|  |
| --- |
| Invasive Species:  A Study of the Disruption of an Ecosystem’s Dynamics |
| Life Science, Grade 7  (Revised July 2018) |
| **Standards addressed in this unit:**  **7.MS-LS2-1.** Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the size of populations in an ecosystem.  **7.MS-LS2-4.** Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.  **7.MS-LS2-5.** Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.\* Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.  **7.MS-LS2-6(MA).** Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.  This unit engages students in an exploration of ecosystem dynamics as seen through the study of invasive species. The unit is focused on the effects of resource availability in an ecosystem and changes in biological or physical components of an ecosystem on organism populations. Students explore how invasive species are introduced, what impact they have on local food webs, and how ecosystems react to the introduction of invasive species. This unit is designed for students in grade seven, using research, models, data analysis, and writing about invasive species to understand changes in an ecosystem. |

*This Model Curriculum Unit is designed to illustrate effective curriculum that lead to expectations outlined in the 2016 Science and Technology/Engineering Curriculum Frameworks (*[*www.doe.mass.edu/STEM/STE*](http://www.doe.mass.edu/STEM/STE)*) as well as the MA Curriculum Frameworks for English Language Arts/Literacy and Mathematics. This unit includes lesson plans, a Curriculum Embedded Performance Assessment (CEPA), and related resources. In using this unit it is important to consider the variability of learners in your class and make adaptations as necessary.*

This document was prepared by the Massachusetts Department of Elementary and Secondary Education. Mitchell D. Chester, Ed.D., Commissioner

The Massachusetts Department of Elementary and Secondary Education, an affirmative action employer, is committed to ensuring that all of its programs and facilities are accessible to all members of the public. We do not discriminate on the basis of age color, disability, national origin, race, religion, sex, or sexual orientation.

© 2015 Massachusetts Department of Elementary and Secondary Education (ESE).ESE grants permission to use the material it has created under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. Additionally, the unit may also contain other third party material used with permission of the copyright holder. Please see Image and Text Credits for specific information regarding third copyrights.

Every effort has been made to acknowledge copyright. Any omissions brought to our attention will be corrected in subsequent editions.

Image and Text Credits:

This unit is modified from a unit developed by the New Bedford Ocean Explorium, *Ecosystems and Invasive Species: Grades 6-8*. Contributing authors of the original unit include: David Welty, Wende Allen, Jack Crowley, Hugh O’Mara; Editor: Jewel Gilbert.

The contents of this Model Curriculum Unit were developed under a grant from the U.S. Department of Education. However, those contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the Federal Government.

Massachusetts Department of Elementary and Secondary Education, 75 Pleasant St, Malden, MA 02148-4906. Phone 781-338-3300, TTY: N.E.T. Relay 800-439-2370, [www.doe.mass.edu](http://www.doe.mass.edu)

Table of Contents

[Unit Assumptions and Comments on Sequence 4](#_Toc5022620)

[Unit Plan 6](#_Toc5022621)

[Lesson 1: Introduction to the Impact of Invasive Species 10](#_Toc5022622)

[Lesson 2: High Profile Invasive Species Research 15](#_Toc5022623)

[Lesson 3: Limiting Factors 20](#_Toc5022624)

[Lesson 4: Broken Food Web 24](#_Toc5022625)

[Lesson 5: Independent Species Research 28](#_Toc5022626)

[Curriculum-Embedded Performance Assessment (CEPA): Controlling an Invasive Species 32](#_Toc5022627)

[Unit Resources 35](#_Toc5022628)

Unit Assumptions and Comments on Sequence

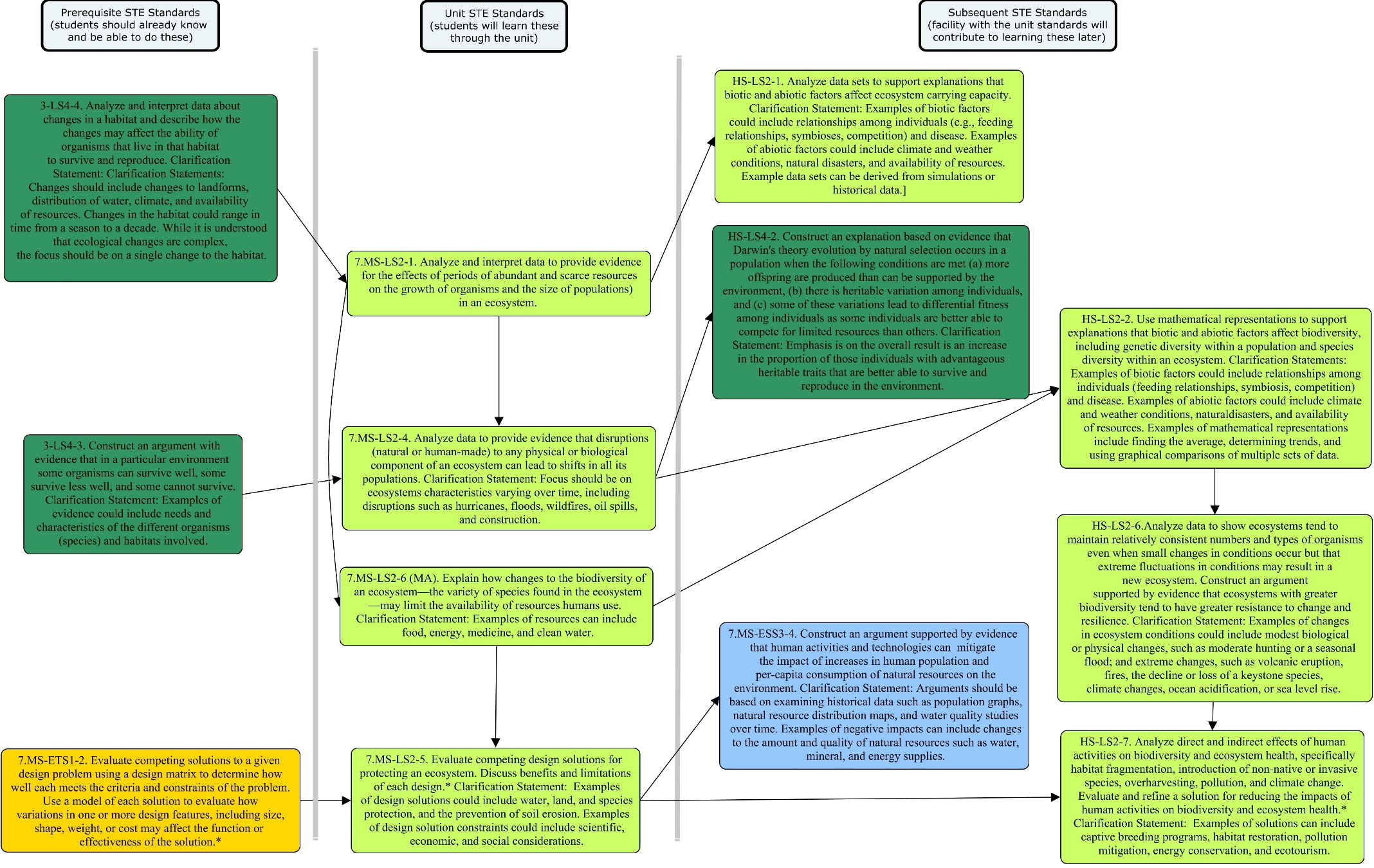
**This unit assumes students already know:**

* What an ecosystem is;
* The dynamics of an ecosystem, in particular:
  + Basics about food webs, including types of organisms (producers, herbivores, carnivores) and general flow of energy and matter through food webs;
  + Interdependent relationships in an ecosystem (e.g., predatory, mutual, parasitic); and
  + Meaning and examples of biotic and abiotic factors.

This unit is most effective when it follows units on these concepts so students can effectively apply their understanding of food webs, interdependent relationships, and extend their understanding of those to ecosystem dynamics.

**Source and Credits**

This unit is modified from a unit developed by the New Bedford Ocean Explorium, *Ecosystems and Invasive Species: Grades 6-8*. Contributing authors of the original unit include: David Welty, Wende Allen, Jack Crowley, Hugh O’Mara; Editor: Jewel Gilbert.



