Population Growth II.
Density Dependence and Regulation

The Power of Exponential Growth

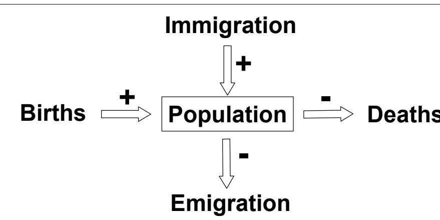
Tale of the tiny tiny bacterium:
Some bacteria (e.g., *E. coli*) divide (by fission) every 20 minutes in an optimal environment
If you started with a single bacterial cell, and it constantly reproduced at this rate, how many bacteria would there be after 2 days?
    2 days = 2,880 min = 144 generations
    $N_{144} = N_0\lambda^{144}$ = 1 x 2^{144} = about 10^{43} cells
How much would all those cells weigh?
A single bacterial cell weighs about 10^{-13} g (1 ten-trillionth of a gram)
    10^{43} cells x 10^{-13} g per cell = 10^{30} g
So what?
    The earth weighs about 6×10^{27} g!
This colony of bacteria would weigh 170 times more than the earth!

The 2nd Law of Population Growth

No population grows exponentially for very long.

Population growth must be *density dependent*

Population Dynamics



As a population gets large, immigration and/or births go down emigration and/or mortality go up

Density Dependent Population Growth

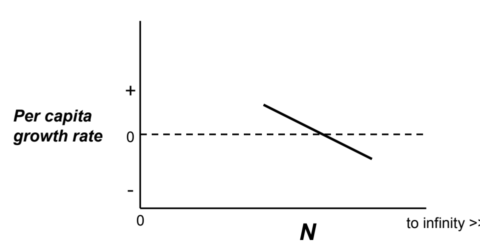
Per capita population growth rate: $\dfrac{dN}{Ndt}$

= birth rate – death rate (per capita)

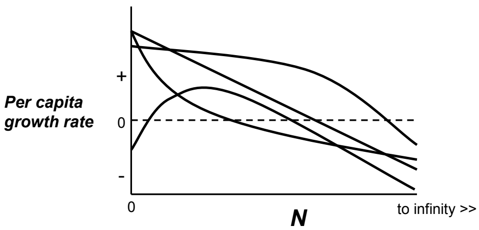
In general, we expect the population will decline if it gets very large.

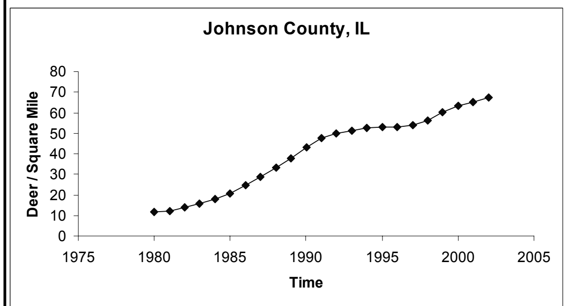
That is: $dN/Ndt < 0$ for very large N

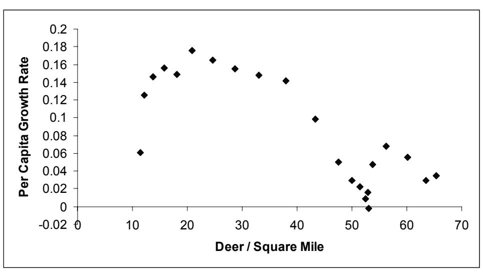
Density Dependent Population Growth



Density Dependent Population Growth

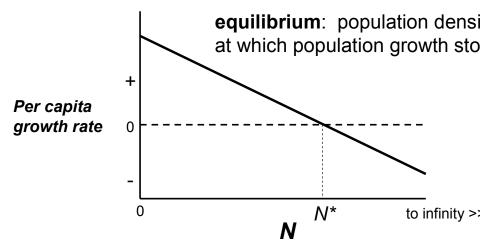






Density Dependent Population Growth

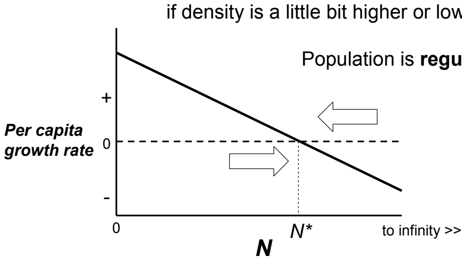
equilibrium: population density at which population growth stops



Density Dependent Population Growth

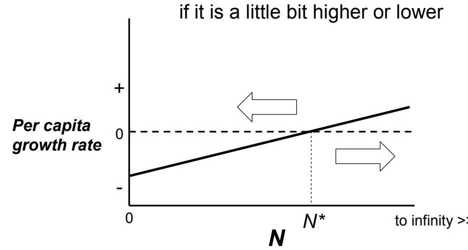
stable equilibrium: equilibrium that population density will return **<u>toward</u>** if density is a little bit higher or lower.

Population is **regulated**.

