Population growth

How can there be so many mosquitoes?

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

- 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
- \( r = \text{__________} \)
  - \( b = \text{_____} / \text{______} \)
  - \( d = \text{_____} / \text{______} \)
- If \( r > 0 \), population is ?
- If \( r = 0 \), population is ?
- If \( r < 0 \), population is ?

Species | \( r \) | Doubling time
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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?

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

\( e \) equals the initial number times \( e \) raised to the power \( rt \)

The number at time \( t \)...

Base of the natural logarithms

Intrinsic rate of increase, in offspring per time interval

Number of time intervals in hours, days, years, etc.

\[ e = 2.71828 \]

Fig. 11.4 bottom

Exponential growth in nature

Since their protection in 1940, the whooping crane population grew exponentially from 22 to 230 individuals in 2005.

Fig. 11.6
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.

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

(Differential form)

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

Logistic growth

- Shape?
**What is K?**

- Medium ground finch

![Fig. 11.17](image)

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**Logistic growth**

- Shape?

![Fig. 11.8](image)

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**Optimal yield**

- Figure 4 Catches of Peruvian anchovy
  - Million tonnes
  - El Niño years

![Source: FAO Fishery Database](image)

**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)](image)

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**Logistic growth equation**

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

\[
\frac{dN}{dt} = r_{max} N \left(1 - \frac{N}{K}\right)
\]

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

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**What are some factors affecting population size?**

- Which ones are "density dependent" factors?
- Which ones are "density independent"?