|  |  |  |
| --- | --- | --- |
| Unit Plan  **Stage 1 Desired Results** | | |
| **ESTABLISHED GOALS G**  **Science & Technology/Engineering**  **7.MS-LS2-1.** Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the size of populations in an ecosystem.  **7.MS-LS2-4.** Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.  **7.MS-LS2-5.** Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.\* Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.  **7.MS-LS2-6(MA).** Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.  **Literacy Standards**  **CCSS.ELA-Literacy.RST.6-8.4** Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.  **CCSS.ELA-Literacy.WHST.6-8. 8** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrases the data and conclusions of others while avoiding plagiarism and following a standard format for citation.  **CCSS.ELA-Literacy.WHST.6-8. 9** Draw evidence from informational texts to support analysis, reflection, and research. | ***Transfer*** | |
| ***Students will be able to independently use their learning to…***  Make informed personal and civic decisions that affect how living systems maintain balance and stability, minimizing impact on factors that disturb stability.**T** | |
| ***Meaning*** | |
| **UNDERSTANDINGS U**  ***Students will understand that…***   * Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. * The organisms in an ecosystem are interdependent/interconnected. * Population growth is limited by access to resources. * The introduction of non-native species to an ecosystem can have devastating effects. * Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. * Humans are a part of the ecosystem they inhabit. * Human activity, especially trade and movement, can have serious impacts on ecosystems. | **ESSENTIAL QUESTIONS Q**   1. What is the probable extent of the impact of an invasive species on an ecosystem’s dynamics? 2. In what ways and to what extent can the impact of an invasive on an ecosystem be prevented or mitigated? |
| ***Acquisition*** | |
| ***Students will know that…* K**   * Factors such as birth, death, and migration impact the population size of a species. * Invasive species can threaten ecosystems by preying on native species, out-competing native species for food or other resources; causing or transmitting disease; preventing native species from reproducing or killing their young; changing food webs; decreasing biodiversity; and altering ecosystem conditions. * Humans are often the ones to introduce an invasive species into an ecosystem. * Humans can eradicate an invasive species or mitigate its effect on an ecosystem in many ways. * Humans constantly spend vast amounts of resources, including money and time, trying to control the spread of or get rid of an invasive species. | ***Students will be skilled at…* S**   * Determining the meaning of key terms within a scientific context. * Summarizing and analyzing expository text. * Independently researching an invasive species. * Collecting, graphing, and analyzing data on invasive species * Analyzing a food web. * Predicting the disruption of a food web caused by an invasive species. * Synthesizing information on invasive species. * Using, manipulating, and testing models. * Making inferences based on data. * Calculating the change in the population size of a species. |
| **Stage 2 - Evidence** | | |
| **Evaluative Criteria** | **Assessment Evidence** | |
| (see the CEPA rubric) | **CURRICULUM EMBEDDED PERFORMANCE ASSESSMENT (PERFORMANCE TASKS) PT**  Students are familiar with the local food web created in lesson 4 and are able to predict changes to the food web when an invasive species is introduced to the ecosystem. They are able to access the Internet to research characteristics of certain invasive species. They are able to work in groups.  **Goal:** Students will evaluate competing design solutions for protecting an ecosystem and discuss benefits and limitations of each design. Specifically, students will evaluate multiple solutions for controlling an invasive species and present their findings including the benefits and limitations of each solution.  **Role:** Students are biologists hired by the town conservation committee.  **Audience:** Town conservation committee  **Situation:** Students will choose a solution, based on their research and the evidence provided, for controlling a particular invasive species. The students will then present an argument to the committee that their solution is best by using evidence to explain why the benefits outweigh the limitations.  **Product Performance and Purpose:** Students will prepare an argument for the town conservation committee in favor of a particular solution. They will present this solution in front of the committee. Students will have the opportunity to engage in argument from evidence. | |
|  | **OTHER EVIDENCE: OE**   * (Lesson 1) Creative Writing Assignment – The Invasion of an Invasive Story * (Lesson 1) Analysis of the article, “Maryland Wages War on Invasive Walking Fish”, and discussion * (Lesson 2) Invasive Species Research and analysis (worksheets) * (Lesson 3) Whole class discussion of impact of environmental changes on caribou. * (Lesson 3) Analysis of predator-prey population data * (Lesson 3) Hypothesis of possible limiting factors on Zebra Mussels population * (Lesson 4) Interactive food web design * (Lesson 4) Manipulation of interactive food web given the introduction of an invasive species * (Lesson 5) Independent Species Investigation Worksheet | |
| **Stage 3 – Learning Plan** | | |
| ***Summary of Key Learning Events and Instruction***  Lesson 1: Introduction to the Impact of Invasive Species: Students read a case of an invasive species, the “walking fish”, then discuss and record their current ideas about invasive species and their impacts on environments. This lesson serves as a pre-assessment to inform adjustments to instruction throughout the unit. (50 minutes)  Lesson 2: High Profile Invasive Species Research: Students will research a number of high profile invasive species, particularly aquatic species, now found in the United States using a U.S. Government database ([www.invasivespeciesinfo.gov](http://www.invasivespeciesinfo.gov)) and other websites. Each student collects information about a specific species then compares its location of origin to the new ecosystem in the US highlighting the impact on the new environment. (50 minutes)  Lesson 3: Limiting Factors: Students will examine various resources such as videos, data, and a simulation to develop a list of factors that limit population size. Students will also examine how changes in population size affect an ecosystem’s dynamics. Students will also read information on the life history of zebra mussel. They will then hypothesize possible limiting factors and how these factors might be used to control the zebra mussel population. (90 minutes)  Lesson 4: Broken Food Web: Students use a food web with a minimum of eight organisms from a local environment illustrating the relationships of the organisms and principles of energy flow from sun to producer to herbivore to carnivore. Students will then introduce an invasive species at different levels and predict the consequence for the organisms in the food web. (50 minutes)  Lesson 5: Independent Invasive Species Research: In this learning experience, students will read a public bulletin about the invasive species *Hemigrapsus sanguineus*. They will be assigned an invasive species to investigate, and they will examine how the species became invasive and explore the role of humans and technology played in this biological invasion. Students will list and categorize their data to look for trends and commonalities. (100 minutes).  Curriculum Embedded Performance Assessment.  Students will evaluate multiple solutions for controlling an invasive species and present their findings including the benefits and limitations of each solution. | | |
| Adapted from Understanding by Design 2.0 © 2011 Grant Wiggins and Jay McTighe Used with Permission | | |

Lesson 1: Introduction to the Impact of Invasive Species

**Brief Overview of Lesson:** Students read a case of an invasive species, the “walking fish,” then discuss and record their current ideas about invasive species and their impacts on environments. This lesson serves as a pre-assessment to inform adjustments to instruction throughout the unit.

**Prior Knowledge Required:**

* Ability to read and analyze 6th grade informational text.
* Ability to share ideas in small groups.
* Interdependent relationships in an ecosystem (e.g., predatory, mutual, parasitic)
* Basic knowledge of food webs

**Estimated Time: 50 minutes**

**Resources for Lesson (list resources and materials):**

* Lesson 1, Handout 1: Word War – Creative Writing Assignment about Ecosystems and Invasive Species
* Lesson 1, Handout 2: National Geographic News Article, “Maryland Wages War on Invasive Walking Fish” by Hillary Mayell <http://news.nationalgeographic.com/news/2002/07/0702_020702_snakehead.html>
* Lesson 1, Handout 3: Discussion Questions and Summary of Article
* Background information on Ecological and Economic Impact of Invasive Species:
  + US Forest Service: [www.fs.fed.us/pnw/invasives/](http://www.fs.fed.us/pnw/invasives/)
  + The Impact of Invasive Species: <http://www.pbs.org/wgbh/nova/nature/impact-invasive-species.html>
  + Center for Invasive Species Management: <http://www.weedcenter.org/inv_plant_info/impacts.html>
  + Encyclopedia of Life: <http://eol.org/info/460>
  + Colorado State University: <http://lib.colostate.edu/research/agnic/impacts.html>
* Chart paper, markers, or dedicated board

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

* 7.MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.
* RST 4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

**Essential Question(s) addressed in this lesson:**

* What is the probable extent of the impact of an invasive species on an ecosystem’s dynamics?
* In what ways and to what extent can the impact of an invasive on an ecosystem be prevented or mitigated?

**Objectives**

**By the end of this lesson students will be able to:**

* Describe and identify patterns about how invasive species affect communities of native species.
* Describe some of the resources and methods humans use to control the spread of an invasive species.

**Language Objectives**

* Write a story about an invasive species
* Read and orally answer questions about an article about a specific invasive species

**Targeted Academic Language**

* Content specific: ecosystem, consumer, omnivore, extinct, indigenous, invasive, native, non-native, alien, pest, producer, predators, eradication, established, resources, voracious, habitat, fishery, temperate, risk assessment, decomposer, endemic, food web, and energy transfer.
* Academic specific: brainstorm, discuss, glossary, entity

**What students should know and be able to do before starting this lesson:**

* Ability to read and analyze 6th grade informational text.
* Ability to share ideas in small groups.
* Interdependent relationships in an ecosystem (e.g., predatory, mutual, parasitic)
* Basic knowledge of food webs

**Anticipated Student Preconceptions/Misconceptions**

* Invasive species can benefit an ecosystem. Invasive species will kill other organisms in an ecosystem.
* Humans do not have an impact on ecosystems (An ecosystem is “natural,” so it doesn’t have to do with humans.) Humans are not a part of an ecosystem.
* Non-native (alien) and invasive species are the same: Invasive species are defined as ones that cause economic or environmental harm, or cause harm to people’s health. Most species not originally found in an ecosystem are non-native but do no harm (Nature Conservancy’s Conservation Gateway: [www.conservationgateway.org](http://www.conservationgateway.org)).

**Instructional Tips/ Strategies/Notes for Teacher:**

* Use the students’ responses to assess their understanding of the vocabulary necessary for this unit.
* Use the students’ responses to assess how well they understand ecosystems and invasive species.
* Consider whether there are there other materials from previous lessons that will need to be reviewed so students can fully understand the concepts being taught in this unit.
* Use the students’ responses to identify misconceptions (see above). If there are any, consider the instructional changes that need to be in place for the next lesson.

**Lesson Sequence:**

**Homework Assignment before Activity 1:**

* Distribute **Lesson 1, Handout 1: Creative Writing Assignment – The Invasion of an Invasive**
* Explain to students that in this unit they will be learning how invasive species can impact different ecosystems. They will be learning the difference between non-native and invasive species.
* Ask students to create a short story (2-3 paragraphs long) using 15 of the 30 words/phrases on the handout. Explain to the students that they can be creative. This is a brainstorming activity.
* This is not intended to be an assignment that is graded.

**Activity 1: Review Homework and Read Article**

Review Homework (suggested time: 15 minutes)

* In groups of 2 or 3, have students read to each other their short stories from their homework the night before. Encourage students to listen attentively while a story is being read as they will be asked the following questions about each other’s stories in a whole class discussion afterwards: (Note to teacher: Write the following questions on the board or post on chart paper for students to see and keep in mind as they listen to each other’s stories.)
* In the stories you heard:
  + How was the invasive entity able to infiltrate the ecosystem?
  + What effect did the foreign entity have on the ecosystem?
  + How widespread was the effect?
  + How did the ecosystem respond to the changes that ensued?
  + What could the organisms in the ecosystem have done (or do in the future) to prevent the invasion?

**Activity 2: Read and Analyze Article** (suggested time: 30 minutes)

* Distribute **Lesson 1, Handout 2: National Geographic News Article**, “Maryland Wages War on Invasive Walking Fish” by Hillary Mayell
* Have students individually read the entire article in class. While reading, students should highlight words or
* phrases they think are important to understanding ecosystems and invasive species. They should also circle words or phrases they do not know the meaning to. (You can use your school’s established system for annotating text.)
* Ask the students to write on the board any words and phrases they were unfamiliar with. Address these either through the questions below or add additional discussion topics or questions to address these words and phrases.
* Ask students questions about the article, such as:
  + How can a single invasive species, such as the northern snakehead, impact an entire ecosystem? What is the ecosystem the article is referring to? Are scientists concerned about the pond where the snakehead was found or other bodies of water? Why are they concerned about these bodies of water? How far-reaching are they compared to the pond?
  + If the snakeheads spread rapidly, what other organisms will be affected? How will they be affected? Why will they be affected? (Make sure to differentiate between the “how” and “why” which will enable students to make ecosystem connections.)
  + What role did humans possibly play in the introduction of the snakehead to the pond? What steps did authorities and local citizens take (or suggest taking) to deal with the invasion of the Northern Snakehead? What are the possible eradication methods used to control the snakehead? How will these help to manage the spread of the snakehead? When will they do the most good and why? What are some benefits and drawbacks to the different types of methods?
  + **Note to teacher:** You can give questions to students to ask the class to increase participation. Encourage students to take notes during the discussion. They can write on or highlight the article as the discussion is taking place.

**Formative assessment:** (suggested time: 5 minutes)

As a wrap up activity: Have the students answer the Essential Question, “How can a single species impact an entire ecosystem?” This can be a self-reflection writing or an in-class discussion.

Lesson 2: High Profile Invasive Species Research

**Brief Overview of Lesson**: The class researches a number of high profile invasive species, particularly aquatic species, now found in the United States using a U.S. Government database ([www.invasivespeciesinfo.gov](http://www.invasivespeciesinfo.gov)) and other websites. Each student collects information about a specific species then compares its location of origin to the new ecosystem in the U.S. highlighting the impact on the new environment.

