An introduction to using population matrix models in R

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Course Information

Department: Biology Level: **Lower Undergraduate** Course type: **Lecture** Students: **Majors** Number of Students: 27

Focus: The focus of this lesson is to learn how to set up a population matrix model in R and use it for demographic analysis of a population.

Overview: In this exercise students use a population matrix model to represent demographic parameters for a population. Like life tables, matrix models are another way to summarize age- (or stage-) specific survival and fertility rates. They also can be used to model population growth. Using a matrix model we can determine a population's growth rate λ and the stable age (or stage) distribution it will achieve. We can also use the model to illustrate a population's growth trajectory. We will perform an elasticity analysis of the matrix model that tells us which vital rates (age-specific survival and fertility rates) are most important in determining the growth rate of the population.

Learning objectives: After completing these swirl lessons, students should know how to

- develop a population matrix model using R
- understand the components of a population matrix model
- use a population matrix model to project population size in the future, estimate λ , and determine the stable age distribution
- interpret the values from an elasticity analysis

Lesson sequence:

1. In preparation for this activity, students should visit a Canvas page for this assignment which has a link to the pdf "Getting started with swirl." Students

should try to install swirl and the swirl course (.swc) before class. Ideally they should email the instructor if they have any issues.

- Short lecture (≈20 minutes) during class describing life cycle diagrams and matrix models (slides provided; in original implementation, only slides 1-26 were shown). Students can follow along with the pdf "An introduction to using population matrix models in R" (available on the same Canvas page).
- 3. Students work through lesson 1 of the swirl course (setting up matrix). This lesson introduces them to entering a matrix into R, interpreting its elements, and performing matrix multiplication to project population size. Some R code they will need is found in the pdf "An introduction to using population matrix models in R."
- 4. Students work through lesson 2 of the swirl course (analyzing matrix models), which entails using the "popbio" package to determine population growth rate and stable age structure, graph population growth over a set time period, and generate elasticity values. Students who do not finish the swirl lesson in class are expected to complete it on their own in preparation for a future assessment.

Pre-lesson activities: Students should install the swirl package and the course (.swc) on their laptops before class. If they have any issues with the installation, they should consult the instructor before the day of the activity.

Post-lesson activities: This activity was followed up by a longer homework assignment written in RMarkdown that assessed students' understanding of how to implement these analyses in R and apply principles learned in class to their results.

Implementation notes: This lesson was developed for a sophomore-level Principles of Ecology course required of our biology majors. Students already had several R-based homework assignments in the course involving visualizing data and statistical analysis. Most students come into the course with some experience with R as they use it in our General Biology labs (but their confidence with R varies greatly).

To ease implementation, I recommend that students be given the swirl instructions and course file to install ahead of time and be asked to consult the instructor with any problems before the day of the activity. This would save valuable in-class time. No students completed the entire swirl activity during the time allotted in class (about 25 minutes after my introductory lecture). (The course was originally provided as one lesson; I have since divided it into two and added a few more multiple choice questions.) I expect that the two lessons together would take students 45-60 minutes, provided they already have swirl and the course installed. If course time allows, or if using more of a flipped classroom model requiring viewing of recorded lectures, having the introduction to life cycle graphs and matrix models on a different day than the swirl

activity would relieve some of the time pressure in the class session. I believe the swirl activity could also easily be performed outside of class on students' own time, especially if they already had some exposure to swirl (my class did not).

I did not build in any assessments into the swirl course to ensure their completion of the activity, but one possibility would be for them to export the graph of population growth that they produce and email it to the instructor or submit it via Canvas. One could also ask them to record the answers to the multiple choice questions in the lesson in a different file to submit; alternatively, one could give them additional questions based on the output they produce. For my course, the purpose of the swirl lesson was to prepare them for a longer homework assignment on matrix models written in Rmarkdown; this is one of five such assignments using R that they have throughout the semester.