Lecture 7

Population Regulation and Intraspecific Competition

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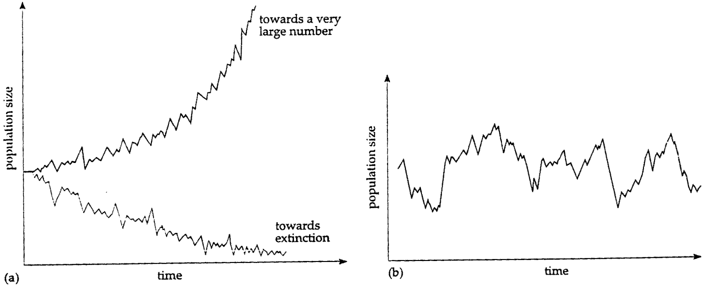
03 December 2012

Outline

Regulated vs. unregulated populations

- Unregulated populations either:
  1. Go extinct ($0 \leqslant \lambda < 1,\ r < 0$).
  2. Or explode ($\lambda > 1,\ r > 0$).
- These are monotonic trends, i.e., either monotonically decreasing or monotonically increasing.
- However, population explosions / extinctions are rare.
- Usually population size / density fluctuates up and down around some more or less fixed average value.



Regulated vs. unregulated populations

- Although stable population size is theoretically / mathematically possible for unregulated populations (if $\lambda = 0$ or $r = 0$), it is very unlikely from a biological point of view.
- $\longrightarrow$ Requires exact cancellation of births and deaths ($b = d$) – i.e., the constant parameter b and the constant parameter d must be equal – this is extremely unlikely!
- We require an additional mechanism to account for population **regulation** – the fact that populations usually do not show monotonic trends towards extinction or explosion.
- That population size / density fluctuates up and down – "correcting" deviations from some average value.

Examples of population regulation

- Even populations that tend to grow geometrically / exponentially cannot do it indefinitely.
- Eventually population size crashes – "boom and bust" pattern.
- Or growth slows down until some stable population size /density is reached.

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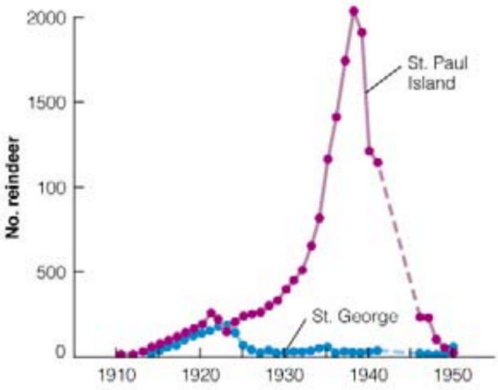
Examples of population regulation

Another example of "boom bust".

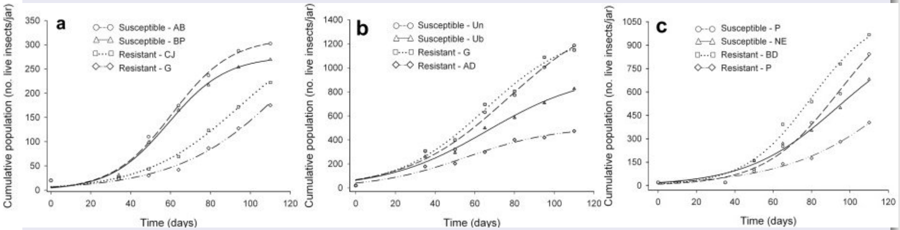
Reindeer. Pribilof islands, Bering Sea, Alaska.