**Prior Knowledge and Skill Required:**

* Ability to navigate and find information on a website
* The definition of an ecosystem
* What an ecosystem is and its dynamics
* Examples and meaning of biotic and abiotic factors

**Estimated Time:** 50 minutes

**Resources for Lesson:**

* Lesson 2, Handout 1: Invasive Species Analysis
* Internet access or printouts of species profiles
* Background information on Ecological and Economic Impact of Invasive Species:
  + US Forest Service: [www.fs.fed.us/pnw/invasives/](http://www.fs.fed.us/pnw/invasives/)
  + The Impact of Invasive Species: <http://www.pbs.org/wgbh/nova/nature/impact-invasive-species.html>
  + Center for Invasive Species Management: <http://www.weedcenter.org/inv_plant_info/impacts.html>
  + Encyclopedia of Life: <http://eol.org/info/460>
  + Colorado State University: <http://lib.colostate.edu/research/agnic/impacts.html>

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

* 7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.
* 7.MS-LS2-6 (MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.
* CCSS.ELA-Literacy.RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.
* CCSS.ELA-Literacy.WHST.6-8. 9 Draw evidence from informational texts to support analysis, reflection, and research.

**Essential Question(s) addressed in this lesson:**

* What is the probable extent of the impact of an invasive species on an ecosystem’s dynamics?
* In what ways and to what extent can the impact of an invasive on an ecosystem be prevented or mitigated?

**Objectives**

**By the end of this lesson students will know and be able to:**

* Gather, read, and synthesize information from multiple sources to explain how an invasive species affects an ecosystem.

**Language Objectives**

* Read research about an assigned invasive species and record the most important details regarding how the invasive species affects the ecosystem it has infiltrated.

**Targeted Academic Language**

* Content specific: invasive, invasion, native, variety, range, impact, ecosystem
* Academic specific: research, complete, answer, explore

**What students should know and be able to do before starting this lesson:**

* What an ecosystem is and its dynamics.

**Anticipated Student Preconceptions/Misconceptions**

* An invasive species will only have negative impacts.
* If a body of water looks healthy, it is healthy.
* The presence of plants in water means it is healthy.

**Instructional Materials/Resources/Tools**

* *Practical Guidebook to the Control of Invasive Aquatic and Wetland Plants of the San Francisco Bay-Delta Region*: [www.sfei.org/nis/index.html](http://www.sfei.org/nis/index.html)
* Center for Invasive Species and Ecosystem Health: [www.invasive.org](http://www.invasive.org)

**Instructional Tips/Strategies/Suggestions for Teacher**

* Prior to beginning this lesson, examine formative assessment information from Lesson 1 to determine students’ preparedness to engage in independent Internet research on examples of invasive species.
* Preparation: Have computers set up before students arrive, with the website already up. Provide students with their species as they walk in the class or the day before so they can get started quickly.
* Review the materials on the Internet prior to the students doing so to help guide the students’ work on the Internet.
* Students visit at least two of the following websites to explore the variety and range of invasive species in aquatic ecosystems as well as the impact of the invasive species on the local ecosystem.
  + National Invasive Species Information Center: <http://www.invasivespeciesinfo.gov>
  + *Practical Guidebook to the Control of Invasive Aquatic and Wetland Plants of the San Francisco Bay-Delta Region*: [www.sfei.org/nis/index.html](http://www.sfei.org/nis/index.html)
  + Center for Invasive Species and Ecosystem Health: [www.invasive.org](http://www.invasive.org)
* If computers and Internet access are not available, print out individual “Species Profiles” for each student.
* A “Species Profile” can be five pages long. Sufficient resources and time will be required to assemble the necessary materials.

**Assessment**

* Check the accuracy of the collected data on the assigned (or selected) invasive species (Activity 1) and review the responses to the analysis questions (Activity 2) for appropriateness and any inaccurate conceptions to inform subsequent classes.

**Lesson Sequence:**

**Activity 1: Invasive Species Research**

* Distribute **Lesson 2, Handout 1: Invasive Species Research** and focus students on Activity 1 only. Tell students that they will be assigned (or can select) one invasive species to research. The directions for navigating a website to conduct their research are on the handout.
* Explain to students that the purpose of this lesson is to explore the variety and range of invasive species in aquatic ecosystems as well as the impact of the invasive species on the local ecosystem. Refer to the essential questions for this unit.
* Instruct students to collect information and map the invasion -- where does the invasive species come from and where did it impact?
* Assign one species to each student or group of students (depending on the number of computers available) from the following species list:

**Aquatic Plants:**

1. Brazilian Waterweed (*Egeria densa*)
2. Eurasian Watermilfoil (*Myriophyllum spicatum*)
3. Giant Reed (*Arundo donax*)
4. Giant Salvinia (*Salvinia molesta*)
5. Hydrilla (*Hydrilla verticillata*)
6. Melaleuca (*Melaleuca quinquenervia*)
7. Purple Loosestrife (*Lythrum salicaria*)
8. Water Chestnut (*Trapa natans*)
9. Water Hyacinth (*Eichhornia crassipes*)

**Aquatic Animals:**

1. Alewife (*Alosa pseudoharengus*)
2. Chinese Mitten Crab (*Eriocheir sinensis*)
3. Eurasian Ruffe (*Gymnocephalus cernuus*)
4. European Green Crab (*Carcinus maenas*)
5. Flathead Catfish (*Pylodictus olivaris*)
6. Lionfish (*Pterois volitans*)
7. Northern Snakehead (*Channa argus*)
8. Nutria (*Myocastor coypus*)
9. Quagga Mussel (*Dreissena bugensis*)
10. Round Goby (*Neogobius melanostomus*)
11. Sea Lamprey (*Petromyzon marinus*)
12. Veined Rapa Whelk (*Rapana venosa*)

**Activity 2: Invasive Species Research**

* Refer students to **Lesson 2, Handout 1: Invasive Species Research** Activity 2 and tell students to read all the questions prior to answering them. Remind them to answer in complete sentences and instruct them to revisit the website if needed.
* Since this activity lends itself to small group discussion, allow students to work together and discuss the questions.
* After answering all of the questions, have the students or student groups report out about their researched species. Use that information to discuss the essential questions with the class.
* Students need to cite their sources (at least two). Check with your school’s citation guidelines. The focus, however, of this research activity is on obtaining information from credible and reliable sources.

**Homework/Extension Options:**

* Research further impacts of the assigned invasive species on other organisms in the environment.
* Research another invasive aquatic plant or animal and its impacts on the environment.
* Create a poster (8” x 11”) that could be posted in a community center that would alert the community of the possible presence of the invasive species you researched. Be sure to include as much information about the species as you feel is necessary; a picture of the species might also be very helpful. Your poster should be not only informative but also eye catching. Your poster should also state what one should do should he/she encounters this invasive species. Example lesson plans and posters can be found from the Illinois-Indiana Sea Grant, Nab the Invaders: <http://www.iiseagrant.org/NabInvader/Lakes/suspects/suspects.html>

Lesson 3: Limiting Factors

**Brief Overview of Lesson:** Students will examine various resources such as videos, data, and a simulation to develop a list of factors that limit population size. Students will also examine how changes in population size affect an ecosystem’s dynamics. Students will also read information on life history of zebra mussel. They will then hypothesize possible limiting factors and how these factors might be used to control the zebra mussel population.

**Prior Knowledge Required:**

* What an ecosystem is and its dynamics
* Examples and meaning of biotic and abiotic factors
* Basic computation skills (ex. addition, subtraction, etc.) and how to plot points on a graph
* Previous concepts learned in prior lessons in this unit

**Estimated Time:** 90 minutes

**Resources for Lesson (list resources and materials):**

* Lesson 3, Handout 1: Deer-Predation or Starvation
* Background information on changes in an ecosystem <https://www.greenfacts.org/en/ecosystems/index.htm>

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

* 7.MS-LS2-1. Analyze and interpret data to provide evidence for the effects of periods of abundant and scarce resources on the growth of organisms and the size of populations in an ecosystem.
* 7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.

**Essential Question(s) addressed in this lesson:**

* What is the probable extent of the impact of an invasive species on an ecosystem’s dynamics?
* In what ways and to what extent can the impact of an invasive on an ecosystem be prevented or mitigated?

**Objectives**

**By the end of this lesson students will know and be able to:**

* Describe factors that limit plant and animal population size.
* Analyze videos, simulations and predator/prey data in order to make inferences about factors affecting population sizes.

**Language Objectives**

* Orally discuss in small groups the observations and conclusions about population size using information from videos, simulations, and predator/prey data.

**Targeted Academic Language**

* Content specific: limiting factors, warming temperatures, environmental challenges, life cycle, ecology, migration, populations, predator/prey, photosynthesis, elements, *Elodea*, oxygen, adapt, light intensity, carbon dioxide, concentration, claim & evidence, abiotic, biotic, factors.
* Academic specific: infer, define, select, preview, discuss, explain, list.

**What students should know and be able to do before starting this lesson:**

* What an ecosystem is and its dynamics
* Examples and meaning of biotic and abiotic factors
* Basic computation skills (ex. addition, subtraction, etc.) and graphing
* Previous concepts learned in prior lessons in this unit

**Anticipated Student Preconceptions/Misconceptions**

* Preconception: Limiting factors primarily impact animals.

**Instructional Tips/Strategies/Suggestions for Teacher**

* Students should work in pairs to discuss the questions and generate their answers. If technology availability is a limiting factor, the videos and simulations can be shown to the entire class (or stations set up for group viewing).

**Assessment**

* Gauge student understanding based on class discussion and answers to worksheet questions.

**Lesson Sequence**

**Introduction:** Define and discuss the meaning of a limiting factor(s). Select a common animal. Ask students to brainstorm what factors might limit that animal’s growth or survival. Explain that they are going to do more investigation into what limiting factors are and how they might impact a population.  
 **Activity 1:** Students will watch the following video on impact of warming temperatures on caribou populations:

PBS Learning Media, *Global Warming Threatens Caribou*: <http://mass.pbslearningmedia.org/resource/ean08.sci.ess.watcyc.caribou/global-warming-threatens-caribou/>

After viewing the video, address the following issues and questions with a whole class discussion:

* Caribou are facing environmental challenges as the climate changes in the Arctic. What are some of the challenges to the caribou life cycle?
* The weather drives the caribou migration. What specific factors in the weather affect their migration?
* How will climate change impact the caribou and increase their need for space?
* In what ways might the caribou adapt in response to changing environmental conditions?
* How might the change in migratory patterns and a population decline of caribou affect Arctic residents?

Begin a class list of possible limiting factors for reference in subsequent activities.

**Activity 2:** Students will analyze predator-prey population data and examine how changes in population size affect an ecosystem’s dynamics.

* Distribute **Lesson 3, Handout 1: Limiting Factors**. As a class, read through the scenario. Go over how to calculate the deer change population and make sure all students are able to do this.
* Ask students to independently fill out the table.
* Go over the graph on the third page with the class and make sure they understand the axes. Ask the students to use different color markers/pens to represent the wolf and deer populations.
* Have the class break into small groups and discuss the results.
* Have each group complete the questions on the last sheet of the handout and have each group report out their results.
* Ask students what (if any) other limiting factor(s) should be added to the class list (predator/prey).

