Population Dynamics

I MSc Botany

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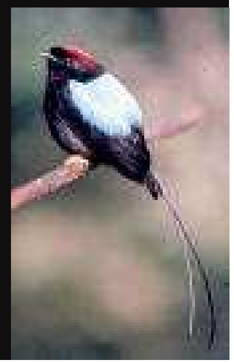
Definition of population dynamics

- Population dynamics refers to changes in a population over time
- Population dynamics includes four variables:
  - density
  - dispersion
  - age distribution
  - size

1. Population Density



- Population density (or ecological population density) is the amount of individuals in a population per unit habitat area
- Some species exist in high densities
  - ex. Mice, cockroaches
- Some species exist in low densities
  - ex. Mountain lions
- Density depends upon
  - social/population structure (ex. territoriality)
  - mating relationships (ex. harems)
  - time of year (ex. lekking species)

2. Population Dispersion

- Population dispersion is the spatial pattern of distribution

There are three main classifications

- clumped: individuals are lumped into groups
  - ex. Flocking birds or herbivore herds
  - due to resources that are clumped or social interactions
  - most common

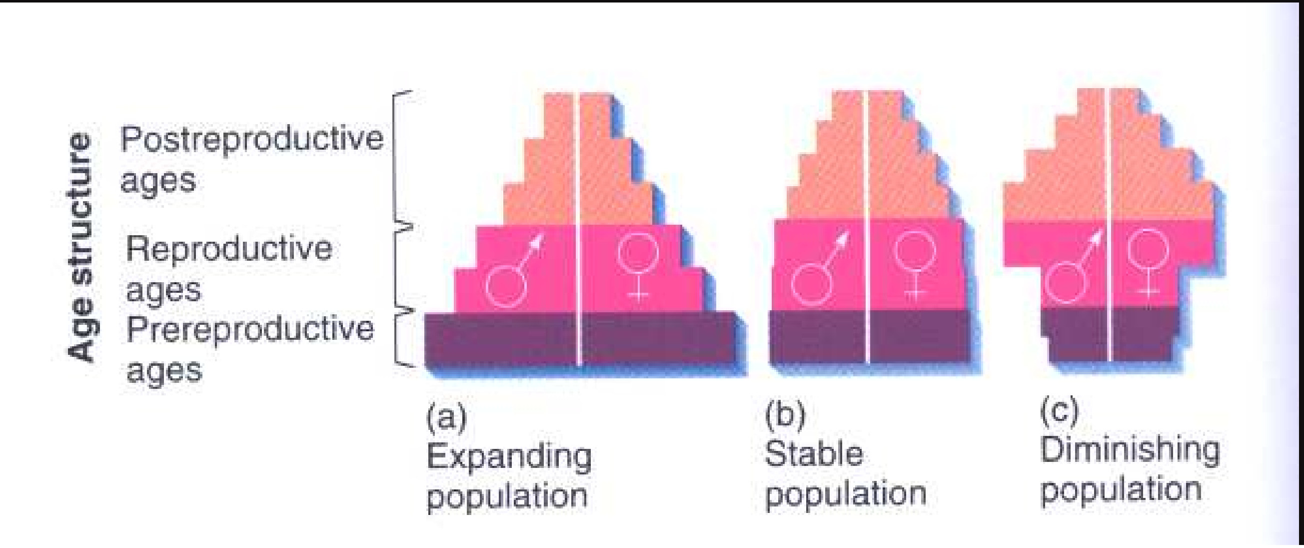
Population Dispersion (cont)

- Uniform: Individuals are regularly spaced in the environment
  - ex. Creosote bush
  - due to antagonism between individuals, or do to regular spacing of resources
  - Less common because resources are rarely evenly spaced

- Random: Individuals are randomly dispersed in the environment
  - ex. Dandelions
  - due to random distribution of resources in the environment, and neither positive nor negative interaction between individuals
    - Often for plants with wind-dispersed seeds
  - rare because these conditions are rarely met

3. Age structure

- The age structure of a population is usually shown graphically
- The population is usually divided up into prereproductives, reproductives and postreproductives
- The age structure of a population dictates whether it will grow, shrink, or stay the same size
- What does a large base indicate about the population?
- What does a large top indicate about the population?



