PURDUE EXTENSION

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FNR-552-W

The NATURE OF TEACHING

WILDLIFE

UNIT 1

The Scientific Process of Conservation Biology: Analyze, Design, Debate

This unit introduces students to the field of conservation biology and the process of conserving a species.

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UNIT 1

The Scientific Process of Conservation Biology: Analyze, Design, Debate

This unit introduces students to the field of conservation biology and the process of conserving a species.

OVERVIEW

ESTIMATED TIME

4 lessons, 45–90 minutes each

VOCABULARY

- Conservation biology
- Extirpation
- Stakeholders
- Management
  - Population
  - Habitat
- Headstarting
- Captive rearing
- Captive breeding
- Translocation
- Augmentation
- Relocation

UNIT OBJECTIVES

Students will be able to:

- Analyze literature, graphs, and figures to discern factors threatening a species
- Summarize and identify key points in scientific literature
- Identify different careers involved in conservation biology
- Use a variety of sources (i.e., newspaper articles, scientific article excerpts, graphs, and pictures) to develop a management plan
- Utilize rhetoric to present and defend an original management plan
- Critically assess the presentation of peers
- Edit and revise an original management plan to better comprehend the iterative process of science

TARGETED LEVEL INDIANA STANDARDS

11–12 LST Standards

1.1, 1.2, 2.2, 4.1, 4.3, 5.1

11–12 English/Language Arts Standards

RN.4.2, W.1, SL.2.1, SL.2.2, SL.3.2, SL.4.1

SEPS

1, 2, 3, 4, 6, 7, 8

PROVIDED MATERIALS

- Case Study, Parts 1–3
- Supplementary materials for Case Study, Parts 1–3
  - Lesson 1
    - Hellbender Population Graphing Assignment
    - Lesson 1 Data Sheet (electronic resource)
  - Lesson 3
    - Hellbender Threat Fact Sheets
    - Management Plan Development Worksheet
    - Management Plan Debate Score Sheet
  - Lesson 4
    - Revised Management Plan Score Sheet

REQUIRED MATERIALS

- Microsoft Excel
- Dice (1 pair)
- Poster boards
- Markers

CONSERVATION BIOLOGY GENERAL OVERVIEW

Conservation biology focuses on *protecting and preserving plant and animal species that are already threatened or endangered or that may face future threats.* Further, it can focus on species at risk of **extirpation**, or *local extinction*, or those at risk throughout their entire range. Conservation biology is a relatively new, but rapidly developing field within biology.

Conservation biology is considered by some to be a "crisis discipline." Decisions within the field must often be made quickly, sometimes without enough time to gather all of the data one would ideally have, and they can decide the fate of a species.

Given the speed at which decisions must be made and the complexity of conservation decisions, most conservation biology projects are interdisciplinary, meaning they involve people from a variety of backgrounds with a wide range of skills. People involved may include field researchers, geneticists, husbandry professionals, engineers, and environmental educators.

Conservation biologists work within a variety of organizations. The group could include a professor at a research university, an employee of a state forestry or wildlife agency, an employee with a nonprofit group, a professional at a zoo, an office worker who issues research permits, or an outreach coordinator within state and national parks. Conservationists also work with a diverse group of people often referred to as stakeholders. **Stakeholders** are *people invested in and affected by the issue at hand*. Examples include landowners, community members, and government agency staff. The list goes on, but this helps to illustrate how multiple people are required for a successful conservation project.

In today's society, conserving and protecting animals often involves management. **Management** takes many forms and is the *attempt to balance the needs of plants, animals, and humans so that all species' requirements are met*. Given the overlap between the basic needs of living organisms (space, food, and water), we don't always reach equilibrium, but management practices try to prevent the scales from becoming perilously out of balance.

- **Population management** involves *altering the number of individuals in a population*. A few techniques include immunizing, implementing a birth control regime, culling (selectively removing particular individuals), head starting, captive breeding and translocation.
- **Habitat management** involves *protecting, restoring, and enhancing the area an animal requires to survive*. This may involve restricting human land use to decrease habitat disturbance, connecting fragmented patches of habitat, or adding supplemental nesting habitat.

Management plans should be created prior to deploying any management techniques. These plans outline the focal species, the management goals, plans for achieving those goals, methods for measuring the success of your efforts. Management plans help focus your efforts and illustrate the logical progression of your strategy to funders and other stakeholders.

If you would like more information on wildlife management see:
WHEP manual: https://texas4-h.tamu.edu/projects/wildlife fisheries, particularly sections 4, 7, and 8

Head starting, captive rearing, and captive breeding are management tactics employed to help many threatened and endangered species.

- **Head starting** is *raising or breeding a species in captivity to an age where they are less vulnerable to threats in their natural environment, then subsequently releasing them*.
- **Captive rearing** is *when eggs or very young animals are raised in captivity*.
- **Captive breeding** involves *bringing sexually mature adults into captivity and breeding them away from threats in the wild.* This is generally a last resort and used when little to no suitable habitat exists. In these cases, the species will remain in captivity, often in a lab or zoo, until habitat can be located — sometimes for the rest of their lives.

The end goal for both captive rearing and breeding is, ideally, to return the young into the wild, if the habitat is available.

- **Translocation** is the general term used to describe *moving animals from one area to another*.
- **Augmentation** is *the act of adding animals to an area where that species still exists*.
- **Reintroduction** is *the act of adding animals where they once existed, but no longer exist*.

Prior to any translocation efforts, however, a scientist must determine what factors in the environment caused the observed decline to see if it was a temporary disruption or if the threat still persists. If the threat still exists, it may not make sense to add animals to that environment. In that case, it may be wiser to attempt an **introduction**, which is *the act of adding animals to an environment where they did not historically exist.* In that case, a scientist must assess what species are already present and how the introduction of a novel species might affect the balance of that ecosystem. None of these techniques should be taken lightly, because all organisms in an ecosystem affect one another in complex and often unpredictable ways.

Hellbender salamanders *(Cryptobranchus alleganiensis)*

Hellbenders are North America's largest salamander, capable of exceeding two feet in length. They are fully aquatic, breathe through the skin and inhabit cool, clean, fast-flowing streams. Like many amphibians, hellbenders are currently threatened or endangered throughout their range due to habitat destruction and disease. They are an ideal focal animal for this case study, because there are currently multiple programs focused on hellbender conservation. These real-time efforts will provide the students with a wealth of resources and examples of the different fields and skills it involved in conservation.

If you would like more information on hellbenders and the threats they face, please visit:
https://www2.ag.purdue.edu/extension/hellbender/Pages/default.aspx.

For additional hellbender photos, research information, and life cycle, please see:
https://www.extension.purdue.edu/extmedia/FNR/FNR-536-W.pdf.

A SLIMY SITUATION

This activity introduces students to the actions required before starting a conservation biology project.

ESTIMATED TIME

60-90 minutes

PROCEDURE

1. Introduce the terms and the introductory information provided in the "Teacher's Notes." Focus particularly on how decisions are made within conservation biology, the definition of management, and the different types of management practices available.
2. Hand out a copy of "Case Study, Lesson 1" to the class. Have students read through the case study
3. Have the students complete the "Graphing Assignment" worksheet individually.
4. As a class, have students discuss whether or not they think the hellbender population requires management and how they came to that decision.
   Note: Students who chose not to manage the hellbender population are not wrong. There are valid reasons to vote against hellbender management, too.

If the class finishes early, you may choose to have them discuss how the change in hellbender numbers may affect other animals in the habitat, such as their prey (e.g., crayfish) or animals that prey upon hellbenders (e.g., otters and smallmouth bass).
In the end, you may choose to inform the class that the data for this lesson is the actual Indiana Department of Natural Resources (IDNR) hellbender survey data. Indiana's hellbender population is currently undergoing conservation management to prevent extirpation.

REQUIRED MATERIALS

- Case Study, Lesson 1 (1 copy per student)
- Hellbender Population Graphing Assignment worksheet (1 copy per student)
- Lesson 1 Data Sheet (electronic resource)
- Microsoft Excel

A SLIMY SITUATION

Jordan Lee is the new state herpetologist with the Indiana Department of Natural Resources (IDNR) and he has an important wildlife management decision to make. Jordan has been tasked with determining whether Indiana's population of hellbender salamanders (Cryptobranchus a. alleganiensis) is at risk of extirpation. The hellbender salamander is a fully aquatic salamander that can reach lengths of 29 inches!

