

## Reading 4.1 – Fluctuation and Stability

Using the computer model in the your class activities, you explored how the outcomes from temporary disruptions resulted in the ecosystem returning to its stable state over time.

Temporary disruptions such as fire in a grassland and the death of a large number of bugs (e.g. from disease) may end up in having little long term impact on the size of the population in a real ecosystem. In both of those cases the remaining populations could reproduce additional individuals (or grow back) to compensate for the temporary reduction in population size. They could rebound and recover to their prior population sizes.

More sustained changes in the environmental conditions, however, might lead to an ongoing and longer term impact on ecosystem. For example decreasing the amount of grassland available in the ecosystem might be a more sustained environmental change.

Temporary disruptions	Longer term environmental changes
<p>Fire that burns down grass, but the grass grows back a few weeks later.</p> <p>Disease that kills off a portion of a population of bugs, but the bug population rebounds through increased reproduction a few generations later.</p> <p>Adding more bugs to the population, but the bug population declines due to starvation and decreased reproduction in the next few generations.</p>	<p>Heavy flooding results in washing away the soil from half of the spots that used to have enough soil for grass to grow there. No grass grows in those spots for hundreds of years.</p>

The difference between what should be considered a temporary change (or a short term effect) and what should be considered a longer term environmental change is a matter of scale and a matter of perspective. Over the course of millions of years, an environmental change that lasts only a hundred years may seem relatively short and temporary. On the other hand, over the course of a year, an disruption that lasts all year long (such as decreased rainfall), may (or may not) lead to longer term impact on the ecosystem that it never recovers from.

**Question 1:** Brainstorm some types of sustained environmental changes that could occur in an ecosystem that might have affects that could last thousands of years :

**Question 2a:** In an ecosystem, there can be variation in the distribution of resources. Circle one of these resources to describe further in the next question:

Food      Water      Shelter      Sunlight

**Question 2b:** What might cause variation in the distribution of this resource in a real ecosystem?

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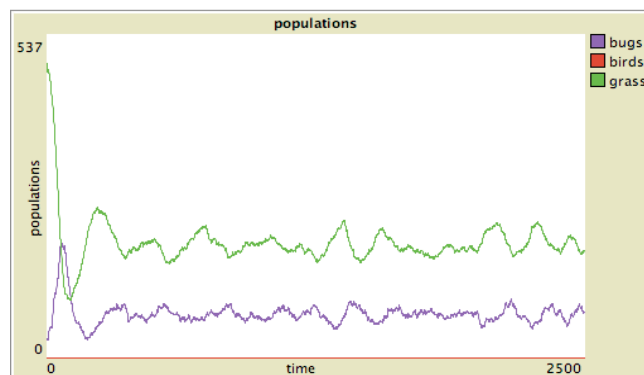
**Question 3:** You may have noticed random variation in where grass grew in the model each time you pressed SETUP. And you noticed variation in where the bugs started in the model each time you pressed SETUP. Do you think the random variation that SETUP uses in the model is an adequate or inadequate way to represent variation in the distribution of this resource in an ecosystem?

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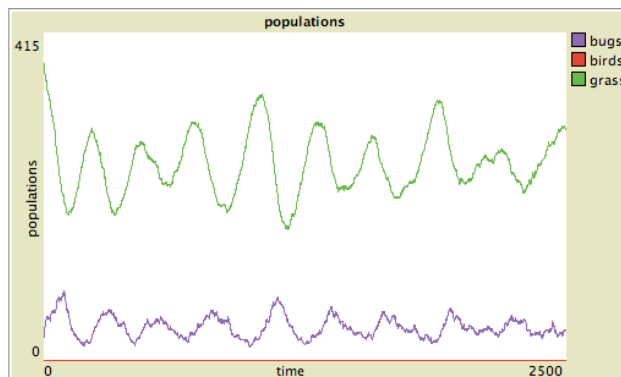
**Question 3:** If you wanted to more realistically model variation in distribution of resources in an ecosystem, what would be the next most important representation(s) you would want to include in your computer model?

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These two graphs show fluctuations in amount of bugs. At the start of both graphs you can see that the number of bugs rose quickly, and then came back down from a peak (maximum) population level.