4. Population growth

- Population growth depends upon **b**irth rates, **d**eath rates, **i**mmigration rates and **e**migration rates

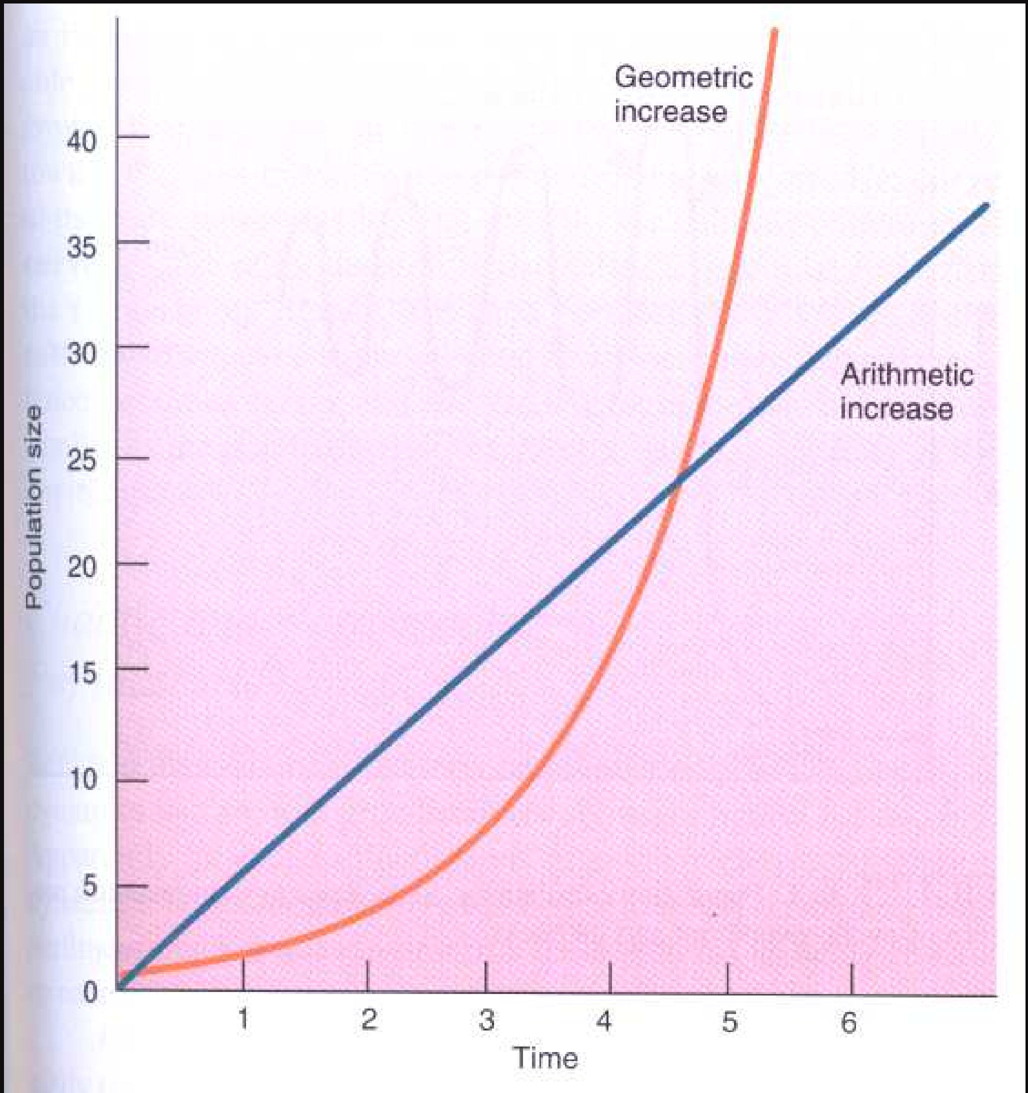
- Pop (now) = Pop (then) + (b + i) – (d + e)
- Pop change = (b + i) – (d + e)
- Zero population growth is when
  - (b + i) = (d + e)

- ex. If a population is growing at a rate of 2% per year, that means that 2 new individuals are added to the population for every 100 already present per year.

