Cycle 11: Ecology in the Anthropocene

Introduction to Human Population

Human population growth through history can be evaluated through different stages ranging from the Old Stone Age, New Stone Age, Bronze Age, to the Iron Age, Middle Ages, and Modern Age.

In these stages, different occurrences including the expansion of geographic range, development of agriculture, advances in healthcare, sanitation, infrastructure, and the Industrial Revolution (technological innovations to use resources more effectively) all impacted population growth. Many factors including food, water, education, contraceptive use, economics, and culture can help us predict human population growth.

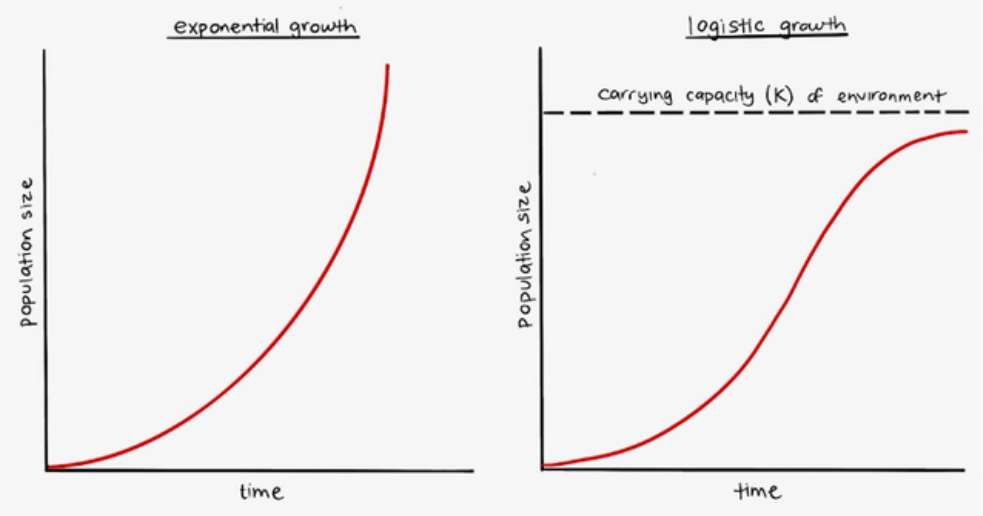
Population Growth Models

Exponential Growth: As long as the birth rate (including immigration) is greater than the death rate, populations continue to grow. However, over time, the availability and accessibility of resources eventually become constrained or more challenging to acquire as the population depletes them.

Logistic Growth: Competition among individuals for limited resources, which can vary depending on habitat and season, constrains population growth (intraspecific competition). The concept of carrying capacity (K) represents the maximum population size an environment can sustain. Thanks to advancements in technology and medicine, our carrying capacity has expanded.
In both models, the difference in birth and death rates is the growth rate, per capita:

r = birth rate - death rate

Population Growth Rate = r × population size (N)



Example 1: What is the population growth rate when the population size is 1000 people and the birth rate is 100 people/month and the death rate is 40 people/month?

A: 1000 * (100-40) = 1000*60 = 60000 people/month

Environmental Factors Affecting Population Growth Rates and Size

Density-dependent factors exert their influence in response to *changes in population density*. Intraspecific competition, which occurs among individuals of the same species, is intensified by crowding and has a direct impact on reproduction. For instance, plants growing at higher densities tend to produce fewer seeds. Parasitism and disease, such as ticks infesting humans, are also examples of density-dependent factors. Interspecific competition, such as lions and cheetahs competing for the same food sources, and predation, like owls hunting mice, are additional factors influenced by population density.

Density-independent factors exert their influence *regardless of population size*. Temperature fluctuations, natural disturbances such as fire, storms, tsunamis, and earthquakes, as well as the quality of available food, are examples of density-independent factors.

Density-dependent and density-independent factors can interact and have combined effects on populations. One example is how extreme heat, which is a density-independent factor, can weaken the overall health of individuals. This weakened health, in turn, increases their susceptibility to pathogens, which is a density-dependent factor since it is easier to spread pathogens in denser populations.

Fecundity refers to the *potential reproductive output of individuals* and involves several factors. These include the age at which reproductive maturity is reached, the number of offspring produced in each reproductive event, and the number of reproductive events that occur over an individual's lifetime.

Generation time, which represents *the average time between two successive generations*, is also an important aspect of fecundity. Smaller organisms typically have shorter generation times, allowing them to grow their population size more rapidly. In long-lived species, age structure also plays a role in population growth, considering the distribution of individuals across different age groups. The relationship between population growth, age structure, and economic development is closely intertwined. Moreover, human populations often adopt self-imposed controls on population growth, such as the implementation of birth control measures and policies like the one-child policy in China. Additionally, factors like education, healthcare, cultural influences, and the increasing participation of women in the workforce indirectly contribute to managing population growth.

What do these factors mean for population size?

Carrying Capacity (K) represents the theoretical maximum size a population can reach. This limit is determined by various factors, including resource availability and competition among individuals of the same species (intraspecific competition). The growth rate of a population is influenced by a combination of density-dependent and density-independent factors, as well as characteristics such as fecundity (reproductive output), generation time (time between generations), and age structure (distribution of individuals across different age groups). These elements collectively shape the dynamics and limitations of population growth.

Human Impacts on Population Growth in other species

- Conservation management: move, cull, or facilitate reproduction to conserve a species or habitat
- Biological control: introduce a species to control another
- Introduction of exotic species: compete with native species
- Habitat alterations, habitat loss, climate change: burning of forests, melting glaciers or warming arctic
- Fishing, hunting: declining fish stocks
- Agriculture: cultivation of food species

Boundary Characterized by the 6th Mass Extinction

The current boundary we find ourselves in is marked by the occurrence of the sixth mass extinction, wherein the rate of extinction has increased beyond the normal background levels. This trend can be attributed to several interconnected factors, including climate change, pollution, alterations to habitats, resource extraction, hunting and fishing practices, as well as the introduction of invasive species.

Terminology related to the Anthropocene

One Health Concept: the well being of people, animals, and the environment through collaborative problem-solving, locally, nationally, and globally
Anthropocene of the future: new approaches to complex problems

Introduction to Interactions between Species

Organisms within the same ecosystem interact with one another. One example of this is found within the human body when it engages in interactions with organisms residing within it. One such interaction is the Gut-Brain Axis, where the gut influences the brain in various ways. This includes impacts on behavior, emotions, stress response, and appetite regulation. Conversely, the brain also influences the gut, affecting epithelial function, mucin production, and motility. Central to these processes are the **gut microbiota**, i.e. microorganisms that play a role in this axis by producing neuromodulators such as serotonin, GABA, and cytokines which can then modulate the central nervous system.

Interspecific Interaction	Relationship	Example
Predator-Prey	+/-	Bear (predator) eating fish (prey)
Herbivory	+/-	Deers eating plant matter
Competition	-/-	Sharks and dolphins that each eat the same fish
Symbiosis	Commensalism, mutualism and parasitism determine the specific relationship	Ants that live in acacia trees and also help protect from predators by attacking them
Commensalism	+ / 0	Birds making a nest in a tree
Mutualism	+ / +	Bacteria in humans eat and digest food we cannot digest, releasing valuable nutrients that we can absorb while they benefit from the food source
Parasitism	+/-	Leeches that infect their host

Coevolution refers to the reciprocal evolution of interacting organisms, as demonstrated in host-parasite coevolution. This dynamic process often results in an "evolutionary arms race", where each organism continuously adapts and evolves in response to the changes and strategies of the other.