**Activity 3:** Zebra Mussels in Massachusetts: Students read information on the life history of the zebra mussel. Students then hypothesize possible limiting factors and how these factors might be used to control the zebra mussel population.

* Print and distribute the information about Zebra Mussels from the MA Executive Office of Energy and Environmental Affairs: <http://www.mass.gov/eea/agencies/dfg/fba/zebra-mussels.html>
* Have students read it and hypothesize possible limiting factors that affect the zebra mussel’s population and how these factors might be used to control it.
* Discuss students’ responses as a class.

**Extension activity:**

* Article: Have students read the article *Mixing Can Affect Lake’s Ecosystem*,  Society for Science & the Public: <https://student.societyforscience.org/article/less-mixing-can-affect-lakes-ecosystem>, and write a brief paper in which they compare and contrast the information in this article with the information they learned from the video on the impact of warming temperatures on caribou populations.

Lesson 4: Broken Food Web

**Brief Overview of Lesson:** Students use a food web with a minimum of eight organisms from a local environment illustrating the relationships of the organisms and principles of energy flow from sun to producer to herbivore to carnivore. Students will then introduce an invasive species at different levels and predict the consequence for the organisms in the food web.

**Prior Knowledge Required:**

* Students will need to have a basic knowledge of a food web that includes trophic energy levels and modes of obtaining energy: producer, herbivore, carnivore, and omnivore.
* Students will need to know how to draw a food web.
* Students will need to know that most food webs are dependent on the sun and photosynthetic producers to transform light energy to chemical potential energy.
* Previous concepts learned in prior lessons in this unit.

**Estimated Time:** 50 minutes

**Resources for Lesson (list resources and materials):**

* Lesson 4, Handout 1(Part A): Creating an Interactive Model of Your Food Web
* Lesson 4, Handout 1(Part B): Broken Food Web
* Red pencils or pens, 3x5 index cards (10-15 per pair/group), white string or yarn, paperclips, red and black markers, scissors (one per pair/group), magazines with pictures of animals and plants
* Internet resources:
* PBS Learning Media Antarctic Food Web: <http://www.teachersdomain.org/resource/lsps07.sci.life.eco.oceanfoodweb/>
* National Geographic, *Antarctica Braces for Influx of Invasive Species*: <http://newswatch.nationalgeographic.com/2013/01/07/antarctica-braces-for-influx-of-invasive-species/>

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

* 7.MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use.Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.
* 7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.

**Essential Question(s) addressed in this lesson:**

* What is the probable extent of the impact of an invasive species on an ecosystem’s dynamics?
* In what ways and to what extent can the impact of an invasive on an ecosystem be prevented or mitigated?

**Objectives**

**By the end of this lesson students will know and be able to:**

* Construct a two-dimensional model of a local food web including eight organisms with a minimum of three energy levels
* Use evidence from models to predict the impacts an invasive species could have on a food web.

**Language Objectives**

* Orally explain, in small groups and in class discussion, a food web and how it affected by an invasive species, using a student-made model as evidence.

**Targeted Academic Language**

* Content Specific: food web, local food web, producer, herbivore, carnivore
* Academic Specific: discuss, brainstorm, predict, debate, construct

**What students should know and be able to do before starting this lesson:**

* Students will need to have a basic knowledge of an ecosystem that includes trophic energy levels and modes of obtaining energy: producer, herbivore, carnivore, and omnivore.
* Students will need to know that most food webs are dependent on the sun and photosynthetic producers to transform light energy to chemical potential energy.

**Anticipated Student Preconceptions/Misconceptions**

* Misconception: Arrows in a food web indicate the direction of consumption as opposed to the flow of energy.

**Instructional Tips/Strategies/Suggestions for Teacher**

* Teacher is encouraged to leave the list generated from activity 1 on the board for the next activity.

**Assessment**

* Students will construct a two-dimensional model of a local food web including eight organisms with a minimum of four energy levels. Students will then introduce at each energy level an invasive species that disrupts the food web. Students will document and diagram their predictions.

**Lesson Sequence**

**Activity 1: Constructing a Multi-dimensional Food Web**

* Prepare for the session by making three columns on the board titled “Producer”, “Consumer: Herbivore”, and “Consumer: Carnivore”, and review each term.
* Have several or all students go to the board and write in the appropriate column the name of a local organism that they think fits into one or more of the three categories. \*\*
* As a class, review the accuracy of the list of organisms and determine the energy level (producer; primary, secondary, and tertiary consumer) of each organism.
* Discuss each organism’s source of food and potential predators.
* Have students work in pairs or groups of 3 to draw a food web using the organisms on the list. Their food web must consist of at least 10 organisms including a human and an aquatic organism. Have a few pairs/groups share their food web with the whole class. Emphasize energy levels and flow, and the significance of arrow placement and direction.

**Teacher Notes:**

Add “humans” to the list if a student does not. Also be sure there are a variety of organisms, including aquatic organisms, represented in each category. Check each pair/group’s food web for accuracy before moving on to Activity Two.

**Activity 2: Using an Interactive Food Web to Predict the Possible Consequences of an Invasion**

Part A: Creating an Interactive Model Food Web

* Distribute Handout 1, Part A, index cards, markers, string, paperclips, magazines, and scissors.
* In their pairs/groups, have students follow the directions to construct an interactive model of the food web they drew in Activity 1.
* Check that students have correctly modeled their food web.

Part B: Broken Food Web

* Distribute Handout 1, Part B. Ask student to simulate the introduction of an invasive species at each energy level and make predictions of the consequence for the food web. Have students write their prediction on the left side of Handout 1, Part B and diagram the corresponding food web on the right. Students do not have to cut strings to model the eradication of organisms due to an invasion, but simply disconnect paperclips wherever necessary.
* Collect materials and prepare students for a whole-class discussion.

Share out and Discussion:

* Have different groups share aloud what they had done. Students should share the design and layout of their food web as well as what the ramifications of the introduction of an invasive species were.
* Engage the class in a discussion of the following:
  + How can a single invasive species impact an entire ecosystem?
  + What can happen to a population in an ecosystem when food webs are stressed?
  + Was the impact of the invasion more or less at one level of the food web versus another?
  + What are the potential impacts to humans and their resources?

Lesson 5: Independent Species Research

**Brief Overview of Lesson**: In this learning experience, students will read a public bulletin about the invasive species *Hemigrapsus sanguineus*. They will be assigned an invasive species to investigate, and they will examine how the species became invasive and explore the role of humans and technology played in this biological invasion. Students will list and categorize their data to look for trends and commonalities.

**Prior Knowledge and Skill Required:**

* What an ecosystem is and its dynamics
* General flow of energy and matter through food webs
* Interdependent relationships in an ecosystem (e.g., predatory, mutual, parasitic); and
* Meaning and examples of biotic and abiotic factors.
* Previous concepts learned in prior lessons in this unit.

**Estimated Time:** 100 minutes

**Resources for Lesson (resources and materials):**

* Lesson 5, Handout 1: *Hemigrapsus sanguineus* Bulletin
* Lesson 5, Handout 2: Independent Species Investigation Worksheet
* Lesson 5, Handout 3: Aggregated Class Data and Identifying Data Trends
* Lesson 5, Handout Four: Class Summary of Trends
* Overhead or white board
* Internet access

**Standard(s)/Unit Goal(s) to be addressed in this lesson:**

* 7.MS-LS2-4. Analyze data to provide evidence that disruptions (natural or human-made) to any physical or biological component of an ecosystem can lead to shifts in all its populations. Clarification Statement: Focus should be on ecosystems characteristics varying over time, including disruptions such as hurricanes, floods, wildfires, oil spills, and construction.
* 7.MS-LS2-5. Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.\* Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.
* 7.MS-LS2-6(MA). Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.
* CCSS.ELA-Literacy.WHST.6-8. 8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrases the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

**Essential Question(s) addressed in this lesson:**

* What is the probable extent of the impact of an invasive species on an ecosystem’s dynamics?
* In what ways and to what extent can the impact of an invasive on an ecosystem be prevented or mitigated?

**Objectives**

* Compile information on invasive species in order to create a class data table on several invasive species
* Identify patterns and trends using evidence from a data set on invasive species

**Language Objectives**

* Read and record information about invasive species
* Orally share, and listen and record information from others regarding invasive species
* Orally share patterns and trends seen in the class data set

**Targeted Academic Language**

* Content Specific: aggregate, trends, commonalities, patterns, data
* Academic: reflect, discuss, identify, categorize

**What students should know and be able to do before starting this lesson:**

* What an ecosystem is and its dynamics
* General flow of energy and matter through food webs
* Interdependent relationships in an ecosystem (e.g., predatory, mutual, parasitic); and
* Meaning and examples of biotic and abiotic factors.
* Previous concepts and skills learned in prior lessons in this unit.

**Instructional Tips/Strategies/Suggestions for Teacher**

* This is a time-consuming learning experience. When dividing the activities, try to plan for Activities 3 and 4 to take place during the same class period.
* The “Creative Hunt” Visible Thinking routine can be used to help students look at the parts, purposes and audience for the bulletin and understand the key components of the posters they create in Learning Experience Seven. The “Creative Hunt” thinking prompts that should be asked about the bulletin are: What is the main purpose here? What are the parts of the bulletin and their purposes? Which parts are especially smart or creative? (Asterisk or mark them.) Who is the audience for this bulletin?

**Assessment**

* Students will complete the student data sheets, which will be assessed for accuracy, thoroughness, and completion. The students will share their data with the class, for everyone to record. Students will then divide into groups to look for trends and commonalities.

**Lesson Sequence**

**Activity 1: Read Hemigrapsus Bulletin**

USGS, Southeast Ecological Science Center <http://fl.biology.usgs.gov/Nonindigenous_Species/Asian_shore_crab/asian_shore_crab.html>

* Distribute **Handout 1** and instruct the students to read it on their own in class or as homework. Ask the students to reflect on the information in the bulletin and prepare for a group discussion.
* Discuss with students the information in the bulletin, what the bulletin is trying to do, and with whom the bulletin is attempting to communicate.

**Activity 2: How Did This Happen?**

* Distribute **Handout 2**. Assign a species to each student or student group, or allow them to select one from the following online lists:
  + MA Executive Office of Energy and Environmental Affairs, MA plants: [www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/land-protection-and-management/invasive-species/invasive-plants.html](http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/land-protection-and-management/invasive-species/invasive-plants.html)
  + The Global Invasive Species Initiative: [www.issg.org/database/species/search.asp?st=100ss&fr=1&str=&lang=EN](http://www.issg.org/database/species/search.asp?st=100ss&fr=1&str=&lang=EN%20)
  + Wikipedia: [http://en.wikipedia.org/wiki/List\_of\_invasive\_species\_in\_North\_America](http://en.wikipedia.org/wiki/List_of_invasive_species_in_North_America%20%20)
* After students/student groups select a species, instruct them to fill in all the data in the table. Tell them to return to [www.invasivespeciesinfo.gov](http://www.invasivespeciesinfo.gov) as needed. After exhausting the database, students should try other search engines to find the remaining information.
* Students identify place of origin, method of species introduction, and the role humans and technology have played.