Ecosystem 1



Ecosystem 2

In these two examples there are two separate stable levels that emerged for the number of bugs in each ecosystem. The stable population level for the bugs did not immediately occur in the model. It took a few fluctuations in the population size, before the bug population reached this “**stable state**.”

The average value of these stable states could be said to be the **carrying capacity** of that ecosystem. The carrying capacity in each model run shown above is different for grass than it is for bugs and it is different for bugs between Ecosystem 1 and 2 and it is different between the grass from Ecosystem 1 and 2. Carrying capacity is a concept that is useful for thinking about about population levels in ecosystems, since it refers to the average stable population size over time, in spite of any fluctuations.

#### Question 4

- Which graph shows an ecosystem with a higher carrying capacity for bugs? \_\_\_\_\_
- Which graph shows greater fluctuations in the bug population size? \_\_\_\_\_

**Question 5:** In this model, bugs have one offspring at a time.

Is this the most realistic way to model reproduction in all bug populations? \_\_\_\_\_

**Question 6:** Suppose you wanted to add birds to the model and the birds were predators who ate bugs. How would you want to represent the reproduction of birds and bugs in the model? Rank in order which of the additional representations you think would be important to include (1 – most important, 5 -- least important) in order to realistically model how population size changes over time.

- \_\_\_\_\_ Weather and climate affects when birds reproduce
  - \_\_\_\_\_ Birds must build & maintain a nest to hatch their eggs in
  - \_\_\_\_\_ Birds must care for and feed their young until they old enough to fly away on their own.
  - \_\_\_\_\_ Male birds engage in mating rituals (songs, feather displays, etc..) competing for the attention of female birds.
  - \_\_\_\_\_ Other:
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Some types of plants can reproduce both asexually and sexually. Most types of animals can reproduce only sexually. Both sexual and asexual reproduction are two important mechanisms by which populations change over time, since both forms of reproduction create new individuals in the population. In some of the later computer models you use in class, you will explore how sexual reproduction leads to changes in distribution of traits in a population. In the some of the simplified ecosystem models (like the one you just used in class), where the focus of the model is to understand the mechanisms that lead to changes in population size, the model will use asexual reproduction.

Think about the models you explored in class and whether the model generated exactly the same outcomes that you would expect to occur in a real ecosystem. When you changed sliders and switches you adjusted the rules in the model. Some of these changes may have led to more realistic outcomes than other changes.

**Question #7:** How would you best summarize the outcomes the model was showing you?

1. The outcomes were based on all the types of interactions that you would find in a real ecosystem and in a real population of bugs.
2. The outcomes were based on some of the types interactions you would find in a real ecosystem and in a real population of bugs.
3. The outcomes were based on interactions very different interactions than you would find in a real ecosystem and in a real population of bugs.
4. The outcomes were wholly random.

When computer models of biological ecosystems are those models often include a vast number of assumptions and simplifications of how individuals interact and behave. Even when you include the most important interactions in a model, you might not be discovering the most useful patterns and outcomes to study when you test the model.

Whether you use a complex or simplified model, one of the most important ways to evaluate the usefulness of a model is to critique the results by comparing the outcomes of the model runs to the outcomes you would expect to see in a real world ecosystem. A useful model will typically generate outcomes similar to those you would see in the real world, and it will help you consider and investigate possible mechanisms that would lead to those same outcomes.

You are encouraged to take opportunities to explore the behavior of the sliders and switches in any of the models you use. Many of the activities you will be doing will help orient you to the behavior of the model and will explain the mechanisms of the model and its limitations. But as time permits, encourage yourself to conduct your own independent experiments with the models in order to test and explore further what you think is happening.

Also, if after using the models in class, you want to explore these kind of models further on your own, you can download NetLogo (available at <http://ccl.northwestern.edu/netlogo>) and use it for free on your own computer. With NetLogo you can open any of the models you used in class and run more experiments. You can also look at (and change!) the rules and mechanisms used in the model. You can do this by either clicking the INFORMATION tab or the PROCEDURES tab at the top of the model. If you click on these tabs and want to return to the interface you had been using, click on the INTERFACE tab at the top of the model. The NetLogo program comes with tutorials to teach you how to make your own models and how to change any of the rules, graphics, and interface elements of the existing models. Have fun modifying these models, running your own experiments, and building your own brand new models