive species is identified, but it may not be in the local ecosystem or its impact may not be identified.</td>
</tr>
<tr>
<td><strong>Do Research</strong></td>
<td>Multiple sources are used and correctly cited; sources are unbiased and reliable; information is appropriately related to the topic.</td>
<td>Multiple sources are used, most of which are unbiased and reliable; sources are cited correctly; some information may not be directly related to the topic.</td>
<td>Several sources are used, but some may be biased or unreliable and some information may not be directly related to topic; sources may not be cited correctly.</td>
</tr>
<tr>
<td><strong>Develop a Solution</strong></td>
<td>Solution to problem is identified and supported by research or evidence; solution is evaluated and revised as needed.</td>
<td>Solution to problem is identified and is mostly supported by research or evidence; solution is evaluated, but may not have been revised or completed based on evaluation.</td>
<td>Solution suggested is reasonable, but not supported by research or evidence; solution may not have been evaluated appropriately.</td>
</tr>
<tr>
<td><strong>Communicate Information</strong></td>
<td>Information is presented in an organized manner; visuals are useful; data is provided.</td>
<td>Information is presented in an organized manner, but some parts may be unclear or missing.</td>
<td>Information is presented in a disorderly manner that is complete, but difficult to follow.</td>
</tr>
</tbody>
</table>

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Unit 2 Ecology | Problem Rubric

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FLORIDA

Miller & Levine

Biology

For Students:
• Florida Student Edition
• Florida Student Edition eText
• Explorer’s Journal: Problem-Based Learning Workbook
• Biology Foundations: Reading and Study Guide Workbook
• Florida Biology Test Prep Workbook
• Pearson Realize™

For Teachers:
• Florida Teacher Edition with Florida Point-of-Use Standards
• Florida Teacher Edition eText
• Digital Explorer’s Journal: Problem-Based Learning Workbook Teacher Edition
• Digital Biology Foundations: Reading and Study Guide Workbook Teacher Edition
• ExamView® Test Bank
• Pearson Realize™

 PearsonSchool.com/FLScience

EXPLORE ONLINE: Visit PearsonRealize.com
User Name: FloridaBioDemo | Password: Pearson7

Contact Your Florida Pearson Representative
Answer your questions, set up a personal walkthrough, and learn about additional support.

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