Chapter 8 Population Ecology

Definitions and concepts:
- Population dynamics
- Keystone species
- Population distribution or dispersion
  - clumping
  - uniform dispersion
  - random dispersion
- Population change
  - births, deaths, immigration, emigration
- Age structure
  - prereproductive, reproductive, postreproductive ages
- Population growth
  - biotic potential
  - intrinsic rate of increase (r)
  - environmental resistance
  - carrying capacity (K)
  - Exponential growth
    - J-shaped growth curve
  - Logistic growth
    - S-curve
  - Overshoot
  - reproductive time lab
  - dieback or crash
  - population density
    - density-dependent
    - density-independent
- Population change
  - stable
  - irruptive
  - cyclic-boom and bust
    - top-down population regulation
    - bottom-up population regulation
  - irregular
- Reproductive patterns
  - asexual reproduction
  - sexual reproduction
    - disadvantages and advantages
  - r-selected species
    - opportunists
  - K-selected species
- life expectancies
- survivorship curve
  - late loss
  - early loss
  - constant loss
  - life table
Population Ecology

- What is a population?
- **Population dynamics**: study of how and why populations change in their distribution, numbers, age structure, and density.

Keystone Specie! Sea otter
# Population Distribution

<table>
<thead>
<tr>
<th>(a) Clumped (elephants)</th>
<th>(b) Uniform (creosote bush)</th>
<th>(c) Random (dandelions)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Most common</em></td>
<td>- Maximize a scarce, evenly spaced resource (water in a desert)</td>
<td><em>Rare because of social interaction and resource availability</em></td>
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<tr>
<td>- Uneven distribution of resources</td>
<td>- Interaction of individuals in a population (some plants secrete chemicals to inhibit growth)</td>
<td>- Wind dispersion</td>
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<tr>
<td>- Protection from predators</td>
<td>- Territorial behavior</td>
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<td>- Prey</td>
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<tr>
<td>- Social behaviors-mating/caring for young</td>
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- Maximize a scarce, evenly spaced resource (water in a desert) - Interaction of individuals in a population (some plants secrete chemicals to inhibit growth) - Territorial behavior - Wind dispersion - Rare because of social interaction and resource availability
Change in population size

Population change = entrances - exits

Births
Immigration

Deaths
Emigration
Age structure

• Proportion of individuals at various ages
  > Prereproductive
  > Reproductive
  > Postreproductive

• Affects how population size increases or decreases

Limits on Population Growth

• **Biotic potential**: populations capacity for growth
• **Intrinsic rate of increase or growth (r)**: rate at which a population would grow if it had unlimited resources. (per capita rate of increase, maximum capacity to reproduce)

Characteristics of species with high r

• reproduce early in life
• short generation times
• can reproduce many times
• many offsprings each time they reproduce
Limits on Population Growth

- There are ALWAYS limits to population growth in nature-limiting factors
  - light
  - water
  - space
  - nutrients
  - competitors
  - predators
  - disease
Limits on Population Growth

- **Environmental resistance**: all factors that act to limit the growth of a population (negative feedback!)
- Biotic potential + environmental resistance determines carrying capacity
- **Carrying capacity (K)**: The maximum population of a given species that a particular habitat can sustain indefinitely
Patterns of Population Growth

1. Exponential or geometric growth
   • J-curve
   • \( G = rN \)
     > \( G \) = growth rate
     > \( N \) = # of individuals
   • Unregulated population growth, only depends on \( r \)

2. Logistic growth
   • S-curve
   • \( G = rN \frac{(K-N)}{K} \)
   • Limiting factors
     • \( K \) = carrying capacity

Describes how limiting factor affects increasing population
Exceeding Carrying Capacity

- Some organisms do not transition smoothly from exponential to logistic growth.
- **Overshoot** occurs.
  > Reproductive time lag: period needed for birth rate to fall and death rate to rise in response to resource overconsumption.
What happens when a population exceeds its carrying capacity?

