

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.

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Larry Hogan, Governor

Mark Belton, Maryland Department of Natural Resources Secretary

December 2015

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History of Invasive Species

The issue of invasive species is not a recent problem. Invasive species have actually been around for centuries, except that people did not think of them as invasive. Many of these introduced species have had a profound effect on history, whether human history or environmental history. The activities in this module encourage students to think about invasive species in historical terms through lessons focused on Smallpox, Chestnut Blight, and American Bullfrogs.

Many diseases in the Western Hemisphere are classic examples of invasive species, and Smallpox is probably one of the best known. The disease apparently originated in the Middle East more than 10,000 years ago and was brought to the U.S. by colonists in the 17th century. Its impact on human history, both in the Old World and the New, has been devastating.

Another disease, of trees rather than humans, had a dramatic impact on the Eastern forest ecosystem. The American Chestnut tree once dominated the eastern forests and was probably the most important food source for wildlife. Chestnut blight, a fungus, was introduced into the U.S. in infected Japanese Chestnut trees around 1870. Within 50 years, virtually every American Chestnut was dead.

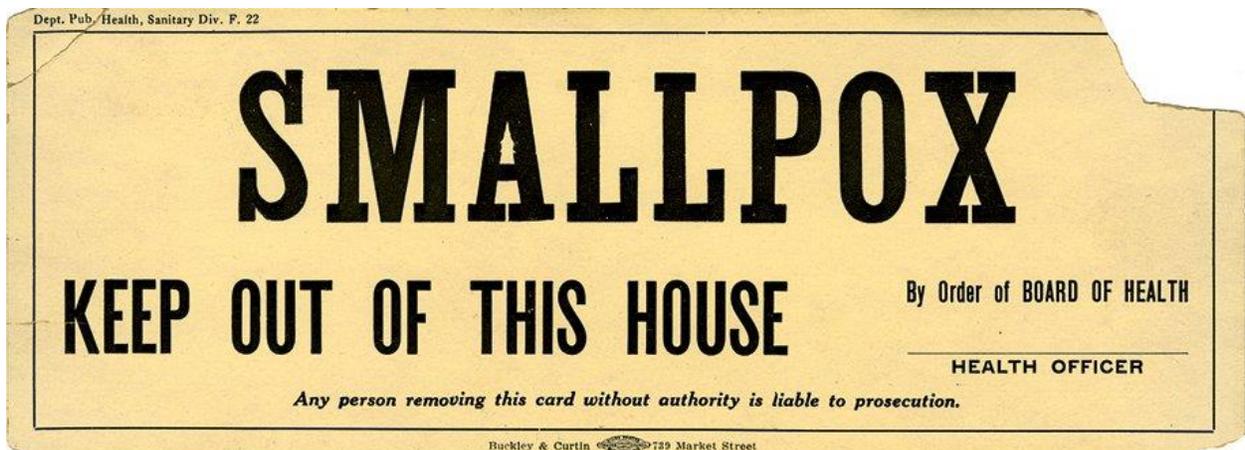
American Bullfrogs, which are native to the Mid-Atlantic, were introduced into the Western part of the U.S. in the early 1900s. Because Bullfrogs are large and will eat anything they can fit in their mouths, Bullfrogs were quickly able to outcompete many native western frogs. In addition, Bullfrogs may be carriers of chytrid fungus and Ranavirus, diseases which spreads to native frogs that have never been exposed to the pathogens. As a result of Bullfrog competition and pathogens, many native amphibian species in the western U.S. are now threatened or endangered.



American Bullfrog by Tim Lindenbaum Flickr Creative Commons

To convey how historical introductions of invasive species have shaped our landscapes, the lessons in this section include:

- **All About the American Chestnut--Grades 9-12; pg 45-50**
 - *Students will learn about American Chestnuts and will create and investigate a researchable question relating to American Chestnuts.*
- **Bullfrog Bullies--Grades 2-3; pg 51-61**
 - *Students will simulate the invasion of Bullfrogs into a fictional ecosystem to see how the introduction impacts native species of frogs.*
- **Chestnut Tree Activity--Grades 3-5; pg 62-72**
 - *Students will learn about the history of the American Chestnut tree and its demise with the Chestnut Blight.*
- **CSI Marshland--Grades 6-8; pg 73-79**
 - *Students will investigate different role players in the story of the American Bullfrog and will evaluate the impact of its introduction to the western United States.*
- **Smallpox Timeline--Grades 6-12; pg 80-92**
 - *Students will learn about the history of Smallpox by conducting a survey and by creating a timeline of historical events.*



All About the American Chestnut

Gr: 9-12

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

- Understand the history of the American Chestnut tree and its functions
- Describe how the Chestnut Blight spread and changed forests of eastern North America
- Construct and investigate a researchable question

Standards:

NGSS	<p>HS-LS2-6 - Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.</p> <p>HS-LS2-7 - Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity</p>
Core Idea	<ul style="list-style-type: none">• LS2.C: Ecosystem Dynamics, Functioning, and Resilience-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. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. 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">• Planning and Carrying Out Investigations• Constructing Explanations and Designing Solutions• Asking Questions and Defining Problems• Obtaining, Evaluating, and Communicating Information
Cross-Cutting Theme	<ul style="list-style-type: none">• Cause and Effect• Systems and System Models• Stability and Change
Reading, Writing & Social Studies	<ul style="list-style-type: none">• CCSS.ELA/Lit.RI.9-10.8 - Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is valid and the evidence is relevant and sufficient; identify false statements and fallacious reasoning.• CCSS.ELA/Lit.W.9-10.1 - Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.• CCSS.ELA/Lit.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.

	<ul style="list-style-type: none">• CCSS.ELA/Lit.W.11-12.1 - Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence
Environmental Literacy	<ul style="list-style-type: none">• 1.A.1: Identify an environmental issue

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

- Understand the history of the American Chestnut tree and its functions
- Describe how the Chestnut Blight spread and changed forests of eastern North America
- Construct and investigate a researchable question

Materials:

- Internet
- Formulating Your Research Question document (optional; on CD)
- Student Pages (on CD)

Teacher Background: The American Chestnut Tree dominated much of the Eastern United States mountain regions and surrounding areas before the turn of the 20th century. It made up at least 25% of these forests and was the most numerous tree species in them. American Chestnuts grew in mixed forests with other hardwood species like oaks and tulip poplars. The American Chestnut towered over many other species. Growing to heights of 100-120 feet and having a diameter of 12 feet or more, American Chestnuts were the giants of the forests. Legend has it that a squirrel could travel from Maine to Georgia by way of the chestnut canopy without ever having to touch the ground. The Latin name is *Castanea dentata*, named this because the edges of the leaves look like rows of sharp teeth.

Chestnuts were the most valuable wildlife food source in eastern forests. They are high in fiber, protein, vitamin C, and carbohydrates while low in calories and fat. Chestnuts, being the most abundant tree, had a more reliable nut crop than any other species. A single tree could produce 6,000 nuts annually and dependably. As a result, chestnuts provided more nourishment than any other member of the plant kingdom in the area. In the early 1900s, a non-native blight fungus began killing American Chestnut trees. This non-native fungus quickly became invasive, spreading rapidly across the entire native range of the American Chestnut over the course of 50 years. This terrible blight changed the east coast forests forever by wiping out the American Chestnut.

Where did the blight come from? The blight likely originated on Japanese Chestnut trees that were brought into this country under extremely loose importation laws. American began importing these foreign relatives of the American Chestnut in the 1870s. Over the next several years, thousands of Japanese chestnut trees were brought

in and sold by nurserymen, shipping all over the country. This is why pockets of blight began to show up all over the range; New York was simply the first place it was noticed. The American Chestnut Foundation has been breeding chestnut trees that they hope will have more resistance to the chestnut blight. They have bred Chinese with American Chestnuts and then have backcrossed the offspring with American Chestnuts in order to create a resistant chestnut tree that is comprised mostly of American Chestnut DNA.

In this activity, students will learn about American Chestnuts and will create and investigate a researchable question relating to American Chestnuts.

