LESSON 39

Biological...*Control?:* Tweaking the Ecological Web

Grade level: 5-8
Subject Areas: Biology, language arts
Duration: One 30 to 60-minute session
Setting: Classroom
Season: Any
Conceptual Framework Topics: Ecological interactions, food webs, biological controls

OBJECTIVES

Students will understand the potential effects of biological controls on non-target species in an ecosystem.

METHOD

Students role-play different members of a Montana grassland food web, and use information collected by researchers in Montana to determine how the introduction of a biocontrol agent affects other members of the grassland community and even changes the occurrence of a deadly human disease.

MATERIALS

- **Biocontrol Cards** (at end of this lesson). You will need to make copies ahead of time; see step 1 under ***Procedure*** for the correct numbers.

BACKGROUND

Invasive species present serious threats to the biological diversity and ecological integrity of ecosystems throughout the world. Biological control ("biocontrol") is the introduction of an organism (usually an insect, fungus or bacteria) that has often evolved with the target plant species and causes deleterious effects on it through herbivory or disease. Biocontrols are promising for weed control for a number of reasons. They have been effective at reducing plant numbers in some cases, they reduce the need for other control methods such as herbicides, and they are self-perpetuating. Biocontrols must undergo thorough screening for host-specificity (that is, that they will only eat or cause direct harm to the target plant species and not other plants) to reduce the chance for their negative impacts on desirable species.

However, this type of careful screening doesn't prevent the use of biocontrols that may have significant impacts on food web interactions in the ecosystem to which they are introduced. These kinds of indirect impacts may be virtually impossible to foresee before introductions, although some general predictions can be made.

U.S. Forest Service and University of Montana researchers studying deer mice in western Montana realized that deer mice populations seemed to be much higher in spotted knapweed-infested areas than in native grasslands. They also found that deer mice were feeding heavily on the larvae of gall flies (*Urophora* species) that had been introduced in the 1970's to cause gall formation in seed heads and reduce seed production in knapweed. The gall flies have considerably reduced

the seed production in knapweed, but it has not been enough to effectively control knapweed, which continues to increase in many areas. The gall flies, however, have become as abundant as the knapweed, and are now many times more plentiful than in their native habitats in Europe.

Researchers Dean Pearson and Ray Callaway began to more closely study the interactions among these species. They found that as the gall fly larvae overwinter in the knapweed seed heads, they provide an abundant food source for Montana's native deer mice at a time when food is otherwise scarce. In fact, in areas heavily infested with knapweed, gall fly larvae make up 85% of deer mice diets in the winter. This allows deer mice populations to double and even triple in knapweed/gall fly areas in some winters, compared to the populations in native grasslands.

This change in a small mammal population may, of course, have further effects on the ecological web of the grasslands in western Montana, potentially affecting the predators and competitors of deer mice, as well as the native plants and insects they prey upon. But an additional very interesting twist to this story is that deer mice are the primary reservoirs, or carriers, of the Sin Nombre Virus, also known as Hantavirus. Hantavirus causes a deadly respiratory disease (Hantavirus Pulmonary Syndrome–HPS) in humans, with a 37% fatality rate among those who contract it (perhaps much higher if left untreated). The virus becomes airborne when disturbed, and humans catch it through exposure to mouse feces, usually in a building, since the virus is destroyed by ultraviolet light.

Pearson and Callaway also collected data on the Hantavirus occurrence in the deer mice in their study. They found that not only did the much more abundant mice in the knapweed areas carry Hantavirus, but that a greater proportion of them carried it than did the mice in the grasslands (although that difference was not great enough to be statistically significant.) So the prevalence of Hantavirus in areas with a lot of knapweed (and gall flies) is more than three times that in other areas. (Montana in 2005 was ranked as second only to New Mexico in the number of cases per capita of HPS in humans).