Hellbenders are relatively sedentary animals who spend the majority of their time beneath large, flat boulders in cool, fast-flowing rivers and streams. They move to hunt for crayfish, their main food source, and to find mates during the breeding season. During the mating season, a male hellbender, called a den master, guards a nest where a female deposits eggs and moves on; multiple females may choose the same nest. Males fertilize the eggs externally and guard them until they hatch. Hellbenders do not need to surface for air, because they breathe through their slime-coated skin, especially the wavy flaps of skin along their sides. In Indiana, they have been recorded in the Ohio and Wabash River drainages.

While they are not the most common sight in a river, it is not impossible to see a hellbender crawling along the river bed…or, that is, it didn't used to be. In 1984, twelve sites were surveyed for hellbenders and the population seemed healthy; 130 hellbenders were found, and two were young adults. Given those promising numbers, the state did not monitor the hellbender population. In the last decade, however, the IDNR began receiving multiple reports from anglers and kayakers that they were no longer seeing any hellbenders. These reports concerned the IDNR and they surveyed for hellbenders from 1998–2007. They tasked Jordan with analyzing this population survey data to determine if the state should pursue managing the hellbenders.

Given the importance of this decision, Jordan has asked for your help. You play the role of one of Jordan's co-workers and help him analyze the survey data. You must create graphs of hellbender population trends and interpret the results. Based upon the graphs you create, you then tell Jordan whether or not you think the hellbenders in Indiana require management.

HELLBENDER POPULATION GRAPHING ASSIGNMENT

In the Excel datasheet, "Hellbender Population Survey Data," data from one historical survey completed by a graduate student (1984) and 10 years of Indiana Department of Natural Resources (IDNR) hellbender survey data (1998–2010) is provided.
Note: Years 2006, 2008, and 2009 had no data because the river was too high to survey. Those years were excluded from the data set.

The data tells you:

- How many hellbenders were caught each year
- How many hellbenders were caught at each site
- How many of each gender (male, female, undetermined) were caught
- How many total unique hellbenders were caught

In Excel, you must create charts and graphs to help illustrate the status of Indiana's hellbender population. From the graphs you create, you need to decide if the hellbenders need management to avoid extirpation. You also must form a few suggestions on what sites to manage and why.

1) Graph the changes in the total number of hellbenders (all sites, combined) over the years surveyed (1984–2010).
   - What variables do you put on your x and y axes?
   - Attach a picture of your graph.
   - What is the overall trend that you see? What is one possible explanation for the increase seen between 1998 and 1999?

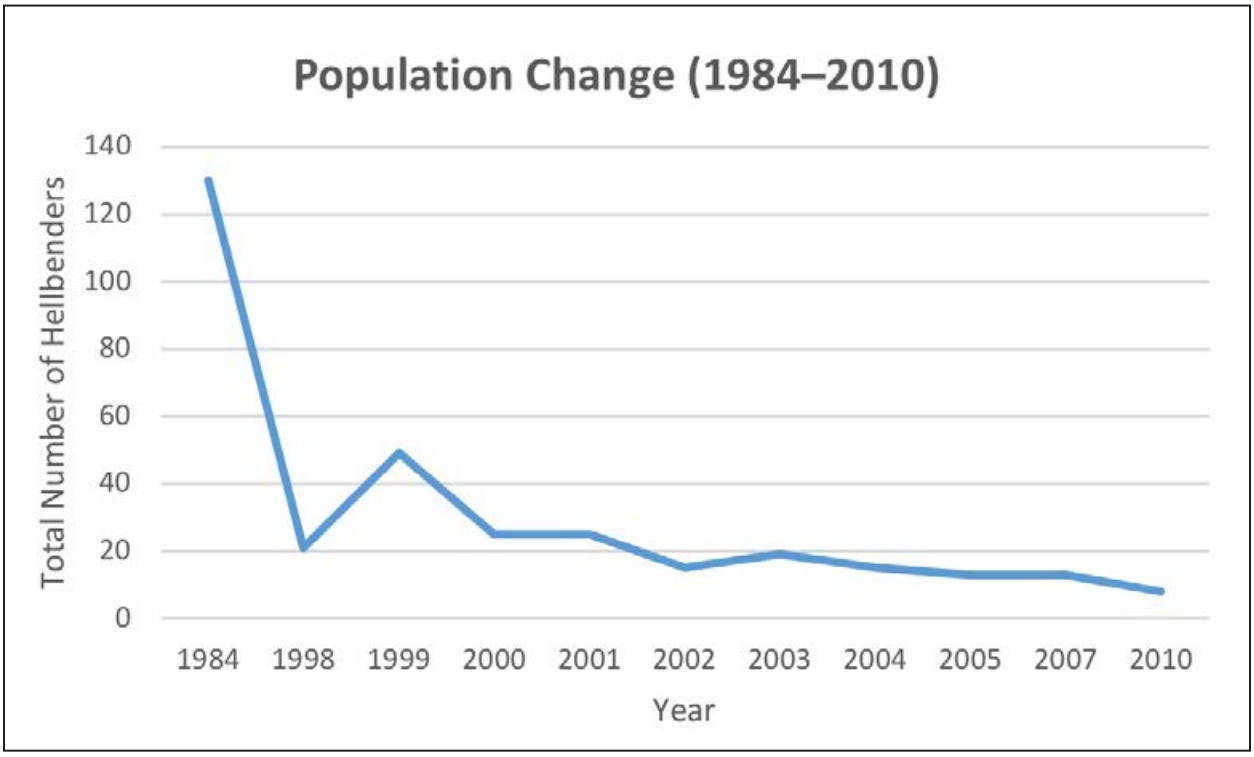
2) Graph the total number of hellbenders found at each site during the combined years of the survey (1984–2010).
   - What variables do you put on your x and y axes?
   - Attach a picture of your graph.
   - Based on this graph, which site was the most populated? Which was the least populated?
   - Based on this graph, if you had to choose one site to manage, which site would you choose? Why?

3) Graph the numbers of hellbenders of each gender (male, female, undetermined) found at each site during the combined years of the survey (1984–2010).
   - What variables do you put on your x and y axes?
   - What variables are in your legend?
   - Attach a picture of your graph.
   - Based on this graph, if you had to choose one site to manage, which site would you choose? Why?

4) Based on the graphs you created and the data provided, would you suggest that the IDNR manage the Indiana hellbender population? Why or why not?

HELLBENDER POPULATION GRAPHING ASSIGNMENT ANSWER KEY

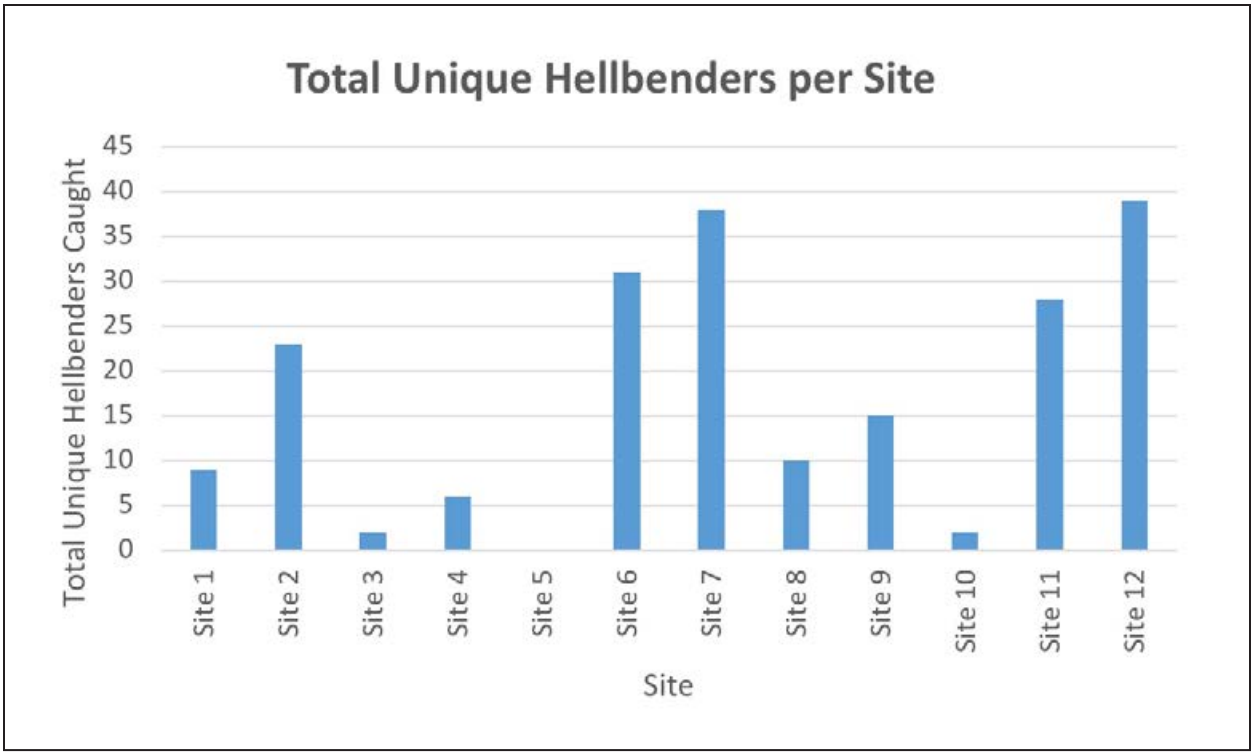
1) Graph the changes in the total number of hellbenders (all sites combined) over the years surveyed (1984-2010).
   - What variables do you put on your x and y axes?
     X-axis: **Year;** Y-axis: **Total Number of Hellbenders** (Exact wording may vary, must indicate some count of hellbenders)
   - Attach a picture of your graph:



   - What overall trend do you see?
     The population is steadily declining.
   - What is one possible explanation for the increase seen between 1998 and 1999?
     - Answers will likely vary, but this question is to get them thinking about possible explanations for odd or unexpected trends in their data. Example answer:
     - In 1999, the IDNR had a year of practice looking for hellbenders and they could target the best sites from the previous year.

HELLBENDER POPULATION GRAPHING ASSIGNMENT ANSWER KEY CONTINUED

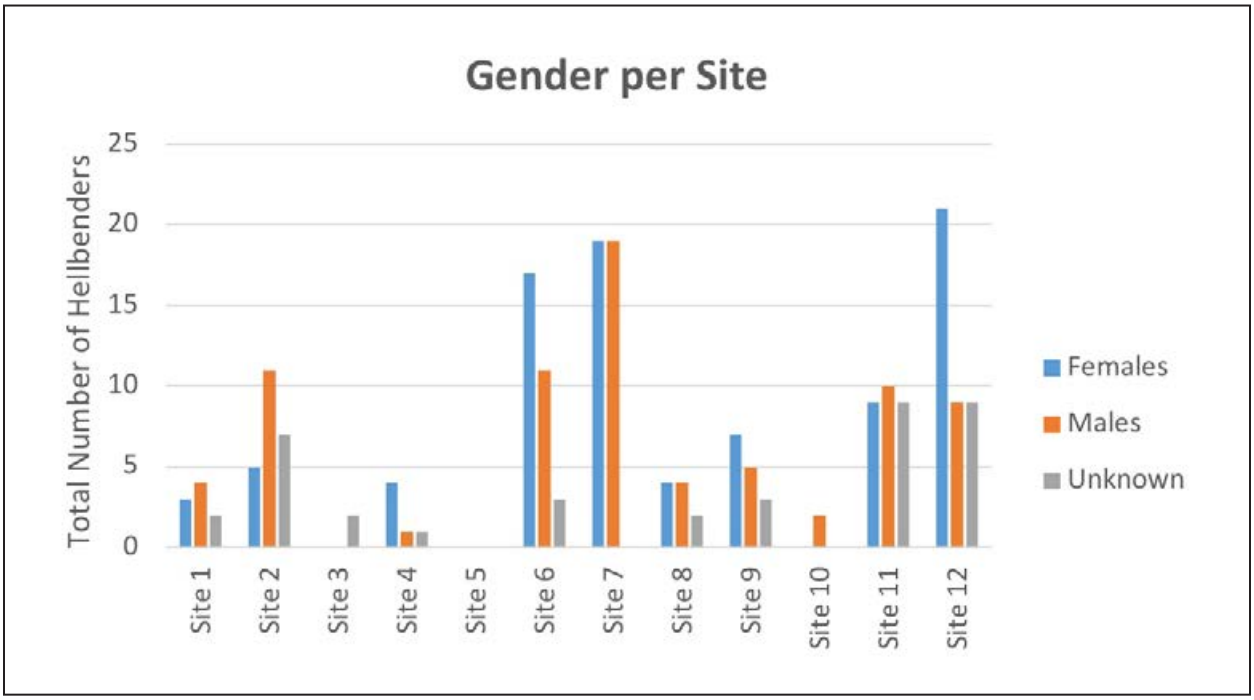
2) Graph the total number of hellbenders found at each site during the combined years of the survey (1984-2010).
   - What variables do you put on your x-axis?
     X-axis: **Site**; Y-axis: **Total Unique Hellbenders Caught**
     (Exact wording may vary, must indicate some count of hellbenders)
   - Attach a picture of your graph:



- Based on this graph, which site was the most populated? Which site was the least populated?
  - Most populated: **Site 12**; Least populated: **Site 5**
  - *Note: if students cannot determine this from the graph, remind them that this information is in the dataset, too.
- Based on this graph, if you had to choose one site to manage, which site would you choose? Why?
  You should receive various answers here. No answer is wrong as long as they can justify their choice. Responses may include:
  - Site 5. It doesn't have any hellbenders, meaning it is most in need of intervention.
  - Site 12. It has the most hellbenders, meaning it has the best chance of succeeding in the long run.
  - I wouldn't choose just one site. I think we should manage them all, because the numbers are too low to risk losing any more hellbenders.

HELLBENDER POPULATION GRAPHING ASSIGNMENT ANSWER KEY CONTINUED

3) Graph the number of hellbenders of each gender (male, female, undetermined) found at each site during the combined years of the survey (1984–2010).
   - What variables do you put on your x and y axes?
     X-axis: **Site**; Y-axis: **Total number of Hellbenders** (Exact wording may vary, must indicate some count of hellbenders)
   - What variables are in your legend?
     Female, Male, Undetermined
   - Attach a picture of your graph:



   - Based on this graph, if you had to choose one site to manage, which site would you choose? Why?
     You should receive various answers here. No answer is wrong as long as they can justify their choice. A few responses may include:
     - Site 12. It has the most females. Since females produce young and we want to increase the number of hellbenders, it makes sense to protect the site with the most females.
     - Site 7. It has an equal number of males and females, meaning there should be plenty of potential mating pairs.

4) Based on the graphs you created and the data provided, would you suggest that the IDNR manage the Indiana hellbender population? Why or why not?
   There is no right or wrong answer, as long as they can justify their response. A few responses may include:
   - No, because the number of hellbenders remaining in Indiana is so low that there is no hope of recovery.
   - Yes, because the population is showing a constant decline, indicating that it needs some kind of management, if the population is to survive.

CAUSE FOR CONCERN

This activity introduces students to the initial stages of developing a management plan.

ESTIMATED TIME

60-90 minutes

PROCEDURE

1. Introduce the terms and the introductory information provided in the "Teacher's Notes." Focus particularly on how decisions are made within conservation biology, what management is, the different types of management practices available, and the information on hellbender salamanders. *Note: Skip this step if your class completed, "Lesson 1: A Slimy Situation." You may wish to review the main concepts and vocabulary.*
2. Hand out a copy of "Case Study, Lesson 2" to each student. Have students read through the case study.
3. Assign students one of four hellbender decline topics: 1) Disease and Injury, 2) Habitat Destruction, 3) Persecution by Humans, and 4) Reduction in Population Size.

REQUIRED MATERIALS

- Case Study, Lesson 2 (1 copy per student)
- Pen and paper
- White board or chalk board

4. Have students break up into their assigned group and look up a peer-reviewed journal article (not a newspaper or nonscientific journal article) about their group's hellbender decline topic (links for papers in "Case Study, Lesson 2"). Each student in the group should read a different article on their group's topic.

   They must read the article, summarize it in one to two paragraphs, and identify a few key points or findings from the article that may explain why the hellbender population is declining.

   Note: If time is short, you can suggest students focus on the abstract, where the major findings are contained. Students could also skim or skip the Methods and Results sections; these sections are not vital for this activity.
5. Have each group present to the class their key findings from the literature about their hellbender decline topic.
6. Explain to the students that conservation biologists would then target these larger areas of concern when they begin to develop their conservation management plans. By focusing on the biggest threats conservationists may slow the immediate decline so that they can focus on the smaller threats at a later time. As a result, they also may actually solve some smaller threats as a by-product. Further, remind students of their discussion about multiple potential causes for hellbender declines. Rarely is there one cause of decline, so the most immediate threat must be chosen and ad dressed or, given time and funding, there may need to be multiple conservation management plans.

CAUSE FOR CONCERN

Jordan Lee, the state herpetologist with the Indiana Department of Natural Resources (IDNR), has discovered that Indiana's hellbender salamander (Cryptobranchus a. alleganiensis) population is on the road to local extinction. Before he can begin making a management plan, however, Jordan needs some important information — namely, what is causing these declines?