Procedure:

Engage

1. Lead a discussion about **native species** and why they are important. Discuss **invasive species**. What do the students think of when they hear the term invasive species? Can students name any local invasive species?
2. Tell students the American Chestnut tree once dominated forests in eastern North America until the invasive Chestnut Blight was introduced. Ask students if they have heard of the Chestnut Blight.
3. Have students complete a quick internet search to answer questions about the American Chestnut on the 'Student Page'. Emphasize that students should cite their sources for information and that they should be sure to use credible sources for their answers.
4. After the search, discuss answers to the questions with students. Be sure that they understand the importance of the American Chestnut and how its loss from the Blight impacted people and wildlife.

Explore

1. Have students work in pairs or small groups to construct a researchable question given their current background knowledge on American Chestnuts. Encourage them to ask questions regarding interesting information they found during their background research exercise. You may want to go over the "Formulating Your Research Question" document from Vanderbilt University. Help guide students to constructing quality questions before handing them their assignment.
 - a. Example questions could include: "*Can selective breeding bring back the American Chestnut?*"; "*Could the use of transgenic American Chestnut trees pose an ecological threat?*"
2. Task students with writing a 2,000 word report investigating their question on American Chestnut. Emphasize that students should cite credible resources (books, journals, government websites, etc.) and should summarize and display data supporting their question.
3. Depending on your students' level of knowledge, you may want to provide practice examples on how to use supporting evidence, how to include citations,

how to incorporate analytical thinking, and how to draw conclusions. A good practice is to go through samples of excellent and poor quality writing.

Explain

Following the research paper assignment, have students present a PowerPoint or poster summary with their findings to the class. Tell students to prepare to answer questions posed by other students in the class.

Evaluate

1. Evaluate reports based on the following:
 - a. **Building the Argument**
 - i. Introduction to the essay
 - ii. Main analysis
 - iii. Supporting evidence
 - iv. Conclusion
 - b. **Formal Aspects of the Essay**
 - i. Organization
 - ii. Use of language
 - iii. Referencing and layout
 - iv. Mechanics of language
2. Evaluate PowerPoints or posters based on the following:
 - a. Thoroughness of research
 - b. Use of legitimate sources
 - c. Good use of data
 - d. Valid reasoning
 - e. Ability to answer questions posed by other students

Extend

Contact a local chapter of The American Chestnut Foundation to inquire if speakers can visit your class: <http://www.acf.org/Chapters.php>

American Chestnut Internet Search

Use the internet to find answers to the following questions. Be sure to cite sources where you found information and to use credible sources.

1. Describe the American Chestnut tree. What did it look like? How large did it get? Where did it grow?
2. What is the Chestnut Blight, and how did it originate in North America?
3. What does the Chestnut Blight do to American Chestnut trees?
4. What is hard mast, and how does hard mast effect wildlife? Describe the American Chestnut's mast.
5. How did the rapid loss of the American Chestnut affect wildlife populations?
6. Why was the American Chestnut tree important to people?
7. What impact did its loss have to residents of Appalachia?
8. What is The American Chestnut Foundation (TACF)? What are they doing to help the American Chestnut?

Bullfrog Bullies

Gr: 3-5

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

- Understand that some frog species require specific habitats
- Explain some of the ways that animals might invade an area and that organisms that are common in one area can easily become invasive in an area in which they are introduced
- Plan ways to help spread the word about the proper care and disposal of invasive species

Standards:

NGSS	3-LS4-2 - Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. 3-LS4-3 - Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
Core Idea	3.LS3.A: Inheritance of Traits - Other characteristics result from individuals' interactions with the environment, which can range from diet to learning. Many characteristics involve both inheritance and environment. 3.LS3.B: Variation of Traits - The environment also affects the traits that an organism develops. 3.LS4.B: Natural Selection - Sometimes the differences in characteristics between individuals of the same species provide advantages in surviving, finding mates, and reproducing. 3.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">• Planning and Carrying Out Investigations• Constructing Explanations and Designing Solutions• Engaging in Argument from Evidence
Cross-Cutting Theme	<ul style="list-style-type: none">• Cause and Effect
Reading, Writing & Social Studies	CCSS.ELA-Literacy.RI.3.5 - Use text features and search tools (e.g., key words, sidebars, hyperlinks) to locate information relevant to a given topic efficiently. CCSS.ELA-Literacy.RI.5.7 - Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. CCSS.ELA-Literacy.W.2.2 - Write informative/explanatory texts in which they introduce a topic, use facts and definitions to develop points, and provide a concluding statement or section. CCSS.ELA-Literacy.W.3.2-5.2 - Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

	<p>CCSS.ELA-Literacy.W.3.7-5.7 - Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.</p> <p>CCSS.ELA-Literacy.W.3.8 - Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.</p> <p>CCSS.ELA-Literacy.W.4.8 - Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.</p> <p>CCSS.ELA-Literacy.W.5.8 - Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.</p> <p>CCSS.ELA-Literacy.SL.3.4-5.4 - Report on a topic or text, tell a story, or recount an experience with appropriate facts and relevant, descriptive details, speaking clearly at an understandable pace.</p>
Environmental Literacy	<p>1.A.1 - Identify an environmental issue.</p> <p>4.B.1- Analyze the growth or decline of populations and identify a variety of responsible factors.</p> <p>4.C.1- Explain how the interrelationships and interdependencies of organisms and populations contribute to the dynamics of communities and ecosystems</p>

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- Explain some of the ways that animals might invade an area and that organisms that are common in one area can easily become invasive in an area in which they are introduced
- Plan ways to help spread the word about the proper care and disposal of invasive species

Materials:

- 10 bean bags (in kit)
- 10 plastic frogs (in kit; small bean bags can also be used)
- Frog information cards (in kit)
- Graph paper
- Internet access
- Materials for making posters/brochures
- Tarp with landscapes (in kit; can also use tarp with areas outlined in colored electrical tape)
- Whiteboard or chart paper

Teacher Background: Frogs are **amphibians**, animals that spend parts of their life in water and on land. Amphibians have an aquatic larval form. Most frogs lay their eggs in the water and will need access to fresh, clean water throughout their life. While some frogs are generalists who can use a variety of water bodies, like Bullfrogs, most require a very specific aquatic habitat. Wood frogs, for instance, are obligate breeders in ephemeral wetlands – they must lay their eggs in a short-term wetland, like a vernal pool. Pickerel frogs and Leopard frogs are found in floodplain swamps and freshwater streams.

Amphibians are especially susceptible to environmental damage due to their semi-aquatic life cycle. Some species are able to handle alterations to the environment better than others or are especially suited to adaptation to a new environment. As healthy, varied wetlands become polluted or filled in for commercial or residential use, habitats are dramatically altered.

Highly adaptable invasive species often are able to take over. The American Bullfrog is one such species. It can live in any type of freshwater and can rapidly move to new areas. Juvenile Bullfrogs can travel up to 6 miles in a few weeks.

Once Bullfrogs establish in aquatic environments, they often can be aggressive and outcompete other species. In their native, northeastern U.S. range, American Bullfrogs have many predators which keep the population in check. However, American Bullfrogs have been introduced to the Midwest and other parts of the world. Their introduction is detrimental to many native species.

The spread of the Bullfrog is a cautionary tale about the dangers of collecting and releasing live organisms outside of their native ranges. Much like the Bullfrog, turtles, fish, snakes, and lizards are often seen as great pets and exciting “souvenirs” to bring home from a fun vacation. Along with the unwanted introduction of these critters, transporting them from one area to another can also encourage the spread of regional diseases even if the animal is a native species. Additionally, the movement of Bullfrogs across the world has been aided by restaurants and pet stores. They have been used as pest control. People raise them for frog legs. Sometimes, pet owners release their Bullfrog into a non-native environment, thinking they are being kind. Instead, this may cause disruptions to native populations of amphibians.

In this activity, students will simulate the invasion of Bullfrogs into a fictional ecosystem to see how the introduction impacts native species of frogs.