For more detailed information on this research, go to
http://www.rmrs.nau.edu/publications/2006_Pearson_Callaway/2006_Pearson_Callaway.pdf

For more information on Hantavirus, go to
http://www.hantavirus.net/

Your students should already be familiar with the concepts of food webs before beginning this lesson.

PROCEDURE

1. ***Ahead of time:*** Copy and cut apart enough of the **Biocontrol Cards** so that you end up with **10 bluebunch wheatgrass** and **10 spotted knapweed** cards, **6 deer mouse cards, 10 *Urophora* gall fly cards,** and **4 hantavirus (Sin Nombre virus)** cards. You might want to copy them onto stiff paper or glue them onto cardboard. You can also change the numbers of each member of the web according to the number of students you have, just keep them in roughly the same proportion.

2. To begin the lesson, if they are not familiar with the concept of biological controls, ask your students to think of different ways people might reduce or control the spread of weeds. Make a list on the board of the ideas they come up with. If they don't come up with it on their own, guide them to the idea of using natural enemies of invasive species to control or destroy them, and explain that these are called *biocontrols*. Make sure they understand the concept and ask if they can come up with some potential concerns associated with introducing one non-native species to control another.

3. Now tell your students that you are going to simulate an ecological web in the classroom, and that they are going to play the roles of different members of this web, which occurs in the grasslands of Montana. Explain that there are lots of different organisms that might be part of this web, but that you are going to concentrate on only a few members of it today. Ask them what important members of the grassland might be. When they mention grass, hand out **bluebunch wheatgrass** cards to 10 students and ask them to stand in a loose group holding their cards so everyone can see what they are. (You might want to mention that bluebunch wheatgrass is a native plant and the official State Grass of Montana.) If students come up with mice (prompt by asking them what lives in the grass), hand out **deer mouse** cards to 2 students and have them mingle with the **bluebunch wheatgrass** students. Ask if any of them know the name of a disease carried by some deer mice that can affect humans in Montana. Explain as much as you need about what Hantavirus is and how it is spread to humans. Explain that deer mice are the primary carriers, and hand out 1 **hantavirus (Sin Nombre virus)** card to a student. Have them stand next to one of the **deer mouse** card holders.

*Note: If you don't have enough students for each card, a student can hold more than one card—for example, a **deer mouse** card and a **hantavirus (Sin Nombre virus)** card. You can also change the numbers of each member of the web; just try to keep them in roughly the same proportion.

6. Tell your students that now they're going to simulate some changes in the web. Explain that spotted knapweed has invaded this grassland. Ask them what changes, if anything, they would expect to see in the web. (Have half of the students exchange their **bluebunch wheatgrass** cards for **spotted knapweed** cards, explaining that knapweed often displaces bunchgrass.)

7. Now tell your students that you are going to give them some information based on research that biologists at The University of Montana and the U.S. Forest Service conducted in the past several years in Montana. Explain that in the 1970's the gall flies were introduced to try to reduce knapweed populations, since by creating galls the flies reduce knapweed seeds in Europe, where both the flies and knapweed are native. Tell them that the flies lay their eggs in the knapweed flowers, and the larvae spend the winter in the seed head after it develops, eating plant tissue, and emerge as adults in the spring. Hand ***Urophora* Gall Fly** cards out to 5 students and have them stand next to the **spotted knapweed** students. What do they think will happen?

They will likely say the knapweed turns back to grass. Explain that while the flies do decrease seed production in knapweed, sometimes by up to 50%, it hasn't been enough to stop knapweed from spreading and becoming more abundant, since knapweed still has lots of seeds. (In some places, used in conjunction with other controls, including other biocontrols, it can help reduce the coverage of knapweed, but it is not very effective when used alone.)

Ask if they can think of any other effects the gall flies might have. Give them some time to discuss. Ask if they know what deer mice eat. Explain that deer mice are omnivorous, eating all kinds of foods such as seeds, insects, fungi, etc. They eat the gall fly larvae in the winter. Now see what they predict for their web. Explain that the researchers found that the mice were three times more abundant where there were knapweed and gall flies than in grasslands without knapweed, and ask how many mice there should be now. Hand out 4 more **deer mouse** cards.

