

The Good, the Bad, and the Ugly:
**Aquatic Invasive Species of
the Mid-Atlantic
Education Guide**



December 2015

Introduction to the Project

Each year, billions of dollars and millions of hours are spent dealing with invasive species around the globe. **Invasive species**, by definition, are non-native species that cause economic, environmental, and/or human health related harm. Invasive species can be plants, animals, and/or pathogens like West Nile Virus. These species typically grow and reproduce rapidly and often lack predators and pathogens in their introduced environments, allowing their populations to explode. Historic invasive species like Chestnut Blight and Smallpox have shaped our landscapes today while others have just begun to impact our environment.

Invasive species management can be costly and time consuming. However, proper education on invasive species can prevent invasions from occurring in the first place. Strong education and outreach efforts can increase public awareness while also promoting prevention.

Due to the need for comprehensive invasive species education, this toolkit was developed to tell the story of invasive species in the eastern United States through 5 distinct units:

1. History of Invasive Species
2. Introduction and Spread of Invasive Species
3. Impacts to Natural Areas
4. Impacts to Students' Lives
5. Student and Community Action

The goal of this project is to raise awareness about invasive species and to turn that awareness into action to prevent and to manage current and future invasions.

This project was generously funded by the Mid-Atlantic Panel on Aquatic Invasive Species (SA7528131-C) and was completed by staff with the Maryland Department of Natural Resources.



Larry Hogan, Governor
Mark Belton, Maryland Department of Natural Resources Secretary
December 2015

Publication # 03 Wildlife & Heritage Service-12212015-794

The facilities and services of the Maryland Department of Natural Resources are available to all without regard to race, color, religion, sex, sexual orientation, age, national origin or physical or mental disability. This document is available in an alternative format upon request from a qualified individual with a disability.

<http://dnr.maryland.gov>

410-260-8540

Toll Free in Maryland: 1-877-620-8DNR, ext.8540

Student and Community Action

Most invasive aquatic species have been introduced and/or spread as a result of human actions. However, just as humans have been responsible for bringing in or spreading these species, humans, including students, can play a part in slowing the introduction or proliferation of invasive species. Students can engage the public in actions to prevent the spread of invasive species as well as promote removal projects. Activities in this module encourage students to create action projects involving invasive species. The focal species for this section include: Green Crab, Purple Loosestrife, Rock Snot, and Water Chestnut.

Green Crabs are tiny terrors for some commercial fisheries, particularly for some species of clams. These predators quickly consume clams, mollusks, and even juvenile fish, causing serious problems for the future. Students can promote ways to utilize invasive Green Crab fisheries.

Purple Loosestrife was brought to the U.S. as an ornamental plant. However, it quickly escaped cultivation and has altered wetland habitats that it has invaded. Students can encourage the public to utilize native species in plantings and can organize Purple Loosestrife pulls as well as plan how to restore Loosestrife-infested wetlands.

Didymo or Rock Snot is a single-celled diatom that forms dense mats on the bottom of cool, freshwater streams. The mat, which may be as much as 4 inches thick, resembles wet fiberglass or toilet tissue. Didymo is spread on fishing equipment, felt-soled waders, boats, and anything else that has come in contact with didymo-infected water. Students can create action projects encouraging the public to 'stop the snot'!

Water Chestnut quickly covers water surfaces, choking out native vegetation and altering food webs. Students can organize Water Chestnut removals and can educate the public on other aquatic invasive species.



Purple Loosestrife invaded wetland by Liz West, Flickr Creative Commons

To encourage students to take action against invasive species, the lessons in this section include:

- **Eradication Nation - Grades 9-12; pg**
 - *Students will learn about the issues with Water Chestnut invasions and will work together to create an action plan to organize an eradication event for a local waterway.*
- **Green Crabs Bring in the \$Green\$ - Grades 6-8; pg**
 - *Students will learn about the issues with Green Crab invasion and will create a marketing campaign to make the harvest of Green Crabs profitable.*
- **Let's Harvest Water Chestnut! - Grades 3-5; pg**
 - *Students will learn about the impacts of Water Chestnut and will create informational brochures to teach the public on ways to control Water Chestnut.*
- **No Aquatic Invasives - Grades 3-5; pg**
 - *Students will learn about the impacts of invasive plants like Purple Loosestrife and then will write persuasive letters to local nurseries to discourage the sale of invasive plants.*
- **Stop the Snot - Grades 3-5; pg**
 - *Students will learn about the impacts of Didymo (aka Rock Snot) by reading a story about Savage Stream and simulating Rock Snot's spread. After learning about Rock Snot, students will create public service announcements to educate the public on this problematic species.*
- **Wetland Restoration - Grades 9-12; pg**
 - *Students will learn about the impact of Purple Loosestrife on wetlands and will create a restoration plan following the removal of Purple Loosestrife from 4 fictional habitats.*
- **Who's Got the Snot? - Grades 6-12; pg**
 - *Students will map the spread of Didymo in Maryland and will put together informational posters or brochures to educate anglers on ways to prevent the future introduction and spread into new streams.*

Objectives: At the conclusion of this lesson students will be able to:

- Describe the problems associated with Water Chestnut invasions
- Demonstrate research skills used to create a viable action plan
- Construct a viable eradication action plan that can be implemented by high school classes

Standards:

NGSS	HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
Core Idea	LS2.C - A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.
Practices	<ul style="list-style-type: none"> • Asking questions and defining problems • Planning and carrying out investigations • Obtaining, evaluating, and communicating information
Cross-Cutting Theme	<ul style="list-style-type: none"> • Systems and system models • Stability and change
Reading, Writing & Social Studies	<p>CCSS.ELA-Literacy.RH.9-10.7 Integrate quantitative or technical analysis (e.g., charts, research data) with qualitative analysis in print or digital text.</p> <p>CCSS.ELA-Literacy.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.</p> <p>CCSS.ELA-Literacy.W.9-10.2 Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.</p> <p>CCSS.ELA-Literacy.W.9-10.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.</p> <p>CCSS.ELA-Literacy.W.9-10.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation</p>
Environmental Literacy	<p>1.A.1- Identify an environmental issue</p> <p>1.A.2 - Develop and write research questions related to an environmental issue</p> <p>1.B.1 - Use recommendations to develop and implement an environmental action plan</p> <p>1.B.3 - Analyze the effectiveness of the action plan for achieving the desired outcomes</p>

Objectives: At the conclusion of this lesson students will be able to:

- Describe the problems associated with Water Chestnut invasions
- Demonstrate research skills used to create a viable action plan
- Construct a viable eradication action plan that can be implemented by high school classes

Materials:

- Internet access
- Student Pages (on CD)

Teacher Background: Water Chestnut (*Trapa natans*) is an invasive, aquatic plant. Water Chestnut is found in fresh water up to 15 feet deep and consists of a long submerged stem with fine roots that anchor the plant in the mud. The leaves are triangular or diamond shaped, about 1 ½ - 2 inches wide, with toothed edges. The leaves form a rosette, as wide as 12 inches, which float on the surface of the water. If a rosette breaks off, it can drift away and re-establish itself somewhere else. The seed is a hard nut with four ½ inch spines which can remain viable for as long as 12 years. The nuts can spread by floating to new areas or by clinging to birds or floating objects. Each seed can produce 10-15 rosettes, and each rosette in turn can produce 15-20 more seeds.

Water Chestnut is native to Europe, Asia, and Africa and was first found in this country near Concord, Massachusetts in 1859. How it was introduced is unknown, but it obviously was introduced by humans, possibly as an ornamental aquatic plant. In the late 1870s, Water Chestnut was being grown in the Harvard Botanical Garden, where it later escaped into nearby lakes and ponds. It is now found in most of New England and Mid-Atlantic states as far south as Virginia.



*Water Chestnut invasion by Krzysztof Ziarnek, Kenraiz
Wikimedia Commons*

The presence of this invasive species has had major impacts on the water bodies where it is found. The rosettes can grow so dense that they form a continuous mat of vegetation across the water which can shut out as much as 95% of the sunlight.

The lack of sunlight kills the native submerged aquatic vegetation (SAV), which is important food for waterfowl and is important nursery habitat for a variety of species. In contrast, the leaves of the Water Chestnut have very little nutritional value and are not readily consumed. Furthermore, the seeds are mostly inedible because of the hard shell and sharp spines. The dense biomass of Water Chestnut in invaded areas can result in lower levels of dissolved oxygen which reduces the amount of habitat for invertebrates and fish. Water Chestnut also makes swimming and boating impossible, and the seeds can cause injury if stepped upon.

In this activity, students will learn about the issues with Water Chestnut invasions and will work together to create an action plan to organize an eradication event for a local waterway.

Procedure:

Engage

1. Begin the activity by asking students what are some things they can do as a high-school student to help benefit the environment.
 - a. Expected Responses: *Pick up trash, turn off the lights, write letters.*
2. Many responses will likely be very general and will be removed from the environment itself. The teacher should take this opportunity to get the students excited about doing something hands on. Some questions or leading statements might include:
 - a. What if you could do more?
 - b. What if there were issues that you could solve in your own backyard?
 - c. Would you be willing to participate?
 - d. Would you be willing to take a leadership role?
3. Following the discussion, have students watch the U.S. Fish and Wildlife Service video on Water Chestnut (<http://www.youtube.com/watch?v=CusWGXINMjA>). Hand out the Student Page and have students answer the provided questions. Go over answers with students.

Explore

1. Challenge students to make a difference in their own community by creating a local action plan for a Water Chestnut eradication day.
2. Split students into groups of 2-3 and provide each with the following scenario:
 - a. Just as the U.S. Fish and Wildlife Service was asking for volunteers, your state natural resource agency also needs volunteers to harvest Water Chestnut from invaded streams. You and your team will be responsible for planning and carrying out an all-day eradication event in a local waterway.

- b. Note: Depending on the capability and focus of your students you may want to assign group members specific roles. Examples- Publicity Manager, Material Coordinator and/or Volunteer Coordinator*
3. Review the rubric so all students are aware of the necessary requirements and expectations
4. Allow students time to research the problems associated with Water Chestnut and the materials needed for an eradication event. They should begin filling in the Action Plan Template provided in the Student Resource Sheets.
5. Towards the end of class, groups should be encouraged to check in with each other and collaborate on ideas and materials needed.
6. Following their research, have students create materials needed for their eradication event. At a minimum, the materials should include:
 - a. Completed action plan
 - b. Flyer-to inform the public of the event and its environmental importance
 - c. Materials list- should include possible partnerships
 - d. Budget considerations (optional)- As an extension of math and financial literacy, students can be asked to create a budget for the event given a certain amount of money
7. Have students arrange their action plan in a binder, folder, or scrapbook to be submitted for 'review'. If able, classes are highly encouraged to partner with their state natural resource agency or local invasive species task force to create real-world Action Plans.

Explain

1. What are the problems associated with Water Chestnut invasions?
2. While eradicating Water Chestnut, what issues do you need to consider and be aware of in order to have a successful event?
3. How will you get others involved in the project?

Evaluate

1. Evaluate student's action plans using the provided rubric.

Extend

1. If Water Chestnut is not local to your school or center, then have students research another invasive species that is local. Create an eradication plan for that species instead.

Eradication Nation

At this time, the problems of the world can be overwhelming and solutions may seem impossible. However, we all have to remember that if we each do our part, then our environment can be a better place. Our environment needs YOU to help stop the spread of the Water Chestnut!

As you view the video presented by your teacher, answer the following questions

1. Based on the video footage, what environmental problems do think Water Chestnuts can cause in aquatic ecosystems?

2. What are 2 techniques used to remove Water Chestnuts?

3. How can YOU get involved?

Scenario:

Just as the United States Fish and Wildlife Service was asking for volunteers to help remove the Water Chestnut in the video, your state natural resource agency is searching for an eradication event coordination team for your area. You and your team will be responsible for planning and carrying out the all-day eradication event in one of your local streams.

Eradication Nation: Action Plan Template

Time and Site Details

Name of site _____ Date and Time of Event _____

Description of Site

Expected Number of Volunteers _____

Expected Number of Spectators _____

Amenities available to volunteers (food, bathrooms, etc.). If budget is included, then add projected costs.

Description of Environmental Issue

What environmental issue is your event targeting? Why is it important?

Environmental Goals and Targets

What do you hope to achieve through your event? How will you measure event success? Be as specific and reasonable as possible.

Stakeholders and Partnerships

Besides your volunteers, what groups will you reach out to in order to make your event a success? Who will be interested in the success of the event?

Materials Needed for the Event

Environmental and Safety Impacts

What environmental impacts could your event have? What potential problems could arise?

Volunteer Training

Who will make up your event staff? What will their responsibilities be?