Procedure:

Engage

1. Gather background knowledge from students. Have they seen tadpoles, or do they know about the life cycle of frogs? Where would we expect to find frog eggs?
2. Break students into small groups to research frog species found in California where the Bullfrog has been introduced.
3. Provide resources to aid student research. Use resources like the Fish and Wildlife Service, Department of Natural Resources, or a college extension office to get a list of native California frogs.
4. Students should research the following data for presentation to the class: common name, scientific name, preferred habitat, food sources, and significant predators. Highlight specific adaptations to the environment (like webbed legs in aquatic frogs and sticky pads on the toes of tree frogs.)
5. Identify an environmental issue related to the researched species. Human interactions, environmental pollutants, and invasive species are all issues that surround these species.
6. Have students present their information using one of the following formats:
 - a. Informational poster
 - b. Nature brochure
 - c. Oral report
7. Have students share the information with the class.

Explore

1. It is important to frame this lesson by explaining that *Bullfrogs are not invasive in the Mid-Atlantic states but have become highly invasive in the Western U.S. and even in countries around the world.* One reason for this is the accidental (or sometimes purposeful) release of pet frogs or frogs taken from their native range to an area where they are not native. For this reason, the species used in this lesson activity are native to California, an area where introduced Bullfrogs have had major negative impacts, causing some species to be highly threatened.
2. Hand 10 students a numbered frog and its corresponding information sheet. Allow students time to read over the information.
3. Introduce the activity items: Show students the tarp. It is our landscape, and we have lots of different bodies of water shown in it. Have students look over the different habitats represented on the tarp.
4. Line students with frogs at least 5 feet away from the tarp. Allow students to briefly introduce the different frogs they have and their habitat requirements.
5. Have students toss their frogs onto the tarp. The frog will survive if it lands in a body of water that can support its eggs. If the frog does not land in its habitat, then the frog can be removed to the side.
6. Frogs may hit other frogs, moving them out of their habitat on the tarp. This may happen in the wild too, as different species interact in the same habitats. Remove displaced frogs to the side.
7. After all 10 frogs are tossed, count how many of each species survived. Tally the species type on the whiteboard or chart paper. This is the end of round 1.
8. Hand out the surviving “frogs” from Round 1. Introduce yourself as a lover of frogs, and tell students that you just love to catch Bullfrogs in ponds, bring them home to look at, and then let go near your house. Hand out enough large beanbags to make 10 total frogs (replicas and beanbags) in the group. The large beanbags are Bullfrogs. Bullfrogs not only eat the eggs of other frogs, but will eat the tadpoles and adult frogs too, as long as they can fit it in their mouth!
9. Students will take turns tossing the frogs and beanbag Bullfrogs onto the tarp, like before. The Bullfrogs may live in any of the bodies of water, and thus may land on any water body to survive. If the beanbag lands on top of a frog, then large “Bullfrog” eats the smaller one. The frog can be removed to the side. The beanbag Bullfrogs may displace frogs as well. For example, if the Bullfrog lands in a water body like the lake, then all native frogs in the lake will be removed.
10. At the end of the round, tally again how many frogs of each species survived.
11. Continue the activity in rounds, starting out with 10 frogs each time. You will have to add large Bullfrogs each round. Tally at the end of each round.
12. Play 5 rounds, or until there are no small native frogs left.

Explain

1. Graph the number of “frogs” in each species for each round. Did the diversity of species increase or decrease after the addition of Bullfrogs?

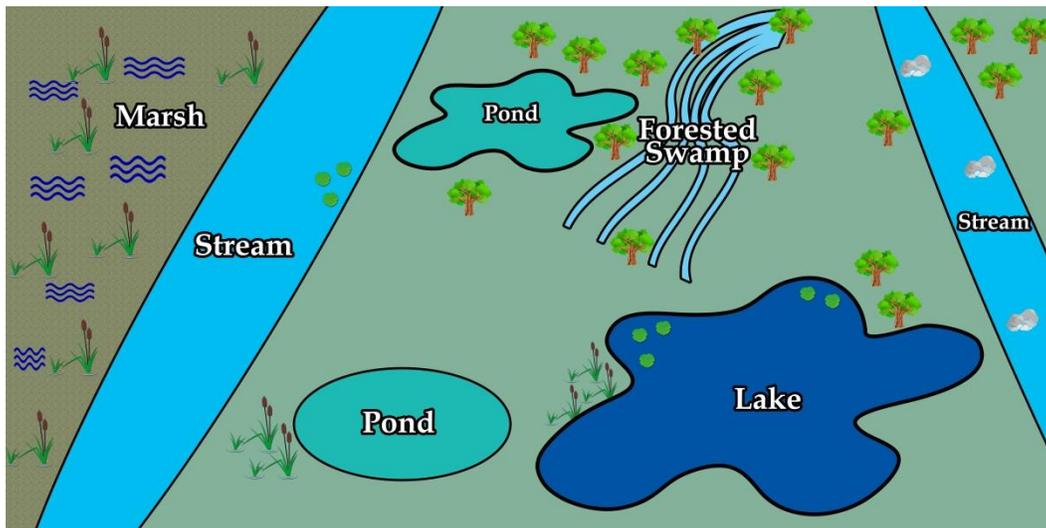
2. Discuss frog adaptations: What kinds of adaptations might encourage the spread of an invasive species like the Bullfrog? (Very long legs, big appetites, response to predation).
3. How can humans affect frogs? Brainstorm ways that humans can both help and hurt amphibian populations.

Evaluate

Discuss the following: Do all frog species have the same requirements? What specific things might one species need to survive? If Bullfrogs eat all other types of native frogs, what keeps them from taking over in a healthy environment?

Extend

1. *K-2*: Simulate the activity but don't allow beanbags to knock the other ones out of the habitats. If they do, then place the beanbags back into the habitat for the students. Emphasize the fact that you are bringing in the Bullfrogs, to help reinforce the idea that transplanting animals is bad for the environment. Discuss predation and allow the large beanbags to "eat" the little ones.
2. *Grade 5*: Conduct research into the amount of freshwater on the earth's surface. How much of this fresh water is available to amphibians? Tie in ecological **niches** to the availability of fresh water to highlight additional constraints to populations and ecosystems.



Example of Bullfrog Bullies habitat map

Common Name: Northern Red-legged Frog

Scientific Name: *Rana aurora*

Preferred Habitat: Forested wetlands, ponds, marshes, and stream sides with plant cover

Food Source: Variety of invertebrates

Predators: Garter snakes, other adult frogs, herons, and raccoons



Common Name: Foothill Yellow-legged Frog

Scientific Name: *Rana boylei*

Preferred Habitat: Rocky streams and rivers with open, sunny banks, forests, and forested swamps

Food Source: Aquatic, terrestrial, and flying insects, spiders, snails, and grasshoppers

Predators: Snakes, newts, Bullfrogs, and fish



Common Name: California Red-legged Frog
Scientific Name: *Rana draytonii*

Preferred Habitat: Ponds, forested swamps, and stream sides with plant cover

Food Source: Variety of invertebrates as well as small fish, mice, frogs, and salamanders

Predators: Opossums, raccoons, skunks, herons, hawks, crayfish, and Bullfrogs



Common Name: Columbia Spotted Frog
Scientific Name: *Rana luteiventris*

Preferred Habitat: Diverse habitats like ponds, wetlands, small lakes, springs, and slow-moving streams

Food Source: Variety of aquatic and terrestrial invertebrates as well as small frogs

Predators: Birds, fish, snakes, weasels, river otters, and coyotes



Common Name: Southern Mountain Yellow-legged Frog

Scientific Name: *Rana muscosa*

Preferred Habitat: Lakes, ponds, meadow streams, sunny riverbanks, and isolated pools

Food Source: Beetles, ants, bees, wasps, flies, dragonflies, and tadpoles

Predators: Snakes, birds, coyotes, and fish



Common Name: Oregon Spotted Frog

Scientific Name: *Rana pretiosa*

Preferred Habitat: Large marshy areas, lakes, ponds, and slow streams

Food Source: Variety of invertebrates as well as small vertebrates such as other frogs and small fish

Predators: Birds such as cranes and herons, fish, snakes, Bullfrogs, mink, and otters



