

Adaptations of Invasive Species

Grades 9-12 Science Curriculum

Instructions



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Curriculum Length:

(4) 50 minute periods (9-12 grades). It can be adapted for Grades 5-8.

National Agricultural Literacy Outcomes (NALOs):

- Identify non-native or invasive species in your state that impact the sustainability and/or economic value of natural or agricultural ecosystems
- Identify current and emerging scientific discoveries and technologies and their possible use in agriculture (e.g., biotechnology, bio-chemical, mechanical, etc.)
- Discuss how agricultural practices have increased agricultural productivity and have impacted (pro and con) the development of the global economy, population, and sustainability

Content Standards:

- HS-LS4-4 - Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
- HS-LS4-5 - Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
- HS-LS4-6 - Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity

Common Core Standards:

- 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.
- 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.

Keywords:

- Trait
- Adaptations
- Acclimation
- Behavioral Adaptations
- Morphological Adaptations
- Physiological Adaptations
- Allelopathy
- Invasive Species
- Biological Control

Curriculum Purpose:

Invasive Species Adaptations lesson is designed to identify different types of adaptations necessary for the survival of organisms by using examples invasive species. The lesson is designed to teach parts of the National Science Standard HS-LS4 and connect NALO's invasive species to assist 9-12 Life Science teachers apply agriculture and environment concepts to a biology curriculum. The examples in the lesson include Asian carp, feral hogs, spotted knapweed, and cane toads. The lesson will end with developing a predator to specifically control an invasive species.

Materials:

- Various art supplies (Crayons, pencils, and/or markers, blank paper)

- Internet
- Printer
- Projector
- 1 computer device per group or lesson can be adapted to computer lab

Vocabulary:

- Trait - feature of an organism
- Invasive Species - Invasive species are plants, animals, or pathogens that are non-native (or alien) to the ecosystem. They cause harm to the economy, environment or human health.
- Acclimation - changes that increase function of an individual that are not genetic
- Adaptations - a change or the process of change by which an organism or species becomes better suited to its environment.
- Behavioral Adaptations - related to the way something acts
- Morphological Adaptations - the form or structure of something
- Physiological Adaptations - related to the way something functions
- Allelopathy - an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms.
- Biological control - is a method of controlling pests (including insects, mites, weeds and plant diseases) using other living organisms.

Background:

What is an Invasive Species?

Introduction

An invasive species is defined legally in the USA as “A nonnative species which causes harm to the economic, environment or to human health... ‘A species can be native in a region but it must be non native in the ecosystem it invades to be considered invasive.

Non-native species can be added to a community either by natural range extensions or because they are introduced as a result of human or animal activity. Most non-native species have harmful ecological effects; these are referred to as invasive species. Virtually all ecosystems are at risk from the harmful effects of introduced invasive species (also see exotic species, marine invasive species, and aquatic invasive species).

Invasive species are a major threat to our environment because they (1) can change habitats and alter ecosystem function and ecosystem services, (2) crowd out or replace native species, and (3) damage human activities, costing the economy millions of dollars. For example, costs to agriculture,

Background continued:

forestry, fisheries, and other human activities by introduced species are estimated at \$137 billion per year to the U.S. economy alone.

Threats to Biodiversity

Invasive species rank second only to habitat destruction, such as deforestation, as a threat to biodiversity. Almost half of the species in the United States that are at risk of extinction are endangered because of the effects introduced species alone or because of their impacts combined with other processes. In fact, introduced species are considered a greater threat to native biodiversity than pollution, harvest, and disease combined. Invasive species threaten biodiversity by (1) causing disease, (2) acting as predators or parasites, (3) acting as competitors, (4) altering habitat, or (5) hybridizing with local species.

Background continued:

Disease

Accidental introduction of the Asian chestnut blight fungus via the nursery trade virtually eliminated American chestnut from over 180 million acres of eastern United States forests in the first half of the 20th century. This extinction caused a whole scale transformation of the Eastern deciduous forest ecosystem, which was dominated by American chestnut. The loss of chestnuts was a disaster for many animals that were highly adapted to live in forests dominated by this tree species. For example, ten moth species that could live only on chestnut trees became extinct.