- Suffer a dieback or crash
- Move to new area
- Switch to a new resource
- Natural selection

Example: Reindeer on St. Paul

- Introduced to replace caribou
- Food source: lichen/moss
- Food source could not recover from overconsumption - why?
Carrying capacity is not constant

• Seasonal variation
• Annual variation depending on climate and other factors
• Changes in carrying capacity due to changes by populations
• Humans have extended carrying capacity through technological, social, and other cultural change
Population density

- **Population density**: Number of individuals in a particular area or volume
  - Different factors can limit populations--some things affect populations more as the density increases.
- **Density-dependent** population controls
  - Competition
  - Predation
  - Parasitism
  - Infectious disease
  - *Tend to regulate population near K
- **Density-independent** population controls
  - Natural disasters
  - Changes in climate
  - Habitat destruction
Types of population change curves

- **Stable:** Population fluctuates very little above/below K
  > Typical in undisturbed tropical rain forest. Why?
- **Irruptive:** Stable most of the time, occasionally irrupt and then crash (stable or very low)
  > Common in short-lived, rapidly reproducing species, in response to seasonal variation or nutrient availability
- **Cyclic:** boom-and-bust
  > top-down population regulation (predation)
  > bottom-up population regulation (resources)
- **Irregular:** Chaos
  > periodic catastrophes
White tailed deer

• Edge species: Suburbanization created favorable habitat
  > Pre 1920s-hunted
  > 1930-hunting restricted, predators eliminated
  > Population explodes
• Negative impacts of deer population:
  > Lyme disease
  > Car accidents
  > Eat down native vegetation, allow nonnative weeds to take over
• Possible solutions?
Reproductive Patterns

- Asexual v. sexual reproduction
- r-selected v. k-selected
Asexual reproduction

- Offspring are clones (exact genetic copies)
- What are the benefits of asexual reproduction?

Bacteria reproduce by binary fission

Paramecium (a protist) can reproduce by binary fission

Whiptails reproduce by parthenogenesis

Coral polyps reproduce by budding
Sexual reproduction

• Mixes genetic material of 2 individuals
• Disadvantages:
  > Males do not give birth: females have to produce twice as many offsprings to maintain population
  > Genetic error and defects
  > Courtship and mating consume time and energy, transmit disease, can inflict injury
• Advantages:
  > Genetic diversity
  > Males can take care of female and young
r-selected species

- **r-selected species:** Capacity for high rate of population increase
  - many, small offspring
  - little to no parental care or protection
  - massive loss of offspring but produce so many that few likely to survive
  - Ex: algae, bacteria, rodents, insects, some plants
- tend to be **opportunists**
  - changes in environment
  - new habitat
- Still limited by habitat
k-selected species

- **k-selected species**
  > reproduce later in life
  > small number of offspring, long life spans
  > offspring tend to develop inside mothers, born fairly mature
  > offspring cared for and protected by parents until reproductive age
  > "competitor" species- few strong individuals that can compete for resources and reproduce
    - tend to do well in competitive conditions when populations is near carrying capacity
  > Prone to extinction- population can't bounce back
**r-Selected Species**

- Cockroach
- Many small offspring
- Little or no parental care and protection of offspring
- Early reproductive age
- Most offspring die before reaching reproductive age
- Small adults
- Adapted to unstable climate and environmental conditions
- High population growth rate ($r$)
- Population size fluctuates wildly above and below carrying capacity ($K$)
- Generalist niche
- Low ability to compete
- Early successional species

**Dandelion**

**K-Selected Species**

- Elephant
- Fewer, larger offspring
- High parental care and protection of offspring
- Later reproductive age
- Most offspring survive to reproductive age
- Larger adults
- Adapted to stable climate and environmental conditions
- Lower population growth rate ($r$)
- Population size fairly stable and usually close to carrying capacity ($K$)
- Specialist niche
- High ability to compete
- Late successional species

- Saguaro
Survivorship Curves

- **Life expectancies**: expected length of life of organisms
- **Survivorship curve**: represents age structure of a population

![Diagram of Survivorship Curves](image)

Shows percentage of members of a population surviving at different ages.
Life table

- Shows projected life expectancy and probability of death for individuals at each age in a survivorship curve
- *insurance
Ways to monitor population size

1. Sample plot method
   - Use a quadrant to calculate density
   - Apply to a given area to estimate population size
   - Works well for sessile organisms

2. Capture-mark-release-recapture method
   - Capture sample of organisms and mark
   - Recapture, use proportions to figure out actual population size
   - Works well for motile organisms
sunflower:
http://www.biologycorner.com/worksheets/random_sampling.html#.Umyh-_GQ1F8
dandelions:
http://www.biologycorner.com/worksheets/dandelion.html#.Umyh_fGQ1F8
estimating population size:
http://www.biologycorner.com/worksheets/estimating_population_size.html#.UmyhSPGQ1F8

on-line zebra mussel, elephant population
http://ats.doit.wisc.edu/biology/ec/pd/pd.htm