Common Name: Arroyo Toad

Scientific Name: *Anaxyrus californicus*

Preferred Habitat: Sandy riverbanks and arroyos (dry creeks and streams)

Food Source: Ants, small flies, other insects

Predators: Few predators except Killdeer (bird), bullfrogs, and occasionally garter snakes



Common Name: Lowland Leopard Frog

Scientific Name: *Lithobates yavapaiensis*

Preferred Habitat: Wide variety of streams, springs, ponds, grasslands, and forested swamps

Food Source: Small fish, frogs, birds, insects, snails, spiders

Predators: Fish, bullfrogs, mud turtles, garter snakes, herons, and a variety of mammals



Common Name: Northern Leopard Frog

Scientific Name: *Lithobates pipiens*

Preferred Habitat: Grassland, wet meadows, potholes, forests, woodlands, canals, bogs, and marshes

Food Source: Leeches, fish, amphibians, snakes, small birds, and insects

Predators: Snakes, birds, other leopard frogs, and Bullfrogs



Common Name: California Tree Frog

Scientific Name: *Pseudacris cadaverina*

Preferred Habitat: Streams and rocky creek beds with permanent pools

Food Source: Insects, spiders, centipedes, and other invertebrates

Predators: Rainbow trout, sunfish, and garter snakes



Chestnut Tree Activity

Gr: 3-5

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

- Discuss the importance of the American Chestnut tree
- Explain how the Chestnut Blight spread across the Chestnut range to eradicate the American Chestnut
- Compare the historic size of the American Chestnut tree to trees in forests and schoolyards

Standards:

NGSS	4-LS1-1 - Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.
Core Idea	<p>2.LS4.D: Biodiversity and Humans - There are many different kinds of living things in any area, and they exist in different places on land and in water</p> <p>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.(secondary)</p> <p>3.LS4.D: Biodiversity and Humans - Populations live in a variety of habitats, and change in those habitats affects the organisms living there.</p> <p>4.LS1.A: Structure and Function - Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.</p> <p>5.LS2.A: Interdependent Relationships in Ecosystems - The food of almost any kind of animal can be traced back to plants.</p> <p>5.LS2.B: Cycles of Matter and Energy Transfer in Ecosystems - Matter cycles between the air and soil and among plants, animals, and microbes as these organisms live and die.</p>
Practices	<ul style="list-style-type: none"> • Planning and Carrying Out Investigations • Engaging in Argument from Evidence
Cross-Cutting Theme	<ul style="list-style-type: none"> • Patterns • Systems and Systems Models • Interdependence of Engineering, Technology, and Science on Society and the Natural World
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.3.3 - Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.</p> <p>CCSS.ELA-Literacy.RI.4.3 - Explain events, procedures, ideas, or concepts in a</p>

	<p>historical, scientific, or technical text, including what happened and why, based on specific information in the text.</p> <p>CCSS.ELA-Literacy.RI.5.3 - Explain the relationships or interactions between two or more individuals, events, ideas, or concepts in a historical, scientific, or technical text based on specific information in the text.</p>
Environmental Literacy	<p>1.A.1 - Identify an environmental issue.</p> <p>4.B.1- Analyze the growth or decline of populations and identify a variety of responsible factors.</p> <p>5.B.1- Analyze, from local to global levels, the relationship between human activities and the earth's resources.</p>

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- Explain how the Chestnut Blight spread across the Chestnut range to eradicate the American Chestnut
- Compare the historic size of the American Chestnut tree to trees in forests and schoolyards

Materials:

- Copies of Student Pages (on CD)
- Chestnut burs (in kit)
- Historic photos of American Chestnut trees (on CD)
- Pencils
- Measuring tapes
- Rulers
- Scissors
- String
- Tape
- Timeline cards
- Tree ID books or dichotomous keys (optional)



Teacher Background: At one time, the American Chestnut (*Castanea dentata*) dominated approximately 200 million acres of land from Maine to Mississippi. In some areas, it is estimated that American Chestnuts covered roughly 20% of the Appalachian forest while other areas contained almost pure stands of trees. Chestnut trees grew up to 100ft tall and often averaged several feet in diameter. The trees were important for wildlife as they produced edible nuts in the fall. One large tree could produce up to 10 bushels or more of nuts (~500-600 pounds)! Ruffed grouse, white-tailed deer, black bears, raccoons, squirrels, and wild turkeys are just some of the species which foraged on American Chestnuts. The trees were also used in the lumber industry to build fences, caskets, and cabins while the bark and inner cordwood were used to tan leather hides.

Unfortunately, during the late 1800s, Chestnut Blight (*Cryphonectria parasitica*), a fungal disease of Chestnut was accidentally introduced to the United States from Asia. It is believed that have entered the United States on imported Japanese Chestnut trees. The disease is an **invasive species**, or a non-native species that causes biological, economic, or human-health related harm. The Blight quickly spread through the American Chestnut stands. The fungal spores of Chestnut Blight spread from tree to tree by

wildlife and the wind. The spores infect cuts in the bark and create a rusty-colored **canker** (blister) on the surface of the tree. A few decades after the Blight's introduction, over 9 million trees died. By 1950, the American Chestnut was nearly gone from the landscape. Today, only a handful of these trees survive.

In this activity, students will learn about the history of the American Chestnut tree and its demise with the Chestnut Blight.

Procedure:

Engage

1. Introduce and define the vocabulary words **native**, **non-native** and **invasive** to the students. List some examples of each.
2. Show students the historic photos of the American Chestnut trees and describe their size and value to the environment. Show students burs from the trees (in kit).
3. Have students read the "Loss of the American Chestnut" student page and have them answer the questions on the sheet. Talk to the class about what they have learned about Chestnuts.
4. Hand out Chestnut Blight timeline cards and have students work individually or in small groups to map out the spread of the blight. Once the dates have been added to the different states, students should color their maps.
5. Discuss the following questions:
 - a. How long did it take for the Chestnut Blight to spread over the entire native range of the American Chestnut? Did it surprise you how fast it spread? How do you think the loss of Chestnuts changed the forests?

Explore

1. Tell students they will now investigate trees in their schoolyard or park to see how they compare to the historic American Chestnut.
2. Visit your schoolyard or park. Have students work in pairs or small groups.
3. Ask the student pairs to select 1 tree in their school yard to observe and measure.
4. Ask the students to examine their tree. Have students investigate the bark, the leaves, and other parts of the tree before handing them the observation worksheet.
5. Hand out the "Tree Observation and Measurement Worksheet" and have students work together to fill it out. You may want to model how to measure tree height or work with small groups of students.
6. If you have a key, then you can work with students to identify their tree. If not, then just have students record observations.

Explain

1. After the class has measured their trees, make a graph with the tree heights. Were any trees as big as an American Chestnut? Ask students to imagine what an American Chestnut tree would have looked like compared to their tree.
2. Ask students what signs of wildlife they saw. Would any of those animals have used American Chestnut? What would happen to the animals if their tree disappeared?

Evaluate

Have students write a short paragraph about what they learned about American Chestnut with their lesson.

Extend

1. Have students write a fictional story about a squirrel or other woodland creature that depended on American Chestnut. Have the animal chronicle the loss of the American Chestnut through the eyes of the animal.
2. Have students create a tree map of their schoolyard. Students can either draw maps of their schoolyard or can use programs like Google Earth to make maps.

The Loss of the American Chestnut

American Chestnut (*Castanea dentata*) is a **deciduous** tree that is related to oaks and beeches. In the Fall, deciduous trees lose their leaves. American Chestnuts can grow up to 120 feet and can live up to 300 years! American Chestnuts were once abundant and could be found growing in many forests in the eastern United States. One large tree could produce up to 10 bushels or more of nuts (~500-600 pounds)! Ruffed grouse, white-tailed deer, black bears, raccoons, squirrels, and wild turkeys all ate the nuts in the Fall. In addition, Native Americans and early European colonists ate the nuts and used the wood for lumber.

Unfortunately, in the late 1800s, a deadly fungus was introduced to the United States. The fungus was called Chestnut Blight. Chestnut Blight was brought to the United States on Chinese Chestnut trees that were planted in New York. In the early 1900s, American Chestnuts in New York City began dying. In less than 50 years, the fungus spread throughout the eastern United States and killed millions of American Chestnut trees.