Predators

Invasive predators can severely reduce the population sizes of native species, or even drive them extinct, because native prey species may not have evolved defenses against the novel predators: The Nile perch, a voracious predator, was introduced to Lake Victoria in Africa as a food fish. Predation from the Nile perch has eliminated over one hundred species of the spectacular native cichlid fishes of Lake Victoria. Invasive herbivores can cause great damage. For example, goats were introduced by sailors to many remote oceanic islands during the age of European seafaring exploration, to provide a source of food when the islands were revisited. Goats introduced to the island of St. Helena in the 16th century eliminated over half the endemic plant species. North American gray squirrels are driving native red squirrels to extinction in Great Britain and Italy. The introduced squirrels forage for nuts more efficiently than the native species, potentially leading to the loss of a native species. Zebra mussels were accidentally brought to the United States from Russia in the ballast of ships. Zebra mussels alter aquatic habitats by filtering large amounts of water, thus reducing densities of planktonic organisms and settling in dense masses over vast areas. At least thirty freshwater mussel species are threatened with extinction by competition from the zebra mussel.

Hybridization

Hybridization occurs when members of two different species mate with one another and produce viable offspring that carry genes from both parents. When an invasive species is much more abundant than a native relative, they may hybridize so often that the invaders genes "flood" the native species, such that no individuals contain the entire genotype of the native species, thus effectively driving the native species to extinction. It is possible that hybridization is common in such cases because the native species has not experienced selection for reproductive isolating mechanisms to prevent hybridization with the invader. Of the 26 known animal species in the USA that have gone extinct since being listed under the Endangered Species Act, at least three were wholly or partly lost because of hybridization with invaders. For example, hybridization between introduced mallards and the native Hawaiian duck and between the rarest European duck (the white-headed duck) and the invasive North American ruddy duck may result in the extinction of the native species.

Invasion Meltdown

Often invading species interact with one another to generate a problem where either species alone would be harmless, a concept known as invasion meltdown. Ornamental fig trees planted in Miami did not spread because they were sterile because they lacked the wasp species required for pollination. However, in the early 1990s a wasp species capable of fertilizing the figs independently invaded the region, so now the figs are capable of reproducing and spreading.

Controlling Invasive Species

Strategies used to control invasive species include (1) keeping potential invaders out, (2) eradicating potential invaders soon after invasion, (3) biological control, (4) chemical control, and (5) mechanical control. Keeping potentially damaging invaders out in the first place is the most cost-effective way to deal with introduced species. The ability of new species to invade can be reduced by monitoring the common invasion pathways such as ship ballast water, wooden packing material, and horticultural plants.

Background continued:**Eradicating after invasion**

It is easier to eradicate invasive species if they are discovered quickly and population levels remain low. Even if it proves impossible to totally eliminate an invader, early intervention can keep the population sizes of invaders at acceptably low levels. For example, Giant African Snails were effectively eliminated from Florida. Currently researchers in California are attempting to eradicate the marine green alga *Caulerpa* which has recently invaded that region.

Biological control**Background continued:**

Biological control involves introducing an enemy of an invasive plant (i.e., a disease, parasite, predator, or competitor) in an attempt to lower the population size of the invader.

Sometimes introducing a natural enemy from the native range of the introduced pest can be effective. For example, prickly pear cactus that invaded Australia from the Americas has been effectively controlled by introducing a moth from South America whose caterpillar feeds on the cactus. In other cases the most effective control comes from finding an enemy from a different area (a novel association) because the invader may not have evolved any defenses to such species with which they have never been in contact. For example, a virus from South America has been used to control European Rabbits in Australia.

A disadvantage of biological control is that some agents attack nontarget species, becoming noxious invaders themselves, and it is very difficult to remove a troublesome introduced natural enemy once it is established.

Chemical control

Chemical control involves using chemical pesticides to kill invaders. Although chemicals can effectively control some species (for example, water hyacinth in Florida), chemical control has some problems. For example pesticides may affect non target species. Chemical control can be expensive and may only be effective for a limited amount of time because pests can evolve resistance to the pesticides.

Mechanical control

Mechanical control involves using machinery or human effort to remove invaders. Mechanical control has been an effective control strategy for invasive Tamarix in the Southwestern US (Tamarix control). Volunteer convict labor has been used in Florida to cut paperbark trees and in Kentucky to rip out Eurasian musk thistle.

The newest technology for managing invaders is ecosystem management, in which the entire ecosystem is subject to a regular treatment (such as a simulated natural fire regime) that tends to favor adapted native species over most exotic invaders. Because it is so new, the specific ways in which ecosystem management can be employed must be determined in each type of habitat.

