

FIGURE SET HEADER for Set #2

Figure Set 2: What are the effects of herbivory on population growth rate?

Purpose:

Figure 2.

Legend

Figure 2. The life cycle of *Lespedeza cuneata* plants in the control treatment. Each circle represents a particular size class, which is based on number of branches. In addition, there are two different types of seed banks (SB) in the life cycle depending on whether the seed was produced from a cleistogamous (CLSB) or chasmogamous (CHSB) flower; these represent seeds that do not germinate immediately but have the potential to germinate in later years. Each arrow represents a transition within the life cycle that occurs from one year to the next. For example, the arrow that goes from small to medium indicates the probability that a plant that is small in year t will grow to a medium plant in year $t + 1$. The arrow that goes from small to small is the number of seeds produced by plants in the small stage class that germinate immediately and become small plants themselves in year $t+1$. Modified from Schutzenhofer, M.R. and Knight, T.M. 2007. *Population effects of augmented herbivory on Lespedeza cuneata*: Implications for biological control. *Ecological Applications* **17** (4): 965-971.

STUDENT INSTRUCTIONS for Set #2 (students2.html)

Student Instructions

Population modeling is a valuable tool to rapidly assess how ecological factors impact the population growth rate of a species. In this experiment population modeling is used to assess the potential effectiveness of biocontrol on the population growth rate of the invasive *Lespedeza cuneata*. Life cycle figures represent what size classes are represented in the study species and the possible transitions between these size classes. In this experiment there are four size classes and two types of seed that can contribute to a seed bank. The life cycle figures also highlight the potential transitions from one year to the next. For example, an arrow going from small to medium would indicate the transition from plants that were small in one year growing to medium plants in the following year. Data gathered from actual seed set and growth is used to calculate the probability of these transitions. These values can then be placed into a transition matrix; matrices are created for each treatment (see example below). Researchers can then incorporate matrix values into modeling programs, such as R (which is freely available on the

conditions when the data was collected. λ is extracted fairly easily from the demographic matrix (it is the dominant eigenvalue of the matrix).

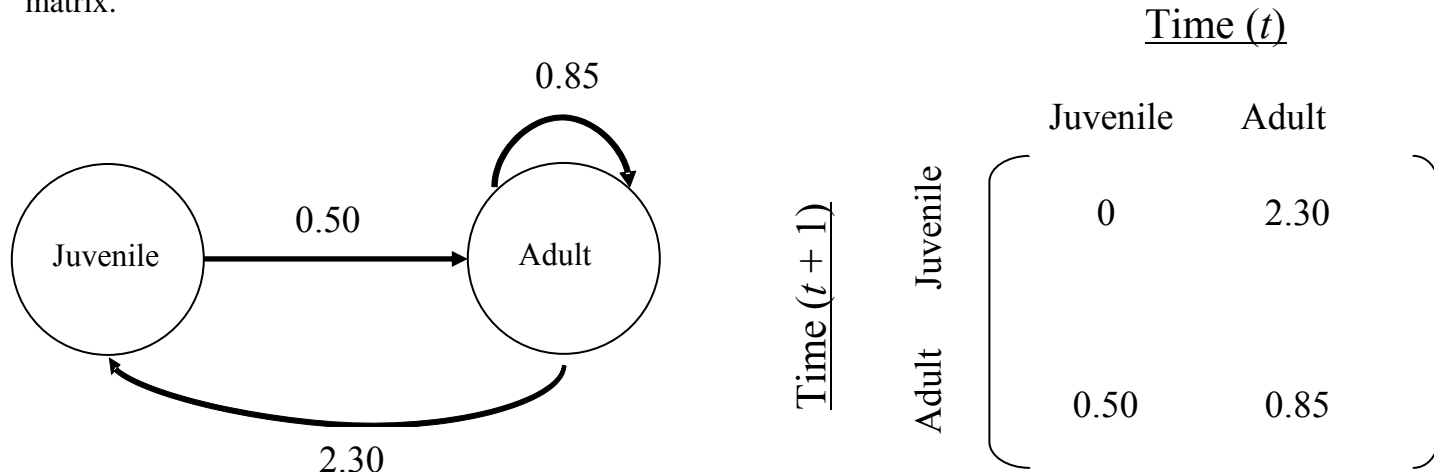
population that is growing. One would predict that an

below 1.

