

Middle School Unit

Ecosystem Management for Regionally Abundant Invasive Plants in an Era of Global Environmental Change

Weeds and Weevils Unit: Knapweed and Biological Control



Study site North of Boulder, Colorado

Ecosystem Management for Regionally Abundant Invasive Plants in an Era of Global Environmental Change

Weeds and Weevils Unit: Knapweed and Biological Control

Developed by INSTAAR scientists (Timothy Seastedt, David Knochel, Anastasia Maines) in collaboration with BVSD teachers (Kim Greene and Dan Tomlin at Manhattan Middle School)

Knapweed and Biological Control Lessons Outline

Contents	Page
Inquiry 2.1 What is a biological control?	3
Biocontrol pictures	4
Inquiry 2.2 Control with insects	7
Inquiry 2.3 Biological Controls and dissections	10
Note: Mature seed heads for dissections are generally available in late summer-early autumn.	

Colorado Academic Standards:

Standard 2: Life Science

Prepared Graduates: Explain and illustrate with examples how living systems interact with the biotic and abiotic environment

Grade 6—concept 1: Changes in environmental conditions can affect the survival of individual organisms, populations, and entire species

Grade 6 – concept 2: Organisms interact with each other and their environment in various ways that create a flow of energy and cycling of matter in an ecosystem

Grade 8 – concept 1: Human activities can deliberately or inadvertently alter ecosystems and their resiliency

Standard 3: Data Analysis, Statistics, and Probability

Prepared Graduates: Solve problems and make decisions that depend on understanding, explaining, and quantifying the variability in data

Grade 6—concept 1. Visual displays and summary statistics of one-variable data condense the information in data sets into usable knowledge

Grade 7—concept 1: Statistics can be used to gain information about populations by examining samples

Grade 8—concept 1: Visual displays and summary statistics of two-variable data condense the information in data sets into usable knowledge

Teaching Note: The Weeds and Weevils unit has two stand-alone sets of lessons each focusing on an invasive plant and its biological control insects. The knapweed lessons are best used in late summer- early autumn, as mature seed heads for the dissections are only available at these times. The goal of this part of the unit is to teach students about what biological controls are and why insects can be useful as biological controls. Development of these lessons was supported by funding from the United States Department of Agriculture (USDA). Any opinions expressed are the opinions of the author(s) and do not necessarily reflect the views of the USDA.

Inquiry 2.1: What is a biological control?

Introduction

Biological control is a way to limit pests (invasive plants or animals) using natural enemies. For example, farmers can use ladybeetles (ladybugs) to protect their crops from damage by aphids. Aphids eat crops, but ladybeetles eat the aphids. Biological controls are usually chosen from a pest's native range. One type of biological control for invasive plants can be insects that specialize in eating it. Before insects can be released they have to be tested to see how closely they depend on one plant (specialize).

In this lesson you will develop a definition for a biological control and brainstorm important characteristics of biological controls.

Objective for This Lesson

Build a definition for the word biological control.

Getting Started

1. Discuss with your group the difference between a generalist and a specialist insect. Write these differences in your science notebook.
2. Brainstorm any connections between plants and insects that you have observed and write them in your science notebook. What role might a biological control fill?

Answer 3 and 4 in your science notebook.

3. Why might a ladybeetle be a biological control?
4. What are important characteristics of a biological control?

Procedure:

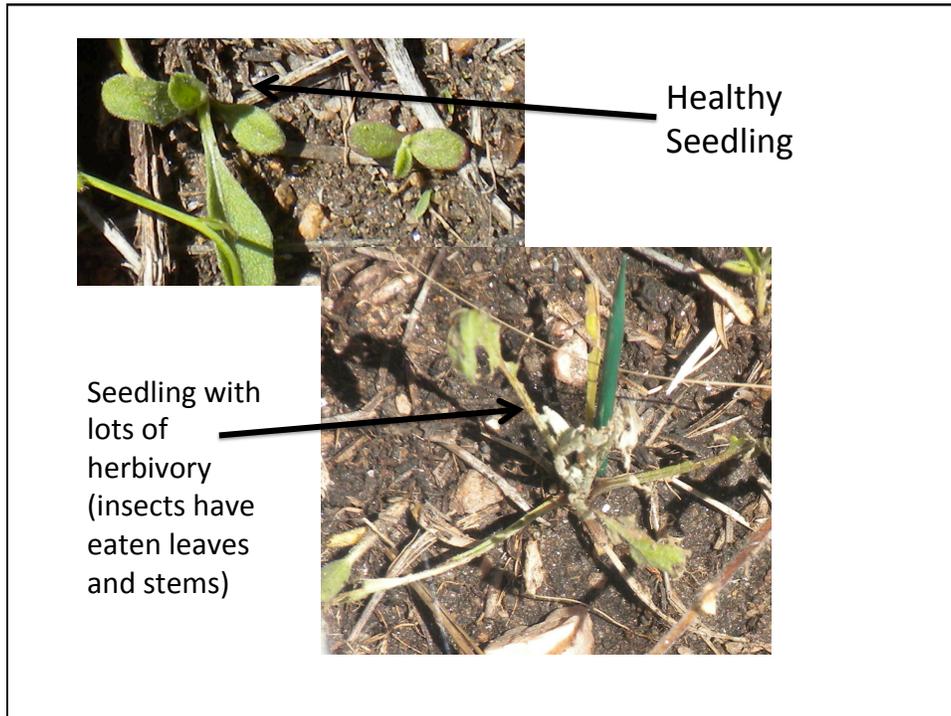
1. Look at the pictures of spotted knapweed and some biological control insects.
2. In your group discuss how these insects might impact spotted knapweed.