Winter food shortage associated with population crash

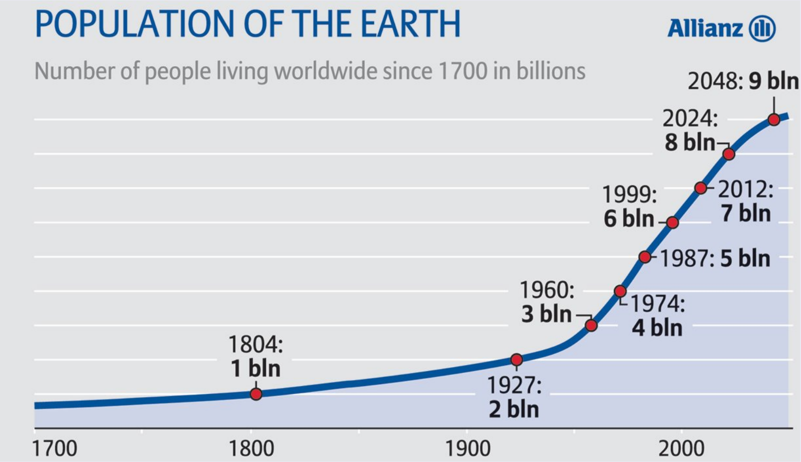
Pests

Stored-products pests



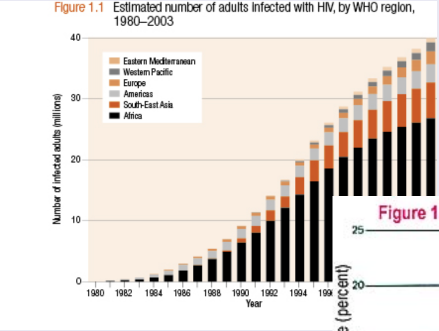
Human population growth

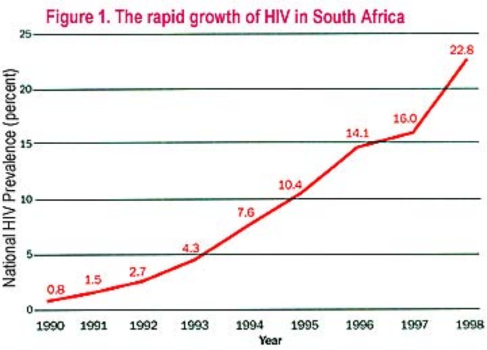
Global human population size



Diseases and epidemics

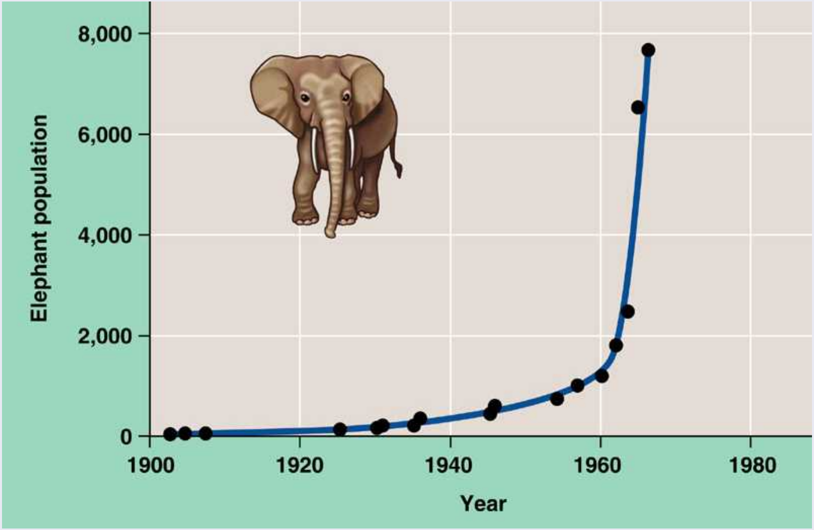
The AIDS epidemic in Africa





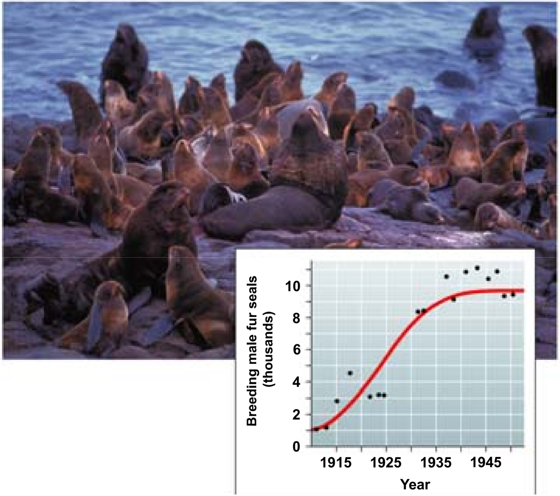
Recovering populations

Elephants in Kruger national park, South Africa



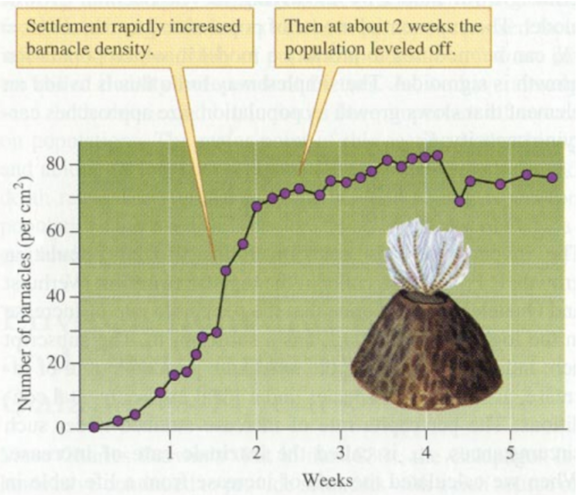
Examples of population regulation

Population recovery of fur seals in west coast of USA.



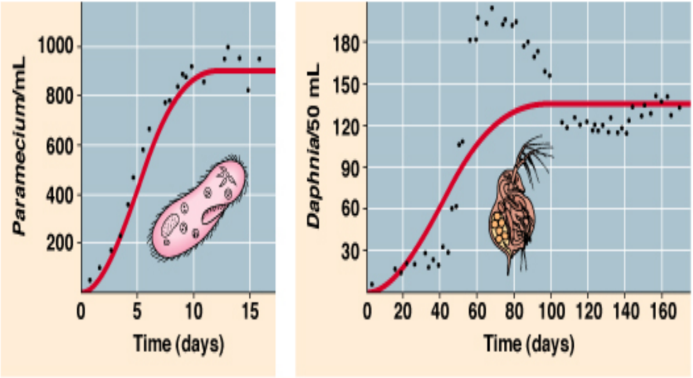
Examples of population regulation