4. Population growth

- Populations show several types of growth
  - Exponential
  - Logistic

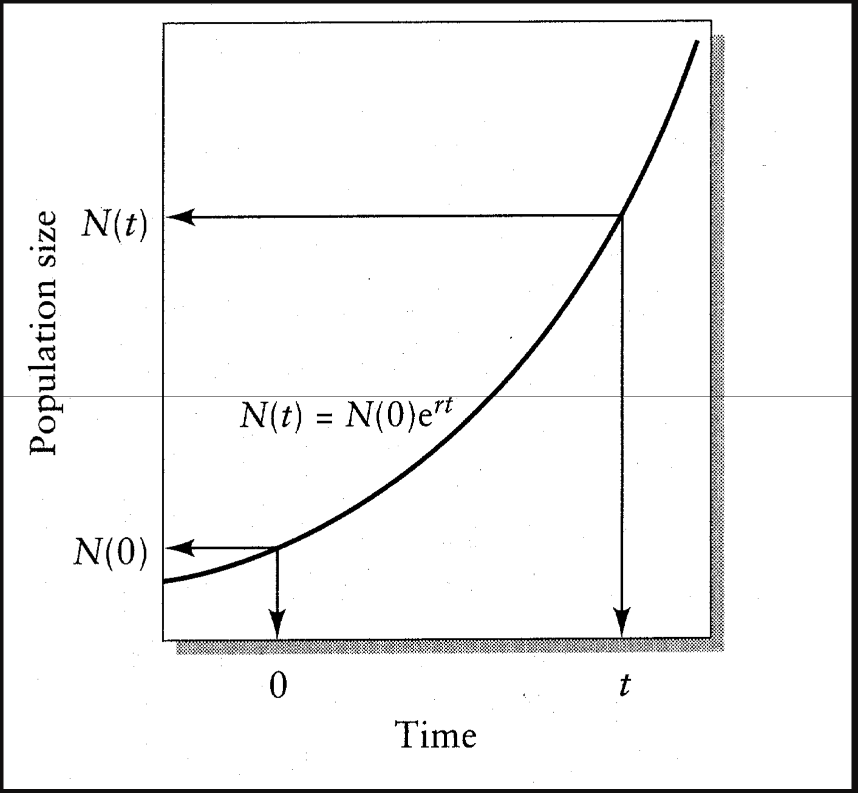
Exponential growth



- Consider the difference between the two sequences:
  - 2,4,6,8,10 (arithematic growth)
    - $N_t = N_0+2$ → the increase is constant as the population grows
  - 2,4,8,16,32 (exponential growth)
    - $N_t = N_0 * 2$ → the increase changes as the population grows – in other words, the larger the population IS, the faster it GROWS

Exponential growth graphically

- J-shaped curve
- Exponential growth is growth that is <u>not</u> limited by resources
  - Species grow at their full **<u>BIOTIC POTENTIAL</u>**
- Exponential growth begins slowly, but quickly increases.