**Activity 3: Group Trend Part A**

* Bring the class back together after the individual research is completed.
* Distribute **Handout 3**, Aggregated Class Data.
* Recreate the aggregated class data table on the board.
* As a class, fill in the first entry to show the students how to complete the table.
* Instruct students or student groups to go to the board and fill in the information they found.

**Note to Teacher:** Make sure the rest of the class fills in the entire data table because it is needed for Activity 4.

**Activity 4: Group Trend Part B**

* After the aggregate data is compiled, divide the students into seven groups and assign one of the column headings to each group. (If the groups are too large, multiple groups can work on the same column heading).
* Each group examines the class data for the column heading they have been assigned in order to identify trends in the information.
* The groups document their findings on **Handout Three** and select one team member to report out the information to the class.
* Distribute **Handout 4**. Instruct students to complete the entire data table as the groups report out.

Curriculum-Embedded Performance Assessment (CEPA): Controlling an Invasive Species

**Teacher Instructions**

**Prior Knowledge and Skill Required:** Students are familiar with the local food web created in lesson 4 and are able to predict changes to the food web when an invasive species is introduced to the ecosystem. They are able to access the Internet to research characteristics of certain invasive species. They are able to work in groups.

**Estimated Time:** 100-150 minutes (2-3 class periods)

**Resources for Lesson** (resources and materials):

* Instructions for Students Handout
* Student Individual Work Handout
* Student Group Handout
* Rubric for Presentation
* Rapid Response Plan for the **Zebra Mussel** in Massachusetts (Source: MA Department of Recreation and Conservation) <http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/downloads/zm-rrplan.pdf>
* Rapid Response Plan for **Eurasian Watermilfoil** in Massachusetts(Source: MA Department of Recreation and Conservation) <http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/factsheet/eurasian-milfoil.pdf>
* **Red-Bellied Pacu Fish** (Source: USGS NAS - Nonindigenous Aquatic Species)

<http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=427>

**Standard(s) to be addressed:**

**7.MS-LS2-5.** Evaluate competing design solutions for protecting an ecosystem. Discuss benefits and limitations of each design.\* Clarification Statement: Examples of design solutions could include water, land, and species protection, and the prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

**7.MS-LS2-6(MA).** Explain how changes to the biodiversity of an ecosystem—the variety of species found in the ecosystem—may limit the availability of resources humans use. Clarification Statement: Examples of resources can include food, energy, medicine, and clean water.

**Literacy Standard(s)**

**WHST 8.** Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrases the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

**Goal:** Students will evaluate competing design solutions for protecting an ecosystem and discuss benefits and limitations of each design. Specifically, students will evaluate multiple solutions for controlling an invasive species and present their findings including the benefits and limitations of each solution.

**Role:** Students are biologists hired by the town conservation committee.

**Audience:** Town conservation committee

**Situation:** Students will choose a solution, based on their research and the evidence provided, for controlling a particular invasive species. The students will then present an argument to the committee that their solution is best by using evidence to explain why the benefits outweigh the limitations.

**Product Performance and Purpose:** Students will prepare an argument for the town conservation committee in favor of a particular solution. They will present this solution in front of the committee. Students will have the opportunity to engage in argument from evidence.

**Information for Teachers:**

Students will work both in groups and individually.

**Individual Work**

* Students will choose or be assigned one of the three invasive species (zebra mussels, milfoil, or red-bellied pacu fish).
* They will conduct independent internet research on the selected species obtaining the following information: what they eat, what eats them, where they live, how long they live, and how quickly they reproduce.
* Each student will refer back to their local food web they created in lesson 4 and hypothesize how their invasive species will disrupt the food web.

**Group Work**

* Students will work in groups based on their invasive species.
* Groups will discuss their internet research and make a table displaying a summary of their findings.
* Groups will create a second table describing if and how their invasive species will affect each organism in the local food web.
* Groups will each read through the different solutions (CEPA Student Instructions Group Handout).
* Groups will evaluate the benefits and limitations of each solution.
* Groups will identify the most effective solution.
* Groups will defend their reasoning to the audience.

Unit Resources

Information on Ecological and Economic Impact of Invasive Species:

* US Forest Service: [www.fs.fed.us/pnw/invasives/](http://www.fs.fed.us/pnw/invasives/)
* NOVA: <http://www.pbs.org/wgbh/nova/nature/impact-invasive-species.html>
* Center for Invasive Species Management: <http://www.weedcenter.org/inv_plant_info/impacts.html>
* Encyclopedia of Life: <http://eol.org/info/460>
* Colorado State University: <http://lib.colostate.edu/research/agnic/impacts.html>
* National Wildlife Federation: <http://www.nwf.org/Wildlife/Threats-to-Wildlife/Invasive-Species.aspx>
* USDA- Aquatic Species: <http://www.invasivespeciesinfo.gov/aquatics/economic.shtml>
* Illinois-Indiana Sea Grant: <http://www.iiseagrant.org/NabInvader/Lakes/suspects/suspects.html>

**Lesson 1: Handout 1**

**Creative Writing Assignment: Invasion of an Invasive Story**

**Purpose:** Through this creative writing assignment, students will show their understanding of the relationships that exist between organisms within an ecosystem and its likely disruption when invaded by an invasive species.

**Story Guidelines:** Write a short story about the invasion of an ecosystem by an invasive species. Your story should be 2-3 paragraphs long, and use 15 or more of the 30 words/phrases listed below. Your story must include the words in bold. Once a word is used, cross it off the list.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Alien | **Ecosystem** | Habitat | Niche | Producer |
| Carnivore | Energy transfer | Hitch-hiker | **Non-native** | Quarantine |
| Collapse | Eradication | **Indigenous** | Noxious | Relationship |
| Competition | Extinct | **Invasion** | Omnivore | **Species** |
| Consumer | Exotic | **Invasive** | Pest | Survive |
| Diversity | Food web | **Native** | Predators | Voracious |

**Lesson 1: Handout 2**

**Maryland Wages War on Invasive Walking Fish**

Hillary Mayell

National Geographic News

July 2, 2002

An angler caught an air-breathing, land-crawling, voracious predator this past weekend in a pond in Crofton, Maryland.

The good news is that the fish, a northern snakehead that has been targeted by biologists for the last several weeks, was caught. The bad news is that it was 26 inches (66 centimeters) long; the fish caught in mid-May that alerted wildlife officers to the possibility of an invasion by an alien species was only 20 inches (51 centimeters) long.



The snakehead is shown here next to a U.S. dollar bill, for scale.

*Photograph courtesy of Cait Gillespie*

"Either the fish grew six inches in a few weeks or we have more than one in the pond," said Bob Lunsford, a biologist with the Maryland Department of Natural Resources.

The knowledge, with the weekend catch, that there is more than one fish in the Crofton pond is what is keeping biologists awake at night.

"Our biggest fear is that there are more than one and they'll reproduce," said Lunsford.

A second fear, based on the fish's ability to breathe out of water and travel across land, is that the snakehead could leave the pond and travel the 75 feet (23 meters) or so to the Little Patuxent River, and from there invade the state's river system.

**Battling Alien Species**

The northern snakehead's arrival in Maryland is only the latest in a long list of invasions by alien species around the world.

Alien species—plants and animals that have become established outside of their natural range as the result of human activity—pose a huge threat to the biodiversity and health of an ecosystem. Once established, the alien species can eat the native species or compete with them for habitat, food, or both. Lacking natural predators in their new environment, the invaders can drive natives to extinction, drastically degrade ecosystems, and cost billions of dollars a year in eradication efforts.

Businesses also suffer. The U.S. government estimates the cotton boll weevil, an exotic insect, has cost the cotton industry $13 billion since its arrival, and that over a ten-year period, pipe-clogging masses of zebra mussels have cost the utility industry $3 billion.

Similar ecological disasters have occurred in other parts of the world too. An invasion of the Black Sea by the comb jelly led to the collapse of the anchovy fishery, estimated to be worth $250 million a year.

"Once an alien species establishes itself they're impossible to get rid of," said Paul Shafland, director of the Florida Fish and Wildlife Conservation's Non-Native Fish Lab.

**Maryland's Snakehead Saga**

An angler fishing in a pond in Crofton, Maryland, east of Washington, D.C., first caught the fish in mid-May. Unable to identify it, he took photographs before throwing it back in the water. Biologists at the state's Department of Natural Resources, working with other experts, identified the fish as a northern snakehead. They immediately began planning strategies for ridding the pond of the creature.

Thus far, sandbags, electroshock equipment, traps, and hordes of anglers have been recruited to capture the alien fish. Wanted posters alert anglers to cut and bleed the fish if they catch it, since it can live on land for several days at least.

"We want this fish dead," said Lunsford. "No question about it."

"The folks in Maryland are not overreacting one little bit," said Walter Courtenay, professor emeritus of zoology at Florida Atlantic University.

There are 28 species of snakeheads; three are indigenous to equatorial Africa, the other 25 to Asia. The species vary in size and aggressiveness, according to Courtenay, who has been preparing a risk assessment on the snakehead for the U.S. Geological Survey since September.

One species, the bullseye snakehead, has already established itself in the waters of southern Florida, although with relatively little impact so far.

"We have not seen, and we don't anticipate, that the presence of the snakehead in Florida waters will have a catastrophic impact," said Shafland. "But it's like throwing trash out the car window; it can't be good."

Courtenay disagrees with Shafland's assessment of the Florida snakehead's potential impact, but in regard to the species found in Maryland, the question is moot. The northern snakehead is nothing like the species down in Florida, according to Courtenay.

"Ninety percent of the northern snakeheads' diet consists of other fishes," he said. "Their temperature range is between zero to 30 degrees Celsius (32 to 86 degrees Fahrenheit), and it can live under waters that have been iced over. They can grow to almost a full meter in length (more than three feet), and the females lay more eggs per year—in the neighborhood of 100,000 annually—than other species."

The snakehead in Florida is a temperate species, unable to withstand water temperatures below 50 degrees Fahrenheit (10 degrees Celsius).

Some snakehead species are imported into the United States as part of the aquarium trade, although the northern snakehead is not one of them. Snakeheads are considered a food delicacy in Asia, and live fish can frequently be found in Chinese markets. Authorities suspect that the fish in the Crofton pond was purchased in Washington, D.C.'s Chinatown district.

"A snakehead species introduced in Uzbekistan in the early 1960s spread with such rapidity and with such devastating effect on native fish populations that fishermen were able to establish a commercial fishery, turning a negative into a positive," said Courtenay.