Stabilization of population size in settling barnacles.



Examples of population regulation

Stabilization of population size in laboratory experiments.

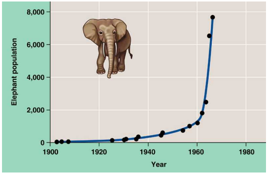


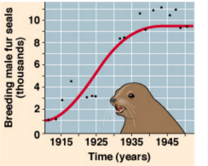
(a) A *Paramecium* population in laboratory culture

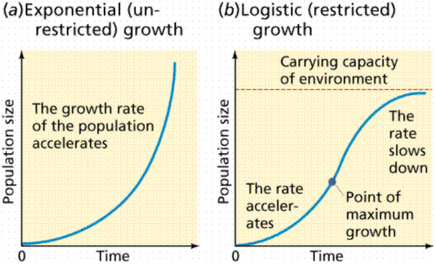
(b) A *Daphnia* population in laboratory culture

J-curves and S-curves

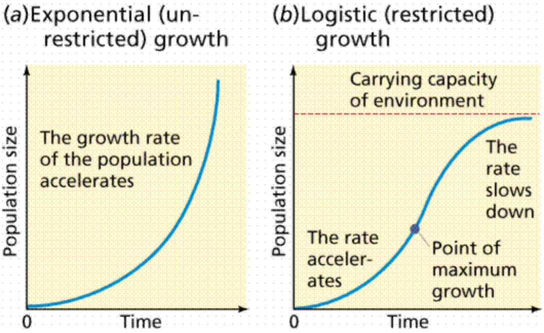
- Typically, unregulated populations have growth curves that are exponential (shaped like the letter J).
- Typically, regulated populations have growth curves that are **sigmoidal** (shaped like the letter S).