Exponential Growth Example

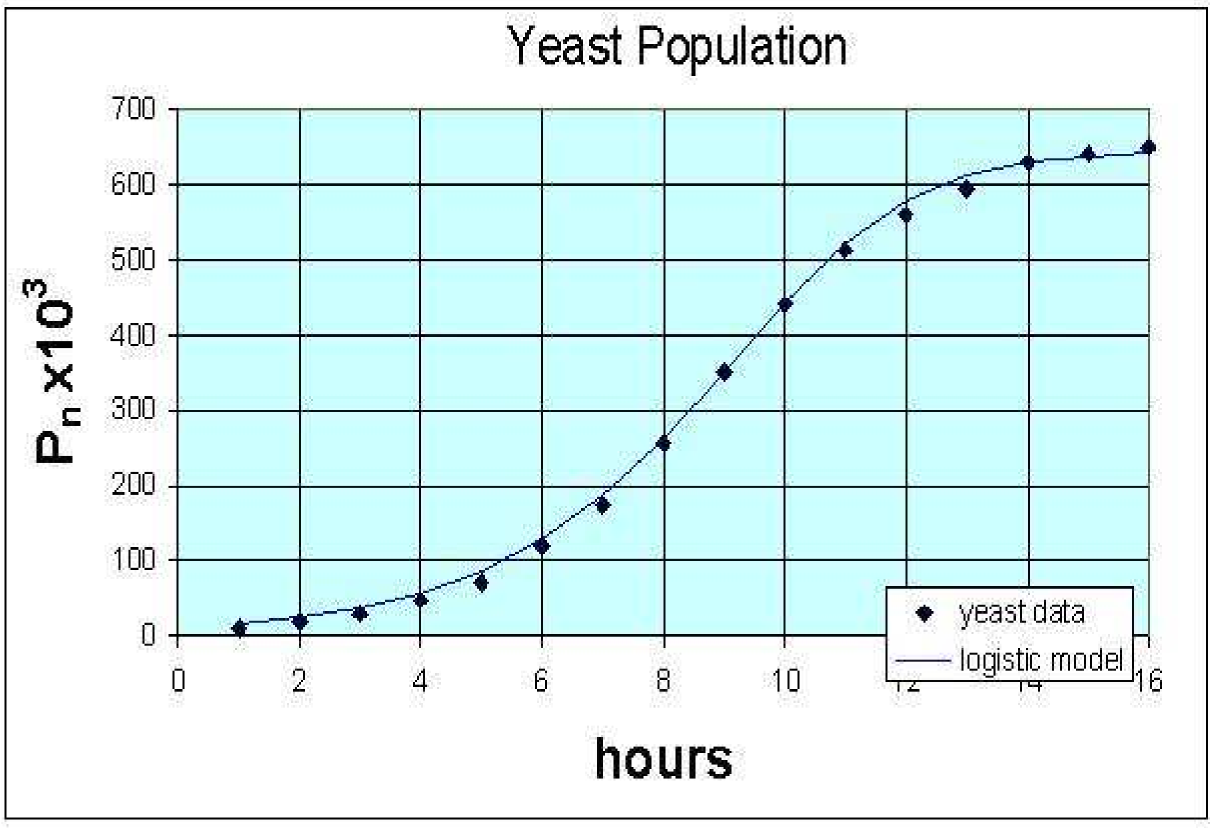
- Darwin pondered the question of exponential growth. He knew that all species had the potential to grow exponentially. He wondered how fast an elephant population could growth exponentially.
  - He used elephants as an example because elephants are one of the slowest breeders on the planet
    - One female will produce 6 young over her 100 yr life span. In a population, this amounts to a growth rate of 2%
  - Darwin wondered, how many elephants could result from one male and one female in 750 years?
  - = 19,000,000 elephants!!!
- Another example:
  - 1 female housefly can produce a population of 6,182,442,727,320 flies in one year.

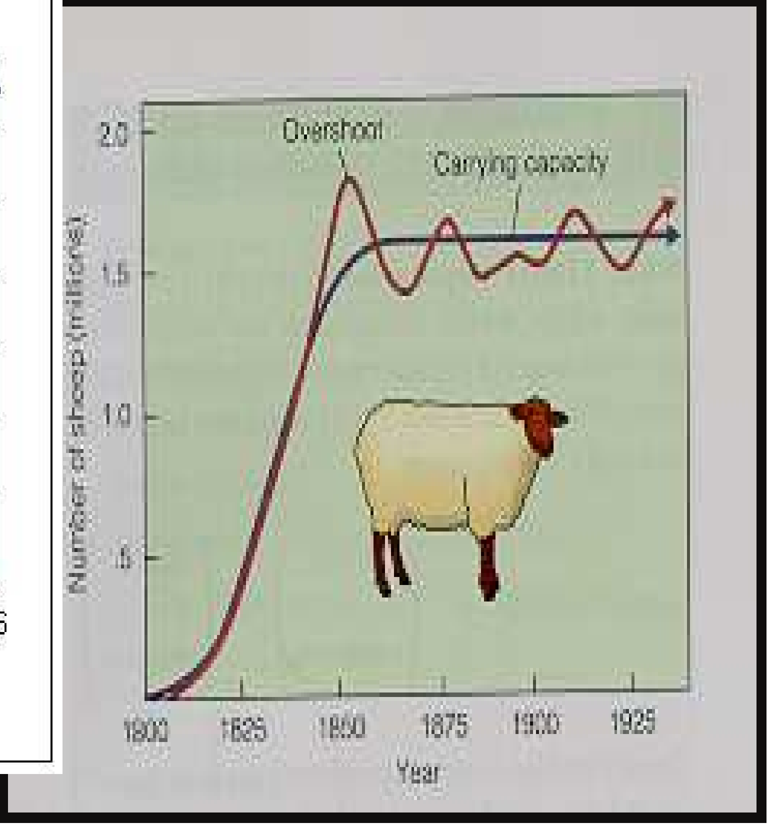
Do all species enjoy exponential growth?

