# Chapter 52 - Population Ecology

Characteristics of Populations

- A population is a group of individuals of a single species that simultaneously occupy the same general area.
- The characteristics of populations are shaped by the interactions between individuals and their environment.
- Two important characteristics of any population are density and the spacing of individuals
  - Populations have size and geographical boundaries.
    - The density of a population is measured as the number of individuals per unit area.
      - Measuring density of populations is a difficult task.
        - We can count individuals; we can estimate population numbers.
        - Unfortunately, it is usually impractical to attempt to count individuals in a population.
        - One sampling technique that researchers use is known as the mark-recapture method.
          - Individuals are trapped in an area and captured, marked with a tag, recorded, and then released.
          - After a period of time has elapsed, traps are set again, and individuals are captured and identified.
          - This information allows estimates of population changes to be made.
    - The dispersion of a population is the pattern of spacing among individuals within the geographic boundaries.
      - Patterns of dispersion.
        - Within a population's geographic range, local densities may vary considerably.
        - Different dispersion patterns result within the range.
        - Overall, dispersion depends on resource distribution.
      - Clumped dispersion is when individuals aggregate in patches.
      - By contrast, uniform dispersion is when individuals are evenly spaced.
      - In random dispersion, the position of each individual is independent of the others.
      - Overall, dispersion depends on resource distribution.
- Demography is the study of factors that affect the growth and decline of populations
  - Additions occur through birth, and subtractions occur through death.
  - Demography studies the vital statistics that affect population size.
  - Life tables and survivorship curves.
    - A life table is an age-specific summary of the survival pattern of a population.
    - The best way to construct life table is to follow a cohort, a group of individuals of the same age throughout their lifetime.
    - A graphic way of representing the data is a survivorship curve.
      - This is a plot of the number of individuals in a cohort still alive at each age.
      - A Type I curve shows a low death rate early in life (humans).
      - The Type II curve shows constant mortality (squirrels).
      - Type III curve shows a high death rate early in life (oysters).
  - Reproductive rates.
    - Demographers that study populations usually ignore males, and focus on females because only females give birth to offspring.

A reproductive table is an age-specific summary of the reproductive rates in a population. For sexual species, the table tallies the number of female offspring produced by each age group.

Life Histories

- The traits that affect an organism's schedule of reproduction and survival make up its life history.
- Life histories are highly diverse, but they exhibit patterns in their variability
    - Life histories are a result of natural selection, and often parallel environmental factors.
    - Some organisms, such as the agave plant, exhibit what is known as big-bang reproduction, where large numbers of offspring are produced in each reproduction, after which the individual often dies.
        - This is also known as semelparity.
    - By contrast, some organisms produce only a few eggs during repeated reproductive episodes.
        - This is also known as iteroparity.
- Limited resources mandate trade-offs between investments in reproduction and survival
    - Life-histories represent an evolutionary resolution of several conflicting demands.
    - Sometimes we see trade-offs between survival and reproduction when resources are limited.
        - For example, red deer show a higher mortality rate in winters following reproductive episodes.
    - The number of offspring produced at each reproductive episode exhibits a trade-off between number and quality of offspring.

Population Growth

- The exponential model of population describes an idealized population in an unlimited environment
    - The text defines a change in population size based on the following verbal equation.

      Change in population size during time interval = Births during time interval – Deaths during time interval
    - Using mathematical notation, it can be expressed as follows:
        - If N represents population size, and t represents time, then N is the change is population size and t represents the change in time, then:
            - $N/t = B-D$
                - Where B is the number of births and D is the number of deaths
            - Simplify the equation and use r to represent the difference in per capita birth and death rates.
            - $N/t = rN$ OR $dN/dt = rN$
            - If B = D then there is zero population growth (ZPG).
    - Under ideal conditions, a population grows rapidly.
        - Exponential population growth is said to be happening
        - Under these conditions, it may be assumed the maximum growth rate for the population ($r_{max}$) to give the following exponential growth equation:
        - $dN/dt = r_{max}N$
- The logistic model of population growth incorporates the concept of carrying capacity
    - Typically, unlimited resources are rare.
    - Population growth is therefore regulated by carrying capacity (K), which is the maximum stable population size a particular environment can support.
    - The logistic growth equation
        - The logistic population growth model incorporates the effect of population density on the rate of increase.