Elasticity matrices yield elasticity values for each vital rate. The highest elasticity value in the matrix is most sensitive to. Therefore, even small

affected by the control agent have high elasticity values.

1. Look over the example given below to understand how values from a life cycle graph go into a matrix.



2. Spend a few minutes examining Figure 2 to ensure that you understand what the circles, arrows, and numbers represent. Then place the numbers where they belong in the control matrix (you can download and print Handout 1). Pair up with your neighbor to check your interpretation.

3. Follow the instructions below (also available as Handout 2) to use the R Program 'Lespedeza' to calculate the λ of plants in the control treatment. Pair up with your neighbor to check that your lambda values are the same.

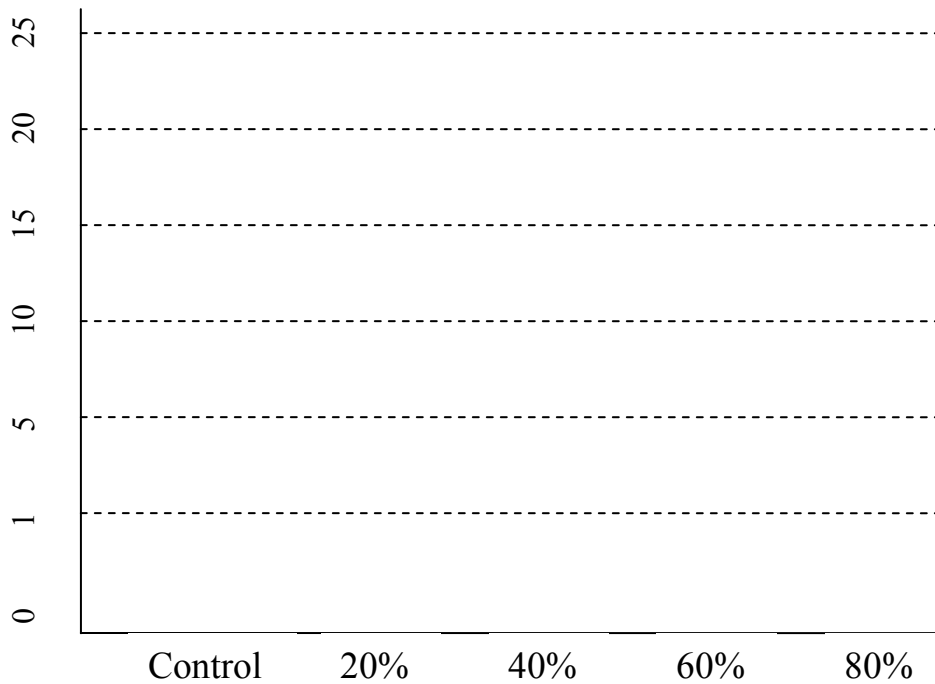
- a.) If you haven't already done so, download R onto your computer from the website: <http://cran.r-project.org/>
- b.) Make sure the file 'lespedeza' is also on your computer.
- c.) Open R. You will see the R console.
- d.) Open the file 'lespedeza' by clicking on **file** and then **open script** (for PC users) or by clicking on **file** and then **open document** (for mac users). Find the lespedeza file on your computer.
- e.) Make sure you are in the lespedeza file (the R editor, not the R console).
For PC users: To run the program, click on **edit** and then **run all**. For mac users: To run the program, click on **edit** and then **select all**. Then click on **edit** and **execute**
- f.) Make sure you are in the console (IMPORTANT: DO NOT TYPE IN CODE, i.e. do not type in the Lespedeza file). Type in 'A' and hit return (note: this is case-sensitive), and

you will see your matrix. Make sure this matrix is the same one you came up with in handout 1.

g.) Type in 'lambda' and hit return, and you will see the population growth rate associated with your matrix.