- NO!
- The exponential growth of most populations ends at some point.
  - Why? (overshoot, dieback/crash)

Logistic Growth

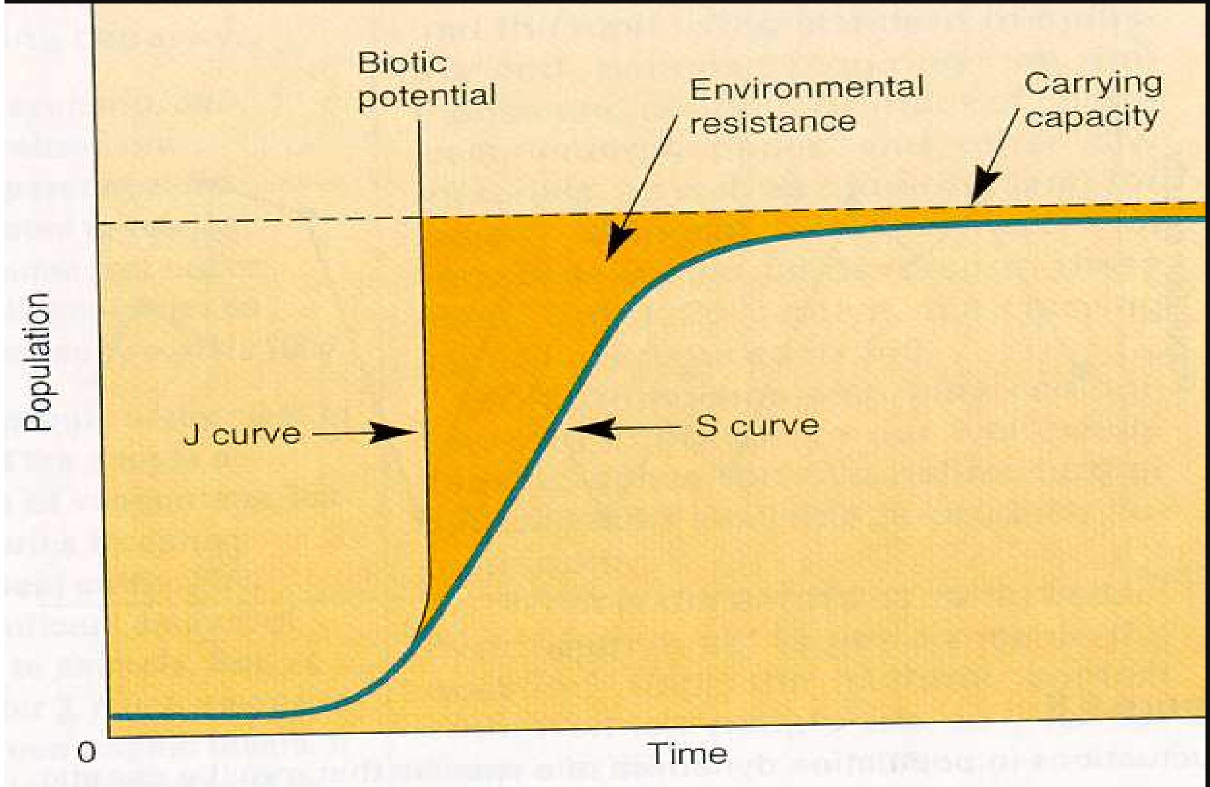
- Populations increase to some level, and then maintain that stable level (with minor oscillations)





Logistic Growth

1. The population experiences exponential growth.
2. Population size (and density) increases, the growth rate decreases as a result of density-dependent factors.
3. The population approaches the carrying capacity, K, the number of individuals that the environment can support



S-shaped growth curve

What limits population growth?