State agencies, such as IDNR, often partner with research universities for management projects. The universities can provide scientifically rigorous research to better inform the agencies' decisions, and the agencies, in turn, can provide funding and workers to implement the management plans developed by the universities.

Jordan reached out to the local research university and was put in touch with Dr. Isabella Lopez. Dr. Lopez's lab focuses on the conservation of amphibians. Understanding the biology of a species helps scientists better understand why they might be threatened or endangered, so Dr. Lopez and her lab decided to read up on hellbender biology. Follow these links to learn some basic hellbender biology:

- What Is a Hellbender? https://www2.ag.purdue.edu/extension/hellbender/Pages/about.aspx
- Their Home: https://www2.ag.purdue.edu/extension/hellbender/Pages/home.aspx
- Their Habits: https://www2.ag.purdue.edu/extension/hellbender/Pages/habit.aspx

As a result, Dr. Lopez's lab now researches factors contributing to hellbender declines. They keep in mind the hellbender biology they learned so they can identify hellbender-specific threats described in the literature. They then present Jordan with suggestions for a few different management plans.

You will play the role of a graduate student researcher in Dr. Lopez's lab. You will be assigned a specific topic on hellbender declines to research. Each member of your group will:

1. Find one, peer-reviewed journal article about your group's topic related to hellbender declines (this does not include newspaper articles or non-research journals). Each group member should find a different journal article. A few sources include:
   - Hellbender Publications: https://ag.purdue.edu/extension/hellbender/Pages/publications.aspx
   - Google scholar: http://scholar.google.com/
2. Summarize that article in one or two paragraphs.
3. Identify the key causes the article mentioned that may be contributing to hellbender declines.

As a group, you will present to the class the key findings you learned from the literature about your group's hellbender decline topic. There is often not enough money or time to address all of the factors that may be causing a decline. As such, conservationists try to target the largest threats in hopes of stabilizing the population as quickly as possible. A secondary goal and by-product of focusing on the larger issue may be that you address some less pressing threats.

THE BIG DEBATE

Students use supporting evidence and rhetoric to gain support for their conservation management plan.

ESTIMATED TIME

60-90 minutes

PROCEDURE

1. Introduce the terms and the introductory information provided in the "Teacher's Notes." Focus particularly on how decisions are made within conservation biology, what management is, the different types of management practices available, the purpose of a conservation management plan, and the information on hellbender salamanders.
   Note: Skip this step if your class completed, "Lesson 1: 'A Slimy Situation.'" You may wish to review the main concepts and vocabulary.
2. Hand out a copy of "Case Study, Lesson 3" to each student. Have students read through the case study.
3. Break students into four equal groups: 1) Disease and Injury, 2) Habitat Destruction, 3) Persecution by Humans, and 4) Reduction in Population Size. (Note: If you completed Lesson 2, have students break into the same groups they were in before). Provide each group with their respective "Hellbender Threats" fact sheets. Students should use the provided "Management Plan Development" worksheets to help them organize their ideas.
4. Allow each group enough time to review their "Hellbender Threats" fact sheets and form a supporting argument for their conservation management plan.
5. Bring the groups back together for the debate. Provide each group with a score sheet. Each group receives four to six minutes to present their case to the other groups. The other groups score their presentation. The two groups with the highest scores get a two-minute rebuttal; their rebuttals must highlight novel points in favor of their plans. The other groups again score the presentation of each group, and the group with the highest score wins the grant.

REQUIRED MATERIALS

- Case Study, Lesson 3 (1 copy per student)
- Hellbender Threat fact sheets (4 different sets, one set for each group)
- Management Plan Development Worksheet (4, one per group)
- Management Plan Debate Score Sheet (4, one per group)

6. Discuss the debate with the students. Did they notice similar themes between the different threats and management plans? Was it difficult to choose and focus on one management plan?
7. Explain to the students that while seeking funding for a project often doesn't take a debate format, it's happening more frequently. Given the lack of funding for ever-increasing numbers of research proposals, scientists are often competing with their fellow researchers for grant money. In lieu of debates, researchers must write proposals that convince funders that their project is the most effective and deserving of the money.

THE BIG DEBATE

Dr. Isabella Lopez and her graduate students have been hard at work reading the research literature on hellbender salamander *(Cryptobranchus alleganiensis)* declines. The hellbender salamander is North America's largest salamander, reaching a length of 29 inches. It is fully aquatic and breathes through the skin, making it very susceptible to changes in the environment. Because of this, the hellbender population in Indiana is facing extinction. The four main threats the research on hellbender declines have proposed are **disease and injury, habitat destruction, persecution by humans, and a reduction in population size.** Ideally, researchers would tackle each problem, but Jordan Lee, the Indiana Department on Natural Resources (IDNR) state herpetologist, was only able to obtain one grant to fund their initial management steps. There is potential for future grants, but only after the group's efforts have produced some tangible results.

Each of Dr. Lopez's four graduate students thinks that one of the threats is more important to focus on than the others. This is a common situation in research, as the number of research ideas often exceeds the amount of funding available. Dr. Lopez has instructed them to use the literature and other documents to make a convincing argument for why their conservation management plan should receive the funding.

You will be in a group playing the role of one of Dr. Lopez's graduate students. You will receive one of the threats to focus on and, using the "Hellbender Threat" fact sheets, you and your group will develop a management plan and a defense explaining how addressing your threat is the most impactful for hellbender conservation.

All groups will score one another's arguments. The argument with the highest score in the end wins the grant.

HELLBENDER THREAT FACT SHEET: DISEASE AND INJURY

Your group will focus on disease and injury. Using the "Management Plan Development" worksheet and the provided evidence below, your group must prepare a preliminary management plan outlining how to handle this problem. You must also prepare a defense explaining how making hellbender disease and injury management the first priority would have the greatest impact on hellbender conservation. You will then present and defend this plan in front of your peers, who will vote to determine which hellbender threat should be addressed first.

Possible Sources of Disease and Injury

Habitat destruction

- Land development (e.g., farms, factories, and homes along the river) leads to chemical and sediment runoff in the water.
  - Hellbenders breathe through the skin. When they absorb oxygen from the water, they also absorb chemicals present in the water.
  - Increased chemical levels lead to algal blooms, which decrease dissolved oxygen (DO) in the water. Hellbenders breathe through the skin using the DO in the water.
  - Sediment fills up the spaces where hellbenders and their main prey sources live. Decreased habitat can lead to competition between hellbenders and other organisms in the river, which can result in cuts and lost limbs. Those injuries are then susceptible to infection.

Pathogens

- A wide range of pathogens are found in the rivers where hellbenders live.
- A subset of those pathogens, which are associated with infections and disease, were only found on the wounded or abnormal hellbenders.
- Chytrid, a virulent disease that is a leading cause of amphibian declines, has been found in hellbender populations.
  - Hellbenders are routinely swabbed to detect the presence of chytrid.
  - Hellbenders can carry chytrid without developing any dangerous symptoms. However, carrying chytrid may weaken their immune systems and make them more susceptible to other pathogens in their environment.

Introduced and reintroduced species

- When a species is introduced into an environment, so are its pathogens. Hellbenders may not have encountered these pathogens before and are thus lacking immunity towards them.
- New species may compete with the hellbenders for resources. This competition could lead to fights, resulting in cuts and lost limbs. Those injuries are then susceptible to infection.
- Reintroduced species, such as otters, prey upon hellbenders. Evading predation can lead to higher stress levels that weaken the immune system, and injuries that are then susceptible to infection.

Recreation

- When people use the river, they potentially introduce novel pathogens and species. Dirty boats and canoes that were used in different rivers are a perfect way to spread germs and small organisms.
- Hellbenders live primarily under boulders. People can potentially injure hellbenders by dragging their boats over these boulders when the water is shallow or by flipping boulders.

Table 1. *A documented decline in a hellbender population from 1969–2005. Throughout time, the number of hellbenders caught significantly decreased while the percentage of injuries and abnormalities increased.*

YEARS SURVEYED	HELLBENDERS CAUGHT	PROPORTION OF POPULATION WITH OBSERVED ABNORMALITIES OR INJURIES	NOTES
1969	479	2.9%	• Healthy, abundant population • Quick to heal when injured • Pristine habitat
1975	400	5%	• Healthy, abundant population • Minimal habitat disruption
2005	55	47%	• Unhealthy, small population • Slow to heal • Increased recreation on the river • Decreased habitat quality • Many otters spotted

Data adapted from Nickerson et al. 2011

HELLBENDER THREAT FACT SHEET: HABITAT DESTRUCTION

Your group will focus on habitat destruction. Use the "Management Plan Development" worksheet and the provided evidence below to prepare a preliminary management plan outlining how this problem could be handled. Also prepare a defense explaining how making a habitat destruction management the first priority would have the most impact on hellbender conservation. You will then present and defend this plan to your peers, who will vote to decide which hellbender threat should be addressed first.

