Population Growth Rates
Student Handout

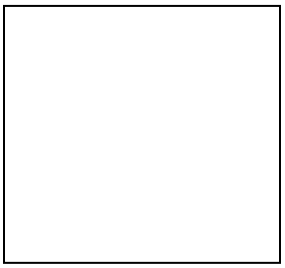
Ecosystems are _____

_____.

They can vary in size. They can be as small as a puddle or as large as the Earth itself. Any group of living and nonliving things interacting with each other can be considered an ecosystem. A _____ is a group of the same species within an ecosystem. A _____ is all species within an ecosystem. The _____ is the environment in which the species resides.

In theory, any kind of organism on Earth could take over by simply reproducing. However, when you look around you notice that there isn't a single species that has dominated this planet. Why is that? All living organisms need specific resources, such as nutrients and suitable environments in order to survive and reproduce. These resources are limited and a population size can only reach a size that match the availability of resources in its local environment.

The general equation for population growth rate (change in numbers of individuals in a population over time):



In this equation, *dN/dT* is _____, *N* is the _____, *T* is _____ and *r* is the _____ – that is, how quickly the population grows per individual already in the population. If we assume no movement of individuals into or out of the population, r is just a function _____ _____.

There are two different growth rates which we will discuss, **exponential** and **logistic** growth.

Exponential growth is _____.

Logistic growth is _____.

Exponential growth: If we were to take 1000 bacteria and let them grow in a flask, after an hour we will have _____ bacteria. Every bacterium produced one bacterium. After 2 hours, we would have _____ bacteria. After 3 hours, we would have _____. The number of individuals added in each generation increases as the population increases. If you were to plot

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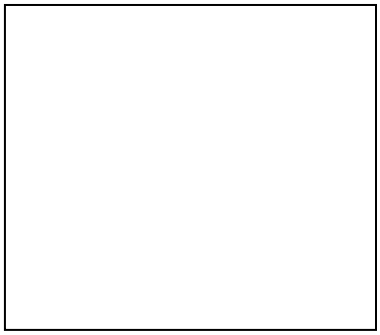
the population growth it would be a _____**:**

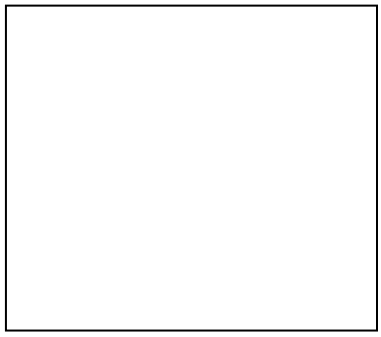
Graph the exponential growth:



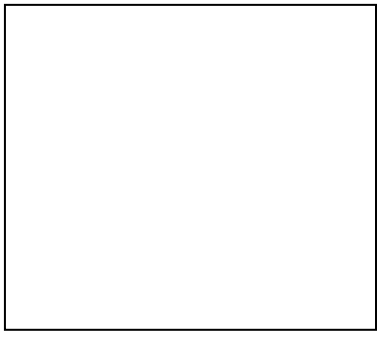
Logistic growth: Exponential growth only happens when the population is in an ideal world i.e. unlimited resources, no predators. When there are a lot of individuals in a population the number of resources decreases and this slows down the growth rate, the per capita rate of increase, *r*.

Eventually, the growth rate will plateau, or level off, making an _____. The population size at which it levels off, which represents the maximum population size a particular environment can support, is called the _____.

Graph the logistic growth:



We can mathematically model logistic growth by modifying our equation for exponential growth rate:



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At any point in time during a population's growth, the expression *K – N* tells us how many more individuals can be added to the population before it hits carrying capacity. *(K -N)/K* is the fraction of the carrying capacity that has not yet been "used up". The more carrying capacity that has been used up, the more the *(K-N)/K* term will reduce the growth rate.

The carrying capacity of populations are determined based on food, habitat, water, and other abiotic factors. For plants, the water, sunlight, nutrients, and the space to grow are some key resources. Limited quantities of these resources result in competition between members of the same population, or _____ (intra - = within; -specific = species). Intraspecific competition may not affect populations that are well below their carrying capacity. However, as a population increases, the competition intensifies.

Materials
- Grass field or at least a 30-m field
- Good weather
    - If you don't have good weather instead of running you can request the students to walk around in a large classroom
- Clipboard and lesson plan for recording data
- Seeds (preferably herbs) 50 seeds per group
- 5 pots
- Permanent Markers
- Pencil
- Water
- Watering can
- Grow light kit
- Soil
- Tape

Safety
Make sure the field does not have any dangerous objects which could hurt the students when running around.

Protocol

Resource Designation:

a. Shelter = triangle over their head
b. Water = hand over their mouth
c. Food = hand over their stomach

Rabbits: Face away from the environment group and choose an environmental resource. Run and tag the corresponding resource on the environment side. If you tag the resource, you live and go back to the rabbit section for the next generation. If you do not tag a resource, you die and decompose (stand next to the teacher).

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Environmental Resource: Face away from the environment group and choose which resource you want to be (shelter, food, or water). If a rabbit tags you, you will become a rabbit in the next generation. If no rabbits tag you, you stay as a resource for the next generation.

Decomposers: Stand next to the teacher for the next generation. Go to the environment side after one turn.

Foxes: Stand next to the teacher. Run and tag as many rabbits as possible when the teacher says "go". If you tag one rabbit, you survive. If you tag more than one rabbit, they become a fox in the next generation.

Data and Analysis

Generation	Rabbit Population	Environment Amount	Fox Population
1	2		0
2			0
3			0
4			0
5			0
6			0
7			0
8			0
9			0
10			1
11			
12			
13			
14			
15			
16			

Graphing:

Create a line graph with population size on the y-axis against number of generations on the x-axis. Use a legend and colored pencils to graph rabbit, environment and fox populations. Mark and label exponential growth and carrying capacity on your graph.

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Discussion Questions

1. What is the independent variable? What is the dependent variable? What are the constants?

_____

_____

_____

_____

2. What is the largest number of rabbits able to survive in the provided environment called?

_____

3. Explain how the fox affected the carrying capacity of the rabbits once it was introduced.

_____

_____

_____

4. Why did the dead rabbits not become an environmental resource in the next generation once the fox was introduced in the game?

_____

_____

_____

_____

5. What was the rabbit population growth rate from generation 1 to generation 5?

_____

6. What was the rabbit population growth rate from generation 6 to generation 8?

_____

7. What was the rabbit population growth rate from generation 9 to the last generation?

_____

Protocol – second activity

1. Prepare 5 pots by labeling each pot with 1 – 5 using tape and permanent marker.
2. Fill the pots with slightly moistened soil. DO NOT push down or pack soil.
3. Plant 2 seeds in pot 1, 4 in pot 2, 8 in pot 3, 12 in pot 4 and 24 in pot 5.
4. Cover the seeds 2 with a thin layer of soil.

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5. Water plants gently from above.
6. Once you see some plants germinating, thin plants 1, 2, 4, 8, and 16 respectively.
7. Add fertilizer to the pots on days 3, 7 and 14.
8. Take measurements every day for days 3 – 18. Write down observations and measurements.
9. Harvest on day 18. Take pictures from the same distance and angle. Record information along with pot density for information for each group of plants.