Courtenay's report, which will be submitted to the U.S. Fish and Wildlife Service later this summer, will recommend a total ban on importation of live snakeheads.

**Educating the Public**

Options for catching the fish in the Crofton pond are somewhat limited. Draining the pond would flush all the fish, including the snakehead, into the Little Patuxent River. In addition, the snakehead has the ability to bury itself in the mud for several months, so it could just hide. The lower end of the pond has been sandbagged to prevent the fish from crawling into the Little Patuxent. Electroshock hasn't worked, and can't be tried again until winter when the dense vegetation in the pond has died back, allowing larger pieces of equipment to be operated.

State and local authorities have about a dozen eel pots, some baited traps, and two floating D-traps in the pond, but even if they catch more snakeheads, there is no way of knowing that all of them have been caught.

Courtenay suggests the only option might be poisoning the pond using Rotenone, a plant-derived toxin. "None of the other methods guarantee that you'll get every fish in the pond," he said.

Although possessing a live snakehead is illegal in 13 states; Virginia, Maryland, and the District of Columbia are not among them. It is however, illegal to release non-native fish into Maryland waters, said Lunsford.

"Obviously we need to do more to educate the public about the serious ecological consequences that the illegal release of exotic species represents," said Shafland. "People need to understand that once exotic species are established they're impossible to eliminate and the consequences can be catastrophic. Releasing them into the wild is not humane and it's not smart."

National Geographic article: <http://news.nationalgeographic.com/news/2002/07/0702_020702_snakehead.html>

**Lesson 1: Handout 3 (Page 1 of 2)**

**Student Discussion and Summary of Article**

**Name: Date: \_**

Write 2 questions you still have after reading the article:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Discuss your questions with your team and summarize your discussion:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

In addition, discuss the following questions and summarize below:

* What are the impacts of an invasive species on an ecosystem? How are different organisms are affected?
* What are some ways we can we control invasive species? How can an invasive species be managed?
* What are some potential impacts of invasive species on human resources?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lesson 1: Handout 3 (Page 2 of 2)**

**Student Discussion and Summary of Article**

Write a summary of the article below. Use evidence from the article and what you have learned from your group discussions to answer the following questions.

1. What are some impacts an invasive species has an ecosystem?
2. What effects can an invasive species have on human resources?
3. What methods could be used to manage an invasive species?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lesson 2: Handout 1 (page 1 of 4)**

**Invasive Species Research**

**Activity 1**: **Collect information about your invasive species and use a map to indicate where it came from and where it has spread. To do this:**

* Go to: National Invasive Species Information Center: [www.invasivespeciesinfo.gov](http://www.invasivespeciesinfo.gov)
* Under “Browse by Subject”, select **Aquatic Species**, **Plants** or **Animals**.
* Under “Species Profile”, select the organism you have been assigned to research.
* Complete the form on the following page.
* Identify where the invasive species originated from and where it has spread to on the provided map.
* Other sites to check:
* *Practical Guidebook to the Control of Invasive Aquatic and Wetland Plants of the San Francisco Bay-Delta Region*: [www.sfei.org/nis/index.html](http://www.sfei.org/nis/index.html)
* Center for Invasive Species and Ecosystem Health: [www.invasive.org](http://www.invasive.org)

**Lesson 2: Handout 1 (page 2 of 4)**

**Invasive Species Research**

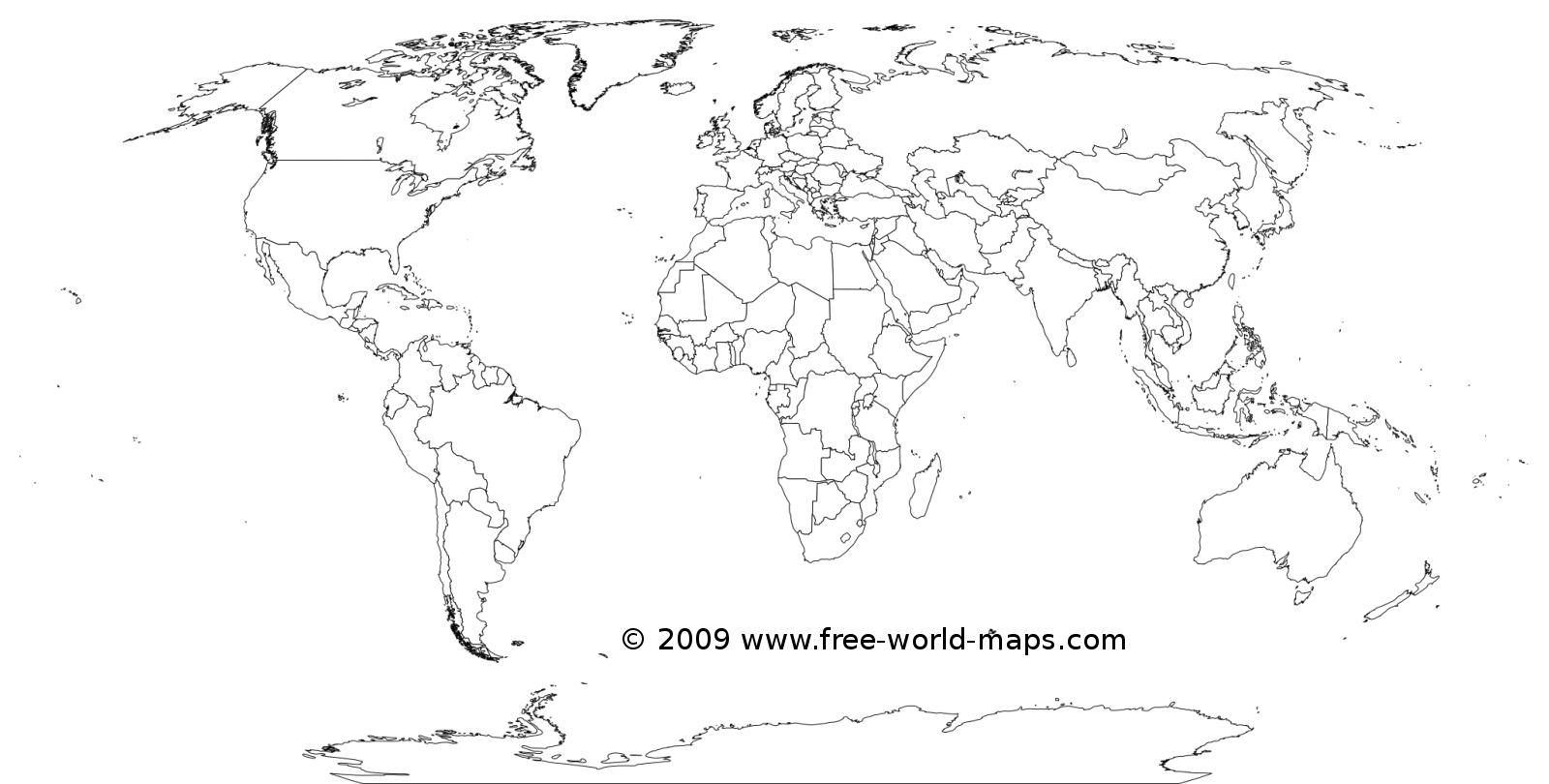
**Name:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  **Date:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |
| --- |
| **Scientific Name:** |
| **Common Names:** |
| **Native to (continent and country):** |
| **Native Environment (describe habitat):** |
|  |
| **Date(s) of U.S. Introduction:** |
| **Means of introduction:** |
|  |
| **Current U.S. Distribution (region and states):** |
|  |
| **Environment(s) now found in (in US):** |
|  |
| **Impact of introduction:** |
|  |
|  |

**Lesson 2: Handout 1 (page 3 of 4)**

**Invasive Species Research**

**Name: Date: \_**

**Directions:** Draw a starwhere the species originally came from. Draw an X where ever the species has invaded. Draw a line or lines between the star and the Xs. 

**Lesson 2: Handout 1 (page 4 of 4)**

**Invasive Species Research**

**Name: Date: \_**

**Directions:** Read all the questions before answering. Be sure to answer all questions in complete sentences.

1. **How is the native ecosystem similar to the ecosystem it is now found?**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **What changes are the invasive species causing to the ecosystem it is now in?**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. **What can be done to control the spread of the invasive species?**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lesson 3: Handout 1 (page 1 of 4)**

**Limiting Factors**

**Changes to the Deer Population: Predation or Starvation**

Scenario: In 1997 the deer population of an island forest reserve about 518 square kilometers in size was about 2000 animals. Although the island had excellent vegetation for feeding, the food supply obviously had limits. Thus the forest management personnel feared that overgrazing might lead to mass starvation. Since the area was too remote for hunters, the wildlife service decided to bring in natural predators to control the deer population. It was hoped that natural predation would keep the deer population from becoming too large and also increase the deer quality (or health), as predators often eliminate the weaker members of the herd. In 1997, ten wolves were flown into the island. The results of this program are shown in the following table.

*Adapted from:* [*www.wolfquest.org*](http://www.wolfquest.org)

**Lesson 3: Handout 1 (page 2 of 4)**

**Limiting Factors**

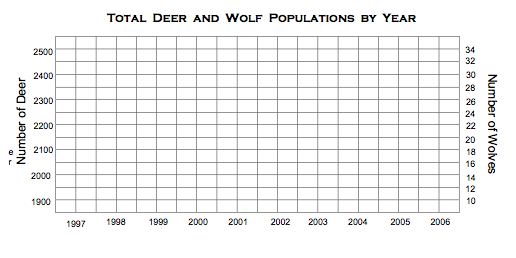
The Population Change is the number of deer born minus the number of deer that died (predation and starvation) during that year. Fill out the last column for each year (the first has been calculated for you).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **Wolf Population** | **Deer Population** | **Deer Offspring** | **Predation** | **Starvation** | **Deer Population Change** |
| 1997 | 10 | 2,000 | 800 | 400 | 100 | +300 |
| 1998 | 12 | 2,300 | 920 | 480 | 240 |  |
| 1999 | 16 | 2,500 | 1,000 | 640 | 500 |  |
| 2000 | 22 | 2,360 | 944 | 880 | 180 |  |
| 2001 | 28 | 2,224 | 996 | 1,120 | 26 |  |
| 2002 | 24 | 2,094 | 836 | 960 | 2 |  |
| 2003 | 21 | 1,968 | 788 | 840 | 0 |  |
| 2004 | 18 | 1,916 | 766 | 720 | 0 |  |
| 2005 | 19 | 1,952 | 780 | 760 | 0 |  |

**Lesson 3: Handout 1 (page 3 of 4)**

**Limiting Factors**

**Name: Date: \_**

**Directions:** Graph the deer and wolf populations on the graph provided. Use one color to show the deer population and another color to show the wolf population. 