Staff Member	Description of Responsibility

How will you train your volunteers to safely remove the Water Chestnut plants? (Include any training materials you will use!)

Publicity Plan

How will you make people aware of your event? How will they know if you are successful? (Include any publicity materials that you will use for flyers and social media!)

Note: Be sure to include citations for information sources and add supplemental information to your final action plan.

Water Chestnut Eradication Action Plan Rubric

Group Name: _____

Category	4	3	2	1
Quality of Action Plan	The action plan contains all required parts including volunteer training materials and publicity materials. It closely follows the template and is easy to comprehend	The action plan contains most required parts including volunteer training materials and publicity materials. It can be understood.	The action plan contains most required parts including volunteer training materials and publicity materials. It lacks organization and can be difficult to understand.	The action plan is missing several of the required components. It lacks organization and is difficult to understand.
Clarity	The action plan contains a complete list of environmental goals and targets. Topics are organized in a clear progression.	The action plan contains a complete list of environmental goals and targets. Topics are organized in a mostly clear progression.	The action plan contains a partial list of environmental goals and targets. Topics are organized in a somewhat clear progression.	The action plan goals and targets are incomplete and disorganized.
Supplemental Materials- Publicity Plan	The publicity materials are well organized and engaging for the public and volunteers. They would be highly successful in drawing people to the event.	The publicity materials are well organized but lack engagement. They would be successful in drawing people to the event.	The publicity materials demonstrate a lack of preparation and understanding. They lack creativity and would be minimally successful at drawing people to the event.	The publicity materials exist, but lack organization and creativity. They would not be successful in drawing people to the event
Supplemental Materials- Volunteer Training	The training materials are well organized and engaging for the public and volunteers.	The training materials are well organized but lack engagement.	The training materials demonstrate a lack of preparation and understanding. They lack creativity.	The training materials exist, but lack organization and creativity.
Sources-Citation	All sources are properly cited at the conclusion of the plan. All sources are reliable.	Sources are improperly cited at the conclusion of the plan. All sources are reliable.	Some sources are improperly cited at the conclusion of the plan. Most sources are reliable.	Few sources are cited at the conclusion of the plan and few sources are reliable.

Green Crabs Bring in the \$Green\$

Gr: 6-8

Objectives: At the conclusion of the lesson, students will be able to:

- Understand the potential impacts of the European Green Crab on the Mid-Atlantic
- Explain the current methods of controlling invasive species
- Develop proposals for innovative control methods for the European Green Crab

Standards:

NGSS	<p>MS-LS2-1 - Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.</p> <p>MS-LS2-5 - Evaluate competing design solutions for maintaining biodiversity and ecosystem services.</p>
Core Idea	<p>LS2.A: Interdependent Relationships in Ecosystems - Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors. In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction. Growth of organisms and population increases are limited by access to resources.</p> <p>LS2.C: Ecosystem Dynamics, Functioning, and Resilience - Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.</p>
Practices	<ul style="list-style-type: none"> • Analyzing and Interpreting Data • Engaging in Argument from Evidence
Cross-Cutting Theme	<ul style="list-style-type: none"> • Cause and Effect • Stability and Change
Reading, Writing & Social Studies	<p>CCSS.ELA-LITERACY.RST.6-8.8 - Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.</p> <p>CCSS.ELA-LITERACY.W.6.2 - 8.2 - Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.</p> <p>CCSS.ELA-LITERACY.W.6.9 - 8.9 - Draw evidence from literary or informational texts to support analysis, reflection, and research.</p> <p>CCSS.ELA-LITERACY.SL.6.5 - Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.</p> <p>CCSS.ELA-LITERACY.SL.7.5 - Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points.</p> <p>CCSS.ELA-LITERACY.SL.8.5 - Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add</p>

	interest.
Environmental Literacy	1.A.1: Identify an environmental issue. 4.C.1: Explain how the interrelationships and interdependencies of organisms and populations contribute to the dynamics of communities and ecosystems. 5.A.2: Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes 7.E.1: Analyze and explain global economic and environmental connections

Green Crabs Bring in the \$Green\$

Gr: 6-8

Objectives: At the conclusion of the lesson, students will be able to:

- Understand the potential impacts of the European Green Crab on the Mid-Atlantic
- Explain the current methods of controlling invasive species
- Develop proposals for innovative control methods for the European Green Crab



Materials:

- Board
- Internet access
- Materials for creating poster or brochure

Teacher Background: European Green Crabs (*Carcinus maenus*) are small crabs, measuring 2-3 inches in width. They are not always green but may be green, brown, gray, or red, depending on the environment and the crab's molt cycle. Green Crabs also have yellow patches on their abdomen. Like most invasive species, Green Crabs are extremely adaptable. They can tolerate temperatures ranging from 30-85° F (5-30° C) and salinities ranging from 5-30 ppt. Females can produce 200,000 eggs each year. They prey on many commercially valuable native species - scallops, hard and soft clams, oysters, mussels, other crustaceans, and juvenile fish. Adult crabs tend to occupy protected rocky shores or jetties and forage in tidal marshes and sandflats.

The Green Crab's native range includes the Atlantic coasts of Europe and North Africa, but they have been introduced to South Africa, South America, Australia, New Zealand, and both the Atlantic and Pacific coasts of the United States. They were first seen in the United States in the early 1800s and may have arrived in ballast water or by clinging to the hulls of wooden ships. They have now spread as far north as Nova Scotia and as far south as the mouth of Chesapeake Bay and the Delmarva Coastal Bays.

While it is difficult to actually calculate the total cost of invasive species, including control methods, eradication efforts, and damages to native ecosystems, it is known that states all across the country are spending billions of dollars each year to stem the effects of these alien invaders. Currently in the United States, invasive species cause an estimated \$120 billion of economic losses due to damages every year (Pimental et. al 2005). Common control methods typically include chemical, mechanical, and biological processes such as herbicides, physical removal or destruction of invasive organisms, and the introduction of living predators to combat the target species. However, there is no cure-all for this issue and each control method has its own drawbacks.

Another control method is currently being employed and could prove effective on certain species. That method is the creation of a market to utilize and actually profit from the invasive plants and animals. A 2011 New York Times article titled, “Answer for Invasive Species: Put It on a Plate and Eat It” suggests the re-branding of certain invaders such as the lionfish, Asian carp, and European Green Crab, from worthless nuisance to delicious delicacy and marketing these species for human consumption. Other markets include the sport fishing industry, use in commercial fishing as bait, and use in the manufacturing of various products. Again, this method of control does not seem to be the perfect fix as much debate has risen over the end result, claiming that profiting from invasive species could create the incentive to encourage the spread of these organisms instead of eliminating them.

In this activity, students will learn about the issues with Green Crab invasion and will create a marketing campaign to make the harvest of crabs profitable.

Sources:

Pimentel, D., Zuniga, R., and D. Morrison. 2005. Update on the environmental and economic cost associated with alien-invasive species in the United States. *Ecological Economics* 52. pp 273-288

Procedure:

Engage

1. Introduce the topic of **invasive species** through a brainstorming activity having students name all of the invasive species they can think of in the United States today. Well-known invaders that have been in recent news include Zebra Mussels, Snakeheads, Lionfish, and European Green Crabs. For more examples consult the Center for Invasive Species and Ecosystem Health at <http://www.invasive.org> List student ideas on the board.
2. Ask students in what ways could some of those invasive species be controlled? Make a list of brainstorms on the board.
3. Ask students if different control methods may be costly. Why or why not?
4. Ask students if they think there could be any way to make money from invasive species. Why or why not?
5. Introduce the different types of control methods: chemical, mechanical, and biological, briefly discussing the pros and cons of each.
6. Introduce ideas on how invasive species can be marketable. Ask students what they think about marketing invasives for a profit. The following web pages show ideas:
 - a. Creative Uses for Invasive Plants: <http://www.ecolandscaping.org/07/invasive-plants/creative-uses-for-invasive-plants/>
 - b. Eat the Invaders: <http://eattheinvaders.org/>

- c. Making the Best of a Bad Situation: Rethinking Invasive Species:
<http://theecotoneexchange.com/2014/04/08/making-the-best-of-a-bad-situation-rethinking-invasive-species/>
7. Explain to students that they will be focusing on the European Green Crab and its potential impact on the Chesapeake Bay. Watch the Youtube video (https://www.youtube.com/watch?v=r070MII_krY) so students gain a better understanding of how the Green Crab takes over and the damage it has caused in New England.

Explore

1. Tell students a new start-up company (fictional) operating in the Mid-Atlantic States is hoping to effectively control the spread of the European Green Crab through the creation of a profitable market. While this company has the necessary man-power and infrastructure to harvest the crabs, it needs to determine the most successful method for marketing Green Crabs to the public.
2. Assign the students to research teams of 3-4 and have them create a marketing campaign for the company. The students should carry out their own web search in order to gather information about the biology and spread of the crabs as well as potential uses. Once the information has been gathered, the research teams should decide on one profitable use for the crabs and create marketing materials in the form of a poster, video, or brochure. Possible uses include lobster or other fishing bait, human consumption, and aquaculture but other creative ideas should be encouraged. Try to have them be specific to the Mid-Atlantic region. Items that should be considered by the research teams are:
 - i. Audience – restaurants, commercial fisheries, general public, etc.
 - ii. How to identify the crabs
 - iii. Why the market is being created – to help control an invasive species
 - iv. Harvesting methods – traps, by hand, live crabs, dead crabs, etc.
 - v. Benefits of using crabs

** A possible variation would be to have one group represent the anti-market campaign and create materials that argue against using invasive species for profit.*

Explain

1. After the teams have created their marketing materials, they should take turns presenting to the rest of the class. Encourage students to ‘dress the part’ for their marketing presentation.
2. Tell each group in the audience that they represent investors and can be given an imaginary amount of money to invest in the other campaigns. The groups can invest all of their money in one plan or spread it around among the plans but they must provide reasoning for their decisions.
3. Allow other groups to ask questions.

Evaluate

1. Lead a discussion on the pros and cons of using market creation for the control of invasive species. What are the benefits to this method? What are the drawbacks? What information must be taken into consideration by invasive species' biologists in creating management plans? If time allows, this can take the form of a debate.

Extend

1. Mechanical Control Method (STEM extension) – research different methods of mechanical control and have students invent a mechanism specific to the control or eradication of European Green Crabs

Let's Harvest Water Chestnut!

Gr: 6-8

Objectives: At the conclusion of the lesson, students will be able to:

- Understand the problems with Water Chestnut invasion
- Create an informational brochure on Water Chestnut removal

Standards:

<p>NGSS</p>	<p>MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services. MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.</p>
<p>Core Idea</p>	<p>LS4.D: Biodiversity and Humans - Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on.</p>
<p>Practices</p>	<ul style="list-style-type: none"> • Constructing explanations and designing solutions • Obtaining, evaluating, and communicating information
<p>Cross-Cutting Theme</p>	<ul style="list-style-type: none"> • Cause and effect: mechanisms and explanation
<p>Reading, Writing & Social Studies</p>	<p>CCSS.ELA-Literacy.RI.6.1 Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. CCSS.ELA-Literacy.RI.6.2 Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments. CCSS.ELA-Literacy.W.6.1 Write arguments to support claims with clear reasons and relevant evidence. CCSS.ELA-Literacy.W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. CCSS.ELA-Literacy.W.6.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. CCSS.ELA-Literacy.RI.7.1 Cite several pieces of textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text. CCSS.ELA-Literacy.W.7.1 Write arguments to support claims with clear reasons and relevant evidence. CCSS.ELA-Literacy.W.7.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content. CCSS.ELA-Literacy.W.7.4 Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. CCSS.ELA-Literacy.RI.8.1 Cite the textual evidence that most strongly</p>

	<p>supports an analysis of what the text says explicitly as well as inferences drawn from the text.</p> <p>CCSS.ELA-Literacy.RI.8.2 Determine a central idea of a text and analyze its development over the course of the text, including its relationship to supporting ideas; provide an objective summary of the text.</p> <p>CCSS.ELA-Literacy.W.8.1 Write arguments to support claims with clear reasons and relevant evidence</p> <p>CCSS.ELA-Literacy.W.8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.</p>
Environmental Literacy	<p>5.A.1: Analyze the effects of human activities on earth’s natural processes.</p> <p>5.A.2: Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes.</p> <p>7.A.1: Investigate factors that influence environmental quality.</p> <p>7.B.1: Examine the influence of individual and group actions on the environment and explain how groups and individuals can work to promote and balance interests through.</p>

Objectives: At the conclusion of the lesson, students will be able to:

- Understand the problems with Water Chestnut invasion
- Create an informational brochure on Water Chestnut removal

Materials:

- Computers with Internet access
- Student Page on brochure guidelines (on CD)
- Brochure rubrics (on CD)
- Pictures of Water Chestnut (on CD)
- Water Chestnut fruit specimen (in kit)

Teacher Background: Water Chestnut (*Trapa natans*) is an annual, aquatic plant found May through November. Thread-like submersed leaves are arranged alternately on the lower portions of leaf stalks. Water Chestnuts can be free-floating or firmly rooted to the substrate, and they can grow in depths of 2 to 16 feet, but do best in 2 to 6 feet of water. It has a shiny green fan-shaped leaf that is toothed near the tips. It is in the same genus as *Trapa bispinosa*, the species used in Asian cuisine.