- Biotic potential
  - capacity for growth without limits
- Intrinsic rate of increase (r)
  - rate of growth with unlimited resources
- Environmental Resistance
  - limiting factors

Carrying Capacity (K) =

biotic potential + environmental resistance

What limits population growth?

- Density-independent factors:
  - affect populations randomly (without respect to density)
  - ex. Hurricanes, tornadoes, fire, drought, floods
  - Are they biotic factors or abiotic factors?
  - They have the ability to cause rapid increases or decreases in populations, but they are poor regulators of populations

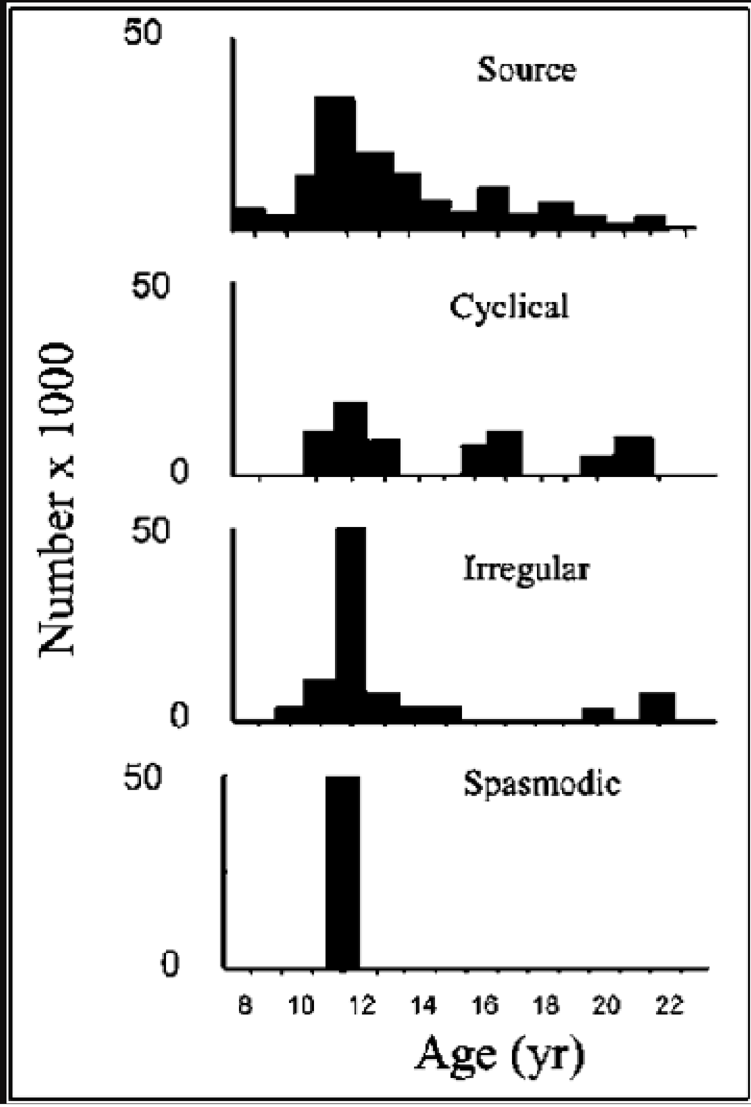
- D-I factors affect all populations (with all growth patterns)

- Density-dependent factors:
  - affect populations most when densities are high
  - ex. Disease, competition, predation, parasitism
  - Are they biotic or abiotic factors?
  - These act to limit population growth only when populations are large, and are therefore good regulators of populations

