Population Ecology – Part 1: Size, Growth and Regulation

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*Number in outline corresponds to slide number the PowerPoint presentation.

1. Population Ecology: Size, Growth, and Regulation.
   a. Populations can be characterized in a number of different ways. The most obvious, and a large part of the focus we will give population ecology is size. How many individuals are part of the populations, how often they give birth, movement in and out of the population, are all thing to consider when thinking about population size. This lecture will focus on this important aspect. Other aspects, such as how a population distributes itself through a habitat will be the topic of the next lecture in this series.

2. Terms to know. Before we really dive into the topic of population growth, let's define some of the most important reoccurring terms you will hear over the course of this lecture.
   a. A **habitat** is simply a specific area, or place that is occupied by a variety of different interacting organisms.
   b. A **population** is defined as a group of individuals of the same species that share a habitat.
   c. A community is all of the different populations that live in the same habitat
   d. **Ecosystem** encompasses the community in a given habitat and how member of that community interact with the physical and chemical feature in the surrounding environment.
   e. **Biotic factors** are all the living components of the ecosystem: These factors include things such as predator-prey interactions, reproductive strategies of the species that live in the ecosystem, as well as the organisms that live there.
   f. **Abiotic factors** are the non-living components: temperature, weather patterns, global location, annual rainfall, etc.

3. Biotic Potential.
   a. When talking about how population sizes change, we often put it in terms of rates. How fast, or slow, a population grows over a certain period of time. Biotic potential refers to the maximum rate of increase that a population can grow when it has access to unlimited resources.
   b. The type of species we are talking about is going to determine that specific population's ideal conditions. A population of Asian elephants, for example has a completely unique set of ideals compared to a population of western bluebirds.
   c. It is important to realize however, that biotic potential is rarely achieved in nature because of environmental resistance, or the limits that an environment puts on a population that lives in it. These factors include things such as the age at which the species becomes capable of reproducing, how often they reproduce, the number of children they have in each reproductive event, and length of life span.

4. Population Growth.
   a. There are three ways that populations can change through time: by births, deaths and migrations in and out of a population. Let's take a hypothetical population of 2000 mice to demonstrate how to predict how a population will change over time. In our mice population, let's assume every month 1000 mice are born and 200 mice die.
   b. Growth rates, or how quickly a population grows, are influenced by births and deaths that occur in a given time, and these rates are in turn dependent upon the size of the original population size. So let's first define the measurements that are used to estimate population growth, before we talk about how an environment can control these rates. This population of mice has reproductive events every month; therefore, our unit of time in this example is per month.
   c. In reality, the lifestyle of the organism we are examining will determine the most appropriate unit of time. Humans, who can reproduce as often as once a year, or bacteria that can reproduce in a matter of hours would have different time units.

5. Changes in a Population Over Time
   a. Changes in population size are a function of the number of births and deaths over time. Birth and death rates are simply calculated by taking the number of births or deaths that occur, and dividing by the total population size. So birth rate (b) would be 1000/2000 = .5 or 50% Death rate is calculated by dividing 200 by the total population size 200 / 2000 = 0.1 or 10%

6. Growth Rate (r)
   a. Mathematically speaking, growth rate, also known as natural rate of increase, is defined as the overall change in population size per individual in a given period of time and takes into account both births and deaths that occur in that period of time. In lay terms this refers to the average contribution to the next generation an individual has within the population. It is calculated by subtracting the birth rate by the death rate. In our mouse population, r = 0.5 -0.1 = 0.4. In lay terms this means our population increases in size by 40% every month.
   b. But what happens when growth rate results in a negative number? Let's turn the tables on our mice and assume the numbers are reversed. Only 200 mice are born and 1000 die each month. This would result in r = 0.1 – 0.5 = -0.4. A negative growth rate means that the population is shrinking by 40% every month!

7. Population Grwoth (G)
   a. The culminating application of the calculations we just performed is to determine population growth per unit of time (G). Note that this is different from r, which is defined as growth RATE per unit of time. G represents the number of individuals that are added to a population, based upon the growth rate.

8. Apply What You Know.
   a. So, in our population of 2000 mice, (assuming the population at the beginning of the month is 2000 mice). Here is how to determine population size in month 2, using the growth rate of 0.4 that we calculated: G = 0.4 x 2000 = 800. This means the population of mice grew by 800 in the first month. (Remember, r of 0.4 takes into account both births and deaths that occur in the month!).
   b. So, at the beginning of month 2, the population size is now 2800 mice. In month 2, you apply the growth equation again to determine how many mice were added in month 2: 2800 x 0.4 = 1120. At the beginning of month 3 then, the population is now 3920.

9. Exponential Growth.
   a. If our mouse population were to keep growing without constraints, i.e. continue calculating population growth month after month, this is what the data would look like. Exponential growth occurs when the growth rate of a population remains constant, and is not influences by environmental resistance factors. This represents the growth pattern if the population were achieving its biotic potential.

10. Logistic Growth
   a. In truth, exponential growth rarely happens in nature and when it does, it is not sustainable for very long. Eventually, resource availability is going to come into play and start limiting how fast a population can grow.
   b. This is referred to as logistic growth. The math behind this type of growth pattern is slightly more complicated, so you will not be held responsible for using this calculation, but you should have at least a conceptual grasp on the variables involved in this type of growth pattern.