**Lesson 3: Handout 1 (page 4 of 4)**

**Limiting Factors**

**Name: Date: \_**

1. Describe what happened to the deer population over time. Explain your reasoning.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Describe what happened to the wolf population over time. Explain your reasoning.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Make a claim about whether the introduction of the wolves was good for the deer population. Support your claim with evidence from the chart. Explain your reasoning.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Explain how the changes to the deer and wolf populations affect the ecosystem of which they are both a part.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Lesson 4: Handout 1, Part A**

**Creating an Interactive Model of Your Food Web**

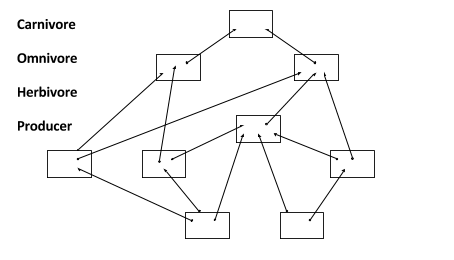
Obtain ten 5x3 index cards (one for each organism of your food web). On one side of the index card put an image of an organism that makes up your group’s food web. Images can either be drawn, cut out photos from magazines, or images found on the internet. If the images are not drawn, then attach the images to the front of the index card. On the back of the index card write the name of the organism, indicate the size, and mode of nutrition: producer, herbivore, omnivore, or carnivore. See example below.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Paramecium diagram. | |  | | --- | |  | | **Name**: Paramecium | |  | | **Size**: Microscopic | |  | | **Nutritional Mode**: Omnivore | |  | |  | |

**Creating Your Local Food Web Model**

Constructing a Food Web:

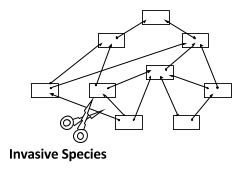
* Put a paperclip on each index card.
* Arrange on a desk or table the organisms of the food web at the proper nutritional level.
* Using markers, color one end of each string or yarn red and the other end black.
* To show what organism eats what other organism, tie the black end to the prey and the red end to the predator.



**Lesson 4: Handout 1, Part B**

**Broken Food Web**

**Name: Date: \_**



**Directions:**

* Once your interactive food web is completely constructed, remove the paperclip(s) and string to show where an invasive species has removed an organism(s) from the food web.
* In box number 1 below, write a prediction of what would happen if an invasive species removed a **Producer** organism from within the food chain.
* Diagram the new food web.
* Reconstruct your original interactive food web before moving on to numbers 2 and 3.

|  |  |
| --- | --- |
| 1. Prediction if invasive species removed a **Producer.** | Use your interactive food web to diagram the impact of the invasion on the food web. Describe the impact below. |
| Prediction: | Impact: |
| 2. Prediction if invasive species removed an **Herbivore.** | Use your interactive food web to diagram the impact of the invasion on the food web. Describe the impact below. |
| Prediction: | Impact: |
| 3. Prediction if invasive species removed a **Carnivore.** | Use your interactive food web to diagram the impact of the invasion on the food web. Describe the impact below. |
| Prediction: | Impact: |

**Lesson 5: Handout 1**

**NONINDIGENOUS SPECIES INFORMATION BULLETIN**

**Asian shore crab, Japanese shore crab, Pacific crab,**

***Hemigrapsus sanguineus* (De Haan)**

**(Arthropoda: Grapsidae)**

**IDENTIFICATION:** The Asian shore crab has a square-shaped shell with 3 spines on each side of the carapace.  The carapace color ranges from green to purple to orange-brown to red.  It has light and dark bands along its legs and red spots on its claws. Male crabs have a distinctive fleshy, bulb-like structure at the base of the moveable finger on the claws.  This species is small with adults ranging from 35 mm (1.5 in) to 42 mm (1.65 in) in carapace width.

**NATIVE RANGE:** *Hemigrapsus sanguineus* is indigenous to the western Pacific Ocean from Russia, along the Korean and Chinese coasts to Hong Kong, and the Japanese archipelago.

**LIFE HISTORY:** This species is an opportunistic omnivore, feeding on macroalgae, salt marsh grass, larval and juvenile fish, and small invertebrates such as amphipods, gastropods, bivalves, barnacles, and polychaetes.  The Asian shore crab is highly reproductive with a breeding season from May to September, twice the length of native crabs. The females are capable of producing 50,000 eggs per clutch with 3-4 clutches per breeding season.  The larvae are suspended in the water for approximately one month before developing into juvenile crabs. Because of this, the larvae have the ability to be transported over great distances, a possible means of new introductions.    
  
**HABITAT:** This versatile crab inhabits any shallow hard-bottom intertidal or sometimes subtidal habitat.  They can live on artificial structures and on mussel beds and oyster reefs.  They also tend to aggregate at high densities under rocks where they overlap habitats with native crab species.  *Hemigrapsus* can tolerate wide ranges of salinity and temperature as well as damp conditions in the upper intertidal regions.  
  
**NONINDIGENOUS OCCURRENCES:** *Hemigrapsus* was first recorded in the United States at Townsend Inlet, Cape May County, New Jersey in 1988.  This species is now well established and exceptionally abundant along the Atlantic intertidal coastline of the United States from Maine to North Carolina.  It is actively breeding and expanding its population within its nonnative range. Because the species is tolerant of a wide range of environmental conditions, it is likely that the invasion will continue along the US coastline.

**MEANS OF INTRODUCTION:** It is not known how this species was introduced to the United States Atlantic coast, but many speculate that adults or larvae were brought by incoming ships of global trade via ballast water discharge.

**IMPACTS:** Because this species has a very broad diet, it has the potential to affect populations of native species such as crabs, fish, and shellfish by disrupting the food web. It also occupies habitats very similar to our native mud crabs, possibly overwhelming and dominating their habitat. This potential impact on native species populations may be a result of direct predation or competition for a food source.  *Hemigrapsus* may compete with larger species, like the blue crab, rock crab, lobster, and the nonnative green crab. Recent trends show numbers of shore crabs are steadily increasing while native crab populations are declining.  These opportunistic omnivores may also pose threats to coastline ecosystems and aquaculture operations.  There are still many questions to be answered by scientists about impacts this species may pose to biodiversity in those ecosystems affected.  
  
**CONTROL AND MANAGEMENT:** Preliminary evidence shows that rockfish and seagulls may prey upon *Hemigrapsus*.  Parasites, which help control populations of *Hemigrapsus* in its native range, are not present along the US Atlantic coast. The shore crab may continue to expand its range along the US Atlantic coastline until it reaches its salinity and temperature tolerance levels.  Scientists are monitoring changes in native species, tracking the shore crab’s spread along the coastline, and conducting experiments to increase their knowledge of basic biology and ecology of this species. Ballast water management is also being researched to reduce or eradicate new introductions from occurring.



Source: USGS, Southeast Ecological Science Center <http://fl.biology.usgs.gov/Nonindigenous_Species/Asian_shore_crab/asian_shore_crab.html>

**Lesson 5: Handout 2**

**Independent Species Investigation Worksheet**

(Return to [www.invasivespeciesinfo.gov](http://www.invasivespeciesinfo.gov) as needed)

**Student Name: Date:**

**Species Name**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
| **Place of Origin** |  |
| **Climate/Habitat** |  |
|  |  |
|  |  |
| **Resource Needs** |  |
|  |  |
|  |  |
| **Transportation** |  |
|  |  |
|  |  |
| **Motivation to Introduce** |  |
|  |  |
|  |  |
| **Damage to the Environment** |  |
|  |  |
|  |  |
| **Methods to Eradicate** |  |
|  |  |
|  |  |
| **Solutions to Invasion** |  |
|  |  |
|  |  |

**Lesson 5: Handout 3**

**Aggregated Class Data**

**Student Name: Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**(Complete this table as a class)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Place of Origin** | **Climate/**  **Habitat** | **Resource**  **Needs** | **Transportation** | **Motivation to Introduce** | **Damage to the Environment** | **Methods to Eradicate** | **Solutions to**  **Invasion** |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

**Lesson 5: Handout 3**

**Identifying Data Trends**

**Directions:** As a team, examine the class data in the column that you have been assigned. Look for patterns (similarities) and describe them in the table below. Select one team member to report findings to the class.

|  |  |
| --- | --- |
| **Team Name** |  |
| **Category** |  |
| **Trends Found** |  |
|  |  |
|  |  |
|  |  |

**Lesson 5: Handout 4**

**Class Summary of Trends**

**Student Name: Date:**

**Directions:** Record trends found by the expert groups in the table below.

|  |  |
| --- | --- |
|  | **Trend** |
| **Place of Origin** |  |
|  |  |
|  |  |
| **Climate/Habitat** |  |
|  |  |
|  |  |
| **Resource Needs** |  |
|  |  |
|  |  |
| **Transportation** |  |
|  |  |
|  |  |
| **Motivation to Introduce** |  |
|  |  |
|  |  |
| **Damage to the environment** |  |
|  |  |
|  |  |
| **Methods to Eradicate** |  |
|  |  |
|  |  |
| **Solutions to Invasion** |  |
|  |  |
|  |  |

**Curriculum Embedded Performance Assessment (CEPA):**

**Controlling an Invasive Species**

**Student Instructions**

**Performance Task:** You will be assigned one of three invasive species (zebra mussels, Eurasian watermilfoil, red-bellied pacu fish) to individually research. You will then work in groups to evaluate different design solutions for protecting an ecosystem and discuss benefits and limitations of each design based on your species. Your group will present your findings including the benefits and limitations of each solution to the class.

**Goal:** Your goal is to evaluate the different design solutions for protecting an ecosystem from your invasive species. You will evaluate multiple solutions for controlling an invasive species and present your findings including the benefits and limitations of each solution.

**Role:** You are biologists hired by the town conservation committee.

**Audience:** Town conservation committee (class)

**Situation:** Choose a solution, based on your research and the evidence provided, for controlling a particular invasive species. You will then present an argument to the committee (class) why your solution is best option by using evidence to explain why the benefits outweigh the limitations.

**Product Performance and Purpose:** Prepare an argument for the town conservation committee in favor of a particular solution. Present this solution in front of the committee. You will have the opportunity to engage with the audience.

**Individual Work Directions:**

* You will be assigned one of the three invasive species (zebra mussels, milfoil, or pacu fish).
* Conduct independent research on the selected species obtaining the following information: what they eat, what eats them, where they live, how long they live, and how quickly they reproduce. A handout is provided for you to fill out.
* Refer back to your local food web you created earlier and hypothesize how their invasive species will disrupt the food web.

**Group Work Directions:**

Part 1:

* Read through the different invasive species management solutions.
* Work with your group to complete the table on the following page with the following information:
  + Determine if each solution is appropriate and reasonable for your species and write yes or no in the second column.
  + For each of the solutions you identified as appropriate for your species, list the benefits of the solution in column three and the limitations in column five.
  + Assign a value from 1-5 for each benefit, where 1 = not beneficial and 5 = very beneficial.
  + Assign a value from 1-5 for each limitation, where 1 = minimal cost and 5 = high cost.