Are there predictions for more changes? Explain that Hantavirus increases more than three times, because not only are there more mice, but since their population is denser the virus in spread among them more easily, so a greater *proportion* of the mice carry it! Hand out 3 more **hantavirus** (**Sin Nombre virus**) cards.

Questions for discussion:

1. What are the implications for using the Biocontrol gall flies to control the noxious weed knapweed in Montana?

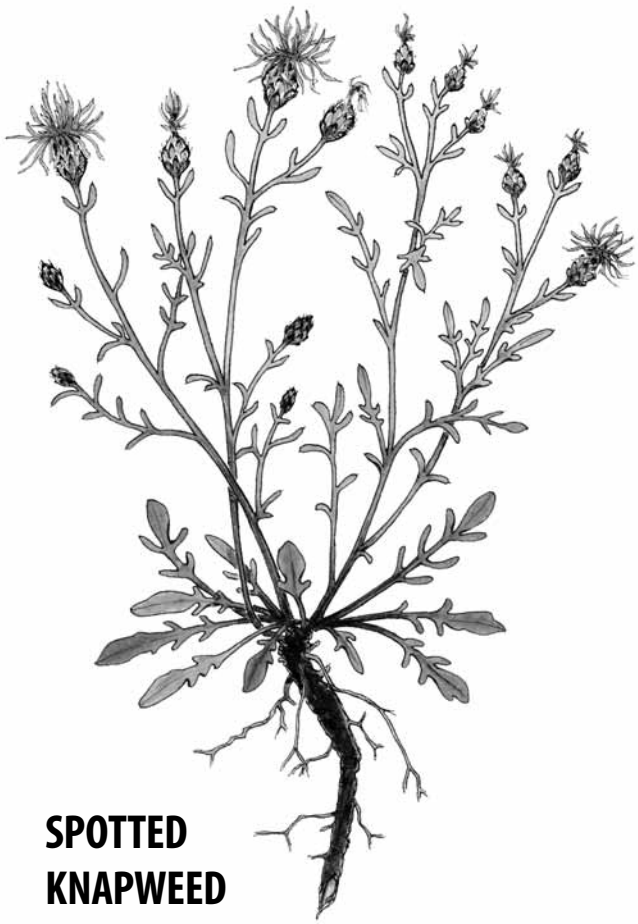
2. Could anyone have predicted that introducing gall flies to control knapweed could have an effect on a deadly human disease?

3. What other kinds of effects could these changes have? Can they imagine some other possible types of issues that might arise from introducing exotic insects or microorganisms to control invasive species?