In mid-May, the central rosettes emerge from the water. In mid-June, secondary rosettes emerge, with central rosettes forming flowers. By early July, the secondary rosettes are flowering and mature seeds are already viable on central rosettes. In late July, hundreds of viable seeds are present on each plant.

Water Chestnut, native to Asia, was introduced to North America near Concord, Massachusetts in 1859. Within a few years, it had taken over large areas of northern New York waterways, and by 1920, it had made its way south to the Potomac River. In 1923, a geologist from a national museum found it in Oxon Run, across the Potomac from Alexandria, Virginia. From there, it took hold in Hunting Creek and covered 35 miles of river. In 1938, the Washington, D.C. Chapter of the Izaak Walton League held its first meeting, gaining congressional support for removal of this rapidly spreading invasive. In 1939, the first aquatic plant harvesting machine was developed by the U.S. Army Corps of Engineers (USACOE). By 1944, 12 machines were in use and the USACOE Washington District had cleared 40 miles of river. Water Chestnut removal efforts in the Potomac River ultimately required \$2.8 million dollars in today's money.

Why is Water Chestnut a problem? Its prolific growth and spread makes it almost impossible to navigate infested waterways. The spiny fruits also can pierce feet of swimmers, boaters, and anglers. Few wildlife species consume the plant. Water Chestnut infestations can also impede the growth of native species of **submerged**

aquatic vegetation (SAV) by creating dense mats that block available sunlight. SAVs provide critical food and habitat for native fish, invertebrates, and birds. SAVs also are crucial to good water quality. When SAV beds are lost, the ecosystem services provided by the beds are also lost. Additionally, Water Chestnut infestations create breeding grounds for mosquitoes.

Water Chestnut can be managed chemically or mechanically. Herbicides such as 2, 4-D can be used to keep plants under control, but this technique also may kill native vegetation. Plants also can be pulled by hand or mechanical harvesters can be used. Mechanical harvesters have cutting blades on the front and sides of the boat. They are lowered as deep as possible into the water, and as the boat moves forward, the blades on the sides and bottom cut the roots and bring them in the boat along a conveyor belt. Once the harvester has reached capacity, it unloads the material from the rear conveyor onto land or onto smaller boats. The harvester continues this process until most of the surface is clear of plants. While this process does leave some root material, it removes nearly all of the biomass and frees up the water for navigation.

When using smaller vessels, it is easier to reach into the water and pull the root out of sediment by hand. This removes the entire plant, and while it is more time consuming, it is much more effective. Crews of biologists and volunteers can paddle into shallow tributaries and remove every plant that is visible.

In this activity, students will learn about the impacts of Water Chestnut and will create informational brochures to teach the public on ways to control Water Chestnut.

Procedure:

Engage

1. Before the lesson, have students bring in samples of informational brochures. These can include flyers, pamphlets, or booklets. Have students point out what they liked and didn't like about the brochures. Ask what the purpose of the brochure was, and if it achieved that purpose. Have students explain their answers.
2. Ask students to close their eyes and imagine a local river that may have visited or seen pictures of. Describe its features such as the types of plants and wildlife found there. Were there any plants floating on the surface of the water? If so, did the plants cover much of the surface?
3. Show students pictures of waterways clogged with Water Chestnut. Ask if this could be a problem and have students explain their answers.
4. Tell students that the plant in the pictures is the invasive Water Chestnut. Go over the definitions of native and invasive species with your students.

5. Tell students Water Chestnut was introduced from Asia. Show students pictures or specimens of the spiky fruits. Ask students if they would want to swim or fish in the river with Water Chestnut.
6. Tell students that Water Chestnut was introduced to 35 states and is now a large problem in many areas.
7. Explain to students that they will have to research information on Water Chestnut to create informational brochures to inform the public about the problems with Water Chestnut and how the public can help.

Explore

1. Pass out brochure guidelines and review the grading rubric with the class. Have students work individually or in teams to design the brochures. Remind students that their ultimate goal is to inform the public about the problems with Water Chestnut and how they can stop the spread.

Explain

1. Have students share interesting information they researched.
2. Have students share brochures with classmates and consider passing out copies in your local community.

Evaluate

1. Evaluate brochures using attached rubric.

Extend

1. Research and map out invasive species in your schoolyard. Create a Google Earth map or drawing of the different locations of invasive plants.
2. Organize an invasive plant removal at school or encourage students to participate in an invasive plant removal in a local park or nature center.

Let's Harvest Water Chestnut!

Water Chestnut (*Trapa natans*) is an aquatic, invasive species introduced from Asia. Its prolific growth and spread makes it almost impossible to navigate infested waterways. The spiny fruits also can pierce feet of swimmers, boaters, and anglers. Few wildlife species consume the plant. Water Chestnut infestations can also impede the growth of native species of **submerged aquatic vegetation** (SAV) by creating dense mats that block available sunlight. SAVs provide critical food and habitat for native fish, invertebrates, and birds. SAVs also are crucial to good water quality. When SAV beds are lost, the ecosystem services provided by the beds are also lost. Additionally, Water Chestnut infestations create breeding grounds for mosquitoes.



For this assignment, you will create an informational brochure to encourage people in your community to remove Water Chestnut from local waterways.

Create a Brochure that Discusses:

1. Basic information on Water Chestnut including brief identification characteristics
2. Impacts of Water Chestnut
3. Ways to help stop the spread of Water Chestnut

Brochures should include the following:

1. Title
2. Headings
3. Pictures with captions
4. Graphs (if applicable)
5. Maps
6. Diagrams
7. Citations for information sources

Informational Brochure Rubric

	4	3	2	1	Score
Organization W.7.2a	Topic is clearly introduced and ideas are organized.	Topic is not clearly introduced but ideas are organized.	Topic is not clearly introduced and ideas are disorganized.	No clear topic or organization present.	
Content W.7.2b	Information is accurate, clear, and well developed. Depth of content is evident.	Information is accurate, clear, and covers the content.	Information is usually accurate and clear. Information covers some of the elements of content but not others.	The information is inaccurate and may not address content.	
Writing W.7.4	Clear and coherent writing in which the development and style are appropriate to task, purpose, and audience.	Writing mostly clear and coherent. Development and style mostly are appropriate to task, purpose, and audience.	Writing somewhat clear and coherent. Development and style are somewhat appropriate to task, purpose, and audience.	Writing is not clear. Development and style are lacking.	
Critical Thinking RST.6-8.1	Topic fully researched. Consistently used and properly cited primary sources.	Topic has been researched and most sources are properly cited.	Basic research is evident. Sources are not properly cited.	No evidence of research.	
Design	High quality graphics are used, and contain appropriate captions. Community Action	Good quality graphics are used and contain appropriate captions.	Fair quality graphics are used and may contain appropriate captions.	Poor quality images are used, or no images are used. Captions lacking.	303

Lose the Loosestrife

Gr: 3-5

Objectives: At the conclusion of the lesson, students will be able to:

- Describe the differences between native and invasive species
- Understand problems with Purple Loosestrife invasions
- Write a persuasive letter to discourage the sale of invasive plants by local nurseries

Standards:

NGSS	3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
Core Idea	LS4.D: Biodiversity and Humans - Populations live in a variety of habitats, and change in those habitats affects the organisms living there.
Practices	<ul style="list-style-type: none">• Planning and carrying out investigations• Constructing explanations and designing solutions• Obtaining, evaluating, and communicating information
Cross-Cutting Theme	<ul style="list-style-type: none">• Cause and effect: mechanisms and explanations• Stability and change
Reading, Writing & Social Studies	<p>CCSS.ELA-Literacy.RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.</p> <p>CCSS.ELA-Literacy.RI.3.10 By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2–3 text complexity band independently and proficiently.</p> <p>CCSS.ELA-Literacy.RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.</p> <p>CCSS.ELA-Literacy.RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.</p>
Environmental Literacy	<p>1.A.1- Identify an environmental issue</p> <p>1.B.1 - Use recommendations to develop and implement an environmental action plan</p>

Objectives: At the conclusion of the lesson, students will be able to:

- Describe the differences between native and invasive species
- Understand problems with Purple Loosestrife invasions
- Write a persuasive letter to discourage the sale of invasive plants by local nurseries

Materials:

- Ball of yarn
- Board
- Internet access
- List of Invasives Commonly Sold in Nurseries (on CD)
- Magazine or newspaper articles with local wetland species
- Alternatives for Invasive Ornamental Plant Species (optional; on CD)
- Pictures of Purple Loosestrife (on CD)

Teacher Background: Purple Loosestrife (*Lythrum salicaria*) was first imported into the United States in the 1800s for use as an ornamental and for traditional medicine. Since its introduction, Purple Loosestrife has rapidly spread throughout the United States and is now labeled as ‘noxious’ by several states. Some states even ban the sale of it!

Purple Loosestrife invades wetland habitats. This invasion can result in the suppression of the native plant community which ultimately impacts the animals which depend on the plants. Purple Loosestrife has been documented crowding out at least 44 kinds of native grasses, sedges, and other flowering plants that offer higher-quality nutrition for wildlife. The plant competes with native wetland plant species including some federally endangered orchids and swamp rose mallow, and it reduces habitat for waterfowl. Declining species directly affected by its invasion are the bog turtle, black tern, and canvasback duck. Large stands of Purple Loosestrife also can alter soil chemistry, making the environment more favorable for Purple Loosestrife to grow. Adult plants can produce up to 2 million seeds annually which are dispersed by water, sediment, and animals. Annually, over \$45 million a year is spent on habitat restoration and control methods relating to Purple Loosestrife.

Unfortunately, despite the problems Purple Loosestrife causes, it is still sold in some nurseries across the United States. Other invasive plant species like Japanese Barberry, Bradford Pear, and English Ivy also are commonly sold as ornamentals.

In this activity, students will learn about the impacts of invasive plants like Purple Loosestrife and then will write persuasive letters to local nurseries to discourage the sale of invasive plants.

Procedure:

Engage

1. Ask students if they can name any native plants or animals found in local wetlands. You may have to define what a native species is before the brainstorming session. You also may want to provide newspaper or magazine articles to help students with creating a list. List ideas on the board.
2. Ask students if they have ever seen any of those species. Can they describe them?
3. Pick one of the species students listed on the board. (*Note: It is best to choose a species that the most students can identify with*). Ask students what would happen if that species disappeared? How would they feel? What impacts would its loss have?
4. Tell students that sometimes non-native species are introduced into new areas and cause problems. These species are known as **invasive species**. The introduction of invasive species can sometimes lead to the disappearance of native species.
5. To demonstrate this point, have students form a circle. Have 1 student hold the end of a ball of yarn and then toss the yarn across the circle to another student. Continue until all students are holding a section of yarn and a web is formed.
6. Tell students that one invasive species found in wetlands is Purple Loosestrife. When Purple Loosestrife invades wetlands, it crowds out native plants and the loss of the plants affects the wildlife that depend on the native plants.
7. Have the girls in the class slightly tug on the yarn. This tugging represents Purple Loosestrife invading the wetland.
8. Have the boys let go of the yarn. This release represents the loss of native species in the ecosystem web.
9. Discuss that when a change happens in an ecosystem web, it affects everything connected by the web. In this case, the Purple Loosestrife had a negative effect on the web.

Explore

1. Show students pictures of Purple Loosestrife. Have students read the Student Page 'All About Purple Loosestrife'. After the reading, ask the following questions:
 - a. What is an invasive species?
 - b. Why is Purple Loosestrife invasive?
 - c. How can you identify Purple Loosestrife?
 - d. How can you stop Purple Loosestrife invasions?

2. Tell students that many states have banned the sale of Purple Loosestrife, but other invasive plants are still often sold in nurseries. These plants include species such as Japanese Barberry, Bradford Pear, English Ivy, and Chinese Silvergrass.
3. Tell students that they should visit a local plant nursery (either in person or online) to see if the nursery is selling invasive plants. You may want to review the 'List of Invasives Commonly Sold in Nurseries' and select a couple of species for students to focus upon. Have students write down the invasive plants being sold.
4. After the nursery visit (or research), write down the different invasive plants seen at the nurseries. Ask students how this makes them feel. What could students do to educate the public about these species?

