

General Ecology – Population Biology Writing Assignment

How do different life-history stages affect population growth rate?

Learning objectives:

- Efficiently search for relevant scientific research articles
- Understand and synthesize the results from scientific research articles
- Construct and understand a complex stage-based population model
- Use model results to inform management practices

You will be randomly assigned to one of four different species. Each species has data you can use to build a stage-based population model. Your goal is to:

1. Research the biology and history of your species
2. Build the population model for your species
3. Analyze the model to determine the most valuable life stage
4. Propose management actions that could be taken to maintain the population

A word about **collaboration**: I do strongly encourage you to work together on this project – use the Blackboard discussion boards to run ideas past each other, exchange tips on model construction, background readings you found to be helpful, etc. However, I expect each of you to turn in original work.

A word about the **style** of your paper: I have provided a bunch of bullet points below listing all the information you should incorporate, but you *should not* write your paper as a bulleted list of responses. Please integrate the information you acquire into one coherent paper. Your writing should be technical, not colloquial, but you do not need to follow the typical scientific paper formula of Intro-Methods-Results-Discussion. Instead, write this more in the style a narrative essay crossed with a technical report.

A word about **formatting** your paper: Please double-space your paper and use a font and font size that are easy to read (Times New Roman, 12 pt. is best). Use proper in-text and bibliographic citations – the style found here is typical of most ecology journals: <http://libraries.wsu.edu/quickguides/sssa>. Other than these items, I have no strong preferences about your formatting, so long as it's readable. I anticipate that your paper will end up about 6-8 pages in length, but you will not be penalized for being outside this range, so long as all the necessary content has been adequately addressed.

A word about **confusion**: In this assignment, as in everything we do in this class, please get in touch with me if you run into a wall about what you're supposed to find, supposed to do, or supposed to understand. I'm always happy to help. But I do expect that you will have made solid efforts to work out the problems on your own first. When you do ask for assistance please include information about what you've already tried, so that I know that you have already given it a go (and so I don't head down the same path you were on when you encountered trouble!).

Literature searching

If you are unfamiliar with how to use the WSU Library's scientific literature search tools, please review the guides on our Blackboard page, and my tips from Week 2's lab instructions. These can help you with locating scientific articles and verifying the reliability of those articles.

Background

Before you start working with your species' population model, it's important to know what this creature is. Do some literature searching and reading to learn about your organism. When you write this section of your paper, provide proper citations of **any and all** information you use. I expect that you will find, read, and incorporate into this section at minimum 4 different **peer-reviewed articles** about your species. (More is fine, of course, but you must have at least 3.)

In your paper, include the following basic species biology information:

- General anatomy, including basic body plan, size, unique characteristics, etc. No need to go into depth on internal anatomy unless it's particularly interesting, but the idea here is for someone else to get a good idea of what this organism would look like if they encountered it out in the world.
- General life cycle, including typical longevity, life history stages (such as larva/pupa/adult for insects; resting seed/seedling/adult for plants), age at reproduction, parental care, seed dispersal mechanisms, mating habits, etc.
- Interesting interactions with other species, including predators, prey, parasites, mutualists, epiphytes, hitchhikers, etc.
- A general idea of the organism's fundamental niche, including temperature, moisture, salinity, etc. tolerances, where in the world it can be found

Also explain why it is important to know about this particular species' population growth

- Is the species economically important? Ecologically important? Culturally important? Threatened, endangered, or otherwise at-risk? Include explanatory information such as what the species is used for, what caused its at-risk status, how much financial value it actually has.

Model construction and interpretation

Now it's time to run the model and see how this population grows. First, perform these tasks:

- Use the provided fecundity, survival, growth, and retrogression parameters to construct a stage-based population model for your species. Use the Excel files from Week 4's lab to help you design your model. Ask for help sooner than later if you have trouble creating your model.
- Start your model with 500 individuals in the youngest stage and 0 in all other stages
- Extend your model from time $t = 0$ out into the future until a stable stage distribution is found.
- Find the asymptotic λ and use it to determine the trajectory of your population
- Create a graph of your population, separated by stage, through time

Next, write about these topics in your paper:

- For each of the different parameters in the model, explain what they mean in words. For example, what do F_3 or $G_{2,4}$ and their numeric values mean to your population?
- What happens to the population through time as it approaches a stable stage distribution? Are there fluctuations in relative stage abundances? Large spikes in one stage that eventually settle out?
- How long does it take for your population to reach a stable stage distribution? Describe your stable stage distribution, and explain what the stable population looks like in words. That is, if you went out surveying your species, what would the individuals you encounter look like?
- Is your population increasing or decreasing in abundance? How can you tell? If your model runs out into the future several hundred years using current parameters, what does it predict for your population? Is this a realistic possibility? Why or why not? If it's not realistic, what would need to be added into the model to improve realism?
- Provide a transition matrix of your population model. Include a legend for this table. This legend should explain what the table is (e.g. "a transition matrix for *Felis domesticus*"), and should give a brief explanation of what each of the parameters in the matrix are (i.e. what survival, growth, retrogression, and fecundity mean, and where in the matrix they can be found).
- Provide a graph of your population through time. Make sure this graph displays the abundance of each stage class, and runs at least long enough for the stable stage distribution to become apparent. Be sure your graph is clearly labeled, with named axes, units, a key, and any other information needed to explain it. Finally, include a figure legend that explains the graph. This legend should explain what the figure is, should describe the patterns of abundance of each stage through time, should discuss the stable stage distribution, and should address the overall population growth trajectory of the population.
- (Yes, there will be a lot of overlap between the information presented in the two legends and that presented in the text of your paper. Typically, the text of a scientific paper explains the research in great detail, and figures and tables supplement the text. But readers can be lazy and don't always read the text thoroughly, or want to be able to rapidly access the main findings of the paper, so legends need to very briefly explain the meaning and importance of figures and legends independently of the text.)

Elasticity analysis

First, perform these tasks:

- Conduct an elasticity analysis of your population model by individually increasing each demographic parameter by 10%.
- Compare the resultant overall λ s to the original model's λ
- Compare the resultant stable stage distributions to the original model's.

Next, write about these topics in your paper:

- Which model parameter has the largest effect on the overall population? Closely examine the model – why is it that this parameter has the largest effect?
- Which model parameter has the smallest effect on the overall population? Closely examine the model – why is it that this parameter has the smallest effect?
- Provide an elasticity matrix for your model. This is laid out in the same format as your transition matrix for the model, but with elasticity values instead of transition probabilities. Like above, provide a legend for this table that explains what the table is and what the contents of the table mean.

Using the model to manage the species

Now that you have built and explored your population model, it's time to put it to use.

- Let's suppose you are tasked with managing this population. Your goal is to ensure a stable total population size – you don't want the population to be increasing or decreasing, just staying constant. Using the most elastic model parameter, how much do you need to adjust it, and in which direction, to get a stable population size? Discuss the practicality of making this adjustment, and propose some ideas of how you might accomplish it in real life if you were in charge of the species.
 - When you are considering practicality, keep in mind that transition probabilities (e.g. growth from one stage to the next, survival within one stage) cannot ever go above 1 or below 0. That is, the probability a 1-yr old grows into a 2-yr old can never be higher than 100% or lower than 0%. So, report the actual value necessary to achieve stable population size, but make sure you compare it to 0 and 1 to make sure it's within the realm of reality!
 - When you're considering practicality, also keep in mind the logistical practicality of making these adjustments. Although 100% survival of a given stage is theoretically possible, how reasonable would it be to *actually* ensure 0 deaths?
- Our basic elasticity analysis assumed that the financial cost of making adjustments is equivalent for each parameter. What if this isn't the case? Let's say the first and second most elastic parameters are prohibitively expensive to adjust. What other options do you have to bring the population to a constant size? Describe at least three combinations of less elastic parameters that provide the same change to λ as adjusting just the most elastic parameter. Like above, for each of these combinations, discuss the practicality of making the adjustments and propose some ideas of how you might actually accomplish them.
- In your responses here, be sure to refer back to the background information you found earlier, where appropriate.

Summary

Write one final paragraph that summarizes what you've learned about this species' population biology. Use this paragraph to briefly tie together everything about you've discovered in your research and modeling.