Healthy Flowering Plant



A mature flower forms a seed head



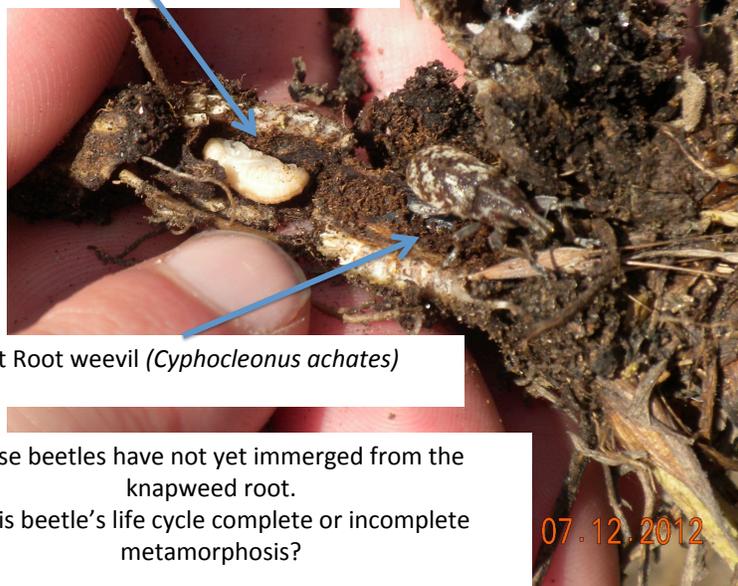
Another biological control for spotted knapweed

Root weevil (*Cyphocleonus achates*) as larvae



Notice how the root is hollowed out? These insects eat the root tissue as they develop. How do you think this impacts a plant's ability to draw water from the soil?

Root weevil (*Cyphocleonus achates*) in pupil stage



Adult Root weevil (*Cyphocleonus achates*)

These beetles have not yet immersed from the knapweed root.
Is this beetle's life cycle complete or incomplete metamorphosis?

Inquiry 2.2: Control with Insects

Introduction: Biological controls limit the growth or reproduction of invasive plants. They can eat plant parts and introduce infection, reducing plant survival. Biological controls can also eat the seeds, reducing the number of new plants produced.

Objective of this Lesson:

Document change in seed production following the release of biological control insects.

Getting Started

1. In our last lesson your group developed a working definition for a biological control. Talk about the definition with your group. Anything you would like to change?
2. Predict: In your notebook predict what you might see if a biological control is working.
3. Discuss with you work group - How do you know a biological control is successful?

Procedure

Look at the data set.

Develop a graph illustrating seed production over time.

Data Set -The data set documents the seed production per square meter for diffuse knapweed in Spruce Gulch, near Boulder, Colorado. These data was collected by David Knochel, M. Garmoe, S.A. Shosky, and Timothy Seastedt from the University of Colorado from 1997 to 2006 following the release of biological control insects in 1996.

Diffuse knapweed seed production per square meter from 1997 - 2006.