Explain

1. Have students research basic information about the invasive plants they encountered for sale. Tell students to focus on the impacts these plants have in their introduced environments. Encourage students to find native alternatives to these commonly sold invasive plants. For ideas, review the 'Alternatives for Invasive Ornamental Plant Species'.
2. Following their research, students should write a persuasive letter to the nursery (or nurseries) to encourage the nursery to not sell invasives. Tell students about successful writing campaigns, like the students in New Hampshire which were able to nominate the State Amphibian through a letter writing campaign. Use the provided template or create your own.

Evaluate

1. Evaluate student's persuasive letters. Grade letters based on the following:
 - Issue clearly identified
 - Two or more points provided with support
 - Opinion summarized
 - Organization
 - Mechanics and grammar properly used

Extend

1. Have students create seed packs or seed balls with native seeds that they can hand out to friends and family members. Use the provided template or have students create their own.
2. Have students grow native plants in the classroom and then distribute plants with information to other students, friends, and family members.

Student Page: All About Purple Loosestrife

Purple Loosestrife is an **invasive species**. Invasive species are non-native species that cause problems.

Purple Loosestrife was brought over from Europe. It was planted in gardens, and some plant stores (nurseries) still sell it today. Purple Loosestrife likes to grow in wet soils. It can grow along lakes, rivers, wetlands, and ditches. Purple Loosestrife has red-purple flowers and a square-shaped stem. It can grow 2-7 feet tall and can produce over a million seeds!

Purple Loosestrife can cause problems. It can spread and crowd out native plants. The loss of native plants means that some animals will lose their food supplies. Purple Loosestrife also doesn't provide good shelter for many animals, either.

To prevent the spread of Purple Loosestrife, you can:

- plant native plants at your house and school
- remove Purple Loosestrife from local wetlands
- teach friends and family about invasive species



Wetland invaded by Purple Loosestrife by Liz West, Wikimedia Creative Commons

Student Page: Persuasive Letter Template

Now that you know more about invasive species and the problems they cause, write a persuasive letter to a local nursery. The letter should include the following information:

Nursery Name

Street Address

City, State Zip Code

Greeting

Body

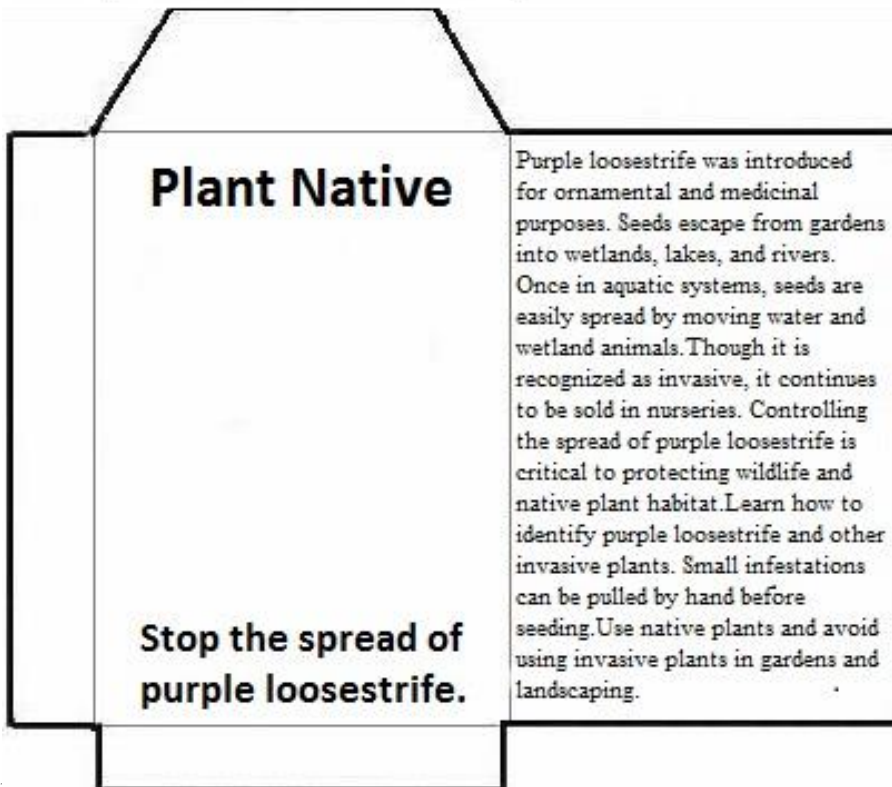
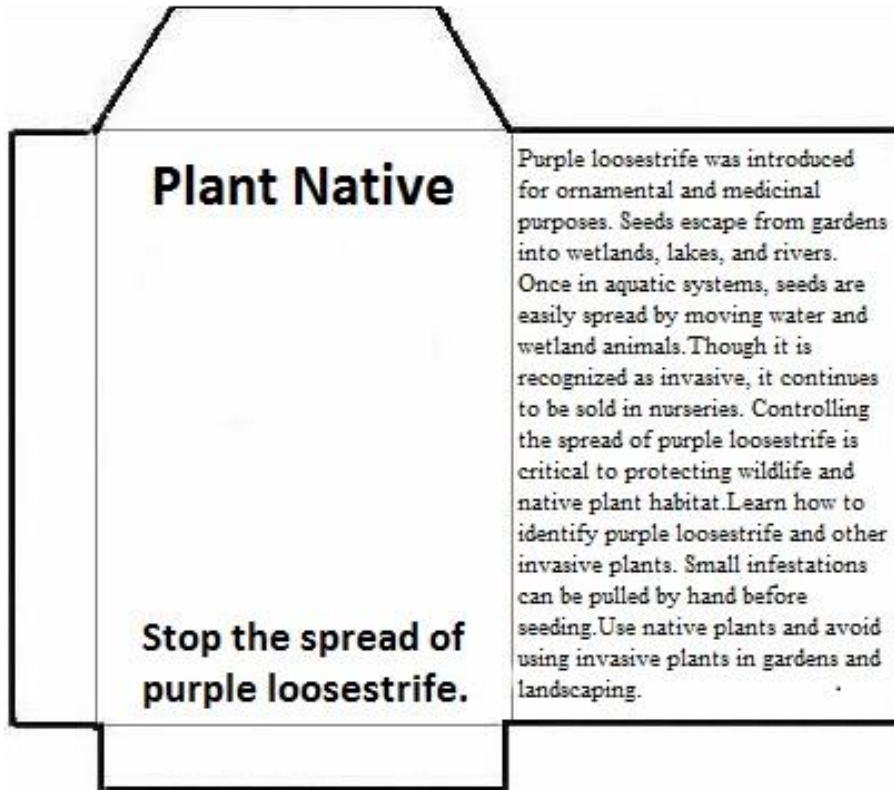
1. What is the problem?
2. Why are changes needed? Provide 2 examples.
3. How can we fix the problem? Suggest other plants to sell.
4. Closing

Signature

Printed Name

Seed Packet Template

Have students write the name of and draw the native plant whose seeds are being given away. Cut along edges of template, fold text summary inward then fold bottom and side flaps. Tape flaps. Add seeds then fold and tape top flap.



No Aquatic Invasives

Gr: 3-5

Objectives: At the conclusion of the lesson, students will be able to:

- Describe the differences between native and invasive species
- Explain how aquatic invasive species are harmful to ecosystems
- Create a newspaper on local invasives

Standards:

NGSS	3-LS4-4 - Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change. 5-LS2-1 - Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment
Core Idea	3-LS2.C: Ecosystem Dynamics, Functioning, and Resilience - When the environment changes in ways that affect a place's physical characteristics, temperature, or availability of resources, some organisms survive and reproduce, others move to new locations, yet others move into the transformed environment, and some die. 5-LS2.A: Interdependent Relationships in Ecosystems - The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants... A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.
Practices	<ul style="list-style-type: none">• Obtaining, evaluating, and communicating information
Cross-Cutting Theme	<ul style="list-style-type: none">• Cause and effects: mechanisms and explanation• Stability and change
Reading, Writing & Social Studies	CCSS.ELA-Literacy.RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. CCSS.ELA-Literacy.RI.3.10 By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2-3 text complexity band independently and proficiently. CCSS.ELA-Literacy.RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text. CCSS.ELA-Literacy.RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.
Environmental Literacy	1.A.1 - Identify an environmental issue

Objectives: At the conclusion of the lesson, students will be able to:

- Describe the differences between native and invasive species
- Explain how aquatic invasive species are harmful to ecosystems
- Create a newspaper on local invasives

Materials:

- Board
- Green Invaders article (on CD)
- Internet access
- Playing field

Teacher Background: **Invasive species** are non-native species that cause environmental, economic, and/or human health related harm. In contrast, non-native or **exotic** species are those which have been introduced from another area. Not all exotic species are invasive.

Invasive species of plants, animals, and pathogens affect our every day life, often in very visible ways as they change our natural landscape, but many times in ways that are not readily apparent to the public. They are one of the major threats to native plants and wildlife, particularly those which are threatened or endangered. Annual losses due to aquatic invasive species in the Great Lakes region alone have been estimated to cost at least \$200 million. Invasives of every type have spread as a result of animal activity, water and wind; but human actions, whether intentional or accidental, are a primary cause. As our native flora and fauna, their habitats, and human health continue to be affected by the spread of exotic invasive species, we must find more effective ways to engage the public in understanding their role in causing – and more importantly, in reducing – these threats to our ecological, economic, and human welfare. One way to do that is through outreach and education.

In this activity, students will learn background information on invasive species and will then create a newspaper on aquatic invasive species to distribute.

Procedure:

Engage

1. Have students read the National Geographic article on “Green Invaders”.
2. After reading, ask students the following questions:
 - a. What are green invaders?

- b. How do green invaders spread?
 - c. Why are green invaders a problem?
 - d. Do you think only plants can be invaders?
3. Following the reading, write 'native', 'exotic', and 'invasive' on the board. Discuss the definitions of those terms with students and brainstorm what students think about when they hear those words.
4. After the discussion, tell students they are going to model how invasive species can quickly spread through a game of tag.
5. Set up a large playing field outside or in a gym.
6. Assign approximately 1/3 of the class as 'invasive species' while the rest of the students are 'native species'. Write down the initial number of native versus invasive species.
7. Have the 'native species' spread throughout the playing field and have the 'invasive species' wait on the edges. Tell the 'invasive species' that their goal is to tag as many 'native species' as possible. When 'native species' are tagged, they become an 'invasive species'. Allow students several minutes to play, and then end the activity. Tally the number of 'native species' and the number of 'invasive species'. Compare the new numbers with the old ones. Ask students to explain what happened. Be sure that students understand that the native species did not turn into invasive species but that the native species were replaced in the ecosystem by the invasive species.
8. Tell students the 'natives' were milkweed and the 'invasives' were a plant known as Purple Loosestrife. Ask students how the decrease of milkweed in the area might affect other species. (*They might know about the relationship between milkweed and monarch butterflies.*)
9. Explain to students that native animals depend on native plants and vice versa. With the loss of native species due to invasives, the food web can be negatively impacted.

Explore

1. Tell students that they are now tasked with creating a newspaper to tell their community about aquatic invasive species. Provide copies of newspapers and age-appropriate articles for students to explore.
2. As a class, go through the different elements in each newspaper and discuss what the students like and don't like. Go over the newspaper article sections like the title, lead/headline, who, what, why, when, and where, etc. Work with students to identify these sections so they understand how news articles are constructed.
3. Allow students time to research aquatic invasive species in their state. You can allow students to find their own list of invaders, or you can provide a list. Species to consider include Northern Snakehead, Purple Loosestrife, Rock Snot, Water Chestnut, Zebra Mussel, etc. The Wisconsin Environmental Education for Kids (EEK) website is a great resource:

<http://dnr.wi.gov/org/caer/ce/eek/earth/aliens.htm> If they are doing their own research, check to make sure that the species they choose is truly invasive in their state and not invasive somewhere else.

4. Tell students they should gather background information about their species including the problems it causes in the environment and how people can stop its spread. Encourage students to ask themselves what they would like to teach other people about aquatic invasive species.
5. Hand out the Student Page on the Newspaper Story Format. Tell students to use this page to brainstorm ideas for their article.
6. After completing the Newspaper Story Format page, students should begin writing their article. Encourage students to include at least one photo and a caption with their article.

Explain

1. After completing articles, students should present a summary of their articles to the rest of the class. Encourage other students to ask questions to learn more from their peers.
2. As a class, brainstorm a title for your newspaper. Have students pitch ideas and then vote on the titles that they like the best.
3. Once a newspaper title has been selected, assemble the articles together. You can use online programs like <http://www.makemynewspaper.com/> to create digital documents, or you can assemble hard copies of the articles.
4. Have students distribute their newspaper to others in their school or at a local park, etc.

