Population growth

How can there be so many @&X!! mosquitoes?

Lecture outline

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

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…

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
  - $r = \frac{b}{d}$
- Either way, populations only change in abundance because of four parameters…

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

One equation for exponential growth

- When is this applicable?

Integrated form

$N_t = N_0 e^{rt}$

$r$ equals the initial number times $e$ raised to the power $rt$

$N_t = N_0 e^{rt}$

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

Base of the natural logarithms

Intrinsic rate of increase, in offspring per time interval

Exponential growth in nature

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

- \( r = 0.1 \)
  - at \( N = 1,000 \), add 100 individuals each year
  - at \( N = 100,000 \) add 10,000 individuals each year
  - at \( N = 1,000,000 \) add 100,000 individuals each year

Importance of magnitude of \( r \)

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

Is exponential growth always realistic?

- Why or why not?

Logistic growth in the lab and field

- Paramecium caudatum in the lab
- Gause (1934)

Logistic growth

- Shape?
- Carrying capacity: theoretical maximum population in which growth stops; population size stabilizes at carrying capacity, \( K \)
What is $K$?

- Medium ground finch

**Fig. 11.17**

Logistic growth

- Shape?

**Fig. 11.8**

### Logistic growth equation

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

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

- As the ratio $N$ increases, population growth slows.
- Change in numbers
- Change in time
- Intrinsic rate of increase
- Carrying capacity

### Optimal yield

**Figure 4**

Catches of Peruvian anchovy

Million tonnes

Source: FAO Fishery Database

Hannesson 2008

### 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"?