Aliens among Us: The Effects of Invasive Exotic Plants on Forests

Essential Question: Why does the introduction of exotic species often create rapid and disruptive changes in established ecosystems?

Introduction/Background:

All ecosystems change over time. But the introduction of "exotic" species from distant regions to an ecosystem can spark changes that occur so rapidly that ecosystems cannot cope. According to the USDA, "invasive plants are *introduced species* that can thrive in areas beyond their natural range of dispersal. These plants are characteristically adaptable, aggressive, and have a high reproductive capacity. Their vigor combined with a lack of natural enemies often leads to outbreak populations."

Here's an example of a plant that causes problems in New York and throughout the East Coast: Japanese Barberry is a densely growing deciduous shrub that reaches heights between two and eight feet. Its branches are grooved, brown and zig-zag in form. They feature a single sharp spine at each node. Once barberry is established it displaces native plants, in turn reducing wildlife habitat and forage. Its red berries, compact growth, and resistance to deer browsing make it a popular ornamental in nurseries. Barberry is very adaptable growing in shaded, open and wooded habitats as well as wetlands. It is often spread by birds and small animals that eat the plant's berries. The seeds of the Japanese barberry are estimated to have a 90% germination rate, so it spreads very quickly

←Photo credit Jill M. Swearingen, National Park Service, Center for Urban Ecology, Washington, DC

Another example: Multiflora rose is often considered a beautiful ornamental plant. It was introduced in 1866 as an ornamental plant and used for wildlife cover. It grows so tenaciously and rapidly that it forms impenetrable barriers of thorny shrubs, disrupting pastures and preventing the native plants from thriving. It is so thick that native plants can't germinate around it. Despite the fact that deer (a population much larger than its historical numbers) like this rose, in many eastern states it is considered a noxious weed.

Photo credit: James H. Miller, USDA Forest Service, www.invasive.org

Close observation and controlled experiments can help students understand why these invaders out-compete the native plants in an area.

National Science Education Standards

Content Standard C: As a result of their activities in grades 5-8, all students should develop an understanding of:

- Populations and Ecosystems
- Diversity and adaptations of organisms

Student Learning Objectives

As a result of these activities, students will:

- Define an exotic plant.
- Measure herbivory (the amount of plant eaten by herbivores).
- Draw inferences from first hand observations.
- Construct and analyze food webs.

Materials List

- Journal
- Hand lens
- Gloves (to use when touching unknown plants, especially Japanese Barberry, which has caustic sap)
- Sampling tools (such as transect tapes and quadrats)

Procedures

Invasive plants can be found in virtually any ecosystem. This outline illustrates how one plant found in New York and Pennsylvania might be studied. It can easily be adapted to other plants. Students (or student groups) may collect data to support or refute each of these five hypotheses regarding Japanese Barberry:

Japanese Barberry is more successful than a similar native plant (Wild Carrot or Queen Anne's Lace) because:

- It has fewer natural enemies.
- It produces more seeds per plant.
- Its seeds disperse more quickly.
- More of its seeds germinate.
- It grows more quickly.

First, students should survey the area that contains Japanese Barberry to develop a food web. Include as many of the plants and animals as possible. (While field guides are helpful to name the organisms, the organisms can be identified by drawings and arbitrary species numbers as well.)

Next, students should practice inquiry to evaluate the hypotheses above. For each of the hypotheses, students should develop a protocol to compare and contrast the two plants. The protocol might include journal drawings, photographs, seed counts, quadrat studies, surveys of seed dispersal, or controlled experiments (seed germination ratios).

Sample procedures that might be developed:
Students may decide to compare the percentage of leaf material eaten by herbivores of similar plants to determine whether one plant has more natural enemies than another. One way to take these measurements is to prepare a transparency master with 1 cm grids, and overlay a representative sample of leaves from various plants, counting the percent of the average leaf that is eaten. In the photo, about 40% of the left leaf has been eaten, while almost none of the leaves on right (invasive loosestrife) have been eaten.

Students may decide to conduct a controlled experiment calculating the percent of seeds that germinate from mature plants using soil collected from the field.

Students may develop a procedure for measuring the growth rate of Japanese Barberry vs. Queen Anne's Lace over a period of weeks, controlling for light and humidity.

Students may survey a variety of plants including invasive plants for the presence of herbivorous insects.

Data Sheet

Students may invent their own data tables corresponding to their data collection protocols. This is a sample.

Characteristic/Plant	**Herbivory** **Average % eaten**	**Seed Production** **Seeds produced per stem** **(or per 10 g plant mass)**	**Seed Dissemination** **(Radius of seed dispersal observed in a mature plant)**	**Seed Germination** **Percent of mature seeds that germinate in a sample of soil taken from area in which plant is growing.**	**Growth Rate** **Percent increase in mass/height per period of time**
Japanese Barberry					
Queen Anne's Lace					

Conclusions

Invasive plants often have adaptations that make them highly competitive in new areas. These adaptations might include resistance to herbivores, rapid growth, or more effective seed germination.

Adaptations/Elaboration

Observe where both plants grow and under what conditions (sun, shade, soil type). What is the environment like? What plants grow around them? Compare and contrast these environments. *(Multiflora rose is more abundant in the inactive pastures, Barberry in the woods. Both do well along forest borders or the edges of natural communities.)*

Both plants create problems for local wildlife by outcompeting native plant species that provide food and shelter. However, each benefits some wildlife as well. Can you guess what species benefit from these invasives and how?

Both plants have been used historically as borders for domestic animals (livestock). Why characteristics would make these ideal for this purpose?

Evaluation

Students should be able to construct food webs with and without the presence of invasive plants, to show the effects on the structure of a natural community.

Rubric for Evaluation:

	Acceptable	**Good**	**Excellent**
Protocol development	Sequential steps listed	Steps include separation and control of variables	Steps include control of variables and quantitative measurements
Safety Precautions	Described in general terms	Described in specific terms	Described in specific terms, with factual information to support each step
Data collection	Organized	Organized and quantitative	Organized, quantitative and clearly related to the hypothesis
Food Web	Fewer than 10 organisms	10 to 20 organisms	20 or more organisms, with logical inferences about changes which might occur due to Japanese Barberry competition.

Sources for Related Activities

Cappuccino, Naomi and David Carpenter, Invasive exotic plants suffer less herbivory than non-invasive exotic plants.
http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1626367

Invasive Plant Council of New York State.
http://www.ipcnys.org/sections/target/default.htm

USDA. *National Invasive Species Information Center*
http://www.invasivespeciesinfo.gov/plants/main.shtml

Plant Conservation Alliance's Alien Plant Working Group,
http://www.nps.gov/plants/alien/fact/beth1.htm

University of Maine, Cooperative Extension Publications,
http://umaine.edu/publications/2509e/