Mathematically, start with the equation for exponential growth, creating an expression that reduces the rate of increase as N increases

$dN/dt = r_{max}N((K-N)/K)$

The graph of this equation shows an S-shaped curve.

How well does the logistic model fit the growth of real populations?

The growth of laboratory populations of some animals fits the S-shaped curves fairly well.

Some of the assumptions built into the logistic model do not apply to all populations.

It is a model which provides a basis from which we can compare real populations.

The logistic population growth model and life histories.

This model predicts different growth rates for different populations relative to carrying capacity.

Resource availability depends on the situation.

The life-history traits that natural selection favors may vary with population density and environmental conditions.

In K-selection, organisms live and reproduce around K, and are sensitive to population density.

In r-selection, organisms exhibit high rates of reproduction and occur in variable environments in which population densities fluctuate well below K.

Population-Limiting Factors

- The effects of increased population density.

  Density-dependent factors increase their affect on a population as population density increases.

  This is a type of negative feedback.

  Density-independent factors are unrelated to population density, and there is no feedback to slow population growth.

- Negative feedback prevents unlimited population growth

  A variety of factors can cause negative feedback.

  Resource limitation in crowded populations can stop population growth by reducing reproduction.

  Intraspecific competition for food can also cause density-dependent behavior of populations.

  Territoriality, defense of a space, may set a limit on density.

  Predation may also be a factor because it can cause mortality of prey species.

  Waste accumulation is another component that can regulate population size.

  In wine, as yeast populations increase, they make more alcohol during fermentation.

  However, yeast can only withstand an alcohol percentage of approximately 13% before they begin to die.

  Disease can also regulate population growth, because it spreads more rapidly in dense populations.

- Population dynamics reflect a complex interaction of biotic and abiotic influences

  Carrying capacity can vary.

  Year-to-year data can be helpful in analyzing population growth.

  Some populations fluctuate erratically, based on many factors.

- Some populations have regular boom-and-bust cycles

  There are populations that fluctuate greatly.

  A good example involves the lynx and snowshoe hare that cycle on a ten year basis.

Human Population Growth

- Humans are not exempt from natural processes.
- The human population has been growing almost exponentially for three centuries but cannot do so indefinitely

- The human population increased relatively slowly until about 1650 when the Plague took an untold number of lives.
    - Ever since, human population numbers have doubled twice.
- The Demographic Transition.
    - A regional human population can exist in one of 2 configurations.
        - Zero population growth = high birth rates – high death rates.
        - Zero population growth = low birth rates – low death rates.
        - The movement from the first toward the second state is called the demographic transition.
        - Age structure is the relative number of individuals of each age.
        - Age structure diagrams can reveal a population's growth trends, and can point to future social conditions.
- Estimating Earth's carrying capacity for humans is a complex problem
    - Predictions of the human population vary from 7.3 to 10.7 billion people by the year 2050.
    - Wide range of estimates for carrying capacity.
    - What is the carrying capacity of Earth for humans?
        - This question is difficult to answer.
        - Estimates are usually based on food, but human agriculture limits assumptions on available amounts.
    - Ecological footprint.
        - Humans have multiple constraints besides food.
        - The concept an of ecological footprint uses the idea of multiple constraints.
        - For each nation, we can calculate the aggregate land and water area in various ecosystem categories.
        - Six types of ecologically productive areas are distinguished in calculating the ecological footprint:
            - Land suitable for crops.
            - Pasture.
            - Forest.
            - Ocean.
            - Built-up land.
            - Fossil energy land.