1. Why was the American Chestnut important to wildlife and people?

2. What happened to the American Chestnut trees?

Print out the cards below and use them to map the spread of Chestnut Blight.

<p>1904 American Chestnut Trees start dying in New York.</p>	<p>1908 American Chestnut trees begin dying in New Jersey.</p>	<p>1909 Pennsylvania begins to lose Chestnut trees.</p>
<p>1910 Connecticut confirms Chestnut trees are dying.</p>	<p>1914 The blight fungus has become well established throughout the State of Virginia.</p>	<p>1919 Delaware, Rhode Island, Massachusetts, and Maryland all have the Chestnut Blight.</p>
<p>1923 The blight fungus is found in North Carolina</p>	<p>1930 Ohio, New Hampshire, Maine, Vermont, and West Virginia confirm they have the Chestnut Blight.</p>	<p>1940 Georgia, Indiana, Kentucky, Tennessee, and South Carolina all have the Chestnut Blight.</p>

Map It!

Using the timeline cards, label the map with the dates the blight was found in each State. Once labeled, color the states based on when the blight was found.

- 1900-1909: Blue
- 1910-1919: Purple
- 1920-1929: Green
- 1930-1939: Orange
- 1940-present: Red



Tree Observation and Measurement Sheet



With a partner, find a cool tree and fill out the information below.

1. What color are the leaves? _____
2. How big are the leaves? _____
3. Does your tree have any flowers? _____ Or fruit? _____
Describe what you see:

4. Look around your trees and up and down the trunk. Can you find any signs that animals have used your tree? Write what you see.

Sketch a picture of your Tree

A large, empty rectangular box with a thin black border, intended for a student to draw a sketch of the tree they observed.

Tree Observation and Measurement Sheet (Continued)

5. Have one person in your group stand at the bottom of your tree and hold a ruler straight out in front of them in a vertical position. Have the person with the ruler close one eye and back away from the tree until they reach the point at which the ruler and the tree appear to be the same size. Stop and have a partner measure the distance between the tree and the ruler using the measuring tape. That is the approximate height of the tree.

How tall is your tree? _____

6. Go up the trunk of the tree. Measure 4.5 feet up the trunk from the ground. Wrap your string around the tree trunk at 4.5 feet. Make sure the string is straight and tight around the trunk, and mark or cut the string where it overlaps. Measure the length of string to get the circumference of the tree.

What is your tree's circumference? _____

7. Convert the circumference measurement to diameter by dividing the circumference by pi (3.14).

Diameter= $\frac{\text{Circumference}}{3.14}$ = _____

8. American Chestnut trees could reach heights of 120 feet and could have a diameter of over 12 feet! Was your tree bigger or smaller than an American Chestnut? _____

9. What do you think would happen to wildlife if your tree died?

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

- Investigate differing stories and data sets
- Evaluate the reliability and accuracy of sources
- Explain how American Bullfrogs have been introduced and what impacts they cause

Standards:

<p>NGSS</p>	<p>MS-LS1-4 - Use argument based on empirical evidence and scientific reasoning to support an explanation for how...specialized plant structures affect the probability of successful reproduction. MS-LS2-4 - Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.</p>
<p>Core Idea</p>	<p>LS1.B: Growth and Development of Organisms - Animals engage in characteristic behaviors that increase the odds of reproduction. 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>
<p>Practices</p>	<ul style="list-style-type: none"> • Engaging in Argument from Evidence • Constructing Explanations and Designing Solutions
<p>Cross-Cutting Theme</p>	<ul style="list-style-type: none"> • Cause and Effect • Stability and Change
<p>Reading, Writing & Social Studies</p>	<p>CCSS.ELA-Literacy.RST.6-8.1 - Cite specific textual evidence to support analysis of science and technical texts.-RI.5.1 Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text. CCSS.ELA-Literacy.RST.6-8.2 - Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions. CCSS.ELA-Literacy.RST.6-8.6 - Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text. CCSS.ELA-Literacy.RST.6-8.7 - Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). CCSS.ELA-Literacy.RST.6-8.8 - Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. CCSS.ELA-Literacy.WHST.6-8.1 - Write arguments focused on discipline-specific content. CCSS.ELA-Literacy.WHST.6-8.2 - Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments,</p>

	<p>or technical processes.</p> <p>CCSS.ELA-Literacy.WHST.6-8.4 - Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.</p> <p>CCSS.ELA-Literacy.WHST.6-8.8 - Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.</p> <p>CCSS.ELA-Literacy.WHST.6-8.9 - Draw evidence from informational texts to support analysis reflection, and research.</p>
Environmental Literacy	<p>1.A.1 - Identify an environmental issue.</p> <p>5.A.2 - Analyze the effects of human activities that deliberately or inadvertently alter the equilibrium of natural processes</p>

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

- Investigate differing stories and data sets
- Evaluate the reliability and accuracy of sources
- Explain how American Bullfrogs have been introduced and what impacts they cause

Materials:

- “Invading Bullfrogs Appear Nearly Unstoppable” by National Geographic (on CD)
- Role cards (in kit)
- Internet Access

Teacher Background: Bullfrogs are native to most of the eastern United States of America. Around 1900, Bullfrogs were brought to military and mining camps in Colorado and California to sate the appetite for frog legs. Since Bullfrogs have such large legs, in some places they were released into the ecosystem to grow in small aquaculture ponds. Young Bullfrogs can travel up to 6 miles in a few weeks, and these opportunistic Bullfrogs quickly took over many waterbodies in their introduced range.

American Bullfrogs are problematic in their introduced range due to their competition with native species. American Bullfrogs have voracious appetites and often consume eggs, juveniles, and adult frogs in their introduced range. Furthermore, American Bullfrogs are prolific reproducers. Bullfrogs may lay as many as 20,000 eggs, while native West Coast species such as the Red-legged (*Rana aurora*) and Pacific Tree Frog (*Pseudacris regilla*) only produce 530-830 and 400-750 eggs per clutch, respectively. Bullfrogs also tend to harbor high levels of chytrid fungus (*Batrachochytrium dendrobatidis*). This fungus has been associated with amphibian mortality in many localities and by many researchers.

While the American Bullfrog is not invasive in the Mid-Atlantic States, it has caused and continues to cause great damages in other parts of the U.S. and around the world. The spread of the Bullfrog is a cautionary tale about the dangers of collecting and releasing live organisms outside of their native ranges. Much like the Bullfrog, turtles, fish, snakes, and lizards are often seen as great pets and exciting “souvenirs” to bring home from a fun vacation. Along with the unwanted introduction of these critters, transporting them from one area to another can also encourage the spread of regional diseases even if the animal is a native species. Additionally, the movement of Bullfrogs across the world has been aided by restaurants and pet stores. Bullfrogs have been used as pest control. People also raise them for frog legs. Sometimes, pet owners release their

Bullfrog into a non-native environment, thinking they are being kind. Instead, this action may cause disruptions to native populations.

In this activity, students will investigate different role players in the story of the American Bullfrog and will evaluate the impact of its introduction to the western United States.

Procedure:

Engage

1. Ask students if they have ever seen a Bullfrog. Where was it? What was it doing?
2. Ask students to define invasive species. Can Bullfrogs be invasive?
3. Assign as pre-reading, or allow time for students to read the National Geographic article: "Invading Bullfrogs Appear Nearly Unstoppable".
4. After reading the article, ask students questions to gauge comprehension. Where have Bullfrogs been introduced? Why is this a problem?

It is important to frame this lesson by explaining that Bullfrogs are native to the Mid-Atlantic States but have become highly invasive in the Western U.S. and even in countries around the world. One reason for this invasion is the accidental or deliberate release of pet frogs or frogs taken from their native range to an area where they are not native.

