Introduction

In this activity, you will use two simple population simulations that show different types of population growth to learn more about how populations grow over time. The Populations and Communities chapter discusses two major types of population growth: exponential and logistic. A population that grows at a steady, unrestricted rate over time is said to be growing exponentially. On the other hand, a population whose growth slows over time as a response to a limit is said to be growing logistically.

1. Before you begin, consider what you already know about how populations grow. Biologists argue that there are four factors that determine how a population grows over time: birth rate, death rate, immigration, and emigration. Discuss how each of the following combinations of these factors would affect a population’s growth:

   • Birth rate exceeds death rate.

   • Emigration rate exceeds immigration rate.

   • Birth rate, death rate, and emigration rate are stable, but immigration rate is increasing.

Part 1: Population Growth

To begin, open the Population and Communities Guided Data Exploration: “The effect of Growth Rate on an Animal Population.” Imagine you are examining the growth trends of a herd of wildebeests on the grassy plains of Tanzania in Africa. Change the two variables on the graph (initial population size and growth rate) in order to display a line graph that shows how an animal population grows over time based on the values you entered.

2. If a herd of wildebeests has an initial population size of 100 and grows at a rate of 1% per year, approximately how many wildebeests are in the herd in 200 years?
3. Looking at your graph, when was the population size changing the slowest and when was it changing the fastest? Why?

4. Discuss: Many people assume that if a population of 100 individuals grows at 1% per year, 1 individual will be added to the herd each year (and therefore, 100 individuals will be added in 100 years). According to this logic, the wildebeest herd you examined above should have 200 wildebeests after 100 years. Why is the herd’s population actually much larger than 200 wildebeests after 100 years?

5. Using the same scenario (with a starting population of 100 wildebeests and a 1% growth rate), determine approximately how many wildebeests are added to the population in the first hundred years. Remember, the population started at 100 wildebeests. Then, determine approximately how many wildebeests are added to the population in the second hundred years. About how many more wildebeests are added in the second hundred-year period than are added in the first?

6. Discuss: In the scenario you just examined, the wildebeest population with an initial population of 100 is growing at a steady rate (1%), but about three times as many wildebeests are added to the herd in the second 100-year period than they are in the first 100-year period. Does this scenario represent exponential or logistic population growth and why?
Part 2: Predicting Growth at Different Rates

On the graph below, graph the population growth curves for the same wildebeest population you examined above (starting with 100 individuals) at growth rates of 1% and 2%. (Notice that, in the online graph, the scale of the y-axis changes as you change the input variables.)

7. Approximately how many more wildebeests are in the herd in 200 years when it grows at a rate of 2% compared to a rate of 1%?

8. Based on what you learned above, predict (without using the simulation) approximately how many wildebeests will be in the herd after 200 years at growth rates of 3% and 4%.

3%: ____________________________ wildebeests

4%: ____________________________ wildebeests
9. Now, check your answers using the simulation. Discuss the accuracy of your predictions below. Notice that even though about 4,300 wildebeests were added to the herd when the growth rate rose by 1% (from 1% to 2%), many more wildebeests are added when the growth rates rise by an additional 1% (from 2% to 3%, or 3% to 4%) under exponential growth.

**Part 3: Logistic Growth and Carrying Capacity**

For the following questions, you will use a slightly different model of population growth that includes a carrying capacity. Carrying capacity is the number of individuals than can live in a certain environment without diminishing the capacity of that place to support future populations. Return to the Population and Communities Guided Data Exploration and select “The Effect of Growth Rate and Carrying Capacity on an Animal Population.”

10. Discuss: What types of factors in an ecosystem may restrict a population from growing exponentially, as you observed before?

11. Imagine now a herd of wildebeests that has an initial population of 100 individuals, grows at a rate of 4%, and lives in a habitat that has a carrying capacity of 1,400 individuals. In approximately what year does growth begin to level off as the herd approaches the carrying capacity?

12. Discuss: You may have noticed that as a population approaches the carrying capacity of the environment, it grows much more slowly than it would under the conditions of unlimited, exponential growth. In other words, as the population reaches carrying capacity, the growth rate increasingly slows, unlike the first simulation in this activity, in which the growth rate remained the same over time. This is displayed in the graph “Comparing Exponential and Logistic Growth Rate.” Which type of population growth (exponential or logistic) is likely to occur more often in nature and why?
13. Looking at the logistic graph, at what point was the population increasing the fastest? (Hint: When was the line at its steepest?) Why would the growth be the fastest at this point?

14. If you wanted to “harvest” the wildebeest for food, what population size would you want to maintain in order to maximize the production of baby wildebeest for future years?

15. How does this population size relate to the carrying capacity (think in terms of the numbers)?

16. Discuss: Imagine you are raising a herd of sheep on a field with a limited carrying capacity. What types of ecological consequences may occur if the sheep population exceeds the carrying capacity of the field? What management actions could you take to increase the carrying capacity of the field?
Part 4: Differences Among Species

17. Species differ in terms of the rate at which they produce offspring; some species have slow growing populations, while others have populations that grow more quickly. Think of some examples of slow growing and fast growing species. Try to think of both plant and animal examples.
   - Slow growing:
   - Fast growing:

18. Think of these examples as you try to guess their population characteristics and fill in the following table page (just use relative terms – low vs. high, slow vs. fast, etc.):

<table>
<thead>
<tr>
<th>Population Characteristic</th>
<th>Slow growing species</th>
<th>Fast growing species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low $r$ or high $r$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number and size of offspring</td>
<td></td>
<td></td>
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<tr>
<td>Growth rate of offspring</td>
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<tr>
<td>Amount of parental care</td>
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<td></td>
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<tr>
<td>Age of maturity (younger or older)</td>
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<tr>
<td>Life span</td>
<td></td>
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<tr>
<td>Population size at carrying capacity</td>
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<tr>
<td>How much change can they handle?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Can they do well in unstable environments?)</td>
<td></td>
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<tr>
<td>Niches: “generalist” or “specialist”</td>
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<tr>
<td>Early or late successional species</td>
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<tr>
<td>(When would they show up in succession)</td>
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<td></td>
</tr>
<tr>
<td>Potential to be an invasive species</td>
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</tbody>
</table>

19. Why do you think species tend to fall towards one side or the other of these categories? That is, why can’t there be a species that has the best of everything (long life, fast reproduction, large number of offspring, etc.)?

20. Do you think these traits are affected by natural selection? If so, can you think of any implications that might have for population managers or those wishing to regulate hunting or fishing?