

BIOL 208 – POPULATION AND COMMUNITY BIOLOGY

POPULATION ECOLOGY LAB

Population sizes are regulated by a combination of factors including their own propensity for growth, resources in their environment, and interactions with competitors or predators. This lab will address these major concepts in population ecology using the Population Ecology Lab (PopEcoLab) simulation models (<http://www.biologylab.awlonline.com/>). This model operates quite similarly to the Evolution Lab model (Galapagos finch model) and will enable us to study the factors affecting growth of individual and interacting populations, which would be impossible in a single semester let alone a single week. Initial exercises will focus on single-species population growth to address the following concepts: **fecundity, survivorship, exponential and logistic growth, carrying capacity, and intraspecific competition**. Subsequent exercises will become more complex as we add a population of either competitors (**interspecific competition, competitive exclusion, phase-space plots**) or predators (**cycles, predator-avoidance, top-down vs. bottom-up regulation**) to see their effects on population growth. Finally, the effect of predators on competition will be examined (**predator-mediated coexistence**).

At lab, we will provide you and your partner with a lab booklet, username, and password for the **PopEcoLab** module on the internet (from your original course packet). The background for the model and conceptual information about population growth and regulation are contained in the lab booklet. We will follow the basic format and exercises in the PopEcoLab booklet, but there will be some additional experiments and specific changes to the questions you need to answer. This handout is intended to serve as your guide to what is expected for you to complete and write up (shown in **bold**). Your report should include answers to questions asked on this handout **ONLY**. Several graphs of output from your simulations are requested for your reports, so please be aware and export appropriate graphs when necessary (“save picture as”).

Part 1: Single-species population growth

1. Population growth experiments

a. Initial simulation

Follow instructions in lab book for experiment

- **What is the carrying capacity of brown sparrows under default conditions?**
- **What type of population growth do brown sparrows exhibit in the first 2 years? What type of population growth do brown sparrows exhibit over 100 years?**

b. Changing clutch size

Perform experiments in lab book by varying clutch size of brown sparrows. Change the model to “multiple run mode” to get multiple runs (instead of “repeating experiment several times”).

- **What is the range (minimum and maximum) of clutch sizes needed to keep the population from going extinct? What causes extinction at the minimum and maximum clutch sizes (1 reason for each)?**
- **What happens to the period (time) involved in changing population size as you increase clutch size from 3.0 to 9.0?**
- **What happens to the amplitude of population size change as clutch size increases from 3.0 to 8.0?**
- **Why do period and amplitude show these patterns at higher clutch sizes?**

c. Mortality rates

Perform experiments in lab book

- **What is the threshold life span required to avoid extinction?**
- **What happens to population variability (i.e. fluctuating population size with time) as you increase life span? Why does variability in population size show this pattern with increasing life span?**

d. Resource density

Perform experiments in lab book

- **How does changing available resource density affect population size?**

2. Relationships between fecundity and survivorship

Perform experiments varying both clutch size and lifespan *systematically*

- **Can a population be sustained by balancing fecundity (clutch size) and survivorship (lifespan)? Explain the possible mechanisms for the combined effects of clutch size and lifespan on population size.**

Part 2: Interspecific competition

1. Competing species

Complete initial experiment described in lab book (using multiple run mode)

- **What were approximate carrying capacities for each species?**

a. Competition coefficients varied separately

Follow experiments in lab book. Be sure to vary competition coefficients for both species.

- **What happened to sizes of both sparrow populations when increasing relative spider consumption of brown sparrows?**
- **What happened to sizes of both sparrow populations when increasing relative seed consumption of blue sparrows?**

b. Competition coefficients varied simultaneously

Perform experiments in lab book

- **For your report, provide 2 graphs:**
 - 1) Brown and blue sparrow output from 10 runs with low competition
 - 2) Brown and blue sparrow output from 10 runs with high competition
- **What happens as you increase the amount of competition between the 2 species of sparrows? Does one species predictably outcompete the other if resources are “shared” at high but equal amounts? (you will need to use multiple runs to see results from several experiments)**

c. Resource densities

Perform experiments in lab book

- **How does varying resource density affect competition? Why? (hint: think about what factors determine the strength of competition between 2 species)**

2. Phase-space species plots

Perform experiments varying initial population sizes and competition coefficients of both brown and blue sparrows *systematically*. Run separate experiments with unbalanced initial population sizes under low and high competition for both species and unbalanced competition. Follow directions in lab book to view results in phase-space. Be sure to set resource densities back to equal before running these experiments.

- **Under what situations do initial sparrow population sizes affect the outcome of competition? Why do initial population sizes affect competition in these situations?**

Part 3: Predator and single prey species

1. Predator-avoidance

Perform experiments by varying flight speed of brown sparrows

- **What happens to population sizes of sparrows and hawks at faster flight speeds?**
- **For your report, provide 2 graphs:**
 - 1) **Brown sparrow and hawk output from a run with slow flight speed**
 - 2) **Phase-space diagram (brown sp vs. hawks) of output from same run with slow flight speed**
- **What happens to population sizes of sparrows and hawks at slower flight speeds?**
- **What does the phase-space graph tell you about the stability of predator and prey populations? How is this different at faster flight speeds?**

2. Predator and prey fecundity (“top-down control”)

Perform experiments varying brown sparrow and hawk clutch size (separately)

- **What happens to population sizes of sparrows and hawks as sparrow clutch size changes?**
- **What happens to population sizes of sparrows and hawks as hawk clutch size changes?**
- **Do hawks exhibit “top-down control” of brown sparrow populations? Explain.**

3. Bottom-up effects on predators (“paradox of enrichment”)

Perform experiments to see how increasing resources for brown sparrows affects hawk populations.

- **For your report, provide 2 graphs:**
 - 1) **Phase-space diagram (brown sparrows vs. hawks) of output from a run with low resource**
 - 2) **Phase-space diagram (brown sparrows vs. hawks) of output from a run with high resource**
- **What happened to sparrow and hawk populations as resource abundances increased? Why do prey and predator show these patterns when food for sparrows is extremely abundant?**

Part 4: Predator and competing prey species

1. Predator-mediated coexistence

Develop a situation in which brown and blue sparrows coexist only when hawks are present (vary competition between sparrows with relative resource consumption or resource densities only, use flight speed to vary predation effects on each sparrow population)

- **What were the values you used to generate the situation described above? How do predators maintain coexistence of brown and blue sparrows?**

2. Generalist survival

Develop a situation where hawks go extinct with only one population of sparrows but survive when both sparrow species are present (do not simply make one sparrow population unavailable to hawks and add the other that is available... this does not make the hawks “generalists” to survive)

- **What were the values you used to generate the situation described above? Why are hawks only able to survive with both species of sparrows?**

3. Competition-driven extinction

Design a situation in which hawks persist in the presence of brown sparrows but go extinct when blue sparrows are added

- **What were the values you used to generate the situation described above? How do blue sparrows cause extirpation of hawks?**

POPULATION ECOLOGY LAB REPORTS:

Your lab reports should include all of the specified graphs (6 total) along with answers to the questions in this document. Your answers should be complete and concise – stick to the questions being asked and don’t overdo it! Single-word (or number) answers are appropriate for some questions. Lab write-ups must be typed and single-spaced (double-sided printing encouraged). Graphs should be small to conserve paper but large enough to read. Be sure to include a short caption for each graph so that we know which results they are showing. The heading for your write up should include the name of your lab partner in addition to your own name. Organize your report using headings for each part and sub-headings as written in this document. Reports are due in lab next week.