Possible Sources of Habitat Destruction

Mining activities Leads to runoff which pollutes the rivers and streams	*Pollutant-caused rise in water temperature* Leads to hellbenders moving downstream or upstream to find more suitable habitat, which wastes their energy and exposes them to predators
Air pollution Leads to airborne pollutants ultimately deposited in the river	*Reduced survival, fitness, and reproduction for hellbenders and their prey*
Livestock in streams Increase nitrogen and phosphate levels in streams that lead to oxygen-consuming algal blooms	*Lower dissolved oxygen in the water* Leads to difficulty breathing. Hellbenders breathe underwater, so if the amount of oxygen in the water decreases, hellbenders have a harder time breathing

IInformation adapted from Briggler et al. 2007

SILTATION & SEDIMENTATION	
CAUSES of siltation and sedimentation	**EFFECTS of increased siltation and sedimentation on hellbenders**
Urban and rural development Increases amount of land surface that cannot absorb water or fine sediment (i.e., silt), allowing the particles to be swept away and deposited into the rivers	*Silt-covered cobble and boulders, filling in the spaces between rocks* • Leads to reduced hellbender habitat quality and availability • Smothers hellbender egg masses
Agriculture and animal farming Leads to the removal of vegetation near rivers and streams, which removes the buffer zone between agriculturally produced waste (e.g., pesticides and silt) and the river	*Changes in river habitat and composition* Leads to: • less habitat for prey • alteration in the types of available prey • changes in the quality of available prey • less habitat and food for hellbenders
Silviculture (forestry) Leads to removal and reduction of trees near rivers and streams, which can decrease streambank stability, allowing more silt to run into the river	*Reduced survival and reproduction for both the hellbenders and their prey*

Information adapted from Briggler et al. 2007

HABITAT FRAGMENTATION	
CAUSES of stream and habitat fragmentation	**EFFECTS of stream and habitat fragmentation on hellbenders**
Dams and roads Alter stream flow; divide rivers into isolated patches	Habitat loss • Leads to reduced prey abundance • Results in fewer places for hellbenders to live and breed
Urban and rural development Alters stream flow to accommodate human usage (e.g., drinking water, recreation, energy production)	*Reduced dispersal* Leads to: • decreased ability to find mates • decreased ability of prey to enter the habitat
Increased siltation • Can alter stream flow and sometimes cause silt build-up and dam-like effects, creating isolated pools of habitat •Common side-effect of development	*Altered stream characteristics* • Leads to increased periods of drought, reducing prey and hellbender habitat • Increases chance of flooding, which may sweep hellbenders out of their habitat or wash their habitat away
Mining and rock removal • Changes river flow; removes and disturbs potential habitat • Leads to runoff which pollutes the water	*Reduced survival, fitness, and reproduction for both hellbenders and their prey*

Information adapted from Briggler et al. 2007

HELLBENDER THREAT FACT SHEET: PERSECUTION BY HUMANS

Your group will focus on persecution by humans. Using the "Management Plan Development Worksheet" and the provided evidence below, your group must prepare a preliminary management plan outlining how this problem could be handled. You must also prepare a defense explaining how combatting persecution by humans of hellbenders as a first priority would have the most impact on hellbender conservation. You will then present and defend this plan to your peers, who will vote to decide which hellbender threat should be addressed first.

Articles illustrating the persecution of and common misconceptions of hellbender salamanders:

KILL WATERDOGS AND WATERSNAKES

The Freeport Sportsmen, under the direction of their president, Mr. Loyd, conducted an intensive drive against the watersnakes and waterdogs in Buffalo Creek, Armstrong county. Acting under a special gigging permit and accompanied by Fish Warden J. H. Simmons of Rochester, they staged two highly effective forays against these destroyers of fish life.

The first night's kill consisted of 137 salamanders or waterdogs and 50 watersnakes, while on the second night 100 waterdogs and 25 watersnakes were destroyed.

SPORTSMEN WILL WAR ON WATERDOGS

Sportsmen in Lycoming county will make a determined drive against the salamander, or waterdog, in county streams, Oliver M. Deibler, Fish Commissioner, said today.

Salamanders, waterdogs, or hellbenders, as they are sometimes called, have been found to be very detrimental to fish life, the Commissioner said. Not only will they eat spawn, but larger fish also are killed by the ungainly creatures. A salamander opened recently was found to contain an eight-inch trout and the tails of five smaller fish.

Old fishermen who are familiar with Lycoming county waters believe that there is a very noticeable increase in waterdogs in recent years, and that they are a real menace to fish life.

H. J. Bressler, special fish warden in Lycoming county, has been issued a permit to organize the campaign against the salamanders, and the sportsmen will work under his directions in trying to reduce the number of waterdogs.

Dark, moonless nights are considered the best time in catching the creatures.

Some of the older fishermen were "dead against" river alligators or hellbenders. When they got on the hooks or nets, the punishment was to nail them to a block of wood and send them adrift down the river to gradually starve to death.

Fri., Sept. 9, 1966 PRESS, Binghamton, N. Y. 3-A

Hellbender... Putting It Nicely

It's been a good summer for sea monsters and bad dreams along the Susquehanna River.

The biologists at Harpur College have their happy hands on several of what is known as Cryptobranchus Alleganiensis.

It is the most repulsive creature yet to be taken from the river. The Susquehanna is the only place it can be found between the Atlantic Ocean and the Mississippi River Basin.

Dr. Roger Conant, one of the principal authorities on the subject, describes old Cryptobranchus Alleganiensis and his brothers and sisters as characters that look "more like bad dreams than live animals."

He also calls CA "a huge, grotesque, thoroughly acquatic salamander."

* * *

TO REPORTERS, it looks like a busted horseplayer confronted by his wife, or a sour spinster aunt.

To Dr. Ted Murphy ecologist and natural historian at Harpur College, it is a great find for his students to study. One of them, Mary Ellen Lyon, is writing her master's degree thesis on Old Repulsive.

"They're called hellbenders, too," she said. "The reason is they bend when you pick them up. They're very primitive."

Frank Dolan, the naturalist writer in these parts, says, "They're right out of the Stone Age. You ought to see a fisherman who accidentally catches one. Scares him to death."

The specimen that newsmen saw at Harpur yesterday was 24 inches long — scaly, leathery (that is because it had been pickeled), with a fatuous grin on its face, semi-gilled and with four feet. As Dr. Conant said in his book, it is a nightmare.

It is not what is known locally as a "mudpuppy." It's older by several million years.

* * *

THE LOCAL SPECIMENS were pulled out of the Susquehana near Windsor by Harold Bowers and his sons while they were hunting for hellgrammites to sell as bait for local fishermen.

The Bowers clan yanks the hellbenders out of the river and disposes of them because they eat the hellgrammites and then fleece an honest baitman out of a good day's living.

They don't mate like ordinary animals. They don't come out of the water and they reproduce near the bottom of the Susquehanna, with the female laying from 350 to 400 eggs at a time and the male dropping sperm on the eggs from above and then wandering away, his dorsal fin flapping negligently, without apparent interest.

Their purpose?

"They are good," Mrs. Lyon said, "for nothing. As Dr. Conant said, a bad dream."

—TOM CAWLEY

—PRESS PHOTO BY LEO FAHEY.

BEAUTY AND THE WHATIZIT—Martha Snyder of 115 Pine Knoll Drive, Endicott, a secretary in Harpur College's Biology Department, is surrounded by characters like this in her daily chores around the laboratories. It is Cryptobranchus Alleganiensis, a rarity in the East. In fact, the upper Susquehanna is the only place you can find one of these between the Atlantic Ocean and the Mississippi.

The misconceptions, fear, and hatred expressed about hellbenders in the provided articles are often fueled by unfamiliarity and lack of factual knowledge. Few people have ever seen or heard of a hellbender, given their threatened or endangered status. Educating the public about hellbenders can help to change their perspecitves of and behaviors toward hellbenders.