11. The S-Curve of Logistic Growth
   a. Logistic growth is characterized by a slowing and eventual halt to growth. This means that our growth rate (r) = 0. Carrying capacity represents the maximum number of individuals a habitat can sustain based upon the amount of resources that are available in it.

12. Overshooting Carrying Capacity

- **a.** Sometimes, when a population initially exhibits exponential growth, it can grow faster than what a habitat can sustain long term. This is known as overshooting carrying capacity, and can have varying results. This can happen because when a population is growing rapidly, at the point that K is reached, there are still likely to be a large proportion of the population who are still reproducing. They haven't gotten the memo yet that resources are running low.
- **b.** At the extreme, they could overshoot so dramatically that they permanently and irreparably damage the ecosystem to the point it can no longer sustain a population of any size. A lesser extreme might result in a permanent lowering of carrying capacity.
- **c.** A good example of this would be the introduction of reindeer to the island of St. Paul near the coast of Alaska. In 1911, a military outpost was set up on the island, and reindeer were bought to the island as a food source for personnel stationed there. But as is the case with many introduced species, the reindeer population exploded. Within 30 years, their numbers expanded to over 2000 animals. Such large numbers decimated the island and permanently destroyed some of the resources they relied on to survive. By 1950, 20 years after their peak numbers, reindeer were all but extinct.

13. Environmental Resistance

- **a.** Environmental resistance is just a fancy way of saying that there are factors in the environment that limit population growth and result in logistic growth. Logistic growth and carrying capacity is influenced by two types of environmental resistance, Density <u>in</u>dependent, and density <u>de</u>pendent factors. To understand what these really mean, we need to understand what density means.

14. Density

- **a.** Density refers to how many individuals are in an environment, relative to how big the habitat is. In mathematical terms, population density is defined as the number of individuals per unit of area.
- **b.** For instance, Malheur County in central eastern Oregon, which covers 9,930 acres of land, is estimated to be home to 10,000 deer. To express this as a density, you divide the number of deer by the number of acres of land. This gives you the number of deer per acre in Malheur County. (~1 deer per acre of land.)
- **c.** The density of sea urchins that live in a tide pool would have density expressed differently, perhaps as urchin per square meter. The habitat determines the unit of space used.

15. Density Independent factors

- **a.** Density Independent factors are those that are not influenced by the size or density of the population. These are things like natural, disasters, fires, floods, etc. A population will be negatively impacted by events such as these, regardless of size.

16. Density dependent factors

- **a.** Density dependent factors are factors whose influence will increase as the population size gets larger. These are going to be things like disease, parasites, nutrient and space availability, predator prey relationships, and competition between members of the community. The individuals who are better competitors will get the resources they need, that those who are not as good will do without, and lower their potential to survive and reproduce.

17. Predator – Prey Cycles

- **a.** Looking at the relationship between Lynx and hare populations gives us a good view of how density dependent factors work. Notice that in each cycle an increase in hare populations brings about an increase in lynx populations.
- **b.** The more prey available, the less competition, and more lynx obtain all the resources they need to reproduce. But as their numbers increase, that triggers a decrease in hare populations. Population size of each is dependent upon the size of the other, thereby demonstrating density dependence.

18. Human Populations.

a. Applying basic ecological concepts to humans can sometimes be challenging, because of how drastically different we are from other organisms in terms of how we interact with your surroundings.

19. Human Population Growth

a. Things such as agriculture, modern medicine, urbanization, the industrial revolution have allowed humans to sidestep the controls that are put on other species. We manipulate our environment in ways no other species is capable of; and have over time dramatically increased the carrying capacity of our species.

b. The fear is that we are nearing a point in human history, like that of the reindeer at the peak of their existence. Many would say we will inevitably experience a similar population crash, just as the reindeer did in the 40s while others believe that we can and will continue to bend the earth to our needs. I will leave it you to decide the level of truth in that statement and instead talk about some of the ways we do study changes in human populations.

20. The Demographic Transition

a. Socioeconomic factors have significant influence over rates of growth. Patterns in Demographic transition model can illustrate how the level of modernization (First world vs. third world) predicts the type of growth pattern a population will exhibit.

b. In the least developed pre-industrial countries, there have been little to no medical or industrial advancements, populations are small and not growing because even though they have high birth rates, they have very high death rate as well.

c. As medical and industrial advancements are bought into the country, they move into the transitional stage of development. Because of increased food production and access to modern medicine, we still have relatively high birth rates, but we see a dramatic decrease in death rates and the population experiences rapid growth.

d. As a country reaches the industrial stage, growth begins to slow and stabilize. Industrial countries have a high level of urbanization, advanced health care and access to family planning. Now we contribute to have low death rates, but birth rates begin to slow as well, and in turn population growth slows.

e. By the time a country can be described as post industrial, birth and death rates are equal, and the population stops growing. The country is nearly entirely urban and industry based, and have reach a RLF of 2.1

21. Replacement Level Fertility

a. RLFis when people only have enough children to replace themselves. Sweden is a country that is experiencing RLF and not growing. So why is RLF 2.1? Well, it’s 2 because it takes two to tango. You need one female and one male to reproduce, so RLF really refers to the number of children born to each set of parents. The .1 because there will always be a small proportion of children who don’t make it to reproductive age and contribute to the next generation.