Explore

1. Explain to students that they are part of a local Task Force on Invasive American Bullfrogs in the West Coast town of Marshland. The Task Force is concerned that Bullfrogs are causing declines in populations of native frogs and should be eradicated wherever found.
2. Divide students into groups of 2-3 and give each group a Role Card to investigate. Role Cards represent different stakeholders concerned about American Bullfrogs.
3. Students will then have to use the Internet to research information relating to the different Role Cards. Remind the students that they will be evaluating scientific data as well as eyewitness testimonies. How will they evaluate the information from these sources?
4. Once students have completed their research, they are to create a presentation explaining their position. It can be in the form of an oral report, poster, or PowerPoint presentation. Remind students to use data and to cite sources.

Explain

1. Once the presentations are complete, have the groups share them with the class. Students should be encouraged to ask questions to clarify details, question reasoning or bias of sources, etc. Remind them to take notes during the

presentations because they are going to be asked their position and they'll need evidence.

2. After all students have presented, invite discussion. What are the ecological effects caused by invasive American Bullfrogs? Can differing viewpoints be reconciled? Are the first-person accounts reliable? Which viewpoints are the most supported? Are any of the scientific data misrepresented or unsupported?
3. Have students accept or reject the Task Force's concern that Bullfrogs are causing declines in populations of native frogs and should be eradicated wherever found. Have students write a paragraph explaining their position, citing evidence from presentations and their research.

Evaluate

1. Students must make decisions based on scientific evidence and must use supporting documentation to back up their claims.
2. Teachers should evaluate critical thinking, use of appropriate resources, and asking appropriate questions for research.
3. Grade the presentations and written paragraphs on accuracy of information, appropriateness of message, and grade-specific writing proficiency in science and technical subjects.

Extend

1. Have students research the various control methods that have been utilized to control or eradicate invasive Bullfrog populations including chemical, biological, and mechanical processes. Have students debate the pros and cons of each method.
2. Have students contact local veterinary offices and pet shops to see what practices they use to mitigate local habitat damage by released pets. Have students create informational brochures or flyers for distribution, explaining how ecosystems can be disrupted by the introduction of these disease vectors and non-native species. While American Bullfrogs may be the greatest pet threat to other amphibians, no pets should be released into the environment since they could either become invasive, carry diseases that kill native animals, or die due to lack of adaptation to the wild. **Note: This is a good place to reiterate that Bullfrogs are not invasive in the Mid-Atlantic States but have caused a great deal of problems in other parts of the U.S. Bullfrogs serve as a good example of why wild animals do not make good pets and pets should not be released into the wild.*
3. STEM extension – have students design their own methods for Bullfrog control or eradication while focusing on fixing the issues with current mechanical controls.

Free Range Fish Farmer

My fish live in a number of small ponds near here. We prefer the natural habitat since all the food for these fish is found here already. Our naturally raised fish are healthy and strong!

Lately, most of the tadpoles in the pond are Bullfrogs. They secrete foul-tasting chemicals from their skin that our fish don't like. The adult Bullfrogs eat other frog eggs and tadpoles too, so there is less good food for our poor, little fish!

West Coast Researchers, Sequoia National Park

Native species are on the decline. We have 50% less native species in some of our waters that we did 10 years ago. We are seeing a large drop in biodiversity which means that the ecosystem isn't as strong, healthy, or resilient as it was.

We have seen an increase in the number of Bullfrogs in the same time span. They eat our local frogs tadpoles and adults. It's not looking good for our native frogs.

Bullfrog Breeder

I sell the most brightly-colored Bullfrogs I can find! When I travel to reptile and amphibian shows, I sell many frogs to people who want a hardy pet. I can fetch a fair price for a long jumper, but the pretty frogs sell the best!

I raise frogs inside so that I can cross the two that look the best. When I get frogs that are dull, gray, or slow, I let them go out into the wild. I can't afford to take care of the ones that won't sell.

Annual Bullfrog Race Coordinator

We used to invite all frog species to our race, but the owners of other frogs didn't stand a chance. We encourage healthy, happy, large Bullfrogs who can out-hop all the competition!

Participants visit our ponds before the race to catch the biggest Bullfrog they can find. Winners get to go home with their racers!

I don't know what I'd do without all these long-legged Bullfrogs.

International Union for Conservation of Nature (IUCN) representative

Protecting biodiversity is the most important thing we do. To save sensitive species from extinction, we must study and control the movement of invasive species.

Invasive Species, like the American Bullfrog, cost economies billions of dollars each year in habitat destruction and decreases in human and animal well-being. We need our governments to recognize that native species are imperiled.

Then, we can create strong laws that will protect them from these invasive species.

Bullfrog Defenders of the Coast

Bullfrogs get a bad rap. As an organization, we seek to improve the community's views on American Bullfrogs. After all, these Bullfrogs are American, so it makes sense that they would want to spread across the nation. We should all work together to protect these species.

U.S. Geological Survey Biologist

Bullfrogs have been in the state of Montana since the 1920s, when they were brought in for their legs by restaurateurs. Now, they are taking over areas of the Yellowstone River where they have never been seen before. This is a problem for native frogs.

We are conducting research into the best way to remove or eradicate these invasive animals. We are using bait traps, seining for tadpoles, and using nets and other means to remove the adults. We must stop them before they spread to other, more fragile waters.

French Chef

Chicken legs are so bourgeois. *Mais oui*, frog legs are a delicacy! I import thousands of frogs each year for my restaurant.

I can't sell small frog legs. People only want to eat the juiciest, plumpest, longest legs. The little Bullfrogs always get mixed in with my shipments though.

I release the small Bullfrogs behind the restaurant.

Smallpox: A Timeline

Gr: 6-12

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

- Explain why Smallpox can be considered an invasive species
- Describe the impacts of Smallpox on human health, history, and populations

Standards:

NGSS	MS-LS2-2 - Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. MS-LS2-4 - Construct an argument supported by empirical evidence that changes to... biological components of an ecosystem affect populations. HS-ESS3-1 - Construct an explanation based on evidence for how the occurrence of natural hazards has influenced human activity.
Core Idea	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. ESS3.B: Natural Hazards Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.
Practices	<ul style="list-style-type: none">• Developing and using models• Using mathematics• Constructing explanations• Obtaining, evaluating, and communicating information
Cross-Cutting Theme	<ul style="list-style-type: none">• Cause and Effect• Stability and Change
Reading, Writing & Social Studies	CCSS.ELA/Lit.RST.6-8.7 - Integrate technical or quantitative information expressed in words in a text with a version of that information expressed visually. CCSS.ELA/Lit.RST.9-10.1 - Cite specific textual evidence to support analysis of science and technical texts, attending to precise details of explanations or descriptions.
Environmental Literacy	6.C.1. Analyze and explain that human activities can involve some level of risk to human health

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

- Explain why Smallpox can be considered an invasive species
- Describe the impacts of Smallpox on human health, history and populations

Materials:

- Adding machine tape (in kit)
- Internet
- Masking tape
- Student page (on CD)
- Timeline cards (in kit)

Teacher Background: Smallpox is caused by the variola virus which is found only in humans. It is easily spread by inhaling the virus or by direct contact with infected body fluids or contaminated objects such as bedding or clothing. The mortality rate ranges from 30-60%, although the death rate may be as high as 90% in children. The survivors are usually left horribly disfigured by the scars and may be left blind.

The native range of Smallpox is unknown but it seems to have appeared in humans around 10,000 BCE. The earliest clinical evidence of the disease is found in the mummy of Ramses V who died in 1145 BCE. It is unknown when Smallpox arrived in Europe, but Saint Nicasius of Rheims became the patron saint of Smallpox victims for having supposedly survived the disease in 450 AD.

Smallpox was probably brought to what is now the U.S. by European visitors (possibly cod fishermen), prior to colonization. The first epidemic apparently occurred in 1617-19 in Massachusetts, which killed up to 90% of the Native Americans in the area. This loss is why the Mayflower colonists found few Native Americans when they arrived. The disease spread rapidly to both Native Americans and colonists because new cases were constantly being brought in by arriving settlers from Europe or slaves from Africa. Accounts of **inoculation** against Smallpox can be found as early as the late 10th century in China; by the 16th century, Smallpox inoculation was widely practiced in that country. In the U.S., the procedure was learned in the early 1700s from an African slave named Onesimus, who belonged to Cotton Mather, a Boston minister. Inoculation involved using live Smallpox virus, with the result that the patient developed a mild case of Smallpox. The disadvantage was that person was contagious and had to be quarantined for about a month. Occasionally, the patient developed a severe case of Smallpox and some even died as a result.

