Population growth

How can there be so many mosquitos?

Modeling population growth

- Depends on how organisms reproduce
  - In a discrete, non-overlapping way, often called _______ growth
  - In a continuous, overlapping way
- Either way, populations only change in abundance because of four parameters...
- Nevertheless, we often assume a closed population, which means we ignore...

Lecture outline

- Two models of population growth
- Little r
- Exponential population growth
- Logistic population growth
- Density-dependent regulation of populations

Modeling population growth

- $r$
  - At any moment in time, an individual's contribution to population growth is modelled as the per capita or intrinsic or instantaneous rate of increase
  - $r = \______$
  - $b = \______/\______$
  - $d = \______/\______$
  - If $r > 0$, population is ?
  - If $r = 0$, population is ?
  - If $r < 0$, population is ?

Species | $r$ | Doubling time
--------|-----|----------------
E. coli | 58.7 | 17 min
Paramecium | 1.59 | 10.5 hr
Tribolium | 0.101 | 6.9 days
Rattus | 0.015 | 46.8 days
Bos | 0.001 | 1.9 yr
Nothofagus | 0.000075 | 25.3 yr

From Gotelli

One equation for exponential growth

- When is this applicable?

\[ N_t = N_0 e^{rt} \]

- This form of the equation for exponential population growth calculates population size.
- $\text{Number of time intervals in hours, days, years, etc.}$
- $\text{Intrinsic rate of increase, in offspring per time interval}$
- $\text{Base of the natural logarithms}$
- $\text{equals the initial number times } e \text{ raised to the power } rt$

Exponential growth in nature

- Since their protection in 1940, the whooping crane population grew exponentially from 22 to 230 individuals in 2005.
- Grus americana
- Fig. 11.6

= 2.71828
A second exponential equation

Instead of just looking at the total number of individuals, we can also express exponential growth as the rate of change in population size.

Differential form in action

\[
\frac{dN}{dt} = rN
\]

Importance of magnitude of \( r \)

- \( r = 0.08, 0.1, \text{or} 0.15; N_0 = 1000; t = 1 \text{ yr}; 1000 \text{ new immigrants each year, too (total = 36,000 to 50,000); note shape} \)

Is exponential growth always realistic?

- Why or why not?

Logistic growth in the lab and field

- Paramecium caudatum in the lab
  - Growth kinetics of after 10 days

- Northern elephant seal in CA
  - Growth slows; population size stabilizes at carrying capacity, \( K \)

Logistic growth

- Shape?

- \( K \text{ is the carrying capacity of the environment.} \)
What is K?

- Medium ground finch

Logistic growth

- Shape?

Optimal yield

Figure 4 Catchs of Peruvian anchovy

Million tonnes

El Niño years

Source: FAO Fisheries Database

Hannesson 2008

Logistic growth equation

- Population size
- Change in numbers
- Change in time
- Intrinsic rate of increase
- Carrying capacity

The logistic equation gives the rate of population change as a function of $r_{max}$, $N$, and $K$.

Population regulation

- K is thought to be an equilibrium density and is maintained by density-dependent regulation
- As population size changes, birth and death rates change, too
- So, for a population to be regulated at this equilibrium, it must be controlled by density-dependent factors

Pearl (1927)

What are some factors affecting population size?

Which ones are "density dependent" factors?

Which ones are "density independent"?