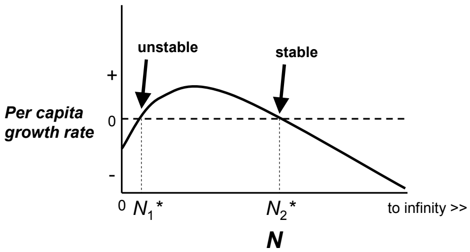


Density Dependent Population Growth

unstable equilibrium: equilibrium that population density will move **<u>away</u>** from if it is a little bit higher or lower

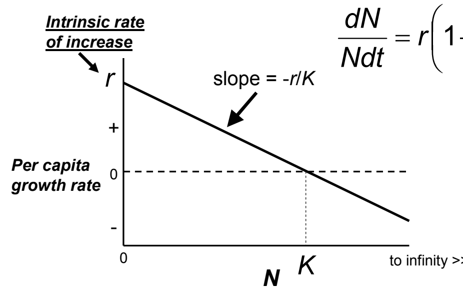


Density Dependent Population Growth



Simplest Case: per capita growth is linear function of *N*

$$\frac{dN}{Ndt} = r\left(1 - \frac{N}{K}\right)$$



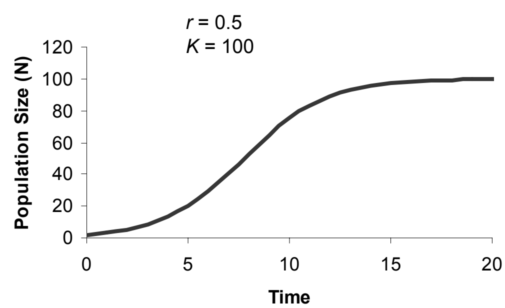
Simplest Case: *r* is Linear

Per capita growth rate: $$\frac{dN}{Ndt} = r\left(1 - \frac{N}{K}\right)$$

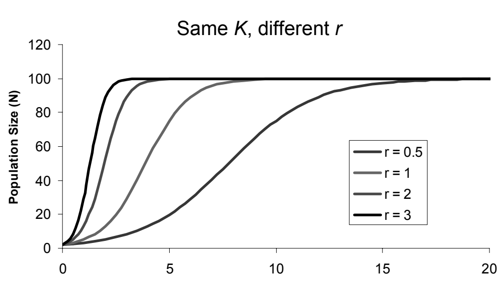
Total growth rate: $$\frac{dN}{dt} = r\,N\left(1 - \frac{N}{K}\right)$$

LOGISTIC GROWTH EQUATION

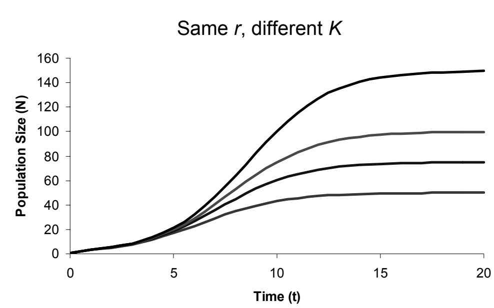
Logistic Growth



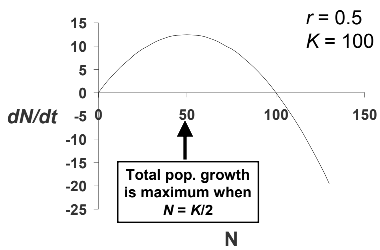
Logistic Growth



Logistic Growth



Logistic Growth

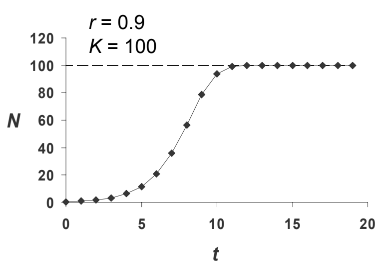


Discrete Logistic Growth

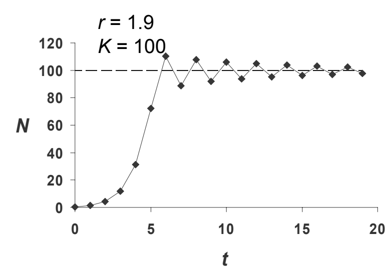
When there is a single birth pulse per year (discrete growth), population growth rate:

$$N_{t+1} - N_t = \frac{\Delta N}{\Delta t} = r\, N_t \left(1 - \frac{N_t}{K}\right)$$

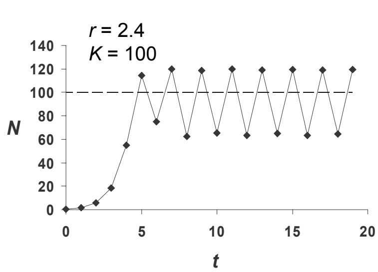
Discrete Logistic Growth



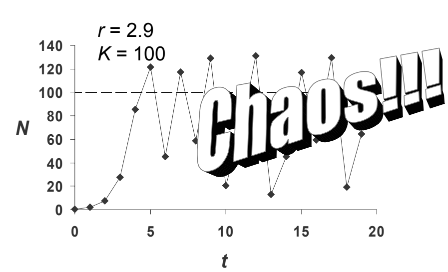
Discrete Logistic Growth



Discrete Logistic Growth



Discrete Logistic Growth



Things to Remember

- Populations cannot grow exponentially for long – growth must be density dependent
- Density dependence can act through births, deaths, immigration, emigration
- Linear change in per capita growth with density produces **Logistic Growth**
  - – know equation
  - – max. growth occurs when $N = K/2$
- Discrete logistic growth is different....