Evaluate

1. Use the rubric at the end of the lesson to evaluate student learning.

Extend

1. Have students create product ads for tools to remove or control invasive species to place in their newspaper.
2. Have students use online tools like the Discovery Puzzle maker to create puzzles, crosswords, and mazes to include in their newspaper.

Student Page: Green Invaders

Catherine Clarke Fox

Green invaders are taking over America. Nope, not invaders from space. Plants. You might not think of plants as dangerous, but in this case they are threatening nature's delicate food web.

The invaders are plants from other countries brought here to make gardens and yards look pretty. Ever since people started to arrive on America's shores, they've carried along trees, flowers, and vegetables from other places.

Now there are so many of those plants, they are crowding out the native plants that have lived here since before human settlers arrived.

And that's a problem, says Dr. Doug Tallamy. He's an entomologist (an insect expert) at the University of Delaware. He explains that almost all the plant-eating insects in the United States – 90% of them – are specialized. That means they eat only certain plants.

Monarch butterfly caterpillars, for example, dine on milkweed. If people cut down milkweed and replace it with another plant, the butterflies will not have the food source that they need to survive.

But the trouble doesn't stop there; it goes right across the food web. When insects can't get the right plants to eat and they die off, then the birds don't have enough bugs for their meals. Tallamy points out that almost all migrating birds depend on insects to feed their young. "We cannot let the plants and animals around us disappear," says Tallamy. "The way to preserve them is to give them food to eat. But when we plant non-native plants, we are clobbering the food web, because then we don't have the insects the birds need to live."

Fewer of the right plants mean fewer bugs, and fewer bugs mean fewer birds. And that's bad for the Earth, because we need a variety of living things to keep the planet healthy and beautiful.

The good news is, gardeners everywhere are working hard to protect native plants and get rid of the invaders. Many local garden centers sell native plants. "Just Google 'native plants' and your location, and you can find out which plants really belong where you live," says Tallamy.

Planting the right things makes a real difference, and fast. He describes planting milkweed in a tiny city courtyard about the size of a living room one spring. By summertime, that milkweed patch had produced 50 new monarch butterflies!

Tallamy encourages kids to go out and plant native plants. "Adopt a bird species in trouble and see if you can't plant some things that will attract the insects they need," he suggests. "It will happen – insects move around a lot, and they will find the plants you put out there for them!"

Resource:

<http://kids.nationalgeographic.com/kids/stories/spacescience/invasive-plants/>

Student Page: Newspaper Story Format

Title:

Lead/headline:

Who?

What?

Where?

When?

Why?

Additional Details:

Newspaper Rubric

Category	4	3	2	1
Headline	Article has a headline that captures the reader's attention and accurately describes the content.	Article has a headline that accurately describes the content.	Article has a headline that does not describe the content.	Article is missing headline.
Supporting Details	The details in the article are clear and supportive of the topic.	The details in the article are clear but need to be developed more. Some details may not fit in with the topic.	Most details in the article are clear. Article does not focus on the topic well.	The details article are neither clear nor related to the topic.
Who, What, When, Where & Why	Article adequately addresses the 5 W's (who, what, when, where and why).	The article is missing one of the 5 W's.	The article is missing 2 of the 5 W's.	The article is missing 3 or more of the 5 W's.
Lead Sentence	Lead sentence grabs the reader's attention and focuses the reader on the topic.	Lead sentence tells most important details.	Lead sentence is not clearly connected to the article.	There is no clear lead sentence in the article.
Spelling and Grammar	No spelling or grammar errors.	No more than a couple of spelling or grammar errors.	No more than 3 spelling or grammar errors.	Several spelling or grammar errors.

Stop the Snot

Gr: 3-5

Objectives: At the conclusion of the lesson, students will be able to:

- Describe the impact of Rock Snot invasions on the food web and on humans
- Create public service announcements to teach the public about Rock Snot and how to prevent its spread

Standards:

NGSS	3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
Core Idea	LS4.D - Populations live in a variety of habitats, and change in those habitats affects the organisms living there.
Practices	<ul style="list-style-type: none">• Constructing explanations and designing solutions• Obtaining, evaluating, and communicating information
Cross-Cutting Theme	<ul style="list-style-type: none">• Constructing explanations and designing solutions• Obtaining, evaluating, and communicating information
Reading, Writing & Social Studies	<p>CCSS.ELA-Literacy.RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.</p> <p>CCSS.ELA-Literacy.RI.3.10 By the end of the year, read and comprehend informational texts, including history/social studies, science, and technical texts, at the high end of the grades 2–3 text complexity band independently and proficiently.</p> <p>CCSS.ELA-Literacy.RI.4.3 Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.</p> <p>CCSS.ELA-Literacy.RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.</p>
Environmental Literacy	1.A.1 – Identify an environmental issue

Objectives: At the conclusion of the lesson, students will be able to:

- Describe the impact of Rock Snot invasions on the food web and on humans
- Create public service announcements to teach the public about Rock Snot and how to prevent its spread

Materials:

- Board
- Digital camera
- Glitter
- Internet access
- Pictures of Rock Snot (in Boulder Booger Bling packet in kit)
- Student Pages (on CD)

Teacher Background: Didymo is classified as an **invasive species**. Invasive species are non-native species that cause environmental, economic, and/or human-health related harm. In contrast, **exotic species** are non-native but do not cause problems. As its common name suggests, Didymo may look like snot, but it's not. Didymo (*Didymosphenia geminata*) is a microscopic freshwater diatom (type of algae) that secretes a fibrous stalk which it uses to attach itself to rocks and plants in aquatic systems.

During blooms, the stalks grow to form thick mats which can completely cover the stream bottom. This diatom may look slimy, but its silica cell walls make it feel more like wet wool. Didymo cells, unlike most other diatoms, grow a yellow-brown or grayish-white, muco-polysaccharide shoot that can extend up to 2 feet long, thus earning it the unflattering nicknames of "Rock Snot" and "Boulder Booger".

The first report of Didymo in the northeastern U.S. came from the northern reaches of the Connecticut River and the White River in Vermont in June 2007. As of 2011, Didymo has been found in 18 U.S. states and 3 Canadian provinces.

Nuisance Didymo "blooms" are often mistaken for raw sewage spills because trailing stalks look like wet toilet paper in the water. In some situations, Didymo can proliferate rapidly, bloom (for reasons not well understood), and form large, visible clumps or mats of tangled stalks. In worst-case scenarios, these mats can cover the entire bottom of the infested river with a layer of cells and stalks up to 20 cm thick. Although Didymo mats may look slimy, they actually feel gritty and somewhat fibrous (like wet wool) when squeezed between a finger and thumb. Didymo stalks are resistant to biodegradation by bacteria and fungi. They can break off, drift downstream, get

snagged on woody debris, and persist for up to 2 months. Unlike other algae, *Didymo* has no characteristic odor.

Like many nuisance, aquatic species, *Didymo* poses myriad ecological threats. From an environmental perspective, the thick mats formed during blooms can completely cover the substrate, trap sediment, and have the potential to disrupt food webs. These extensive mats are a threat to biodiversity because they can smother benthic macroinvertebrates, native diatoms, and aquatic plants, thereby reducing food and habitat for fish.

It should be noted that only limited research has been done to elucidate the ecological effects of *Didymo* in areas where large blooms have occurred. *Didymo* presence causes shifts in the community composition of macrobenthos (invertebrates living on or in the stream sediment) toward more midges and worms with fewer caddisflies, stoneflies, and mayflies. Studies have also observed higher macroinvertebrate densities after *Didymo* becomes established--the average organism size, however, has been recorded as smaller. There is minimal information on the effects of *Didymo* blooms on fish. Some studies report no impact on fish growth and production, while others have observed declines in native fish populations in *Didymo*-infested waters.

In this activity, students will learn about the impacts of *Didymo* (aka Rock Snot) by reading a story about Savage Stream and simulating Rock Snot's spread. After learning about Rock Snot, students will create public service announcements to educate the public on this problematic species.

Procedure:

Engage

1. Have students read the Student Page on 'Savage Stream' and answer the content questions.
2. As a group, go over the student's answers to the questions. Be sure that students understand how Rock Snot impacts stream environments.
3. Show students pictures of Rock Snot and ask them if they would want to fish or swim in areas with Rock Snot. Why or why not?
4. Write the words 'native', 'exotic', and 'invasive' on the board. Ask students if they can define any of the words. Write definitions on the board.
5. Explain to students that Rock Snot is an invasive species. It has been present in Canada for years and was probably introduced into the United States on fishing gear.
6. To demonstrate the spread of Rock Snot, have students count off in 3s. Sprinkle glitter on the hands of the 1s. Have the rest of the students spread throughout the classroom or a large playing field.

7. Tell the 1s that they are fisherman with Rock Snot. Everyone else represents streams. Have the 1s visit the other students, shake their hands, and introduce themselves as a fisherman. When introductions are finished, have everyone look at their hands. What happened? (The Rock Snot was spread throughout the room.)
8. Explain to students that sometimes humans accidentally relocate species like Rock Snot. Ask students how they could have prevented the spread of Rock Snot in their simulation. (*Students will likely say to not shake hands, but try to guide them to the answer that they needed to wash their hands to prevent the spread of the glitter or Rock Snot. This action represents washing gear in between fishing excursions.*)

Explore

1. Ask students if they have ever watched a Public Service Announcement (PSA). Explain that PSAs are short, non-commercial announcements designed to provide information to the public.
2. Ask a student to describe the PSA they watched (What was it about? How was the information presented? etc.)
3. Have students view sample PSAs made by other students. Visit www.schooltube.com and have students watch 1 or 2 elementary school PSAs. Discuss what students liked and didn't like about each of the PSAs. Was the PSA effective? Why or why not?
4. As a group, list of characteristics of PSAs.
 - a. PSAs try to persuade their viewers to take a specific action or to adopt a favorable view toward some service, institution, issue, or cause.
 - b. PSAs use brief language and get to the point quickly.
 - c. PSAs are based on facts and cite data.
 - d. PSAs use an engaging format to hold the viewer's interest.

Explain

1. Tell students that they will now create PSAs designed to teach others in their community about Rock Snot and how to prevent its spread.
2. Split students into groups of 4-5 and tell them that they are to design a 1-2 minute PSA about Rock Snot. Their PSA must:
 - a. Present the issue in short, memorable phrases
 - b. Have a call for action
 - c. Include 3 reasons for the call for action
 - d. Include research to support claims
 - e. Use persuasive writing and speaking
 - f. Contain appropriate visuals
3. Select a format for student PSAs. It can be:
 - a. A movie
 - b. A Prezi (<https://prezi.com/>)
 - c. A storyboard (<http://www.storyboardthat.com/>)

- d. A presentation with visuals (posters, etc)
4. Hand out Student Page on PSAs and allow students time to work in groups to further research Rock Snot and to assemble their PSAs. Work with groups to help set up PSAs.
5. Have students present their PSAs to the class. Make a video of the PSAs using a digital camera. Show videos at environmental fairs, nature centers, state and local parks, and fishing stores.
6. Consider uploading video(s) to www.schooltube.com or www.teachertube.com.

Evaluate

1. Evaluate student's PSAs. Grade PSAs based on the following:
 - a. Issue clearly identified
 - b. Call for action identified
 - c. Three or more points provided with support
 - d. Organization
 - e. Visual content
 - f. Creativity
 - g. Persuasive writing and speaking

Extend

1. One method to stem the spread of Rock Snot is to build wader wash stations where anglers can wash gear after fishing. Have students build a wader wash station for a local stream. You might want to ask for help from the industrial arts class at the local high school. More information can be found here: http://dnr2.maryland.gov/invasives/documents/didymo_waderwash.pdf
2. Besides Rock Snot, what other aquatic invaders can be found in your area? Have students research local invaders and ways to stop their spread.

Student Page: Savage Stream

Savage Stream was a popular place for people and wildlife. The shores were lined with mighty oaks and ashes. Underneath the trees were shrubs and wildflowers that provided food and shelter for many animals. The trees provided shade which helped keep the water cool, and as the leaves dropped into the water, they provided food for the aquatic insects.

As the water rushed along the rocks, brook trout darted around Savage Stream to find their next meal. Brook trout eat aquatic insects like young dragonflies and stoneflies. These insects feed off leaves and live under the rocks.

Children and their families often visited Savage Stream to splash in the cool water and to tube down the stream. The abundant trout made Savage Stream a popular spot for fisherman who waded into the stream to fish.