Table 2. *Potential benefits of increasing the public's awareness and knowledge of hellbenders.*

PEOPLE FAMILIAR WITH HELLBENDERS ARE:	
More likely to	• Support government funding for hellbender management • Agree that hellbenders have an inherent right to live • Agree that hellbenders are important to their native habitat
Less likely to	• Have misperceptions about hellbenders (e.g., poisonous, aggressive, capable of electrocuting) • Fear the hellbender

HELLBENDER THREAT FACT SHEET: REDUCTION IN POPULATION SIZE

Your group will focus on reduction in population size. Using the "Management Plan Development Worksheet" and the provided evidence below, your group must prepare a preliminary management plan outlining how this problem could be handled. You must also prepare a defense explaining how combatting population loss as your first priority would have the most impact on hellbender conservation. You will then present and defend this plan to your peers, who will vote on which hellbender threat should be addressed first.

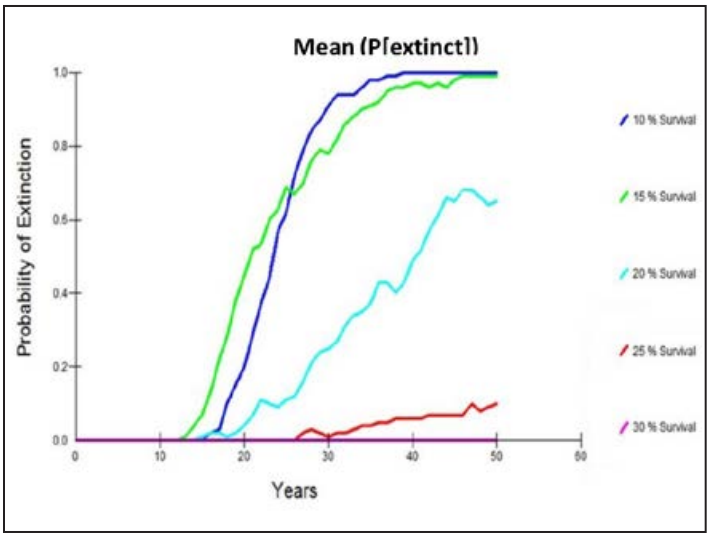
POPULATION OBSERVATIONS	POSSIBLE CAUSES
Since the 1970s, hellbender populations have decreased in size by 77%, on average.	• Low egg and juvenile survival rates • Habitat destruction • Disease and injury • Persecution by Humans
Many populations consist of older adults	Low egg and juvenile survival rates
Some population have more adult males than females.	Mortality rates for adult male hellbenders are pretty constant, whereas mortality rates for adult female hellbenders increase after they have reached 15 years of age.
Few nests are found.	• Older, less fertile hellbender populations • Nest site destruction
Few to no juveniles are found.	• Eggs not hatching as a result of: o predation o defects in the eggs • Male hellbenders feed on a portion of their eggs while guarding their dens. If there are fewer adult hellbenders, there will be fewer breeding pairs. This would result in fewer eggs being laid, so any eggs the male hellbenders eat will be a significant proportion. • High mortality rates for younger hellbenders as a result of: o predation o lack of habitat o competition for limited resources

Information adapted from Taber et al. 1975 and Wheeler et al. 2003

Table 3. *A simulation was run to see how translocation of captive bred hellbenders would affect a wild population. The simulation looks specifically at the wild population's annual population growth rate (r), population size, and percent increase in final population size over a 50-year time period.*

SUPPLEMENTATION SCENARIO	ANNUAL POP. GROWTH RATE (R)	POPULATION SIZE AT 50 YEARS	% INCREASE IN FINAL POPULATION SIZE
200 one-year-old	0.047	1236	68%
20 subadults	0.046	1209	42%
20 adults	0.055	1573	124%
20 adults (female bias 2:1	0.058	1960	197%
20 adults (female bias 3:1)	0.061	2219	220%

Figure 1. *Illustrates that a survival rate of 25%–30% is needed in the juvenile-age class to significantly decrease the probability of extinction over a projected 50 years in Indiana's Blue River hellbender population. Without an increase in juvenile survival rate, the chance of extinction is 100%.*



MANAGEMENT PLAN DEVELOPMENT WORKSHEET

Read the provided materials. Use the information to assess how your group's hellbender threat may be contributing to hellbender salamander declines. Develop a management plan to propose to the class, explaining why this threat should be addressed first.

1. **Consider:**
   - How is your group's hellbender threat contributing to hellbender declines?
   - What aspects of your group's hellbender threat would you focus on? How could that improve the situation?
   - What steps would you take to address the issue?
   - Who are your potential partners or stakeholders?
   - What information and supplies might you need to address the issue?
   - How would you check if your intervention is having a positive effect?

2. **In two to three sentences, briefly explain your plan**.

3. **For the debate:**
   1) Come up with four to five key points to defend your case.
   2) Choose your strongest two to three points for the first round of debate and keep the other point(s) in reserve for a potential rebuttal.

MANAGEMENT PLAN DEBATE SCORE SHEET

Your group will judge this debate and score each team's defense. Each team must explain why their conservation plan should receive the available grant money.

Each team will have 4 to 6 minutes to present their conservation plan. Your group will give each argument a score using the point scale below.

After Round 1, the two teams with the highest scores each get a rebuttal period (approximately 2 min.). Remember, rebuttals will focus on the discussion points each team kept in reserve; they should not repeat the same arguments used in the first round. Your group will score the rebuttal using the same scoring system. The team with the highest score in the end wins the grant.

Possible Scores (choose one point value per cell): 0-Poor 1-Fair 2-Average 3-Good 4-Excellent

GROUP / CRITERIA	DISEASE AND INJURY	PERSECUTION BY HUMANS	HABITAT DESTRUCTION	DECLINES IN POPULATION SIZE	REBUTTAL GROUP 1	REBUTTAL GROUP 2
Argument was fact-based						
Materials used supported the argument						
Delivery was clear and convincing						
Plan was feasible						
Potential impact of plan seemed significant						
Presentation finished in time allotted						
TOTAL SCORE						

MANAGEMENT PLAN DEVELOPMENT ASSIGNMENT ANSWER PROMPTS

Given the novelty and volume of information, some groups may need prompting while they develop their plans. Below are ideas and potential answers that you may use to generate conversation within a struggling group. Their answers cannot be wrong, they just need to be able to justify their plan.

Disease and Injury

This group is provided with information highlighting the role disease and injury may play in the decline of hellbenders as well as potential causes of the increased incidences of disease and injury. They also receive a table highlighting the increasing trend in injuries and disease in a hellbender population.

Main ideas

- Disease and injury could be a major factor in the decline of hellbenders.
- The increase in disease and injury may be a result of human activities.

Potential responses

List parts of the problem you would focus on and how you think focusing on those parts will best alleviate the issue.

- Injuries, because if we collect hellbenders and treat their injuries we can reduce the number that die.
- Invasive species, because they are a potential source of disease and injury. If we remove the invasive species, we will reduce the chances of disease and injury.
- Human river use, because if we restrict people from using the river where hellbenders live they are less likely to get hurt by our boats or infected by pathogens or invasive species our boats may be harboring.

Describe steps you would take to address the issue.

- Collect all the hellbenders in a population, then treat and monitor their injuries at a veterinary clinic. Once healed, release them where they were collected.
- Put up fences around hellbender habitat to keep out invasive species or people who may injure or infect the hellbenders.
- Teach canoers and kayakers what hellbender habitat looks like, so they won't ride or drag their boats over it or flip rocks

Who are your potential stakeholders (e.g., governmental agencies, scientists, landowners)?

- Veterinarians
- Anglers
- Landowners

What information and supplies would you need to address the issue?

- Information on how to treat hellbender injuries
- Knowledge of sites in the river where boaters and hellbenders are most likely to negatively interact
- Funding for medical supplies

How would you check to see if your intervention is having a positive effect?

- Compare the post-treatment occurrence of injury and disease of the wild hellbender population with the pre-treatment numbers.

In two to three sentences, briefly explain your plan.

- (Example) We will collect all the injured or sick wild hellbenders and transport them to a veterinary clinic for treatment. Once they have healed, they will be released back into the wild. A post-treatment survey will be conducted to see if the health of the treated hellbenders remains stable or if the hellbenders accrue more injuries and illnesses.

Habitat Destruction

This group is provided with three lists of ways the habitat is being destroyed (siltation/sedimentation, decreased water quality, and habitat fragmentation) and how that may affect hellbenders.

Main ideas

- Nearly all of these habitat issues are human-mediated and will require behavior changes to prevent them and reverse the damage.
- Our actions have consequences and everything we do is connected to something else.
- Some actions have larger impacts than others and addressing them can address multiple issues simultaneously.

Possible responses

List parts of the problem you would focus on and how you think focusing on those parts will best alleviate the issue.