Citation

Mark McGinley (Lead Author); J. Emmett Duffy (Topic Editor) "Invasive species". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth July 25, 2010; Last revised Date April 8, 2011; Retrieved June 28, 2015

Before Day 1:

- Download & Print off copies of handout for Day 1 (enough for 1 per group of 3 students): <https://neinvasives.com/9-12-educational-materials>.
- Download and save PowerPoint Presentation from this link: <https://neinvasives.com/9-12-educational-materials>. **You will use slides from this PowerPoint each day of this curriculum.**

Day 1: Present Day 1 PowerPoint Presentation Slides:

- Interest Approach (10 minutes)
 - Video <http://shows.howstuffworks.com/what-the-stuff/wts-5-extremely-invasive-species-video.htm>
 - Post three questions. The answers are in italics
 - What is the reason Asian carp were introduced into the United States? *Asian carp Filter feed large amounts of nutrients from the water and help clear algae from ponds.*
 - What trait protects cane toads from predators? *Secretion of poison from glands in their shoulders*
 - What could be done to stop introductions of invasive species? *Answers will vary, commercial hunting, chemical treatments to kill fish, use of chemical or other deterrents to keep them from entering habitats, hunting seasons, etc.*
 - Have class pair up and discuss three questions
 - Have two groups class share with the entire class
- Define adaptation (20 minutes)
 - Define trait as a feature of an organism and review genotype and phenotypes from the genetics units.
 - Use picture of a feral hog. They become feral within one or two generations of breeding of domestic pigs. They develop coarse hair, improved ability to find food and shelter and evade predators.
 - Define Adaptation as genetic change that a species becomes better suited to its environment through better traits or reproductive success
 - Use <https://www.youtube.com/watch?v=vTIxox-46Aw> video to help show feral hog's adaptations. Stop and point out a few: behaviors like wallowing in mud to rid external pests and control temperature, coarse hair for insulation, omnivorous diet, large litters for reproduction success, tusks for protection, fast, long lived.
 - Slow down and check for understanding by focusing on LeBron James or any other famous athlete. Ask students what adaptations does LeBron have physically. Students should say like height, jumping ability, long arms, big hands, quick feet. Ask students what adaptations does LeBron have mentally, like cognitive ability.
 - Move into explaining that acclimation is not adaptation. Adaptation, like LeBron's height is heritable, but he fitness, practice and experiences are not heritable and are called acclimation.
 - Review adaptations by having students look at the feral hog picture and identify a trait, adaptation, and come up with a acclimation from the picture. *Trait-coarse hair, adaptation-travel in groups for protection and to find food, acclimated to the environment through increased body hair and ability to find safe habitat.*
- Define three types of adaptations (20 minutes)
 - Behavioral Adaptation Comic Strip
 - Break class into groups with 2-3 students in each and give each group one copy of the student handout (slide 13)
 - Project the abstract from this weblink on a projected screen for students to read: www.ncbi.nlm.nih.gov/pubmed/16777750.
 - Have the students draw out, in four frames of a comic strip, what adaptations the black snake developed. An example of comic strip frames is displayed on the slideshow. For example:

- Frame one: black snake being happy

Day 1 Continued:

- Frame two: cane toad ruining happiness
- Frame three: black snake reluctantly eating toad
- Frame four: black snake somewhat happy again
- Give students about 15 minutes to complete. Hang up the strips on a wall.

Before Day 2:

- Print off Day 2 Handout Species Sheets & laminate each (if desired): <https://neinvasives.com/9-12-educational-materials>.

Day 2: Present Day 2 PowerPoint Presentation Slides:

- Interest Approach and Review (10 minutes)
 - Watch Video <https://www.youtube.com/watch?v=nmU7etSYYqI> about the snakehead that is invading America. Have the students identify a behavioral adaptation to review day one like aggressive. Explain that we will now discussing the morphological and physiological adaptations like the muscular bodies and being able to breathe atmospheric air adaptations that snakeheads have.
- Continue Defining three types of adaptations (20 minutes)
 - Morphologic Adaptations
 - Discuss morphological Adaptations as the form or structure of an organism
 - Use <https://www.youtube.com/watch?v=WAOEaLGm-Ic> as a video to show adaptations like being able to fly, jaws to bore into bark, green to camouflage.
 - Physiological Adaptation
 - Explain physiological adaptations as ways an organism functions and give examples of like digestive systems of cattle able to break down fiber, tolerance to sunlight like tanning, bull sharks being able to withstand fresh and salt water.
 - Then define allelopathy and how spotted knapweed employs it to inhibit other plants growing around them.
 - Review by pairing up students to read slide and pair up three different adaptations and the three different examples from feral hogs.
 - Morphological - Domestic Hogs grow coarse body hair within one generation of breeding in the wild
 - Behavioral - Wild and search for cover to hide and escape predators
 - Physiological - they are omnivorous to increase the foods for their diet in the wild
- Research Invasive Species (20 minutes)
 - Define Invasive Species as species that are non-native to the ecosystem under consideration and whose introduction causes harm to the economic, environment or human health explain that snakeheads, silver carp, feral hogs, knapweed, emerald ash borers and other species we have been discussing are all invasive species.
 - Divide students into 5 groups. Give each group a species handout: small Indian mongoose, zebra mussels, constrictors, starling, and Asian carp.
 - Groups on a separate piece of paper answer the 3 questions on their species handout (make sure they write each team member's name & their species on their paper)
 - How it was introduced
 - What species or resources it threatens
 - Three adaptations and the type of adaptation that the species has
 - Groups present their answers to the class