J-curves and S-curves



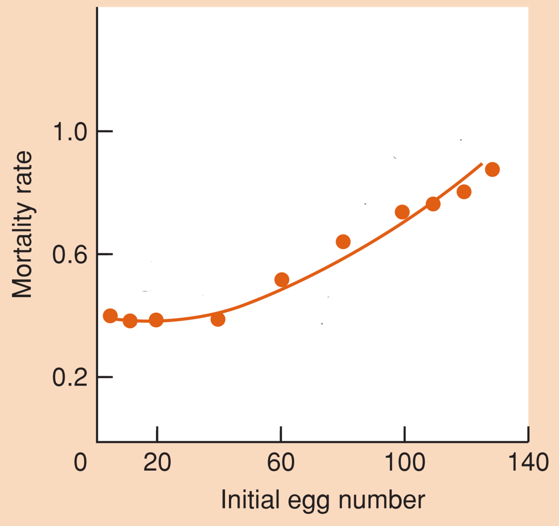
- Exponential or geometric growth cannot produce sigmoidal curves.
- We are obviously missing something – some mechanism that causes population growth to slow down.
- Time to modify our models.

Outline

1. Population regulation
2. Density-Dependence
3. Intraspecific Competition
4. Logistic Growth

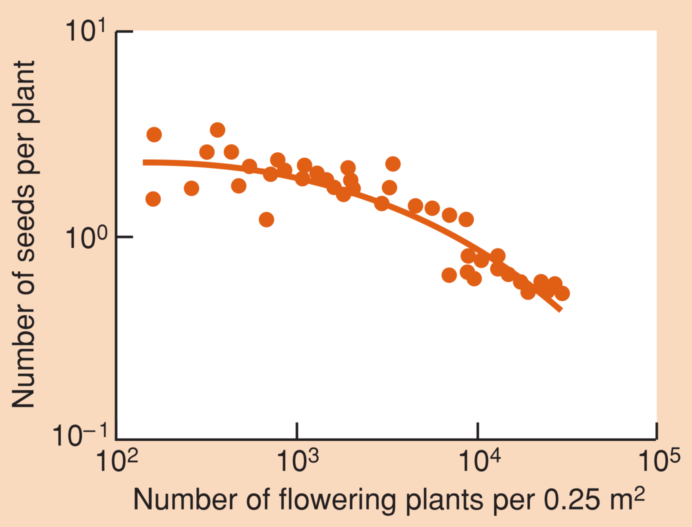
Density-dependent birth and death rates

Density-dependent mortality in flour beetle (*Tribolium*).

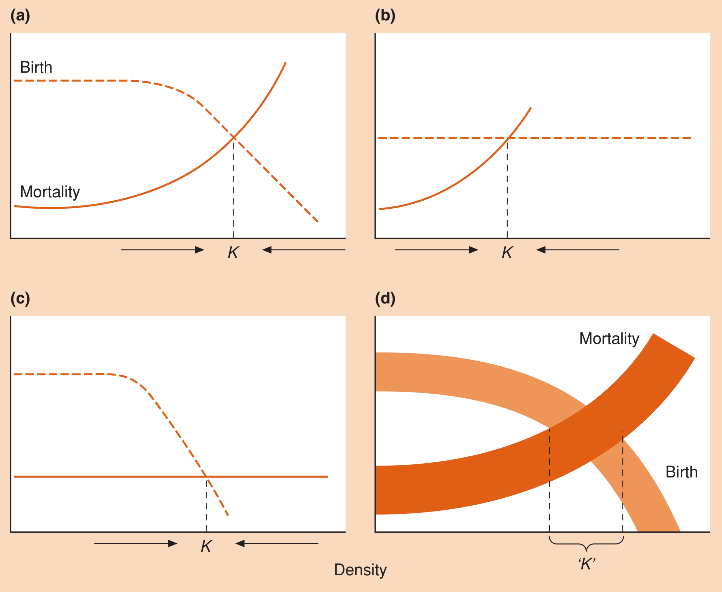


Density-dependent birth and death rates

Density-dependent seed production in an annual plant.