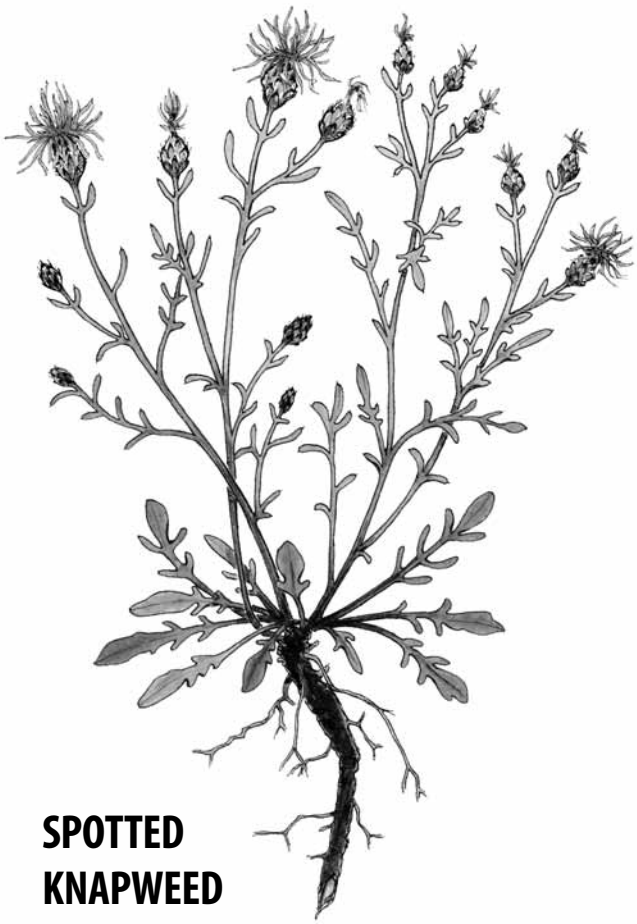
Extensions

Have the students diagram the interactions among the members of this food web.

Have students hypothesize about potential effects on the ecological web of other types of biocontrols.



SPOTTED
KNAPWEED



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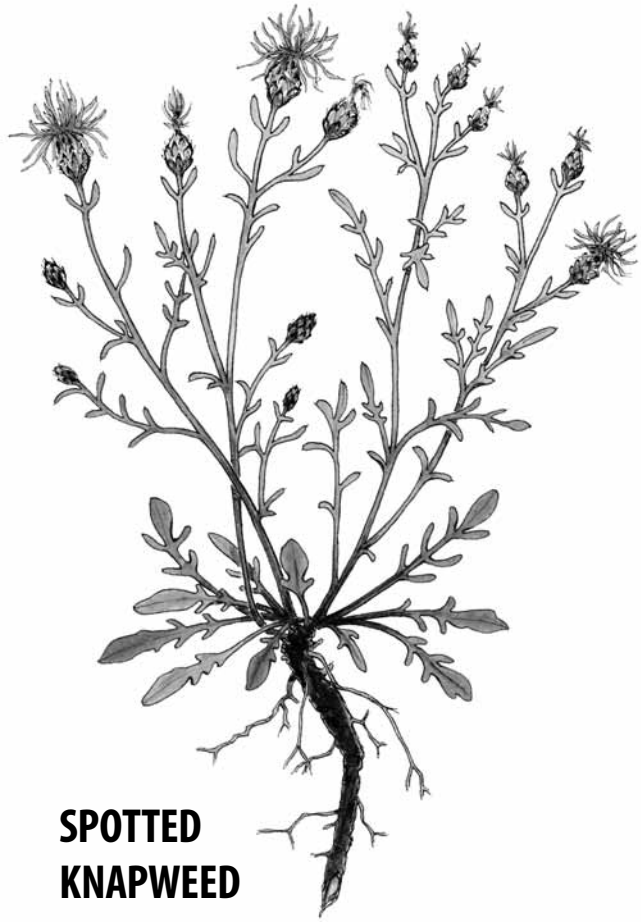

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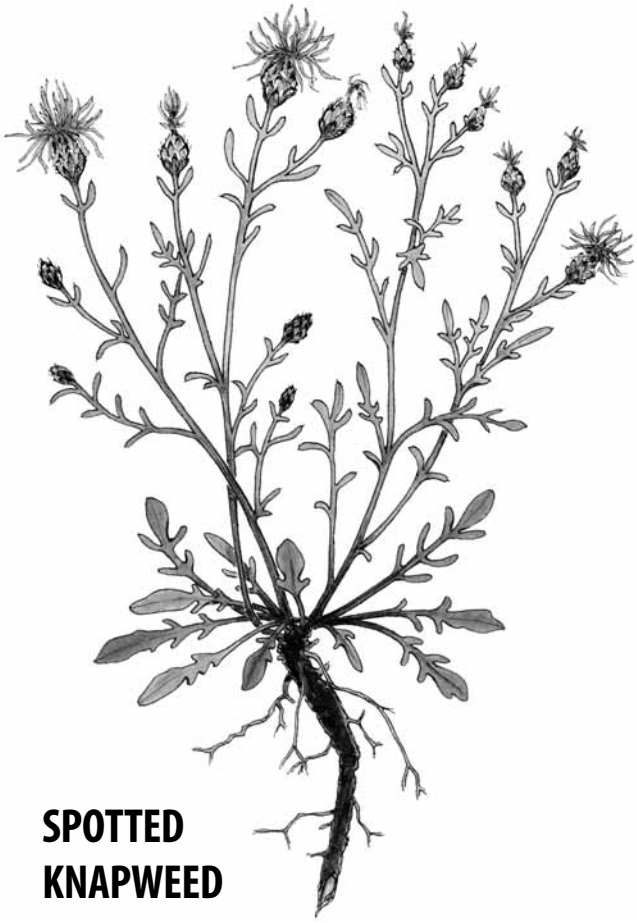