Unfortunately, one day, the rocks in the stream began to get covered with a cottony, snot-like substance known as Didymo or Rock Snot. As the days went by, more Rock Snot covered all of the rocks, making it hard for the insects to find shelter. At first, the trout grew fat from all of the insects that couldn't hide from them, but then, the insects slowly started to disappear. With the loss of the insects, the trout also started to disappear. Fisherman not only had trouble catching trout, but the Rock Snot would snag their lines and would get caught on their gear. Soon, families didn't like to go into the stream because of the Rock Snot. It would cling to their shoes and made it tough to swim in the water. Savage Stream no longer was a popular place for people or wildlife.

1. What did the brook trout eat?
2. What happened to the brook trout's food?
3. Why don't people want to use Savage Stream anymore?
4. What do you think should be done to help Savage Stream?

Student Page: Public Service Announcements

What is a Public Service Announcement (PSA)?

PSAs are short, non-commercial announcements designed to provide information to the public. PSAs are used by organizations to inform and influence public opinion.

What should PSAs do?

- Present the issue in short, memorable phrases
- Have a call for action
- Include research to support claims
- Use persuasive writing and speaking
- Contain appropriate visuals

To help create your PSA, fill out the information below.

Issue (What is the Purpose of your PSA?):

Call for Action:

Reason #1	Reason #2	Reason #3
<i>Evidence</i>	<i>Evidence</i>	<i>Evidence</i>

Wetland Restoration

Gr: 9-12

Objectives: At the conclusion of the lesson, students will be able to:

- Explain the impacts of Purple Loosestrife on wetlands
- Create a restoration proposal designed for a specific aquatic habitat

Standards:

NGSS	HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. HS-ETS1.3- Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
Core Idea	ETS1.B- Developing possible solutions. When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
Practices	<ul style="list-style-type: none">• Developing and using models• Using mathematics and computational thinking• Obtaining, evaluating, and communicating information
Cross-Cutting Theme	<ul style="list-style-type: none">• Scale, proportion, and quantity• Stability and change
Reading, Writing & Social Studies	CCSS.ELA-Literacy.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. CCSS.ELA-Literacy.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. CCSS.ELA-Literacy.RI.11-12.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain CCSS.ELA-Literacy.RI.11-12.7 Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
Environmental Literacy	1.A.1 - Identify an environmental issue 1.A.2 - Develop and write research questions related to an environmental issue 1.A.3 - Given a specific issue, communicate the issue, the stakeholders involved, and the stakeholders' beliefs and values 1.A.4 - Design and conduct the research 1.A.5 - Use data and references to interpret findings to form conclusions

Objectives: At the conclusion of the lesson, students will be able to:

- Explain the impacts of Purple Loosestrife on wetlands
- Create a restoration proposal designed for a specific aquatic habitat

Materials:

- Board
- Internet access
- Native Plant Guide (in kit)
- Pictures of wetlands (on CD)
- Student Pages (on CD)

Teacher Background: Although wetland types are diverse, they all possess several ecological characteristics that distinguish them from upland or other aquatic ecosystems. Wetlands have **hydric** (permanently or seasonally saturated by water) soils, **hydrophytic plants** (adapted to live in wet conditions), and are seasonally or permanently saturated by water. Wetlands are important because they help reduce the impacts from flooding, maintain water quality, recharge groundwater, store carbon, provide habitat for wildlife, provide recreation opportunities, and more. It is estimated that wetlands provide billions of dollars in ecosystems benefits each year.

Unfortunately, wetlands have been disappearing at a phenomenal rate and those that remain can be degraded by pollution and invasive species. Invasive species are non-native species that cause economic, environmental, or human-health related harm. Invasive plants like Phragmites (*Phragmites australis*) and Purple Loosestrife (*Lythrum salicaria*) can invade wetlands and can replace native plant species. With the loss of native plants, the wildlife that depend upon the plants also disappear.

Following many invasive plant removal projects, sites are often left with vegetative gaps. These areas leave possible spots that other invasive species can occupy. In addition, wetland habitats are at high risk for erosion if many bare areas are left after invasive plant removal. Sometimes, restoration projects need to include native plantings to further benefit the site. The choice of plants, seeds, planting methods, and maintenance can all impact restoration success. For the maximum ecosystem benefit, native plants for restoration should be carefully selected for the size and environmental conditions at the site as well as for the area's management goals.

In this activity, students will learn about the impact of Purple Loosestrife on wetlands and will create a restoration plan following the removal of Purple Loosestrife from four fictional habitats.

Procedure:

Engage

1. Begin by asking students to define the term 'wetland'.
2. Ask students why wetlands are important. (*They help reduce the impacts from flooding, maintain water quality, recharge groundwater, store carbon, provide habitat for wildlife, etc*). List ideas on the board.
3. Next, ask students if all wetlands are the same. Are some wetlands more beneficial than others? Why or why not? It's important that students know that not all wetlands perform all functions nor do they perform all functions equally well.
4. Show students pictures of wetlands- including those that are infested with Purple Loosestrife. Ask students what stands out to them when viewing pictures of the wetlands. For the Purple Loosestrife wetlands, ask students if they think the abundance of the 'purple flower' is okay for those wetlands? Why or why not? Can any student identify the purple flower?
5. After a discussion about the wetland pictures, tell students that the purple flower is Purple Loosestrife, an invasive species. If students are unfamiliar with the term 'invasive', then define it for them along with the terms 'native' and 'exotic'.
6. Ask if any students have heard of Purple Loosestrife and if they know why it is invasive.
7. Explain that Purple Loosestrife invades wetlands and eventually takes over, pushing out many native plants that wildlife depend upon. Purple Loosestrife can also alter the soil to make it more favorable for other Purple Loosestrife to grow within.

Explore

1. Tell students that they will now be tasked with designing a proposal to restore aquatic habitats that have had extensive Purple Loosestrife removal. Tell students that following the removal, all of the sites have been left with bare patches of soil that are at risk for erosion. Because these areas need native plants, it will be the student's job to determine what plants to use for restoration of the different systems and how many of each plant will be needed to accomplish a restoration plan.
2. Split students into groups of 4-5. Hand each group the Student Pages for the Restoration Proposal, Restoration Budget, Restoration Planning, and the corresponding Habitat (pond, marsh, etc) for each group. Go over the components of the proposal with the class and then have students read the site description and examine their habitat.
3. Tell students that they are now in charge of creating a proposal to restore their site. One of their main duties is to select the right native plants to restore their site. Students should use the Restoration Planning Student Page to record ideas about what native plants to plant. Encourage students to think about the

available space they have, the size of the plants they are selecting, and the needs for the site/landowner.

4. Encourage students to use the following resources to research plants:
 - a. "Native plants for wildlife habitat and conservation landscaping in the Chesapeake Bay Watershed" by the U.S. Fish and Wildlife Service
<http://www.nps.gov/plants/pubs/chesapeake/pdf/chesapeakenatives.pdf>
 - b. The Lady Bird Johnson Wildflower Center
<https://www.wildflower.org/plants/>
 - c. Local chapters of the Native Plant Society
5. Allow students time to research and select plants for their site. Once they have a list, work with students to review selections. After students have a solid list, have students figure out the total number of each species that will be required to restore the site. Remind students to pay attention to the size of the area available on their habitat sheet and the total size (height & spread) of the plants they selected.
6. Have students draw out their planting designs on their Habitat Page. Remind students to pay attention to scale. Have students tally the number of each species that will be used on their restoration sites. Enter these tallies into the Student Page for their Budget.
7. To fill in the Restoration Budget sheet, have students research vendors and pricing for each of their proposed plants. Encourage students to think of additional restoration expenses (equipment, tree guards, etc) that should be factored in. Have students create a rough budget for their project.

Explain

1. Have students present their restoration proposals to the rest of the class. Presentations should include information on their site, their restoration goals, and why they chose particular species for planting.
2. If more than one group prepares a restoration plan for a site, then have the class decide the best aspects of each plan. Have groups meet and create a composite plan for the site.

Evaluate

1. Evaluate students based on: thoroughness of research, validity of reasoning in choosing plants for restoration, accuracy of planting design, consideration of landowner's needs and wants, and thoroughness of budget calculations.

Extend

1. Have students volunteer with a local restoration project either removing invasive species and/or replanting with native species.

-
2. Have students grow seedlings of native plants to use for restoration work. Give away or sell seedlings at school fairs or environmental events. Have students encourage the local community to plant native species.

Restoration Proposal

Organization Name: _____

Project Area (Size, location, etc): _____

Restoration Goal:

Project Timeline (estimate; include time to order, install, and for maturation of plants; may use additional paper if more space needed):

Estimated Cost:

- Plants:
- Equipment (list):
- Other:
- Total:

Volunteers Needed (for restoration):

Benefits of Restoration:

Other Notes (optional):

Attach Planning Worksheet, Budget Breakdown, and Proposed Map to this Proposal.

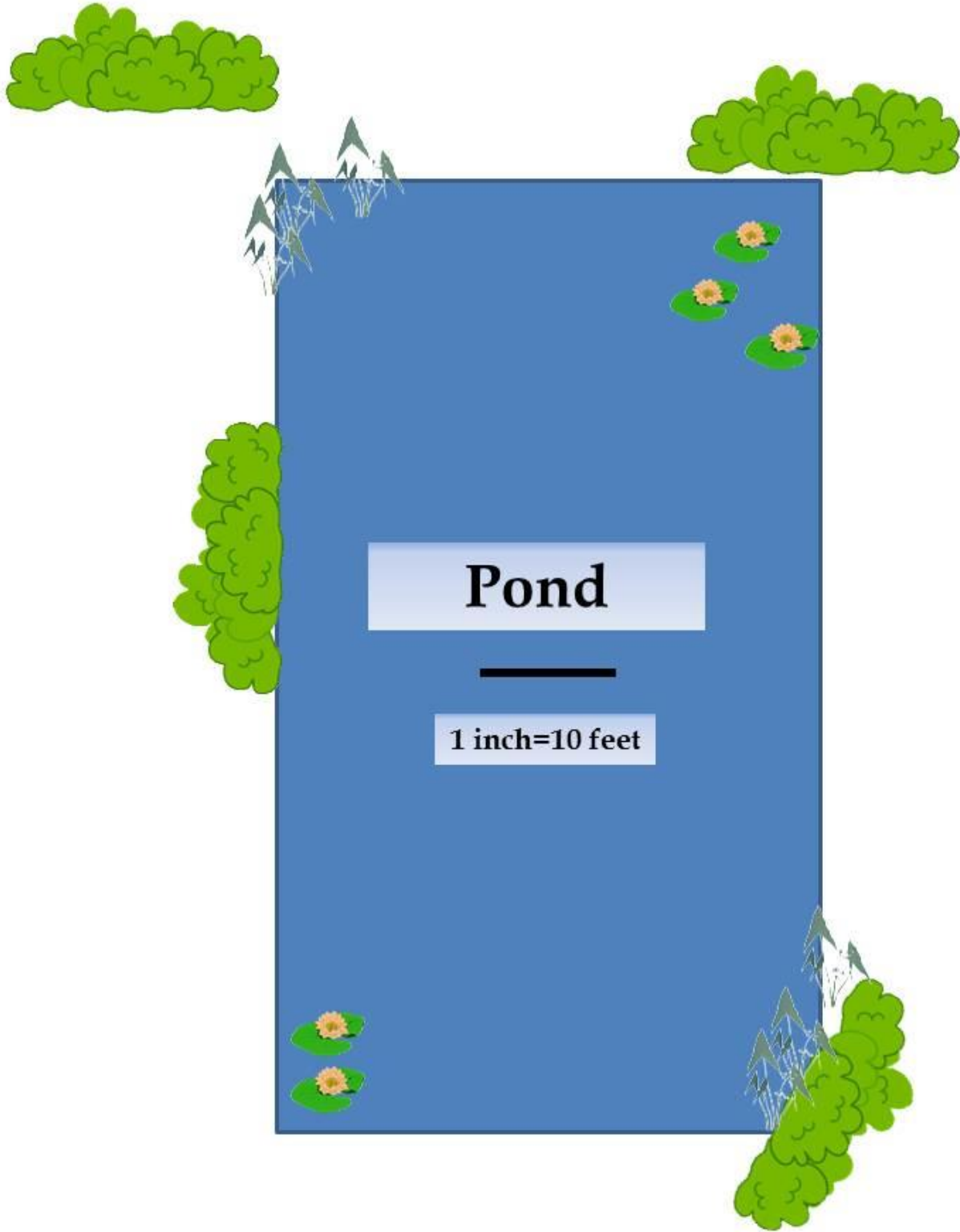
Restoration Planning Worksheet- Pond

The pond is 40 feet by 70 feet with remnant buttonbush (*Cephalanthus occidentalis*) shrubs, arrowhead (*Sagittaria* spp.), and American pond lily (*Nymphaea odorata*). The pond is in full sun, and the pond depth reaches 10 feet at its deepest point. To prevent erosion and to provide wildlife habitat, emergent wetland plants are needed along the edges of the pond as well as other species to provide a buffer around the pond. The pond owners don't want large shrubs or trees planted in the area and prefer to attract amphibians and other predators that help with mosquito control.