4. Fill in the bar graph below (you can download and print Handout 3) based on the results you calculated for the control treatment in *R*. Fill in the bar you make. Now make predictions based

is declining and above 1 is increasing.



5. Provide brief answers to the following questions or follow directions if indicated.

- a.) Recall, which stage (or size of plants) was the only stage that was found to be significantly affected by the herbivory treatments?
- b.) What was the direction of this effect? Explain.
- c.) Given the population growth rate you found for the control treatment, the answers to questions a and b, and your expectations of biocontrol, what do you predict will happen to medium plants in the matrix that were found for each treatment? Explain.

d.) Illustrate your answer to question b on the graph above. Do not fill in the bars.

6. When you are finished, compare your responses with your neighbor.

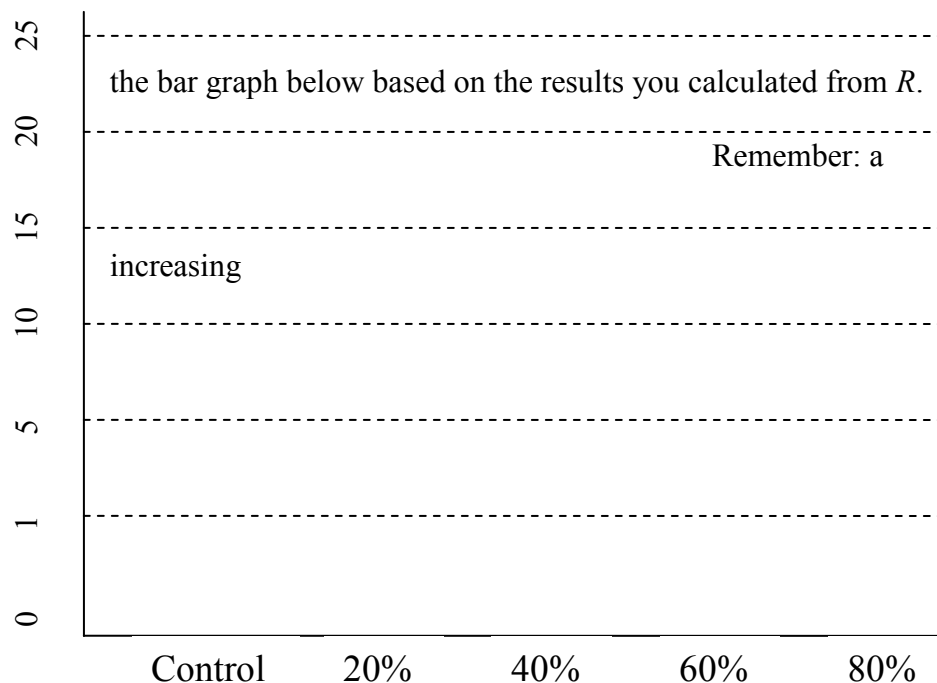
7. Follow the instructions below for changing data in the *R* Program to change the matrix, and re-
 These instructions are also available as Handout 4.

a.)
 small to medium transition (i.e., this one should have an initial value of 0.64). Once you have made the change, re-run the program (For PC users, **edit** and **run all**; For mac users, **edit** and **select all**, then **edit** and **execute**). Switch back to your console, and type in 'A' to see your revised matrix. Check the revised matrix to observe your change was made properly. Next, type in 'lambda' to see the population growth rate associated with that matrix.

Treatment	Small-Medium Transition Probability
Control (0%)	0.64

8. Compare your findings with your neighbor and then individually complete the questions and figure below regarding the population growth rates of the invasive *Lespedeza cuneata* in different clipping treatments. The questions and figure are available as Handout 5.

a.) Fill in



b.) Provide brief answers to the following questions.

- i.) What can you conclude about the results above regarding how effective biological control would be for *Lespedeza cuneata*?
- ii.) How do your results differ from the predictions you made on questions 4 and 5?
- iii.) What are some potential explanations for why your predictions differ from the actual results?