Part 2:

* After completing the table, work with your group to identify the most effective solution.
* Create a presentation that clearly states your claim and gives evidence to support your claim. See rubric for expectations.
* Present your presentation to the committee (class). Be prepared to defend your reasoning to the audience.

**(CEPA) Student Instructions Handout**

**Individual Research Handout**

**Student Name: Date:**

**Directions:** Choose (or one will be assigned to you) of the three invasive species (Zebra mussels, Milfoil, or Pacu fish). Conduct independent internet research on the selected species obtaining the following information: what they eat, what eats them, where they live, how long they live, and how quickly they reproduce. Refer back to your local food web you created in class and hypothesize how their invasive species will disrupt the food web. Write your answers below.

(Return to website as needed)

* Rapid Response Plan for **the Zebra Mussel** in Massachusetts <http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/downloads/zm-rrplan.pdf>
* Rapid Response Plan for **Eurasian Watermilfoil** in Massachusetts<http://www.mass.gov/eea/docs/dcr/watersupply/lakepond/factsheet/eurasian-milfoil.pdf>
* **Red-Bellied Pacu Fish**

<http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=427>

**Species Name**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |
| --- | --- |
| **Place of Origin** |  |
| **Climate/Habitat** |  |
|  |  |
|  |  |
| **Diet** |  |
|  |  |
| **Predator/Prey** |  |
|  |  |
|  |  |
| **Reproduction** |  |
|  |  |
| **Life Span** |  |
|  |  |
|  |  |
| **Damage to the Environment** |  |
|  |  |
|  |  |
| **Methods to Eradicate** |  |
|  |  |
|  |  |
| **Solutions to Invasion** |  |
|  |  |
|  |  |

Refer back your food web. Hypothesize how their invasive species will disrupt the food web. Write down your answers.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(CEPA) Student Instructions Handout**

**Group Work Handout**

**Choosing the Best Solution to the Invasive Species Problem**

**Group Work Directions:**

Part 1:

* Read through the different invasive species management solutions.
* Work with your group to complete the table on the following page with the following information:
* Determine if each solution is appropriate and reasonable for your species and write yes or no in the second column.
* For each of the solutions you identified as appropriate for your species, list the benefits of the solution in column three and the limitations in column five.
* Assign a value from 1-5 for each benefit, where 1 = not beneficial and 5 = very beneficial.
* Assign a value from 1-5 for each limitation, where 1 = minimal cost and 5 = high cost.

Part 2:

* After completing the table, work with your group to identify the most effective solution.
* Create a presentation that clearly states your claim and gives evidence to support your claim. See rubric for expectations.
* Present your presentation to the committee (class). Be prepared to defend your reasoning to the audience.

**CEPA - Strategies for Invasive Species Management**

**Student Research Sheet**

**Insecticides**

Insecticides are any substance, natural or synthetic that will destroy, suppress, or alter the life cycle of any pest. Insecticides work by interfering with insects’ reproduction, behavior, or metabolism so they eat less and produce fewer offspring. Insecticides control aphids, moths, fruit flies, and locusts, among many other insects. They can exist in powder form or can be taken internally as liquids or injected as medicines. There are also natural insecticides which exist in the form of oils.

Insecticides can increase the amount of food farmers can produce because they eliminate the insects which eat the crops. Because farmers have greater crop yield, they will charge less and consumers will pay less for their groceries.

Because insecticides are intended to harm organisms, they can adversely affect other organisms as well. Depending on the type of insecticide, they can remain in the environment for either a long time. Therefore, even if someone hasn’t been directly exposed to insecticides, they can be affected and develop diseases from dermatitis to cancer.

* CropLife America, Benefits of Pesticides and Crop Protection Chemicals: <https://croplife.org/crop-protection/benefits/>
* EPA, What are pesticides and how do they work?: <http://www.epa.nsw.gov.au/pesticides/pestwhatrhow.htm>
* Wikipedia, Health effects of pesticides: <http://en.wikipedia.org/wiki/Health_effects_of_pesticides>

**Barriers**

Barriers work by preventing an invasive species from entering an area, which can cost much less than removing the species once it has established itself. Barriers for invasive species can exist in physical and non-physical forms.

Physical barriers can exist as concrete barriers, sand bags, or shallow parts of rivers which keep fish from continuing down a river or entering a lake. They tend to be permanent structures, only requiring maintenance once established. They can either restore natural waterways which have been disrupted by humans, or they can divert water and create a new river or lake. They can be constructed to eliminate a specific species but can also keep out similarly sized organisms.

Non-physical barriers have the advantage that they do not change water flow and can be designed specifically for one species. They can exist in many forms: creating a barrier of bubbles, flooding the water with light, sending an electrical current through the water, or sending out acoustical signals intended to bother a particular fish. More than one non-physical barrier can be used at time to raise the chances that a species will not enter an area.

* Ontario, Wildlife and Nature: <http://www.mnr.gov.on.ca/en/Business/Biodiversity/2ColumnSubPage/STDPROD_068705.html>
* Great Lakes Commission, New report demonstrates that permanent physical barriers to stop Asian carp at Chicago are feasible:

<https://www.glc.org/new-report-demonstrates-that-permanent-physical-barriers-to-stop-asian-carp-at-chicago-are-feasible/>

* Control Of Invasive Carp Using Non-Physical Barriers by Kaveh Someah, Ovivo USA,LLC: <https://bugwoodcloud.org/mura/mipn/assets/File/MNWIISC%20talks/upload%20folder/Control%20of%20Invasive%20Carp%20Movements%20Sing.pdf>

**Introduced Predators**

Once an invasive species has entered an area and disrupted the food web, an introduced predator can be released to eat it. The introduced predator is not part of the food web naturally and therefore might have other unintended consequences. For example, the mongoose was released in Hawaii in order to control rat populations. It did not kill the rats, instead it went after local bird populations crashing their populations.

Today, there are computer models which can predict what a predator will eat and scientists can run tests to make sure that they do not disrupt other parts of the food web. The USDA did extensive testing on a weevil they wanted to control an invasive plant and determined that it would not eat similar vegetation and the introduction is awaiting approval. While this method seems promising however it is very expensive.

# New York Times, An Invader Advances in Hawaii: <http://green.blogs.nytimes.com/2012/06/11/an-invader-advances-in-hawaii/>

# Science Daily, Predicting The Perfect Predator To Control Invasive Species: <http://www.sciencedaily.com/releases/2008/02/080213133316.htm>

**Physical Removal**

Physical removal is applied primarily to plants but has been used on sedentary organisms such as zebra mussels. Physical removal involves pulling up plants or scraping mussels from where they have settled. Physical removal is inexpensive but is time consuming and laborious. It is most effective in a small area in which people can carefully target only the desired species and leave others alone. It is possible to physically remove invasive species from large areas, but that method may remove other species as well.

# U.S. Fish and Wildlife, Management Methods: Physical Methods: <http://www.fws.gov/invasives/StaffTrainingModule/methods/physical/practice.html>

* U.S. Army Corps of Engineers Tulsa District, Zebra Mussel Action Plan:

<https://corpslakes.erdc.dren.mil/employees/invasive/pdfs/Zebra0-SWT-ActionPlan.pdf>

**Non-Chemical Control**

Non-chemical controls are ways to manage the growth of invasive species without introducing chemicals to the environment. Non-chemical controls may include physical removal, but are also extended to removing oxygen from water, increasing water flow, or painting the surfaces of boats with special anti-fouling paint.

Non-chemical control can target a specific species, but affect others as well. Both decreasing oxygen in the water and increasing the flow of water can affect other species. A careful analysis of other species present in the area is important.

One way to target a specific species is to paint a boat with anti-fouling paint that deters zebra mussels. This paint only affects zebra mussels and prevents their spread from one body of water to another. However, it does have to be done every year and cannot be applied to underwater structures such as docks.

* U.S. Army Corps of Engineers Tulsa District, Zebra Mussel Action Plan:

<https://corpslakes.erdc.dren.mil/employees/invasive/pdfs/Zebra0-SWT-ActionPlan.pdf>

* Nature Conservancy, Scuba Divers Provide Non-Chemical Weed Control on Wisconsin Lake : <http://blog.nature.org/science/2013/11/19/scuba-divers-offer-non-chemical-weed-control-on-wisconsin-lake/>

**Herbicides**

Herbicides are chemicals designed to kill weeds. Weeds often push desirable plants out of the way, limiting their space and amount of light. Herbicides will increase crop yield because they increase the amount of space and other resources available to plants. They can be used in areas where physical removal of weeds would damage crops. They are also relatively cheap and will work quickly.

However, repeated use of herbicides often allow plants to develop resistance and they are no longer effective. Companies such as Monsanto offer an array of herbicides which when used together kill a high number of plants and it takes much longer for a plant to become resistant to them. Herbicides can also cause a number of illness ranging from skin irritation to cancer. They may not stay in the place where they were applied as they can be carried by water to new locations.

* Answers.com, What are the advantages and disadvantages of herbicides on the environment?: <http://wiki.answers.com/Q/What_are_the_advantages_and_disadvantages_of_herbicides_on_the_environment>

# Minnesota Department of Natural Resources, Controlling purple loosestrife with herbicides: <http://www.dnr.state.mn.us/invasives/aquaticplants/purpleloosestrife/control_herbicides.html>

**CEPA- Strategies for Invasive Species Management Summary – Group Work Handout**

**Name of the species: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Solutions** | **Can this solution work for your invasive species? (yes/no)** | **Benefits** | **Total Points** | **Limitations/Costs** | **Total Points** |
| 1. **Insecticides** |  |  |  |  |  |
| 1. **Barriers** |  |  |  |  |  |
| 1. **Introducing Predators** |  |  |  |  |  |
| 1. **Physical Removal** |  |  |  |  |  |
| 1. **Non-chemical control** |  |  |  |  |  |
| 1. **Herbicide Use** |  |  |  |  |  |

**CEPA- Controlling an Invasive Species**

**Presentation Rubric**

**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | **Exceeds Expectations** | **Meets Expectations** | **Approaches Expectations** | **Does Not Meet Expectations** |
| **Content** | The claim is clearly stated. Opposing claims are identified. | **4** | **3** | **2** | **1** |
|  | Benefits and limitations of each solution are discussed. Explains why benefits outweigh the limitations for this solution compared to the other solutions. | **4** | **3** | **2** | **1** |
|  | Makes connections between the background research and the benefits and limitations. For example, the students selected a solution that can be implemented quickly because the species has a fast reproductive rate. | **4** | **3** | **2** | **1** |
| **Presentation** | Clearly and effectively structured. Students take turns speaking; they speak clearly and address the audience. The flow of the presentation is orderly, and the sequence of evidence supports their claim. | **4** | **3** | **2** | **1** |
|  | Uses appropriate academic language and clearly expresses ideas. | **4** | **3** | **2** | **1** |

**Score \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**