- D-D factors cause populations to have logistic growth

Population Fluctuations

- Stable
- Irruptive
- Cyclic
- Irregular

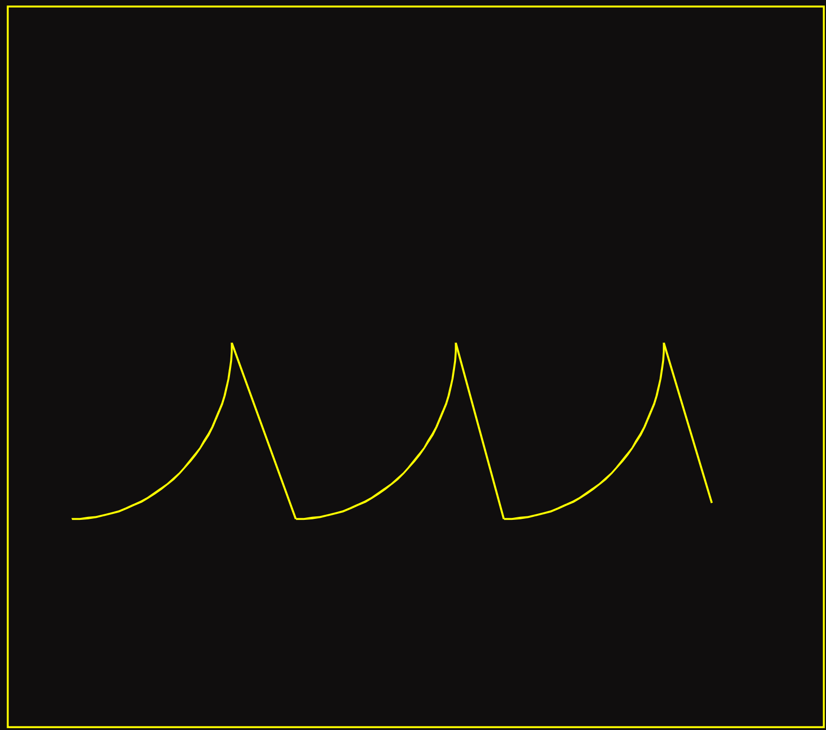


Life History Strategies

- The goal of all individuals is to produce as many offspring as possible
- Each individual has a limited amount of energy to put towards life and reproduction
- This leads to trade-offs of long life vs. high reproduction rate
- Natural selection has favored the production of two main types of species: r-strategists, K-strategists

r - strategists

- r-strategists are so-called, because they spend most of their time in exponential growth
- they maximize their reproductive rate
- Boom-bust cycles

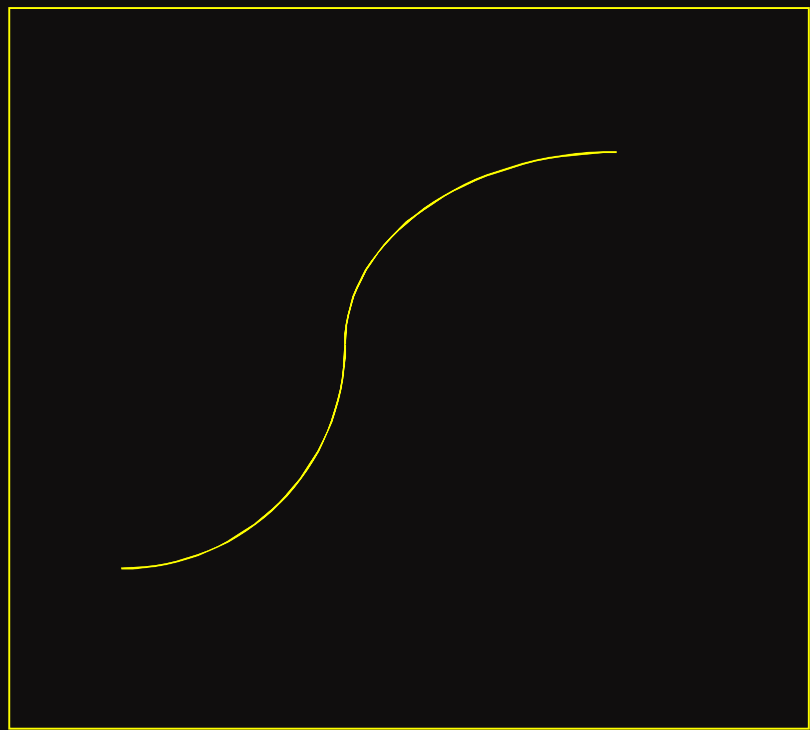


r - strategists

1. Short life
2. Rapid growth
3. Early maturity
4. Many small offspring
5. Little parental care or protection
6. Little investment in individual offspring
7. Adapted to unstable environment
8. Pioneers, colonizers
9. Niche generalists
10. Prey
11. Regulated mainly by extrinsic factors
12. Low trophic level