9. Calculate the elasticity matrix for the plants in the control treatment. To do this, you must first make sure the matrix in the 'lespedeza' program is showing the values for the control treatment (i.e., the small to medium transition should be set at 0.64), and re-run the program as in step 7a. In the console, you can type in 'A' to see your matrix, 'lambda' to see the population growth rate associated with that matrix, and 'e' to see the elasticity matrix. Once you have your elasticity matrix, proceed to the next step.

10. Provide brief answers to the following questions (also available as Handout 6) based on the elasticity analysis of the population growth rate of the invasive *Lespedeza cuneata*.

- a.) Based on the results of the elasticity analysis, what vital rate (specific transition or reproduction of specific stage class) is population growth rate most sensitive to, or rather, what vital rate contributes most to ?
- b.) Recall: the small to medium transition was affected by herbivory. What is the elasticity of this transition? Is it high or low?

c.) How does your hypotheses from question 5c relate to results from the elasticity analysis? (Use your responses to questions 1 and 2 above to help answer this question.)

d.) Based on your elasticity analysis, which vital rates should managers focus on if they want to reduce the population growth rate of *Lespedeza cuneata*? Give some suggestions for how this might be accomplished.

NOTES TO FACULTY for Set #2 (faculty2.html)

Faculty Notes

Students should be given background information on the use of matrix modeling and the nature of life cycle figures. For this exercise, students should individually transfer transition values from Figure 2 into the appropriate positions within the matrix found under step 2 above. You may want to walk through step 1 (above) with them so they understand how values go from a life cycle graph into a matrix. Give students an opportunity to check their number placements with their neighbors. Students should then open the R program and then open the file named 'Lespedeza' (this file can be downloaded from the TIEE site). Have this file in an easily accessible location, such as the desktop, so you can easily direct them to it. Instruct the students to use step 3 and Figure 2 to guide them in using the program to calculate the population growth rate for *Lespedeza* plants in the cont

This means that the population is increasing 25-fold from one year to the next. They should then proceed to steps 4-6. You may expect them to predict that the bars (population growth rate) will get smaller (lower) as the degree of treatment increases. After steps 4-6 are completed, students are to use step 7

the other clipping treatments. Within R, they are to replace the small to medium transition value they entered from the control treatment with the values given for each of the other treatments on the handout, one at a time, to yield the four other population growth rates for the experiment.

They should get the following r

24.22. Students should check their answers with their neighbors and problem solve if necessary. Be sure students understand why they are only changing the values for the small to medium transition. You may have to remind them that the researchers had originally found that only this transition (no other transitions or seed set) was found to be affected by herbivory. The students should then individually complete step 8 and compare their findings with the predictions they made in steps 4 and 5. Let them hypothesize answers to question 8b. They will explore this answer next in steps 9 and 10.

After completing step 9, the students will interpret their results from the elasticity analysis in step 10. The elasticity matrix will show the results for each vital rate - large values of elasticity indicate that small changes in that vital rate would cause large changes in the population growth rate. Management efforts should focus on vital rates with large elasticity values. You may need to remind them that elasticity analyses are used to determine which vital

in step 9.

The transition with the largest elasticity is the small-small transition; this is reproduction of small plants (i.e., small plants produce seeds that germinate immediately and become small plants in the next year). This might be hard for students to interpret at first. You might need to remind them that all arrows in the life cycle graph represent one-year transitions, and that both reproduction and germination can happen in a single year. Their answers in step 10 should reflect

sensitive to (seed set of small plants) was unaffected by herbivory (recall only growth and survivorship of small plants was significantly affected by herbivory). Managers interested in

This might be through

management of the plants (e.g., herbicide) just prior to fruit maturation, or through a biological control agent that is a seed consumer.

Student Assessment: Essay Quiz

Here, we have shown how demographic matrix modeling can aid in the management of invasive plant species. How would the same modeling techniques be used to plan the management of an endangered species?