In 1796, Edward Jenner discovered that using cowpox virus (a related virus) rather than Smallpox virus for inoculation conferred immunity to Smallpox. The advantage to this practice, known as **vaccination**, was that the patient did not have to be quarantined. Before the advent of vaccination, Smallpox spread easily to any person who was not **immune**. In the United States, from 1843 to 1855, first Massachusetts and then other states required Smallpox vaccination. By 1897, Smallpox had largely been eliminated in the United States.

In 1959, a worldwide Smallpox vaccination program was begun in the hopes of wiping out the disease. The last case of Smallpox was in Somalia in 1977 and in May 1980, the World Health Organization (WHO) declared that Smallpox had been wiped out worldwide. All known laboratory stocks of Smallpox virus are supposed to have been destroyed or transferred to 1 of 2 WHO reference laboratories, one in the U.S. (Centers for Disease Control) and one in Russia.

In this activity, students will learn about the history of Smallpox by conducting a survey and by creating a timeline of historical events.

Procedure:

Engage

1. Before beginning this activity, have students conduct a survey asking people whether or not they have been vaccinated against Smallpox.
 - a. Students should survey people from a wide range of ages – other students, teachers, parents, siblings, grandparents, etc.
 - b. Have students keep a record of who they asked and their approximate age (i.e., child, parent, grandparent).
2. When the surveys are complete, summarize the results into 1 document. Ask the students if they noticed any pattern. Leave explanation for the end.

Explore

1. Pose the question: Could Smallpox be considered an invasive species?
2. Have students read:
<http://www.invasivespeciesinfo.gov/laws/execorder.shtml>
 - a. Have students focus on Section 1: Definitions
 - b. Have the class agree on the definition of an invasive species.
3. Tell students that one way to decide whether Smallpox meets the definition of an invasive species is to make a timeline of historical events to review.
4. Have the students read the student worksheet. It will provide some background information as well as directions for setting up the timeline. Make sure they understand the difference between inoculation and vaccination.
5. Give students time to measure and date the timeline and tape it to a wall.
6. Divide the timeline cards among the students.

7. Have each student read his/her cards out loud and then tape them to the appropriate place on the timeline (Hint: Use masking tape in case the cards have to be adjusted as new ones are added).

Explain

1. After assembling the timeline, ask students the following questions:
 - a. Why are there are not as many cards for the earliest dates?
 - b. Based on the timelines, what were some of the impacts that Smallpox had on history?
 - c. What were some of the impacts Smallpox had on human populations?
 - d. What 2 important events occurred in the U.S. in 1721 and 1800s?
2. Have students look at a map of the U.S. and locate the cities.
 - a. What do they notice?
 - b. Why would epidemics tend to occur in ports?
3. Have the students refer back to their survey. Have them compare the information from the last 50 years in their timeline with the results of their survey. Why is there a difference?
 - a. *Children and most of their parents probably were not vaccinated against Smallpox, but grandparents and other older adults were. In 1972, routine Smallpox vaccination for children ended in the United States. Therefore, most people born after 1972 were not vaccinated.*

Evaluate

1. Have each student write a paragraph with supporting information to answer the following questions:
 - a. Does Smallpox meet the criteria for an invasive species?
 - b. What is the evidence?

Extend

1. For a more current example of an introduced disease, have students research West Nile Virus (see resources below). Key questions:
 - a. Where did West Nile Virus (WNV) originate?
 - b. When and where was it first found in the United States?
 - c. How quickly did it spread? By 2012 it was found in all of the lower 48 states
 - d. Why might it have spread so quickly?
 - i. *Neither the host species (birds) nor humans had ever been exposed to the virus and therefore had no immunity.*
 - ii. *Many common species of birds carry the virus.*
 - iii. *Many species of birds migrate.*
2. What impact might climate change have on the incidence and spread of the virus?

- a. *Unusually mild winters allow more WNV-infected mosquitoes to survive, which gives the virus a head start in spring.*
 - b. *The common Culex pipens mosquito, the primary vector of WNV, prefers hot, dry summers with just enough rainfall to provide places to breed (i.e., heat waves and drought).*
 - c. *Hot weather also makes mosquitoes reproduce faster and makes the breeding season longer; it also speeds up the growth of the virus inside the mosquitoes.*
3. For High School students:
 - a. Do not give them the timeline cards or instructions for doing the timeline.
 - b. Challenge them to do their own research on the history of Smallpox and create their own timeline.
 - c. You can have them focus on the impact of Smallpox on world history, American history, or on world populations.
 4. Have students debate the question, "Should the stocks of Smallpox virus still held in the U.S. and Russia be destroyed?" There are plenty of articles, both pro and con, available on the Internet.

Smallpox: A Timeline – Student Background

Smallpox was once one of the most widespread, deadly diseases. Today it is the only human disease to have been wiped out. However, its impact on history is significant. Smallpox is caused by a virus found only in humans. It is spread by breathing in the virus or by direct contact with infected body fluids or contaminated objects such as clothing. The death rate is between 30 % and 60 %, but is much higher (as high as 90 %) in children. Survivors are usually left with horrible scars and may be left blind. In order to understand this timeline, you need to know the difference between “inoculation” (sometimes called “variola”) and “vaccination”.

Inoculation

- Inoculation involved using live Smallpox virus; the patient then developed a mild case of Smallpox.
- The disadvantage was that the patient was contagious (could spread the disease) and therefore had to be isolated for up to a month.
- In some cases, the patient developed a severe case of Smallpox and some even died.

Vaccination

- In 1796, Edward Jenner discovered that using cowpox virus, a related virus, made the patient unable to get Smallpox.
- Vaccination is a much safer procedure because the patient does not get Smallpox and is not contagious.

A worldwide Smallpox vaccination program was begun in the hopes of wiping out the disease. The last case of Smallpox was in Somalia in 1977 and in May 1980, the World Health Organization (WHO) declared that Smallpox had been wiped out worldwide. All known laboratory stocks of Smallpox virus have been destroyed or transferred to one of two WHO reference laboratories, one in the US (Centers for Disease Control) and one in Russia.

Timeline Instructions:

1. Cut a 33 foot long section of adding machine tape and make 11 three foot sections of tape with the following divisions:
 - a. AD 1-1600 1601-1650 1651-1700 1701-1750 1751-1800 1801-1850
1851-1900 1901-1950 1951-2000 2000-Future
2. Tape the timeline to a long wall.
3. You will be given several cards with dates and events on them.
4. When it is your turn, read your cards out loud and then tape them to the timeline in the correct place.
5. The cards may have to be adjusted as new cards are added.

<p style="text-align: center;">10,000 BCE</p> <p>Smallpox is thought to have first appeared in humans.</p>	<p style="text-align: center;">1145 BCE</p> <p>The mummy of Egyptian Pharaoh Ramses V shows evidence of Smallpox.</p>
<p style="text-align: center;">430 BCE</p> <p>Smallpox hits Athens and kills more than 30,000 people (20% of the population).</p>	<p style="text-align: center;">108 AD</p> <p>The “Antonine Plague” kills 7 million people in the Roman Empire. This may have been the beginning of the end of the Roman Empire.</p>
<p style="text-align: center;">251- 256</p> <p>The “Plague of Cyprian” in the Roman Empire may have been Smallpox.</p>	<p style="text-align: center;">450</p> <p>The first evidence of Smallpox in Europe is when St. Nicasius of Rheims (France) becomes the patron saint of Smallpox victims when he supposedly recovers from the disease.</p>
<p style="text-align: center;">581</p> <p>Bishop Gregory of Tours (France) writes a clinical description of Smallpox.</p>	<p style="text-align: center;">1315 BCE</p> <p>The first recorded Smallpox epidemic occurs during the Egyptian-Hittite War.</p>
<p style="text-align: center;">1617-19</p> <p>The first epidemic in the U.S. occurs in Massachusetts when cod fishermen infect the Indians. Up to 90% of the Indians die. This is why the Pilgrims find few Indians when they arrive in 1620.</p>	<p style="text-align: center;">1692</p> <p>Smallpox epidemic in Boston</p>