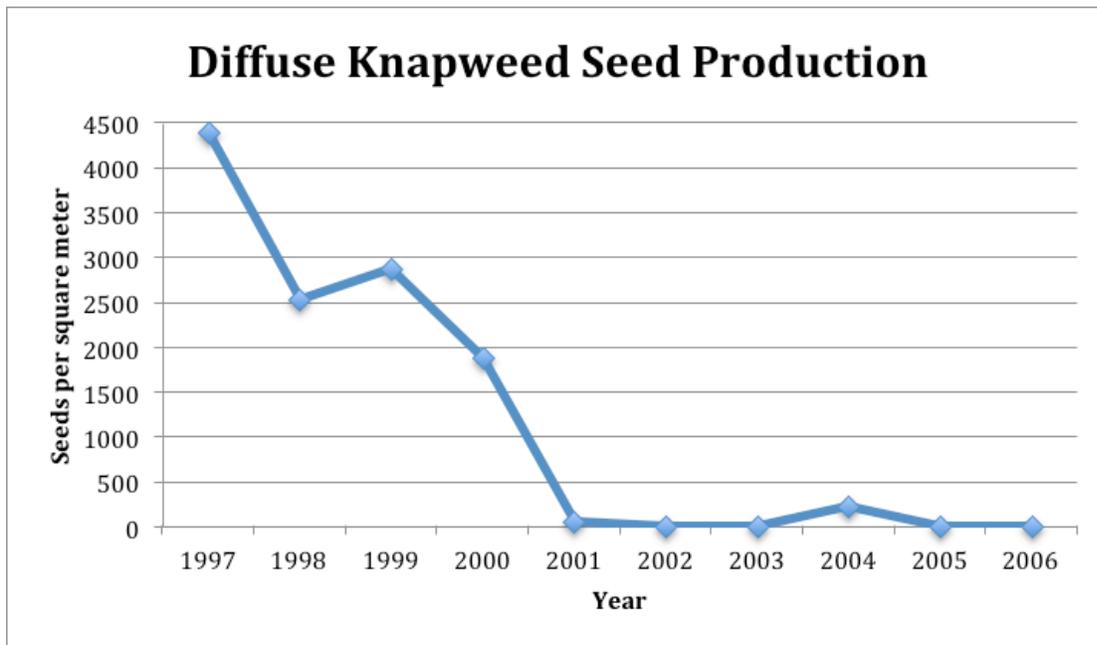
Year	Number of seeds per square meter
1997	4400
1998	2535
1999	2883
2000	1881
2001	61
2002	4
2003	0.1
2004	230
2005	10
2006	0.00

Data from Seastedt et al., (2007)

Reflecting on what you have done...

1. Did your graph look similar to the teacher key?
2. If not, what did you do differently?
3. What did the data show?
4. Try to draw a “best fit line.” (a best fit line runs through all of the data and the line’s slope would show a trend) Are there any trends?
5. How might this change in seed production impact the plant?
How low do you think the seed production can be before the plant disappears?
6. Propose an inquiry to determine how the seed reduction impacts the plant population.

Teacher Key



Reference:

Seastedt, T.R., Knochel, D.G., Garmoe, M., & Shosky, S.A. (2007). Interactions and effects of multiple biological control insects on diffuse and spotted knapweed in the Front Range of Colorado. *Biological Control*, 42:345-354.

Inquiry 2.3 Biocontrol and dissection

Introduction

Just because an insect is present in a particular area, it doesn't mean that plants will be impacted equally. Insect populations can change over time or differ by location. For instance, the insects might all choose one flower to lay their eggs or they might spread out. *Larinus minutus* is a tiny weevil that lays its eggs in knapweed seed heads. How do the number of insects impact the seed production?

In this laboratory lesson, you will work in groups to dissect seed heads from an invasive plant found in Boulder County: Spotted Knapweed. In the process, you will be able to learn more about how biological controls impact plants. Pay close attention! Inside the plant tissues you can find insects in various stages of life.

Objective for This Lesson

To learn the basic parts of a flower and to learn how insects impact plant populations.

Represent and analyze relationship between dependent and independent variables; Scatter plots: construct and interpret; Summarize and describe distributions

Getting Started

Take out your science notebook and working with the person closest to you.

1. Review how a biological control might affect a plant.

Plant and insect dissections:

Materials for lesson

Scissors, newspaper to place plants

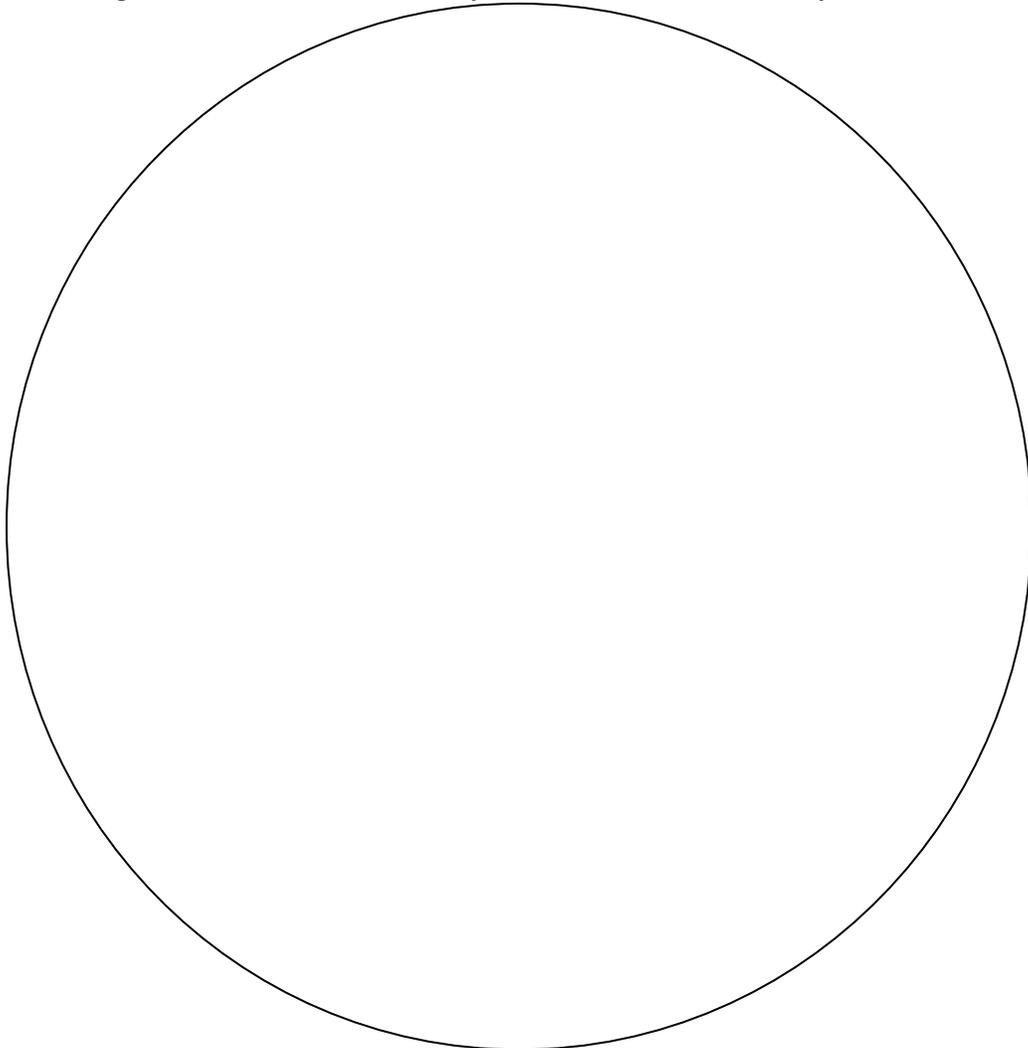
Plant samples from a natural area (diffuse or spotted knapweed)

Drawing sheet for plant dissection

Dissecting microscopes or hand lenses

Knapweed

1. Place a knapweed flowers on newspaper.
2. Dissect open the flower heads, and draw what you find inside. For every flower you open, count how many seeds and insects that you find and record in the table below. Take a flower to the dissecting scope, and draw magnified view of insect. In the seed heads, you may find a hard spherical gall containing a gall fly biocontrol insect, *Urophora affinis*. These will overwinter in the flower head and continue further development in spring. Also, you might find the flower weevil, *Larinus minutus*, which is larger, and could be in the larval, pupa, or adult life stage. Look closely at the seeds, and draw what you observe.
3. Label insect drawings with the following terms: larva, pupa, adult.
4. Dissect 10 seed heads in your lab group and record the number of seeds and insects in each.
5. With your group, count and record the number of insects and seeds in each seed head.
4. Find lab partners at your table or in the classroom who found a knapweed flower insect at a different life stage. Trade with them so that you can also draw what they found.



Seed head	No. Seeds	No. Insects	Notes

5. Calculate the mean and median number of seeds and insects and record it in your science notebook.

6. Using your group's data, draw a scatter plot of the relationship between number of insects and seeds in a flower head.

7. Draw a best-fit line for your scatter plot. Do you notice any trends in your data?

REFLECTING ON WHAT YOU'VE DONE

A. Look at your ideas that you wrote in your notebook for how an insect can affect a plant. Using your experience from the lab dissection, correct or improve your ideas.

B. Draw a picture of a knapweed seed. Do the seeds in flower heads with insects look different?

How are the seeds in flowers without insects similar or different to the ones in flowers with insects?

C. Think about your prediction before lab: what characteristics of the insect life cycle are useful for controlling the invasive plant?

D. How do these biocontrol insects impact their target non-native plant?

Extension:

1. Write an equation for the relationship between seeds and insects in a flower using variables. Be sure to define your variables. (Hint: which is the independent variable and which is the dependent one?)