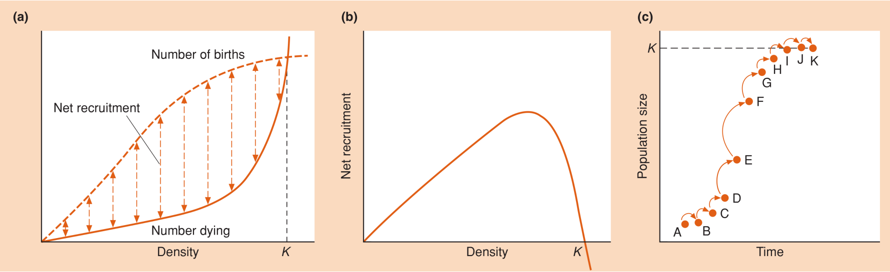


Density-dependent birth and death rates



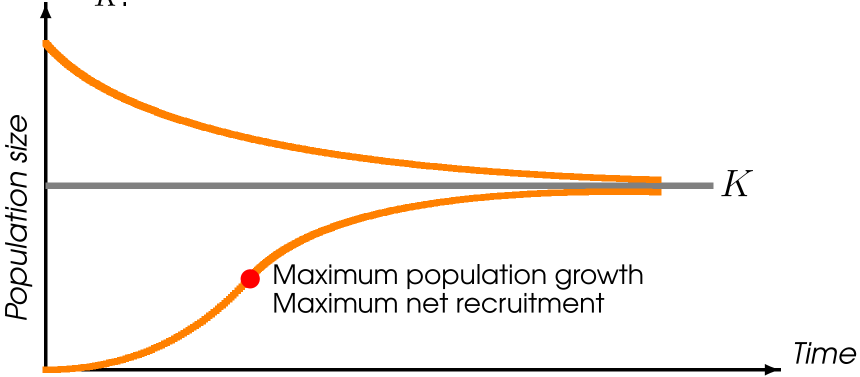
Density-dependent birth and death rates

- Net recruitment (total births minus total deaths) is usually humped-shaped.
- Having maximum at intermediate densities ⟶ population growth is maximal at intermediate densities.
- ⟶ resulting in S-shaped growth curve.



The carrying capacity, K

- The carrying capacity, K, is the long-term stable population size – i.e., where births and deaths cancel each other.
- If starting below, population size will increase towards K.
- If starting above, population size will decrease towards K.



Outline

Intraspecific competition

- Individuals of the same species have similar needs and behavior in terms of resources, habitat, timing of lifecycle events etc.
- Therefore, individuals should suffer strong competition from conspecifics, under conditions of crowding.
- These competition effects eventually manifest themselves as reduced fecundity and survival rates.

Intraspecific competition

Types of intraspecific competition

1. **Scramble vs. Contest**
   - In scramble competition all individuals suffer more or less the same reduction in fecundity or same increase in mortality.
   - In contest competition there are "winners" and "losers" – all or nothing.
     "Winners" do not suffer reduction in survival or fecundity.
     "Losers" suffer maximum reduction.
2. **Interference vs. Exploitation**
   - In Interference competition there is direct interaction (aggression) among individuals, where one individual prevents or reduces access to resources from the other.
   - In exploitation competition there are no direct interactions – individuals affect each other by depleting a common resource.

Of course these are just extremes of a spectrum of possible combined effects of intraspecific competition.

Outline