- Agricultural practices, because they affect water quality, siltation levels, and habitat fragmentation. So, if we can change the practices, we'll improve all three factors.
- Decreased water quality, because everyone can change their habits in simple ways to improve the water.
- Public use, because it would be easy to address reach our target audience by visiting ponds, rivers, and streams and explaining how to safely enjoy the water without causing pollution.

Describe steps you would take towards addressing the issue.

- Visit farmers, alert them to the problems pesticides and livestock can cause, in particular for endangered aquatic animals, and teach them about alternative ways to plant their crops or house their animals to reduce their impacts on the environment.

- Create a pamphlet that teaches people things they can do at home to keep the water clean.
- Organize a community stream clean-up to both increase the local water quality and to expose people to the problem of decreased water quality, especially its effects on local wildlife.

Who are your potential stakeholders (e.g., governmental agencies, scientists, landowners)?
- Farmers
- Homeowners
- Teachers

What information and supplies would you need to address the issue?
- Alternative farming practices that reduce agricultural impacts
- Healthy water habits for homeowners
- Money for river clean-up supplies (e.g., trash bags, gloves, nets)
- Hellbender salamander population status before and after intervention

How you would check to see if your intervention is having a positive effect?
- In five years, revisit the farmers you spoke with to see if they implemented any of the practices you suggested.
- Survey homeowners before and after they read your pamphlet to gauge if they learned anything new and if they intend to adopt any of the practices.
- At a river clean-up day, do a before and after estimate of the amount of litter in the stream.
- Do a pre- and post- survey of your hellbender population to see if there was any change in their numbers.

In two to three sentences, briefly explain your plan.
- Research alternative farming practices and talk with farmers about implementing these practices at riverside or stream-side farms. Five years later, we will revisit these farms and survey the farmers to see how many of them actually made these changes and why they decided to make them. We will then resurvey our hellbender population to see if the changes in practices had any effect on their numbers.

Persecution by Humans

This group is provided with articles highlighting the persecution of hellbender salamanders and how the misperceptions and actions of humans may have contributed to their decline. There is also a table highlighting how increased knowledge of and familiarity with the hellbender could affect people's perceptions of and intended behaviors toward the species.

Main ideas
- The way people perceive a species greatly affects how they will behave towards it.
- Hellbenders are not well understood (the articles contain multiple factual errors). Teaching people facts about hellbenders may change how they treat them.
- Public involvement is a vital aspect of any conservation project.

Potential responses

List parts of the problem you would focus on and how you think focusing on those parts will best alleviate the issue.
- Address the general public's misunderstanding of hellbenders, because if they know the facts about hellbenders people may be less likely to harm them.
- Teach anglers the facts about hellbenders, because the articles make it seem as though anglers are the group of people most likely to actually harm hellbenders.

Describe steps you would take towards addressing the issue.
- Find a lesson plan about hellbenders and visit local schools to teach kids about hellbenders. That way, the next generation grows up knowing the facts and may be able to teach their families the truth about hellbenders, too.
- Set up a meeting with local anglers in the area and hear what they think about hellbenders. Then, we can teach them the facts about hellbenders, if they hold any misconceptions.

Who are your potential stakeholders (e.g., governmental agencies, scientists, landowners)?
- Teachers
- Anglers
- Researchers (to help collect the hellbender facts)
- Mediator (potential neutral party for public meetings)

What information and supplies would you need to address the issue?
- What people in the area believe about hellbenders
- Natural history information about hellbenders
- Funding for supplies for a lesson plan (printing costs, props, etc.)

How would you check to see if your intervention is having a positive effect?
- Survey people's attitudes towards hellbenders before and after our lesson plan to gauge whether additional awareness changed how they felt towards the species. We can then survey the wild population periodically and see if their numbers have changed post-intervention.
- Survey anglers before and after a meeting to gauge how many intend to change their behaviors now that they know the facts about hellbenders. We can then survey the wild population periodically and see if their numbers have changed post-intervention.

In two to three sentences, briefly explain your plan.

- We will hold a meeting with the local fisherman, assess their pre-meeting attitudes and intentions towards hellbenders and learn what misunderstandings they may hold about the species. We will then provide them with the facts about hellbenders and resurvey their attitudes and intentions to see if more information changed their perception of the species. We'll then monitor the wild population to see if there is any effect on their numbers.

Declines in Population Size

This group is provided with a graph and two tables focusing on the declines hellbenders are experiencing in population size.

Main ideas

The hellbender genders and age classes you choose could affect the success of your species.

- The Taber et al. and Wheeler et al. table discusses:
  1) that there is a quantifiable decline in hellbender numbers and notes how the populations are mostly made up of adults with few to no juveniles (the hope is that students will connect these ideas back to the Unger et al. graph and table).
  2) the mortality of different genders and ages, which could influence how many of each gender and age class a conservationist would choose to reintroduce into a wild population in order to increase its long-term chance of surviving.
  3) potential causes for the lack of juveniles, which may give the group a new angle to consider.
- The graph illustrates that certain age classes (i.e., juveniles) can affect the survival of an entire population. By increasing the survival rate of juvenile hellbenders to 30%, the chance of extinction for this population is estimated to go down to 0%.
- The Unger et al. table illustrates how certain age classes and genders could affect a population. For example, adding more females than males increases the annual growth rate of the population more than adding equal numbers of males and females.

Potential responses

List parts of the problem you would focus on and how you think focusing on those parts will best alleviate the issue.

- Increasing the survival rate of juveniles, because the graph showed that the chance of extinction decreases if their survival rate increases.
- Increasing the number of females, because the table showed that adding more females led to a higher annual population growth rate than any other group.
- Increasing the number of hellbenders in all age classes, because if we add hellbenders from all age classes we can address both the small population size issue and the issue of having too few young hellbenders.

Describe steps you would take towards addressing the issue

- Rear juveniles in captivity and then add them to the wild population.
- Translocate females from other populations into our smaller population to both increase the population's size and number of females.

Who are your potential stakeholders (e.g., governmental agencies, scientists, landowners)?

- Zoos (they can provide space and expertise for breeding)
- Other states with hellbender populations (they can provide the females for translocation)

What information and supplies would you need to address the issue?

- Information on how to rear juveniles in captivity
- Eggs to breed in captivity
- Funding for setting up a captive breeding program
- Materials to find and transport the hellbenders

How you would check to see if your intervention is having a positive effect?

- Survey the number of juveniles in our population prior to our captive breeding program and then resurvey the population every year to analyze the number of juveniles that are surviving and how that is affecting overall population size.
- Survey the population size prior to translocating the females, then resurvey the population every year to see if the population is growing.

In two to three sentences, briefly explain your plan.

- We will collect females from a different, healthy hellbender population and translocate them into our small, declining population. We will then survey our population annually to see if the population is growing, especially in the younger age classes.

Remember that these are only a few examples of the answers your students may come up with. You may notice that many of the groups have some overlap in their ideas and plans. This is to be expected and the pattern will hopefully be noticed as many issues in a conservation situation are not isolated but are interconnected. Sometimes addressing one part of the larger problem begins to address and partly alleviate another part of the problem.

CONSERVATION — A NUMBERS GAME

This activity introduces students to the iterative nature of science and challenges them to problem-solve in a research context.

ESTIMATED TIME

45-90 minutes

PROCEDURE

1. Introduce the terms and the introductory information provided in the "Teacher's Notes." Focus particularly on how decisions are made within conservation biology, what management is, the different types of management practices available, the purpose of a conservation management plan, and the information on hellbender salamanders.
   Note: Skip this step if your class completed "Lesson 1: A Slimy Situation." You may wish to review the main concepts and vocabulary.
2. Hand out a copy of "Case Study, Lesson 4" to each student. Have students read through the case study.
3. Once the class has reached the point in the case study where the hellbenders have all disappeared, break the students into six equal groups. Have them roll a die. The number they land on corresponds with one of the scenarios explained below. Groups may do the same scenario, or you may choose to have them roll until they get a novel number.