SPOTTED
KNAPWEED

BLUEBUNCH WHEATGRASS

BLUEBUNCH WHEATGRASS

BLUEBUNCH WHEATGRASS

BLUEBUNCH WHEATGRASS

DEER MOUSE

DEER MOUSE

DEER MOUSE

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***urophora* GALL FLY**

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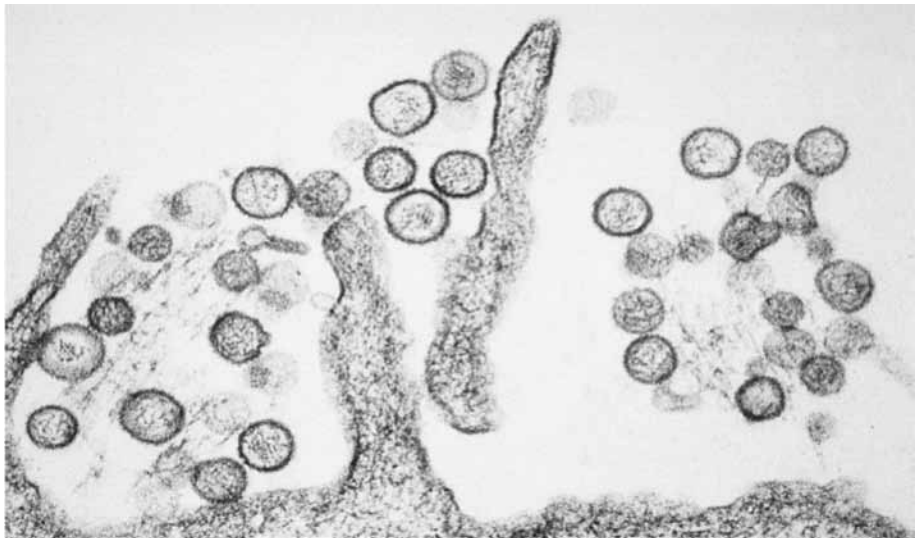
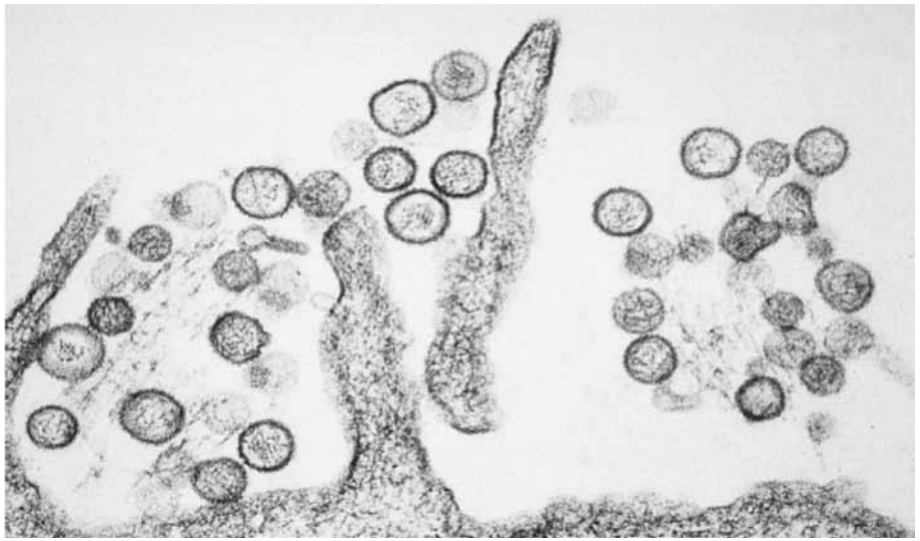