Day 3: Present Day 3 PowerPoint Presentation Slides:

- Interest approach and review. Watch (10 minutes) <https://www.youtube.com/watch?v=Ji9iAuiRIPo> and identify how the Galarucella beetle is being used to control Purple loosestrife an invasive plant. Purple loosestrife can grow fast, reproduce quickly, out compete other plants for water all destroying natural wetlands.
 - Explain biological controls are methods of controlling pests (including insects, mites, weeds and plant diseases) using other living organisms.
 - Have students return to their groups from the previous day. Give each group a blank piece of paper. Each group needs to invent a biological control for the invasive species they worked with the previous day. Students draw a picture of the biological control on the front of the page, the name of the biological control. Then on the back they will state how the biological control works to control the invasive species they were assigned. They will list adaptation(s) it has. They will also write how the biological control will be kept from becoming invasives. Examples of biological controls are: diseases, plants, insects, other competing species. Examples of how to keep them in check: extensive research prior to release, native to the area, have been used successfully in other areas to control the species, are native predators to the species in its place of origin.
 - Go through the example with the class on Slide 33
 - Give groups 20 mins to write complete their biological control
 - Show https://www.youtube.com/watch?v=IFIsz4szc_A to identify that not every biocontrol is a good idea. So, have students think of a genetic modification that they could integrate into the activity that follows.
 - Close the slide explaining not all infestations can be eradicated but instead managed
 - Grade the biological controls from students using the rubric

Day 3 Activity Grading Rubric:

5 points	3 points	1 point	Comment
Clearly identifies adaptation(s) that allow organism to successfully control invasive species and how organism doesn't become invasive itself	Does not clearly provide adaptation(s) that allow organism to control invasive species or does not provide how organism doesn't become invasive itself	Does not clearly provide adaptation(s) that allow organism to control invasive species and does not provide how organism doesn't become invasive itself	

Before Day 4:

- **Purchase produce to bring to class for activity**
- Print off copies (1 per student) of the Activity Handout: <https://neinvasives.com/9-12-educational-materials> Or post article on a screen for the entire class to read.

Day 4: It's (Not) just a Bug Activity

- Students read the article handout
- Follow the activity instructions pdf for activity

Essential Files & Links:

- Adaptations of Invasive Species Curriculum PowerPoint Presentation: <https://neinvasives.com/9-12-educational-materials>
- 5 Extremely Invasive Species | What the Stuff?!
 - <https://www.youtube.com/watch?v=rPeg1tbBt0A>
- Part 1, A Pickup Load of Pigs: The Feral Swine Pandemic - Natural History
 - <https://www.youtube.com/watch?v=vTIxox-46Aw&noredirect=1>
- An invasive species induces rapid adaptive change in a native predator: cane toads and black snakes in Australia.
 - <http://www.ncbi.nlm.nih.gov/pubmed/16777750>
- Invasion of the Snakeheads!
 - <https://www.youtube.com/watch?v=nmU7etSYYqI>
- Emerald Ash Borer
 - <https://www.youtube.com/watch?v=WAOEaLGm-Ic>
- Dangerous invasive species
 - <http://www.popularmechanics.com/science/animals/g257/4344787/?slide=5>
- Video 10 - Purple Loosestrife
 - <https://www.youtube.com/watch?v=Ji9iAuiRIPo>
- Invasive Species, Rats in Pacific Islands (NatGeo)
 - https://www.youtube.com/watch?v=IFIsz4szc_A
- It's (Not) Just a Bug Activity
 - http://learning.blogs.nytimes.com/2007/06/19/its-not-just-a-bug/?_r=0

Did you know? (Ag Facts):

- There are approximately 50,000 non-native species in the U.S.
- There are over 4300 species classified as “Invasive” in the U.S.
- Invasive species cause more than \$120 billion/year in damages in U.S.
- Hunting feral hogs to control the population has proven to be a futile endeavor.

Enriching Activities:

- Read and discuss fact sheet on feral hogs here: https://tpwd.texas.gov/huntwild/wild/nuisance/feral_hogs/

Sources/Credits:

Catherine Hutchings, The New York Times Learning Network

Bridget Anderson, The Bank Street College of Education in New York City