Tips for Selecting Plants

- Select plants native to your state and region
- Examine growth requirements (sun exposure, soil moisture, etc) to make sure the plants you select will grow in your habitat
- Consider plant height and spread when determining where to place plants and how many to plant
- Consider benefits of the plants that you select; for example, do they provide food or shelter for wildlife? What wildlife will benefit?
- Fill in plants in the table below. An example has been provided.

Species	Max. Height (ft)	Max. Spread (ft)	Type	Benefits
Pickerelweed (<i>Pontedaria cordata</i>)	3	2	Emergent	Vigorous spread; provides nectar and shelter



Restoration Planning Worksheet- Stream

Following removal of Purple Loosestrife, the riparian area along the stream is pretty barren. Some mature green ash (*Fraxinus pensylvanica*) and sycamore (*Platanus occidentalis*) line the riparian zone. In addition, patches of the stream edge have soft rush (*Juncus effusus*) growing. The stream area needs buffer plants that will prevent erosion. Most of the stream is in full sun, but the large trees do provide some shade. More shade will help keep the water temperature cool for native species of trout.

Tips for Selecting Plants

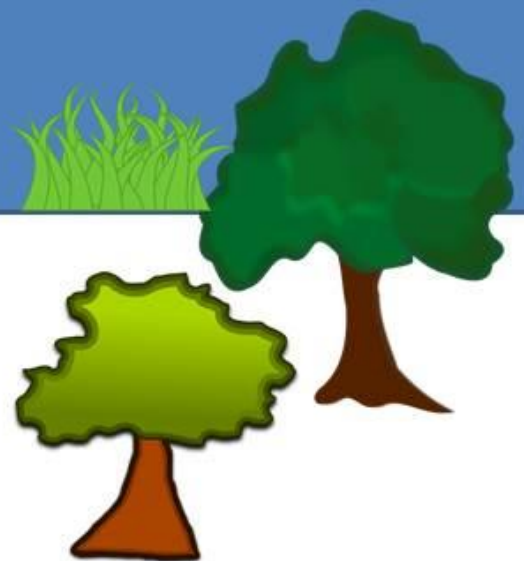
- Select plants native to your state and region
- Examine growth requirements (sun exposure, soil moisture, etc) to make sure the plants you select will grow in your habitat
- Consider plant height and spread when determining where to place plants and how many to plant
- Consider benefits of the plants that you select; for example, do they provide food or shelter for wildlife? What wildlife will benefit?
- Fill in plants in the table below. An example has been provided.

Species	Max. Height (ft)	Max. Spread (ft)	Type	Benefits
Pickerelweed (<i>Pontedaria cordata</i>)	3	2	Emergent	Vigorous spread; provides nectar and shelter



Stream

1 inch=10 feet



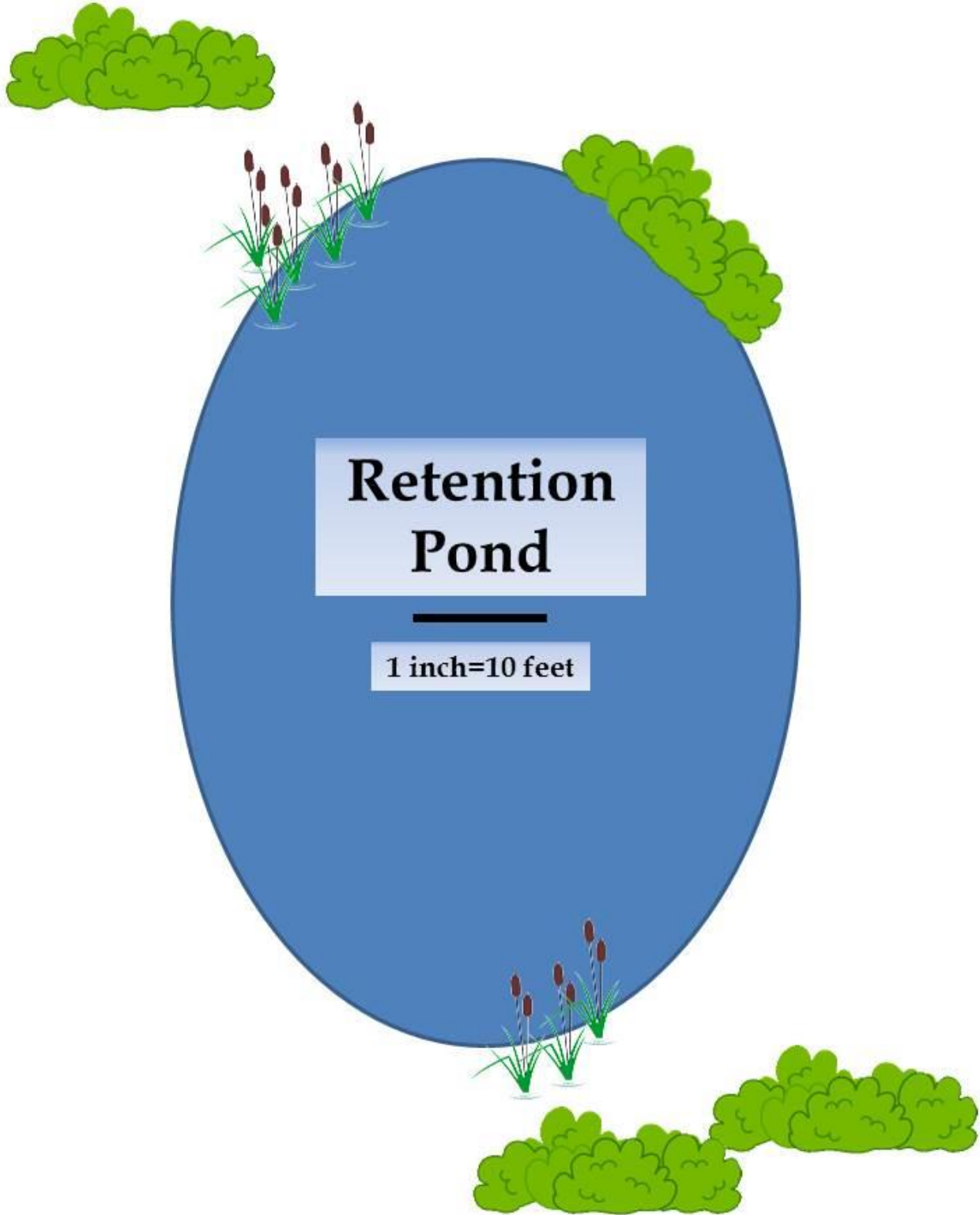
Restoration Planning Worksheet- Stormwater Retention Pond

The stormwater retention pond is designed to trap large amounts of runoff from an adjacent parking lot. The pond stays wet year round but suffers from occasional flood events from heavy rains. Because of this, the retention pond needs plants with large root systems designed to hold in the soil and able to withstand temporary flooding. Plants are needed along the edges of the pond as well as buffer the area. The owners prefer not to have any trees over 15 feet tall (mature height) but are okay with having some shrubs and/or small trees along the edges. The pond is in full sun and sometimes polluted runoff makes its way into the water. Some buttonbush (*Cephalanthus occidentalis*) shrubs and cattails (*Typha* spp.) remain at the site.

Tips for Selecting Plants

- Select plants native to your state and region
- Examine growth requirements (sun exposure, soil moisture, etc) to make sure the plants you select will grow in your habitat
- Consider plant height and spread when determining where to place plants and how many to plant
- Consider benefits of the plants that you select; for example, do they provide food or shelter for wildlife? What wildlife will benefit?

Species	Max. Height (ft)	Max. Spread (ft)	Type	Benefits
Pickerelweed (<i>Pontedaria cordata</i>)	3	2	Emergent	Vigorous spread; provides nectar and shelter



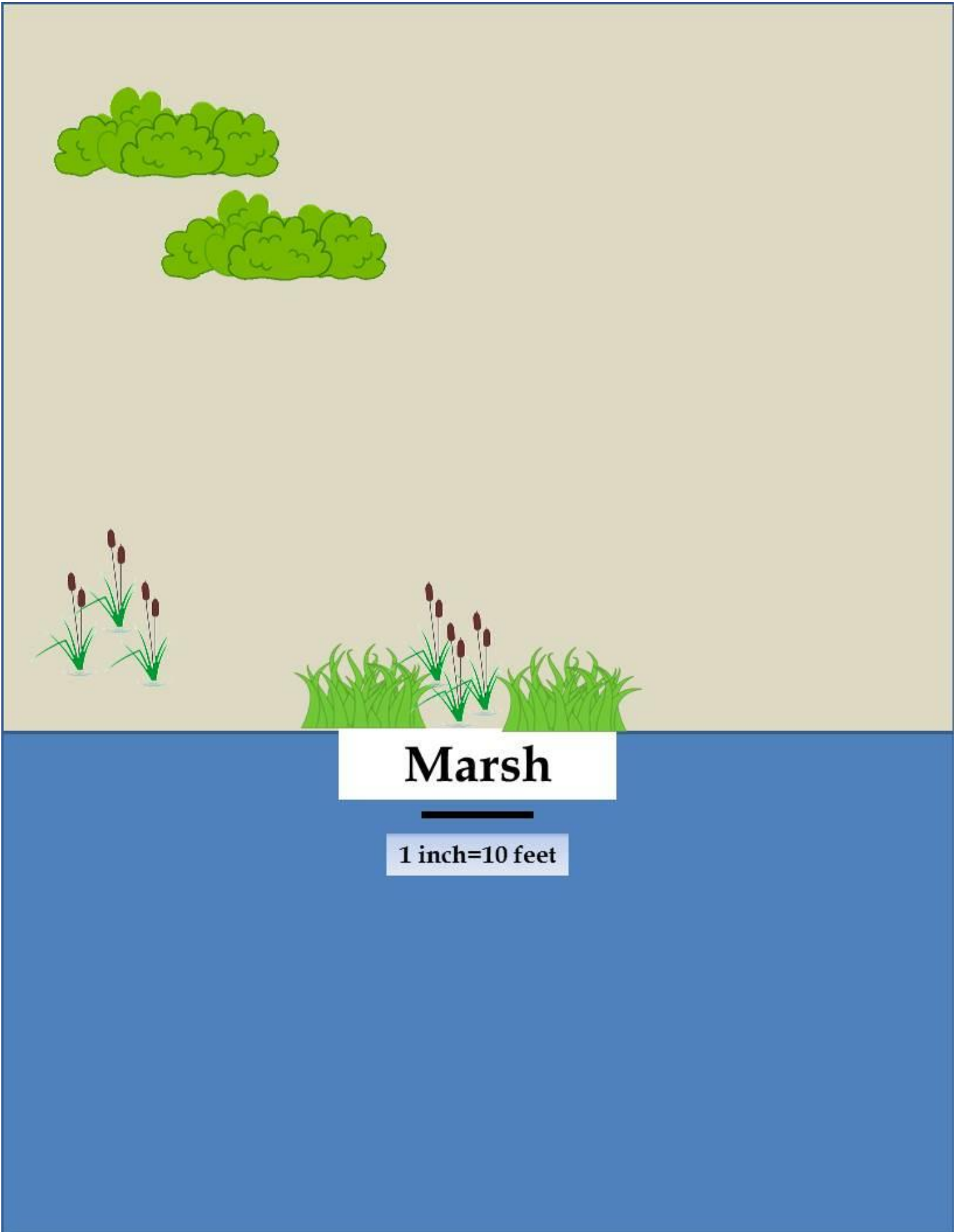
Restoration Planning Worksheet- Freshwater Marsh

The freshwater marsh is a small marsh on the tip of a river. The main restoration goal for this site is to stop erosion of the marsh, but the owners would also like to create a habitat that is beneficial to wildlife. Therefore, a mixture of shrubs and herbaceous plants are preferred. Some buttonbush (*Cephalanthus occidentalis*) shrubs, soft rush (*Juncus effusus*), and cattails (*Typha* spp.) remain at the site.

Tips for Selecting Plants

- Select plants native to your state and region
- Examine growth requirements (sun exposure, soil moisture, etc) to make sure the plants you select will grow in your habitat
- Consider plant height and spread when determining where to place plants and how many to plant
- Consider benefits of the plants that you select; for example, do they provide food or shelter for wildlife? What wildlife will benefit?
- Fill in plants in the table below. An example has been provided.

