

**Supplementary Notes: (PJ Shlachtman, Miller book)  
Population Dynamics, Carrying Capacity, and Conservation Biology**

**Major Characteristics of a Population**

**Population Dynamics:** Populations are dynamic: changing in size, density dispersion and age distribution – in response to environmental conditions.

**Population Size** – the number of individuals in a population at a given time.

**Population Density** – the number of individuals of a population in a certain space at a given time.

**Population Dispersion** – the spatial pattern in which the members of a population are found in their habitat.

- Clumping
- Uniformly dispersed
- Randomly dispersed

**Age Structure** – the proportion of individuals in each age group in a population.

- prereproductive
- reproductive
- postreproductive

A population with a large percentage of its individuals in the prereproductive and reproductive categories has a high potential for growth.

**Population Dynamics and Carrying Capacity**

Four variables that govern population size :

- births
- deaths
- immigration
- emigration

$$\text{Population change} = [\text{births} + \text{immigrations}] - [\text{deaths} + \text{emigration}]$$

**ZPG = zero population growth:** when number of individuals added to a population from births and immigrations equals the number of individuals lost due to deaths and emigration.

Population size is determined by the interplay between its biotic potential and environmental resistance.

**Biotic Potential** – capacity of a population for growth

- **Intrinsic rate of growth (r)** – the rate at which a population could grow if it had unlimited resources
- High r – reproduce early in life, have short generation times, can reproduce many times and produce many offspring each time they reproduce
- **critical size** – a minimum size a population should have to support a breeding population
- There are always limits to population growth in nature.

**Environmental Resistance** – all the factors acting jointly to limit the growth of a population.

**Carrying Capacity (K)** – the number of individuals of a given species that can be sustained indefinitely in a given space; determined by biotic potential and environmental resistance.

**Exponential Growth and Logistic Growth**

**Exponential Growth** – a population that does not have resource limitations;

- J-shaped exponential growth curve

**Logistic Growth** – involves exponential growth when a population is small and a steady decrease in growth in time as the population approaches the carrying capacity

- S-shaped growth curve

### **When a population exceeds the Carrying Capacity.**

Overshoot the carrying capacity due to a reproductive time lag – the time it takes for the birth rate to fall and the death rate to rise in response to resource overconsumption)

- the population will dieback or crash (deer on the Aleutian Island)

**Carrying Capacity** is determined by many factors:

- Competition
- Immigration
- Emigration
- Catastrophic events
- Seasonal fluctuations in food, water, hiding places, and nesting sites

### **How Does Population Density Affect Population Growth?**

**Density-independent population controls** affect a pop. size regardless of its density. (floods, hurricanes, earthquakes, landslides, drought, fire, habitat destruction, pesticide spraying)

**Density-dependent population controls** have a greater effect on a pop. as the pop. size increases (competition for resources, predation, parasitism, disease). Dense populations have lower birth rates, higher death rates.

- Infectious disease (bubonic plague).
- Overcrowding causes hormonal changes that inhibit sexual activity, lower sexual activity, reduced milk production. Stress from overcrowding reduces the number of offspring produced (spontaneous abortion). May also lead to cannibalism and killing of the young.

### **Population Change Curves (Population Cycles)**

**Stable** – pop. fluctuates sl. above and below its carrying capacity

**Irruptive**

- pop. occasionally explodes (irrupts) to a high peak and then crashes to a v. low level.
- caused by some factor that temporarily increases the carrying capacity.

**Cyclic** – boom-bust cycles; poorly understood and involve a number of factors.

### **Reproductive Strategies and Survival**

**r-Strategist Species**

- species with a high intrinsic rate of increase ( $r$ )
- many small and unprotected young

**K-Strategist Species**

- reproduce late, have few offspring with long generation times;
- have big bodies, live for a long time, spend little of their energy on reproduction
- tend to do well in competitive conditions when pop. is near carrying capacity
- prone to extinction

Survivorship Curves show the number of survivors of each age group for a particular species.

- late loss
- early loss
- constant loss

**Life table** – a table showing the number of individuals are each age (used by insur. cos.)

### **Conservation Biology**

Deals with problems in maintaining the earth's biodiversity: its goals are to investigate human impacts on biodiversity and to develop practical approaches to maintaining biodiversity

Three Underlying Principles of Conservation Biology

- Biodiversity and ecological integrity are useful and necessary to all life on earth and should not be reduced by human activity
- Humans should not cause or hasten the premature extinction of populations and species
- The best way to preserve biodiversity is to protect intact ecosystems that provide sufficient habitat for sustaining natural populations of species

### **Conservation Integrity**

- the conditions and natural processes (energy flow and matter cycling in ecosystems) that generate and maintain biodiversity and allow evolutionary change as a key mechanism for adapting to changes in environmental conditions.
- It is better to maintain existing ecosystems than to have to rebuild ecosystems that have been damaged.

**Conservation Biology** seeks answers to the following:

- What is the status of natural populations and which species are in danger of extinction?
- What is the status of the integrity of ecosystems?
- What measures can we take to ensure that we maintain habitat of the quality and size needed viable populations of wild species?

**Habitat Fragmentation** – The process by which human activity breaks natural ecosystems into small and smaller pieces of land called habitat fragments.

### **Corridors**

- Long areas of land that connect habitat that would otherwise become fragmented.
- permit movement of migratory animals
- ensure a diverse gene pool
- one of the best solutions to the problem of habitat fragmentation.

**Bioinformatics** – useful information concerning biodiversity (computer databases)

## ***HUMAN IMPACT ON ECOSYSTEMS***

### **How Have Humans Modified Natural Ecosystems?**

Fragmenting and degrading habitat

Simplifying natural ecosystems

Strengthening some populations of pest species and disease-causing bacteria by speeding up natural selection

Eliminating some predators

Deliberately or accidentally introducing new species

Overharvesting potentially renewable resources

Interfering with the normal chemical cycling and energy flows (throughputs) in ecosystems

### **What can we learn from nature about living sustainably**

Most ecosystem use sunlight as their primary source of energy

Ecosystems replenish nutrients and dispose of wastes by recycling chemicals

Soil, water, air, plants and animals are renewed through natural processes

Energy is always required to produce or maintain an energy flow to recycle chemicals

Biodiversity takes various forms in different parts of the world.

Complex networks of positive and negative feedback loops give organisms and populations information and control mechanisms of adapting to changing conditions

The population size and growth rate of all species are controlled by their interactions with other species and with their nonliving environment. There are always limits to population growth.

Organisms generally only use what they need to survive, stay healthy and reproduce.

**Important Principles to guide us toward a more sustainable lifestyle:**

We are part of the earth's dynamic web of life.

Our lives, lifestyles and economies are totally dependent on the sun and the earth

We can never do merely one thing (the first law of human ecology)

Everything is connected to everything else; we are all in it together.

**Global CPR:** conservation, preservation and restoration

**SOLUTIONS: how can we rehabilitate and restore damaged ecosystems?**

**Prevention strategy** – reduce and minimize the damage we do to nature

**Restoration ecology** – renew, repair or reconstruct damaged ecosystems

**Natural restoration** – an abandoned damaged ecosystem will eventually partially recover through secondary ecological succession

**Rehabilitation** – human intervention to make degraded land productive again through stopping soil erosion, etc.

**Active Restoration** – take a degraded site and reestablish a diverse, dynamic community of organisms consistent with the climate and soil of an area.