<p style="text-align: center;">900</p> <p>Accounts of inoculation against Smallpox in China can be found as early as the late 10th century. The procedure is widely practiced in China by the 1500s.</p>	<p style="text-align: center;">1721</p> <p>Smallpox epidemic in Boston</p>
<p style="text-align: center;">1736</p> <p>Smallpox epidemic in Philadelphia</p>	<p style="text-align: center;">1738</p> <p>Smallpox epidemic in Charleston, South Carolina</p>
<p style="text-align: center;">1770s</p> <p>Smallpox spreads by way of the Indians to the West Coast. 30% of the West Coast Indians die</p>	<p style="text-align: center;">1700s</p> <p>Smallpox kills 400,000 Europeans each year. One out of every seven Russian children dies of Smallpox.</p>
<p style="text-align: center;">1830s</p> <p>Smallpox spreads to Alaska. 50 % of the Indians and Inuit (Eskimos) die.</p>	<p style="text-align: center;">1860-1</p> <p>Smallpox epidemic in Pennsylvania</p>
<p style="text-align: center;">1865-73</p> <p>Smallpox epidemics in Philadelphia, New York City, Boston, and New Orleans</p>	<p style="text-align: center;">1877</p> <p>Smallpox epidemic in Los Angeles</p>

<p style="text-align: center;">1902 Smallpox epidemic in Boston</p>	<p style="text-align: center;">1776 - 81 During the Revolutionary War, 125,000 people die of Smallpox.</p>
<p style="text-align: center;">1736 Benjamin Franklin's four-year-old son dies of Smallpox.</p>	<p style="text-align: center;">1754-67 During the French and Indian War, Sir Jeffrey Amherst deliberately spreads Smallpox-contaminated blankets to Indian tribes who are friendly to the French.</p>
<p style="text-align: center;">1781 Andrew Jackson (7th president) survives Smallpox while being held captive by the British. He was 14 years old at the time.</p>	<p style="text-align: center;">1863 President Abraham Lincoln is suffering from the beginning symptoms of Smallpox when he delivers the Gettysburg Address.</p>
<p style="text-align: center;">1767 The young composer Mozart survives a case of Smallpox when he is 11 years old.</p>	<p style="text-align: center;">1721 The Rev. Cotton Mather learned about inoculation from his African slave, Onesimus. Mather urges the citizens of Boston to be inoculated to stop an epidemic of Smallpox in Boston.</p>
<p style="text-align: center;">1777 Gen. George Washington requires all soldiers in the Continental Army to be inoculated against Smallpox.</p>	<p style="text-align: center;">1801 President Thomas Jefferson urges that all Indians be inoculated against Smallpox.</p>

<p style="text-align: center;">1775-81</p> <p>During the American Revolution, the British use Smallpox as a form of "biological warfare" by placing Smallpox infected people into the American encampment.</p>	<p style="text-align: center;">1717</p> <p>Lady Mary Montagu learns about inoculation while she and her husband are stationed in Turkey. She introduces the practice to England.</p>
<p style="text-align: center;">1764</p> <p>John Adams (Second President) is inoculated against Smallpox.</p>	<p style="text-align: center;">1738</p> <p>A Smallpox epidemic strikes Charleston, SC. Of the 441 people who had been inoculated, 4 % die. Of those who had not been inoculated, 18 % die.</p>
<p style="text-align: center;">1774</p> <p>Benjamin Jesty, an English farmer, inoculated his wife and two sons with matter from a cowpox lesion from one of his cows. However, he did not publish his results, so no one knew about them.</p>	<p style="text-align: center;">1796</p> <p>Edward Jenner vaccinated eight-year-old James Phipps with matter from a cowpox sore. Later, he exposed Phipps with matter taken from a human Smallpox sore. Phipps did not get Smallpox.</p>
<p style="text-align: center;">1800</p> <p>Benjamin Waterhouse, a Harvard professor of medicine, performs the first U.S. vaccinations on his children. He went on to put much effort into encouraging public vaccination.</p>	<p style="text-align: center;">1798</p> <p>Edward Jenner publishes his results on his success in protecting James Phipps from Smallpox infection with material from a cowpox pustule. The information about vaccination spreads rapidly.</p>
<p style="text-align: center;">1813</p> <p>The <u>U.S. Congress</u> passes the <u>Vaccine Act of 1813</u> to make sure that safe Smallpox vaccine would be available to the American public.</p>	<p style="text-align: center;">1832</p> <p>The Federal government of the United States establishes a Smallpox vaccination program for Native Americans.</p>

<p style="text-align: center;">1843 - 1855</p> <p>In the United States, first Massachusetts, and then other states require Smallpox vaccination.</p>	<p style="text-align: center;">1842</p> <p>Great Britain bans inoculation because of the risk of starting a Smallpox epidemic.</p>
<p style="text-align: center;">1853</p> <p>The British government introduces compulsory Smallpox vaccination by an Act of Parliament.</p>	<p style="text-align: center;">1897</p> <p>Smallpox is largely eliminated from the United States.</p>
<p style="text-align: center;">1972</p> <p>The last major European outbreak of Smallpox occurs in Yugoslavia. The epidemic infects 175 people, causing 35 deaths.</p>	<p style="text-align: center;">1978</p> <p>The last cases of Smallpox in the world occur in England. Two laboratory workers are infected and one dies.</p>
<p style="text-align: center;">Early 1950s</p> <p>There are an estimated 50 million cases of Smallpox worldwide each year, mostly in undeveloped countries.</p>	<p style="text-align: center;">1967</p> <p>The World Health Organization (WHO) estimates that there are still 15 million cases and 2 million deaths worldwide from Smallpox.</p>
<p style="text-align: center;">1972</p> <p>Routine Smallpox vaccination for children ends in the United States.</p>	<p style="text-align: center;">1949</p> <p>The last case of Smallpox in the United States occurs in Texas.</p>

<p style="text-align: center;">1990</p> <p>Military personnel in the United States are no longer vaccinated against Smallpox.</p>	<p style="text-align: center;">1977</p> <p>The last natural (not the result of a laboratory accident) case of Smallpox is found in Somalia. No further cases are found worldwide.</p> <p style="text-align: center;">1775</p> <p>The American Army fails to conquer Quebec, Canada at the beginning of the Revolution partly because too many of the troops were weakened by Smallpox. The British troops had been inoculated.</p>
<p style="text-align: center;">1970s</p> <p>Routine vaccination against Smallpox is no longer done in most European countries.</p>	<p style="text-align: center;">1950</p> <p>The first attempt to eradicate Smallpox in the entire Western Hemisphere is made by the <u>Pan American Health Organization</u>. The attempt is successful in wiping out Smallpox in all countries except Argentina, Brazil, Colombia, and Ecuador.</p>
<p style="text-align: center;">1959</p> <p>The World Health Organization (WHO) begins a world-wide program to wipe out Smallpox completely.</p>	<p style="text-align: center;">1975</p> <p>Smallpox cases occur only in Somalia and Ethiopia. Civil war, famine, and refugees make the job of wiping out Smallpox difficult in these countries.</p>
<p style="text-align: center;">1980</p> <p>The World Health Organization (WHO) certifies that Smallpox has been wiped out worldwide. This is the only time so far that a human disease has been wiped out.</p>	<p style="text-align: center;">1757</p> <p>Smallpox epidemic in Annapolis, MD</p>

<p>1882-3 Epidemic of Smallpox in Baltimore. More than 1,500 people died.</p>	<p>1816-17 Numerous cases of Smallpox in Baltimore</p>
<p>1872-3 Epidemic of Smallpox in Baltimore. More than 2,000 people died.</p>	<p>June 2014 A previously unknown stockpile of live Smallpox virus was discovered in an unsecured lab at the National Institutes of Health in Bethesda, MD.</p>