K - strategists

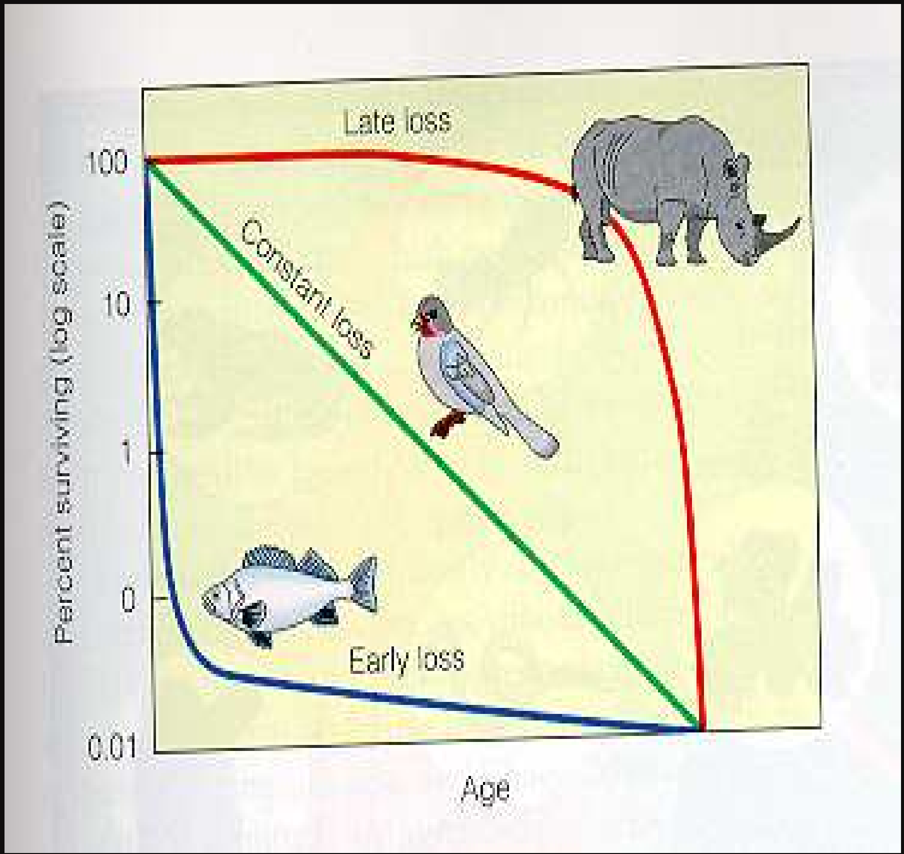
- Those species that maintain their population levels at K (= carrying capacity)
- these populations spend most of their time at K



K - strategists

1. Long life
2. Slower growth
3. Late maturity
4. Fewer large offspring
5. High parental care and protection
6. High investment in individual offspring
7. Adapted to stable environment
8. Later stages of succession
9. Niche specialists
10. Predators
11. Regulated mainly by intrinsic factors
12. High trophic level

Survivorship curves



- There are 3-4 types of relationships between age and mortality rate
- These affect the life-history strategies

Loss of Genetic Diversity:

- Founder Effect: The establishment of a new population by a few original pioneers which carry only a small fraction of the total genetic variation of the parental population

- Demographic Bottleneck: Genetic diversity loss that occurs as a result of a drastic reduction in population by an event having little to do with the usual forces of natural selection.

- Genetic Drift: The process of change in the genetic composition of a population due to chance or random events rather than by natural selection, resulting in changes in allele frequencies over time.

Altering nature to meet our needs

- Reducing biodiversity by destroying, fragmenting, and degrading wildlife habitats.
- Reducing biodiversity by simplifying and homogenizing natural ecosystems.
- Using, wasting or destroying an increasing percentage of the earth's net primary productivity that supports all consumer species.
- Strengthened some populations of pest species and disease-causing bacteria.
- Eliminate some predators.
- We have deliberately or accidentally introduced new or nonnative species into ecosystems.
- Overharvested some renewable resources.
- Interfered with the normal chemical cycling and energy flows in ecosystems.
- Human dominated ecosystems have become increasing dependent on nonrenewable energy from fossil fuels.