Population Growth

Population ecologists use of a variety of methods to model population dynamics. An accurate model should be able to describe the changes occurring in a population and predict future changes.

There are 2 simple models available to describe the rate of change in the size of a population over time which are based on deterministic equations (equations that do not account for random events). Neither model adequately describes natural populations, but they provide key-points for comparison.

Exponential Growth (Biotic Potential = J type growth)

Thomas Malthus (who influenced Darwin) published his book in 1798 stating that populations with abundant natural resources grow very rapidly. However, their further growth is limited by depleting their resources. The early pattern of accelerating population size is called **exponential growth.**

The best example of exponential growth in organisms is seen in bacteria. In **exponential growth**, a population's *per capita* (per individual) growth rate stays the same regardless of population size. It makes the population grow faster and faster as it gets larger. When you plot the population size, *N*, over time *t*, a J-shaped growth curve is produced.

Logistic Growth (S type growth)

The continous exponential growth is possible only when infinite natural resources are available; which is not the case in the real world. Darwin’s description: the “struggle for existence” states that individuals will compete (intra or inter-competition) for limited resources. The successful ones are more likely to survive (natural selection). Thus, to model the reality of limited resources, population ecologists developed the **logistic growth** model.

Carrying Capacity and the Logistic Model

In the real world, with its limited resources, when the number of individuals increase beyond a certain level, the growth rate will slow down. Eventually, the growth rate will plateau. The maximum population size that a particular environment can sustain, is called the **carrying capacity**, or *K*. In real populations, when a population overshoots its carrying capacity, the death rate increases causing the population size to decline back to the carrying capacity or below it. Most populations usually fluctuate around the carrying capacity in an undulating fashion rather than existing right at it.

The logistic growth equation:

Where N indicates the number of individuals

K indicates the carrying capacity of habitat

r indicates the growth rate of the population (maximum reproductive output)

A graph of this equation (logistic growth) yields a S-shaped curve. It is a more realistic model of population growth than exponential growth. There are 3 different sections in an S-shaped curve. Initially, growth is exponential because there are few individuals and lots of resources available. Then, as resources begin to become limited, the growth rate decreases. Finally, the growth rate levels off at the carrying capacity of the environment, with little change in population number over time.

A-Density dependent environmental factors are influenced by the relative size of a population. These factors include:

i. availability of food (starvation) and other resources (shelter, habitat) [COMPETITION; generally intraspecific]; eventually will lead to deaths or migration.

ii. predator abundance

iii. the spread of pathogenic diseases and/or parasites

iv. waste accumulation (toxic chemicals)

B-Density independent factors are generally environmental factors. They are not influenced by the relative size of a population. These factors include weather, climate conditions (or altitude related), dissolved gases (particularly for aquatic organisms) as well as the occurrence of natural disasters (e.g. earthquakes, fires)

Demographic-Based Population Models

Demography is the statistical study of the size, structure, and distribution of populations, and spatial or temporal changes in them in response to birth, migration, aging, and death. Demographic models represent the changes in populations as a mathematical function relating two or more measurable variables. The primary purpose of modelling is simplification or to represent reality without complexity. Such models are also useful to explain life history of organisms.

By the aid of these models population ecologists found that life history characteristics of organisms such as birth rates, age at first reproduction, the numbers of offspring, and death rates evolve just like anatomy or behavior which in turn leading to adaptations that affect population growth. Based on this, population ecologists have described 2 different life-history "strategies"

One major point in life history strategies is observed between the number of offspring and the parent's investment: the "quantity versus quality" question. An organism can have:

a few offsprings that each represent a relatively large energy investment (K)

or

many offsprings that each represent a relatively small energy investment (r)

In other words: **fecundity** tends to be inversely related to the amount of energy invested per offspring.

Organisms that make a few offsprings usually make a large energy investment for each offspring and often provide lots of parental care. These organisms are effectively "putting their eggs in one basket" and are heavily invested in the survival of each offspring (K-selected).

Organisms that produce large numbers of offspring tend to make a relatively small energy investment in each, and don't usually provide much parental care. The offspring are "on their own," and the idea is that enough are produced that *some* will survive (r-selected).