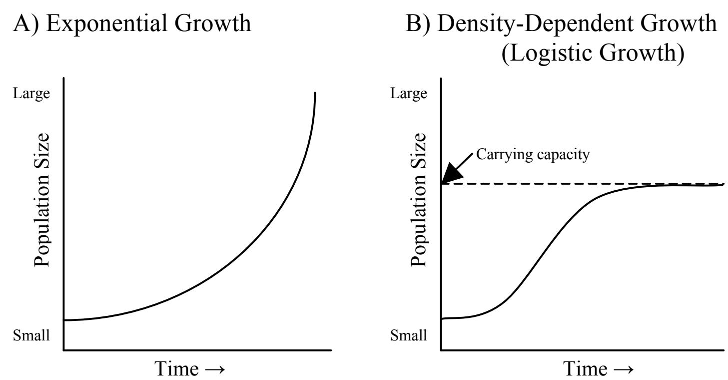
Assignment C: Interactive Population Simulation Model

Biologists studying a natural population can test whether or not the population growth rate depends on the number of individuals in the population. If the population grows more slowly when there are a lot of individuals, then the population growth is *density-dependent*. This often happens because of competition between individuals, which lowers the amount of food or other resources that each one gets. In contrast, if a population's growth rate doesn't depend on the number of individuals in that population, then the population can undergo *exponential growth*. A population experiencing exponential growth would keep increasing in size, and would grow more quickly each year (see Figure A). This can only happen when resources aren't limiting—and so it is extremely rare in nature. Instead, populations can be fairly stable around an average population size, although all populations go up or down at least a little each year.



When biologists first recognized that many species had population sizes that were stable in time, they started asking what environmental conditions affect the number of individuals that an area could support. The resources available to each population, such as the amount of food, will affect the total number of individuals that can survive and reproduce in an area. For example, warblers eat insects, and when there aren't enough insects, some of the birds starve or don't reproduce, leading to a smaller population the next year. The population would keep declining until the number of birds could be supported by the food supply. But, if there are more insects than the birds need to eat and feed their young, more birds will survive and they will raise more offspring, which would lead to a larger population the following year. If the amount of food doesn't vary much between years, the average food supply will set the population size and it can be stable over many years in a given location. This population size is called the *carrying capacity* (see Figure B).

Understanding what resources or environmental conditions affect the carrying capacity of a population is a powerful tool for wildlife managers. For example, if scientists know what limits the number of birds in an area, they might be able to increase the population or predict how the population size will change with time. Researchers have found that the carrying capacity can often be set by food availability, but in some species there are other resources that are limiting, such as good places to put a nest or a den. If predators are very common, they can also lower the carrying capacity of an environment. Finally, the strength of density-dependence also sets the carrying capacity. The strength of density dependence is measured as how much one additional bird in the population affects the demography of the other birds. If high densities lower reproductive success, then the strength of density dependence is measured as how many fewer young the average bird has when the population size is larger.

This simulation explores how density-dependence can keep a population fairly stable through time, and how factors like food availability and the strength of density dependence affect the stable population size (the carrying capacity).

Here are the default parameters for you to refer back to, if needed:
Initial warblers= 45
Density-dependence= 0.037 reproductive decline/warbler (this means each warbler will decrease 0.037 fewer young in that population)
Predators= 3.3 detections/hour
Food = 105 mg/100 leaves (which, by the way, would equal the weight of 54 caterpillars that are 1 cm long!)

1. Run the model with the default parameters (before changing the position of the sliders under the graph—you can refresh the internet window to get back to these positions).

   a) What pattern do you see in the graph? What does it tell you about the population size?

   b) What is the final number of warblers?

   c) What type of population growth, density-dependent or exponential, could give the pattern that you see? Explain your answer.

2. When the population is stable at a given size, this represents the carrying capacity, or the number of birds the environment can support. Hypothesize what will happen if you:

   a) decrease the number below that size. *

   b) increase the number of birds above the stable size.*

* Remember that a hypothesis should be a complete sentence that includes what you think and why.

3. Now you'll increase the initial number of warblers in the population. Set the Initial-Warblers slider to 80. Press 'Setup' and then 'Go' to run the model (you must press setup and go to re-run it after each change).

   a) What results did you get?

   b) What was the final number of warblers?

   c) How does this compare to your hypothesis in Question 2a?

4. Now set the Initial-Warblers to 20, and run the model.

a) What is the final number of birds?

b) How does this compare to your hypothesis in Question 2b?

c) Explain the results from changing the population size. Were they what you expected?

5. Reset the initial number of warblers to 45, then increase the strength of density dependence by moving the density-dependence bar to the right (try around 0.070), and run the model.

a) What pattern do you see in the graph?

b) What is the final number of warblers, and how does this compare to the number in Question 1?

6. Now decrease the strength of density-dependence all the way to zero, and then run the model.

a) What pattern do you see in the graph?

b) What is the final number of warblers?

c) What type of population growth, density-dependent or exponential, could give the pattern that you see?

7. Reset the strength of density-dependence to 0.037, which is the same as Question 1. Next increase the food availability all the way to 200 mg (the furthest to the right).

a) What is the final number of warblers, and how does that compare to Question 1?

b) Hypothesize what will happen if you decrease the food availability all the way to 20mg?

c) Try it and report on final warbler numbers. Was your hypothesis supported or refuted?

8. Choose one more change or combination of changes to make, and answer the following questions. You may want to reset the food to an average level before starting

a) Which factors did you change, and how did you expect it to affect the warbler population?

b) Describe the results. Were they what you expected?