Species	Max. Height (ft)	Max. Spread (ft)	Type	Benefits
Pickerelweed (<i>Pontedaria cordata</i>)	3	2	Emergent	Vigorous spread; provides nectar and shelter



Marsh

1 inch=10 feet

Restoration Budget
Plant Budget

Species	Vendor	Cost	# needed	Total
Pickerelweed (<i>Pontedaria cordata</i>)				
			Total Sum:	

Equipment (list):

Other:

Who's Got the Snot?

Gr: 6-12

Objectives: At the conclusion of the lesson, students will be able to:

- Map the spread of Didymo
- Describe ways Didymo is introduced into aquatic systems
- Describe ways to prevent the spread of Didymo

Standards:

NGSS	HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
Core Idea	LS4.C: Adaptation - For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.
Practices	<ul style="list-style-type: none">• Use Evidence (e.g., observations, patterns) to Construct an Explanation• Construct an Argument• Support an Argument
Cross-Cutting Theme	<ul style="list-style-type: none">• Cause and Effect
Reading, Writing & Social Studies	<ul style="list-style-type: none">• CCSS.ELA-Literacy.RST.9-10.1 Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.• CCSS.ELA-Literacy.RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.• CCSS.ELA-Literacy.RI.11-12.1 Cite strong and thorough textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text, including determining where the text leaves matters uncertain• CCSS.ELA-Literacy.RI.11-12.7 Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
Environmental Literacy	<ul style="list-style-type: none">• 5.A.1: Analyze the effects of human activities on earth's natural processes.• 5.A.2: Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes.• 7.A.1: Investigate factors that influence environmental quality.• 7.B.1: Examine the influence of individual and group actions on the environment and explain how groups and individuals can work to promote and balance interests.

Objectives: At the conclusion of the lesson, students will be able to:

- Map the spread of Didymo
- Describe ways Didymo is introduced into aquatic systems
- Describe ways to prevent the spread of Didymo

Materials:

- 5-10 cotton balls
- Computers with Internet access
- Container
- Light-colored piece of felt
- Pictures of Didymo (in kit)
- Plastic insects (optional)
- Red and green food coloring
- Station cards (in kit)
- Who's Got the Snot Student Page (on CD)
- Water

Teacher Background: Didymo (*Didymosphenia geminata*), also known as "Rock Snot" or "Boulder Boogers" is an invasive algae of cold flowing waters. Individual Didymo are microscopic, but infestations include enormous numbers. Each individual produces a long stalk from the stream bottom. The resulting mass is a yellow-brown slime layer that can dominate the bottom of rivers and streams. Dramatic changes in stream biology have been seen in infested areas, particularly changes in macroinvertebrate communities which function as an important layer in many aquatic food webs.

Didymo blooms were first documented in North America in the 1990s in Canada. Today, over 18 states, 3 Canadian provinces, and a multitude of other countries around the world report Didymo infestations. Many of the streams infested with Didymo include some of the finest fly-fishing spots in the world, causing many in the fishing industry to be concerned. In heavily infested waters, Didymo blooms are likely linked to declines in tourism and freshwater angling - particularly fly fishing, a \$.9 billion industry in the U.S.

Resource managers in North America, and especially in New Zealand, guessed early on that the felt-soled waders of traveling fly fishermen likely were the pathway for its spread. Subsequent field and laboratory studies demonstrated that the felt sole is an almost perfect medium for its spread. Recent studies have found that the felt material can retain and transfer a variety of harmful organisms at a much higher rate than other

commonly used materials. Because felt may remain damp for days after use, these organisms remain viable longer than when carried by other materials.

In response to the problems with felt-soled waders, Maryland banned its use in waters in 2011. Other states such as Alaska, Missouri, Nebraska, Rhode Island, South Dakota, and Vermont have also banned the use of felt-soled waders. However, most states in the Mid-Atlantic still allow anglers to use felt-soled waders. This use provides a possible vector for Didymo spread into new areas.

In this activity, students will map the spread of Didymo in Maryland and will put together informational posters or brochures to educate anglers on ways to prevent the future introduction and spread into new streams.

Procedure:

Engage

1. Prior to the lesson, 5-10 cotton balls should be pulled apart and placed in watered down food coloring mixture (1 drop red and 1 drop green). Add the cotton balls to a bin with water. As an optional effect, add plastic insects to the container. The container will represent a “stream” infested with “Didymo”.
2. Ask students if any have been fishing before. If so, where have they gone? What type of gear do they use? Have they ever traveled to new fishing locations and taken their gear? Have they ever washed their gear between visits? Write down a list of gear and whether or not the gear is usually washed between trips.
3. After several students have provided their responses, show students the model stream. Ask them what they think the cotton balls represent. Ask them if they would want to fish in an area with that material all over the stream bottom. Why or why not? Besides being unsightly, how might the cotton balls affect organisms that live in the stream?
4. Tell students that the cotton balls represent Didymo (aka Rock Snot/ Boulder Boogers) which is an invasive algae that covers the bottom of fast-moving, coldwater streams. Review the definitions of native, exotic, and invasive species with students and provide some background on what Didymo infestations look like. You may want to show students pictures of infestations found in the kit and here: <http://www.livescience.com/45422-rock-snot-algae-photos.html>

Explore

1. Explain to students that they are now going to investigate how Didymo spreads by piecing together clues from Maryland’s initial Didymo infestation.
2. Set up 5 stations with fact cards (in kit) on 5 different aquatic systems in Maryland.

3. Divide students into small groups (2-4) and assign each group to a station. At each station, students should fill in their observations, the presence of Didymo in the columns of their table, as well as mark the sites with Didymo on their map.
4. After students have completed all stations, each group will be asked to make a hypothesis as to “Who’s got the snot?”
5. After students have written down their hypotheses, have them present their ideas to the class. Encourage discussion on what may have caused the spread and ways that students may prevent the spread. At the end of the discussion, reveal how Didymo is likely spread on fishing gear, namely felt-soled waders which are used to wade into streams. Point out that none of the sites in Maryland are directly connected as tributaries. This fact should indicate that humans or animals are a more likely cause of the spread than natural water flow.
6. Following the discussion, take a light-colored piece of felt and place it in the water bin from earlier. Explain that many waders have felt-soles that trap Didymo particles and allow for transport to new streams. Refer back to the list of fishing gear from earlier - did any of the students use waders with felt-soles? Allow students a chance to feel and observe the wet felt so they can understand the connection between it and Didymo spread.

Explain

1. Have students research information about ways to prevent the spread of Didymo on fishing equipment like felt-soled waders. Encourage students to research their state natural resource agency’s actions to prevent the spread of Didymo as well as actions taken by surrounding states.
2. Once students have compiled their research, have them create informative posters or brochures designed to educate local anglers on problems with Didymo and ways they can prevent the spread of Didymo.

Evaluate

1. Evaluate students by grading posters or brochures for clarity, design, layout, and information presented.

Extend

1. Have students research methods of control for Didymo including biological, chemical and/or mechanical control. Have students debate the pros and cons of each method and determine which may be the best solution for their area.

The Potomac River

The banks of the Potomac stretch from Western Maryland, through the heart of Washington D.C. and its waters are a source of fresh water for the largest estuary in North America. The Potomac River is one of the most publicly used rivers in Maryland and provides a wide variety of recreational opportunities for residents and visitors. In the spring and fall, the waters of the Potomac are filled with families kayaking and tubing, people swimming, and families hiking along the banks.

The Potomac also serves as a dumping ground for waste water released from wastewater treatment plants and factories which serve the growing metropolis. In the past 4 decades, the waters of the Potomac have become substantially cleaner, but the pollution is still a growing problem for the river.

From the banks, visitors enjoy sightseeing, history walks, picnicking, and even fishing. Due to the deep, fast moving waters of the Potomac, fishermen are often confined to fishing from the banks. With higher levels of pollution, only pollution tolerant species can be caught such as striped bass, walleye, catfish, and pike. Rock Snot is not present in this river.

The Gunpowder River

The tailwaters of the Gunpowder Falls lead from Prettyboy Reservoir, through Baltimore City, Gunpowder Falls State Park and into the Chesapeake Bay. Because of the State Park, the Gunpowder is surrounded by buffered banks filled with trees. In the summer, locals enjoy swimming, hiking, kayaking, and canoeing.

The nonprofit company, Trout Unlimited, also has an agreement with Baltimore County to stock the river with brown trout and rainbow trout. Because of the shade from the forested buffer zone, the river is very cool and clean, which makes it a great habitat for these trout species. Trout fishermen from all along the East Coast come to the river to wade through its waters in hopes of catching a rare rainbow trout.

The Gunpowder River was the first location where the invasive species Rock Snot, also known as *Didymo*, was spotted in Maryland.

The Savage River

The Savage River is a 30-mile long river in Garrett County that serves as the first tributary to the Potomac River. Downriver is the Savage River Dam which is used for flood control and recreation such as white water rafting and slalom kayaking. Due to its small size, the river is tucked away in a well-forested area. Its waters are clean and contain little pollution because of a lack of industry in the area.

This river is known as a pristine trout fishing stream, with abundant populations of brown trout and rainbow trout. Even with its remote location, the river is often waded through by thousands of trout fishermen each year.

The Savage River is one of 3 rivers in Maryland experiencing problems with an invasion of Rock Snot.

The Patapsco River

The Patapsco River is a 39-mile river that flows through central Maryland and into the Chesapeake Bay. The mouth of the Patapsco forms Baltimore's Inner Harbor. Maryland residents and visitors enjoy swimming and tubing in the Patapsco which is mostly surrounded by county and state parks.

Although the river has a forested buffer zone, the watershed is highly urbanized. This urbanization makes the river subject to a great deal of stormwater run-off and industrial pollution. Amateur fishermen may visit the river but are likely to find only common species such as bluegill and bass. The Patapsco has not yet been contaminated with the invasive Rock Snot.

Big Hunting Creek

Big Hunting Creek is located in Frederick County, Maryland and has long been known for its reputation as a stocked trout stream. The entirety of the creek is surrounded by Cunningham Falls State Park and Catoctin Mountain National Park. The stream is well shaded and very clean. Despite its name, Big Hunting Creek is actually very small in size but is a prime location for fishermen.

In 1974, Big Hunting Creek was declared a fly fishing only trout stream which keeps other recreationalists away from its waters. During fishing season, fishermen often can be found wading its cold waters. Unlike other forms of fishing, fly-fishing requires the fisherman to stand in the water and not on shore. For this reason, most serious trout fishermen use boots or waders to keep themselves dry, warm and safe from falls. Big Hunting Creek is the most recent victim of the invasive Rock Snot. Many are concerned that this nonnative diatom will threaten the pristine trout habitat.

Who's Got the Snot?

Would you want to swim, fish, boat, or eat fish from a river filled with snot??? Rock snot is an invasive algae that showed up in streams and rivers in Maryland, and it's your job to find out WHY!

Challenge: Determine who's got the snot! In this lab, you will rotate from station to station and use the maps and fact cards to find out who dunnit! As you rotate through the stream site stations, use the table below to record your observations for each site. You should include physical characteristics of the waterways, as well as human activities and species found in the streams and rivers. After you record your observations, be sure to find and label the sites with Rock Snot on your map!

Who's Got The Snot Observations		
River Name	Observations	Rock Snot? (Y/N)
Potomac		
Gunpowder		
Savage		
Patapsco		
Hunting Creek		

Using the information at each stream station, draw an X to mark the stream sites in Maryland that are known to contain Rock Snot. What does this tell you about the spread of Rock Snot?

ANALYSIS: Based on your investigation, make a hypothesis on how you think Rock Snot is spread into these different waterways. Support your statement using your observations. What do you think the state of Maryland should do to try and stop the spread? Explain the pros and cons of your suggestion.

Who's Got the Snot? Map



Who's Got the Snot?

Would you want to want to swim, fish, boat, or eat fish from a river filled with snot??? Rock snot is an invasive algae that showed up in streams and rivers in Maryland, and it's your job to find out WHY!

Challenge: Determine who's got the snot! In this lab, you will rotate from station to station and use the maps and fact cards to find out who dunnit! As you rotate through the stream site stations, use the table below to record your observations for each site. You should include physical characteristics of the waterways, as well as human activities and species found in the streams and rivers. After you record your observations, be sure to find and label the sites with Rock Snot on your map!

Who's Got The Snot Observations		
River Name	Observations	Rock Snot? (Y/N)
Potomac	<i>Fishing (from banks), large river, deep, kayaking, hiking, pike, highly polluted</i>	No
Gunpowder	<i>Trout fishing (wade into water), reservoir, tubing, kayaking</i>	Yes
Savage	<i>Rafting, kayaking, Western Maryland, pristine trout fishing stream (wade into water), dam</i>	Yes
Patapsco	<i>Inner harbor, hiking, kayaking, very polluted, some fishing</i>	No
Hunting Creek	<i>Very small, cold, clean, fly-fishing only stream (wade into water)</i>	Yes