FIGURE SET HEADER for Set #1

Figure Set 1: What are the effects of herbivory on individual plant survival and growth?

Purpose: To interpret graphical results and to examine how herbivory affects individual plant survival and growth.
Teaching Approach: Think-pair-share
Cognitive Skills: ________________ Knowledge, Comprehension
Student Assessment: One minute paper

BACKGROUND for Set #1 (back1.html)

Invasive species are species that have been introduced from their native range into an area where they do not have an evolutionary history. Further, invasive species are categorized as highly problematic species, causing both economic and ecological harm (Pimentel et al 2005). There are numerous invasive plant species that have been introduced to the United States that are problematic and need to be managed, including bush honeysuckle (*Lonicera maackii*), garlic mustard (*Alliaria petiolata*), and spotted knapweed (*Centaurea maculosa*). Typical management strategies often include hand-pulling, mowing, chemical spray, or a combination thereof. For some species, these management strategies can be an effective means to reduce the abundance of invasive species, ultimately reducing the negative effects they have on native species and communities. In other cases, typical management strategies are not enough to reduce invasive species' abundance or are too costly to employ. When such traditional management techniques prove inadequate (based on cost or effectiveness), biological control is often considered a feasible alternative. In plants, for instance, biological control consists of introducing enemies (herbivores), often referred to as biological control agents, from the plant's native range. The herbivores are meant to "damage" the invasive plant species by consuming plant tissue, reducing plant resources, and therefore curbing its population growth.

One invasive species that is considered highly problematic is *Lespedeza cuneata* (common name: sericea lespedeza or Chinese lespedeza). *Lespedeza cuneata*

Lespedeza cuneata *L. cuneata*

L. cuneata

cleistogamous seeds

are produced from flowers that never open and are completely self fertilized and chasmogamous seeds are produced from flowers that are open; these seeds may be outcrossed. Cleistogamous seeds are cheaper for the plant to produce, and *L. cuneata* produces a higher proportion of cleistogamous seeds when growing in stressful environments (Schutzenhofer 2007). This flexibility in its mating system might allows *L. cuneata* to produce numerous seeds in many different types of environments.

Lespedeza cuneata

Lespedeza cuneata
cost
costs.
L. cuneata.
(Wehtje et al. 1999) and combinations of herbicide, mowing, native seed planting, and burning (Price and Weltzin 2003) However, these techniques are costly and in many cases do not effectively control *L. cuneata* (Brandon et al. 2004). It is for these reasons, among others, that biocontrol may be considered an option for controlling *L. cuneata*. *L. cuneata*

Much time and effort goes into researching biological control strategies, including finding an appropriate biological control agent to introduce. An appropriate agent must negatively impact the fitness and population growth rate of the target species, and not negatively affect other species in the community. For example, if a leaf-chewing insect is found to consume *L. cuneata* in its native range in Asia, but the same insect is not found in the United States, we might consider introducing that insect to the United States. One question we might ask is: How many leaves does the insect need to damage or consume to control to curb the population growth rate of *L. cuneata* in its invasive range? Answering this question can be achieved before the insect is introduced, by experimentally removing leaves (with scissors) at different levels (e.g., 20% removal, 40% removal…) and measuring plant fitness and plant population growth rate.

- Brandon AL, DJ Gibson, BA Middleton. 2004. Mechanisms for dominance in an early successional old field by the invasive non-native *Lespedeza cuneata* (Dum. Cours.) G. Don. *Biological Invasions* **6**: 483-493.

- Collier, M. H., J. L. Vankat, and M. R. Hughes. 2002. Diminished plant richness and abundance below *Lonicera maackii*, an invasive shrub. *American Midland Naturalist* **147:**60-71.

- Pimentel, D., R. Zuniga, and D. Monison. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics* **52:**273-288.

- Price CA, JF Weltzin. 2003. Managing non-native plant populations through intensive community restoration in Cades Cove, Great Smoky Mountains National Park, USA. *Restoration Ecology* **11**: 351-358.

- Wehtje G, RH Walker, JD Jones. 1999. Weed control in low-tannin seedling sericea lespedeza (*Lespedeza cuneata*). *Weed Technology* **13**: 290-295.

FIGURES for Set #1 (figure1.html)

Figure 1-- Can these be combined to make 1 image labeled a) and b)?
Figure 1a.jpg
Figure 1b.jpg

Legend
Figure 1. The probability that small *Lespedeza cuneata* plants would (a) grow to a medium sized plant or (b) die from one year to the next. Figures modified from Schutzenhofer and Knight (2007). Chi-square analyses presented in Schutzenhofer and Knight (2007) show that there is a statistically significant difference in the fate of small plants (stay the same size, grow or die) between clipping treatments (χ^2=16.0, df=8, P=0.042).

Image 1, please label a) and b)
Image 1a.jpg
Image 1b.jpg

Legend
Image 1. a) *Lespedeza cuneata* plant in the control treatment. b) *Lespedeza cuneata* plant in the 80% augmented herbivory treatment. Photo credit: Tiffany Knight (modified from Schutzenhofer and Knight 2007).

STUDENT INSTRUCTIONS for Set #1 (students1.html)

Student Instructions

Questions and Methods

Biological control is achieved when an invasive plant's natural enemies (herbivores) are introduced to reduce the fitness of the targeted invasive plant. Schutzenhofer and Knight (2007) conducted an experiment to artificially examine how increased levels of herbivory on an invasive plant species, *Lespedeza cuneata*, impact the fitness (growth and seed set) of this species, i.e., would biological control have the potential to curb the growth rate of this invader. Their experiment was set up by first finding plants that were of different size classes: small (1 branched individuals), medium (2-5 branched individuals), large (6-10 branched individuals), and extra-large (>10 branched individuals). For each size class they had five different clipping treatments: control (no augmented herbivory), 20%, 40%, 60%, and 80% augmented herbivory (see image 1a &1b). The purpose of the clipping treatments was to augment herbivory. Clipping consisted of manually removing leaf tissue by hand to mimic a leaf-chewing herbivore (herbivorous biological control agent). As previous work has found that ambient levels of herbivory on this species are minimal, the researchers assumed that all leaves were equivalent with regards to original amounts of damage. For example, in the 20% augmented herbivory treatment, 20% of all tissue was manually removed and plants in this treatment were estimated to have a total amount of 20% “herbivory”.

Results

At the end of the growing season they measured the amount of seed produced by all plants (seed set). They found that the treatments did not affect seed set of plants in any size class. Then, in the next year, they determined if the plants survived and whether or not the plants decreased or increased in size (to measure growth). The only size class in which clipping treatments affected growth and survivorship was the small size class, which is shown in Figure 1a and 1b.

Interpret the results found by the researchers using Figure 1a and 1b.

growth

b. How does increasing levels of herbivory affect the **survival** of small plants (Figure 1b)?

2. Pair up with your neighbor and share your conclusions.
3. Form a generalized statement about the effect of herbivory on small plants.
4. How might the artificial herbivory imposed by the researchers be different from actual insect herbivory?

NOTES TO FACULTY for Set #1 (faculty1.html)

Faculty Notes

Students should be given background information on the experiment and a brief demonstration on how to interpret figures, with particular emphasis on understanding the axes and legends. For this exercise, students should be given several minutes to answer the questions individually. Then ask the students to pair up and compare their interpretations with their neighbor. If they find differences, ask them to come to a consensus and then together they should make a general statement about how herbivory impacts the fitness of individual plants.

Student assessment: One minute paper

For assessment, ask students to turn in a one-minute paper with their answers to the above questions or randomly choose a pair of students (or several) to explain portions of the figure aloud to the class.