   Scenarios:
   You release the juvenile hellbenders. They are doing well until . . .
   1) There is a 100-year flood and they all get swept down stream. You were unable to find them again.
   2) They were all eaten by predators (mainly otters and small mouth bass).
   3) They could not find enough habitat. The hellbenders were either eaten by predators, because they had nowhere to take refuge, or swam away from the release site in search of habitat. You were unable to find them again.
   4) They became infected by bacteria found in the river and died.
   5) A new corn field was planted by the river, increasing runoff (both chemicals and silt) into the river. The chemicals caused vegetation in the river to increase, lowering dissolved O_2 from the water. The silt filled up the spaces where the hellbenders were living. The hellbenders swam away from the site in search of habitat. You were unable to find them again.
   6) Local anglers purposefully caught and removed the hell benders from the river, claiming that the hellbenders were eating their bait and scaring away the fish.
4. Provide each group with a poster board and marker. They will use these to brainstorm and possibly illustrate their plan to try and prevent their scenario from occurring again in the future.
5. Provide each group with a score sheet. Each group will have up to six minutes to present their conservation plan to the class. The groups that are not presenting will score the presenting group's plan. Each group receiving a score of at least 16 will receive additional funding.
   Note: You can either have your students verbally describe their plans or they can illustrate their plan to aid in their explanation. Alternatively, if time is short, you can choose one scenario and discuss it as a class.
6. Explain to the students that needing to rework your research plan is very common. Unlike the predesigned experiments students often do in lab, actual research is unpredictable and requires multiple rounds of problem solving. It requires perseverance, but, in the end, the alterations that must be made to a project often end up making it more rich and interesting than the original design.

REQUIRED MATERIALS

- Case Study, Lesson 4 (1 copy per student)
- Revised Management Plan Score Sheets (6, oneper group)
- Dice (1pair)
- Management Plan Debate Score Sheet (4, one per group)
- Poster boards (6, one per group)
- Markers (6, one per group)

CONSERVATION — A NUMBERS GAME

Jordan Lee, state herpetologist with the Indiana Department of Natural Resources (IDNR), has teamed up with the research lab of Dr. Isabella Lopez to develop a conservation management plan for Indiana's hellbender salamanders *(Cryptobranchus alleganiensis)*. This salamander is state-endangered and is projected to go locally extinct without intervention. The decline of this fully aquatic salamander is potentially the result of multiple threats including habitat destruction, disease and injury, persecution by humans, and a decline in population size. Ideally, each threat could be addressed, but the IDNR only had enough funding to focus on one issue.

Jordan and Dr. Lopez decided to use their grant money to start a captive breeding program to focus on the low number of young hellbenders. By increasing the population's size, the researchers hope to slow the population's decline and maybe even stabilize it. This would buy them time to address the other threats the hellbenders are facing. A captive breeding program also enables the researchers to rear the young hellbenders in the safety of captivity, where they would have all the food they could eat without the risk of predation. Once the hellbenders are big enough, they will be returned to the river where the hellbender eggs were collected in an effort to increase the population size.

It took Jordan and Dr. Lopez ten years of trial and error, but they finally managed to hatch and raise a clutch of hellbender eggs. The successful clutch contained 200 eggs. One hundred and ninety eggs actually hatched and then, of the larvae, 150 survived to their current juvenile stage. The hellbenders have grown up in large tanks of water with added oxygen. The tanks also have large flat boulders on top of cobble and gravel. The added oxygen allows hellbenders to breathe naturally through the skin and the boulders mimic their wild habitat. The hellbenders have been raised on a diet of crayfish, an adult hellbender's main food source. The hellbenders are now three years old and large enough to release back in the river.

Since this is the first time they have reintroduced hellbenders in Indiana, Jordan and Dr. Lopez decide to only put a small group of their hellbenders into the river, just in case something were to go wrong. Of their 150 hellbenders, they released 25 juveniles. To follow them, the researchers put a tracker onto each hellbender before putting it in the river.

For the first week, things seemed to be going swimmingly. Then one day all of the hellbenders disappeared!

You are to play the role of a researcher. You will receive a scenario of what happened to your reintroduced hellbenders. Your goal is to get more funding to try another reintroduction with your remaining 125 hellbenders. Before giving you more funding, however, you must convince IDNR that you have a plan to prevent your scenario from happening again in future releases.

Using the provided poster board and markers, your group will brainstorm different ways your scenario could be avoided. You will then present and defend your final revised management plan to the class, which will give you a score.

Make sure:

- Your revised management plan is feasible
- Your plan has clearly defined steps to address the problem
- You explain how the steps you chose will impact the situation

Revised Management Plan Answer Prompts

Given the novelty and volume of information, some groups may need prompting while they develop their plans. Below are a few main ideas and potential answers to generate conversation within a struggling group. Their answers cannot be wrong, they just need to justify the plan.

- There is a 100-year flood and they all get swept downstream. You were unable to find them again.

  Revised Management Plan Steps

  1. Measure the flow rate of the river.
  2. Build a tank in the lab with flowing water matching the rate of the river.
  3. Put the remaining hellbenders in the new tank for a year, where they will need to hunt for food and find shelter while swimming with the current.

  Justification

  Giving the remaining hellbenders time in the tank with flowing water may acclimate them to a river current they will experience in the wild. They may become stronger swimmers and thus less likely to get swept downstream.

- They were all eaten by predators (mainly otters and small mouth bass).

  Revised Management Plan Steps

  1. Fill a tank will smallmouth bass.
  2. Collect water samples from the bass tank.
  3. Add the bass-scented water to the tanks holding the hellbenders while exposing them to a minor stress (such as lightly pinching their tails).
  4. Repeat step 3 until the hellbenders exhibit stressed behavior with no cues other than the addition of the bass-scented water.

  Justification

  By exposing the hellbenders to the prey scent while causing them minor stress, the hellbenders should form an association between the scent of bass and danger, thus avoiding that scent in the wild.

- They could not find enough habitat. The hellbenders were either eaten by predators because they had nowhere to take refuge or swam away from the release site in search of habitat. You were unable to find them again.

Revised Management Plan Steps

1. Assess the release site habitat to determine what viable habitat exists and where habitat could be augmented.
2. If the habitats are fragmented, create viable patches of habitat that link the two. Add large boulders along the route or install beds of cobble to support younger hellbenders.

Justification

By adding additional habitat (i.e., boulders and cobble) the released hellbenders will have more places to take cover from predators, forage, and mate — so they will not need to leave the release site.

- They became infected by bacteria found in the river and died.

  Revised Management Plan Steps

  1. Assess the bacteria living in the river.
  2. Assess the bacteria living on the hellbender's skin and in their water.
  3. Compare the two cultures.
  4. Gradually expose the remaining hellbenders to small amounts of river water and monitor their health. If there are no negative symptoms, continue to expose them to the water, increasing the amount over time.

  Justification

  This is like an inoculation for humans. By exposing the hellbenders gradually to the river water, they will soon inhabit, their bodies have time to adjust and build up a tolerance to novel bacteria that was not in their tanks in the lab.

- A new cornfield was planted by the river, increasing runoff (both chemicals and silt) into the river. The chemicals caused vegetation in the river to increase and lowered dissolved O2 from the water. The silt filled up the spaces where the hellbenders were living. The hellbenders swam away from the site in search of habitat. You were unable to find them again.

  Revised Management Plan Steps

  1. Identify the landowner of the cornfield.
  2. Discuss with the landowner the repercussions of planting the corn along the bank, repercussions for the hellbenders, people, and things living downstream.
  3. Volunteer to plant a buffer zone of plants and try to convince the landowner to plant the corn further away from the bank the following season.

  Justification

  The buffer zone will help stabilize the bank and filter out chemicals before they reach the water. Having the farmer move their corn back will prevent further erosion and run-off.

- Local anglers purposefully caught and removed the hellbenders from the river, claiming that the hellbenders were eating their bait and scaring away the fish.

  Revised Management Plan Steps

  1. Identify misconceptions held by the anglers. Listen to their stories of interactions with hellbenders to understand where the misunderstandings may be coming from.
  2. Prepare educational materials that inform the anglers of the facts, including information about the benefits to anglers of adding the hellbenders to the environment.
  3. Share your materials with the anglers you spoke with in an attempt to change their perceptions about the salamander.
  4. Repeat step 3 as often as necessary to reach as many people as possible with your message.

  Justification

  Many people have false notions about their interactions with animals. By taking the time to listen to them and develop an educational campaign, you can build mutual respect with local stakeholders. Without the support of the people, reintroductions are unlikely to be successful.

REVISED MANAGEMENT PLAN SCORE SHEET

Using the provided scoring spectrum, your group will decide whether a group's new revised management plan should receive more funding or not.

Each team will have up to 6 minutes to present their conservation plan. Your group will give each plan a score using the grading scale below. Each plan which scores at least 16 points will receive the additional funding to try their revised management plan.

Possible Scores (choose one value per cell): 0-Poor 1-Fair 2-Average 3-Good 4-Excellent

GROUP / CRITERIA	1	2	3	4	5	6
Delivery was clear and convincing.						
Plan was feasible.						
Steps to address the problem were clear and logical.						
Potential impact of plan seemed significant.						
Presentation did not exceed the allotted time.						
TOTAL SCORE						

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