HANTAVIRUS (SIN NOMBRE VIRUS)



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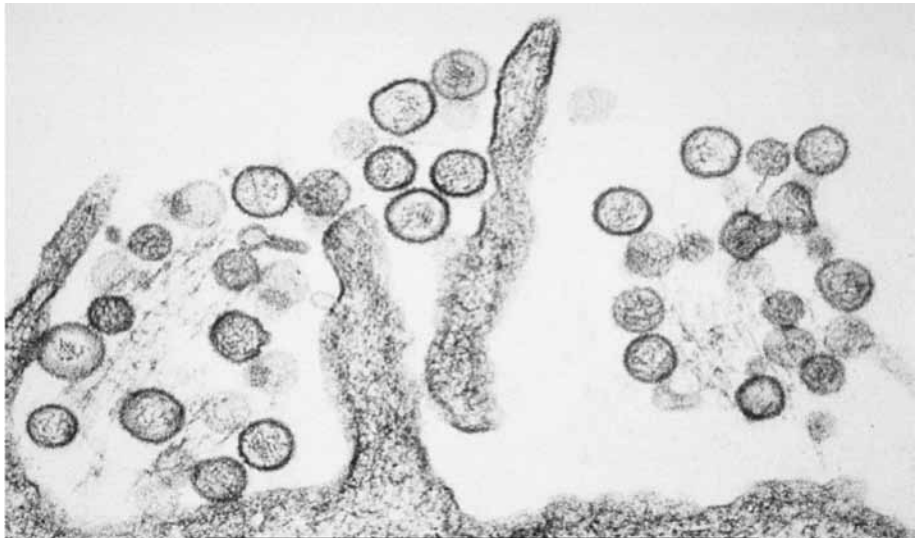

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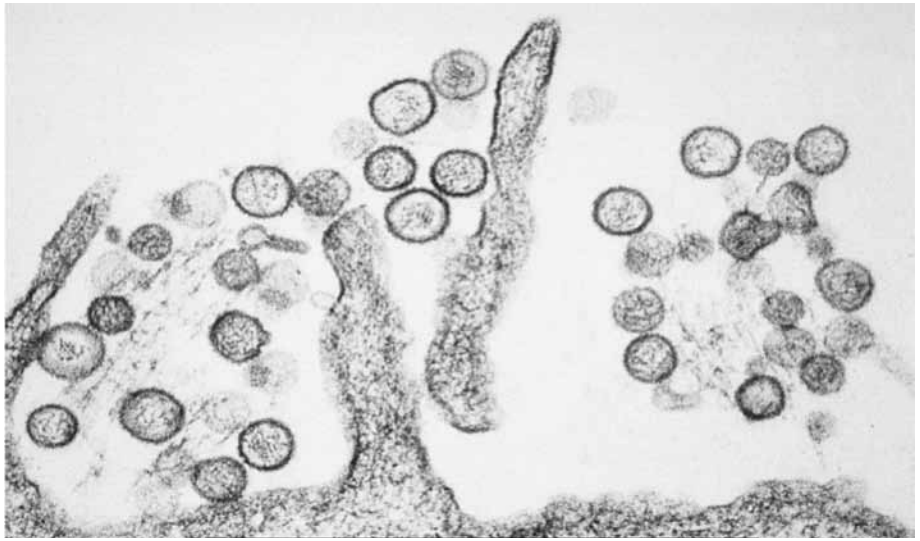

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