

## Neutral Stability

- Predator and prey abundances may oscillate
  - swing like a pendulum, never converge
- Starting conditions dictate size of oscillations
- Starting too far from stable point makes a crash more likely.

Adding density dependence increases stability (spirals in)

## Assumptions of the L-V Predator-Prey Model

- Prey are only limited by predation
  - Density dependence causes damped cycles
- Predator depends on only 1 prey species
  - Eating > 1 species can either stabilize or destabilize the interaction
- Each predator can consume infinite prey
- No immigration, no age or genetic structure

## Stability

- Stability of a predator-prey interaction: persistence of both prey and predator populations
- Models indicate that stability is encouraged when:
  - Prey have refuges (or prey escape/defend)
  - Density dependence occurs in either species
  - Predator switching to other prey

## Predator satiation

## Periodical Cicadas in Ohio

*Magicicada septendecim* (L.)  
17-year cicada  
Adults emerge once every 17 years

- Brood VIII
  - Last emergence 2002
  - Next expected 2019
- Brood X
  - Last emergence 2004
  - Next expected 2021

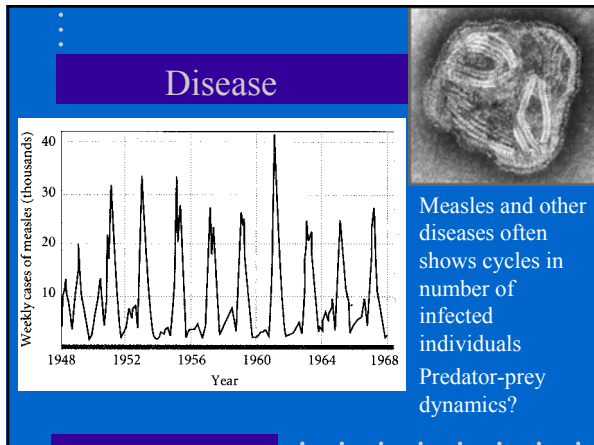
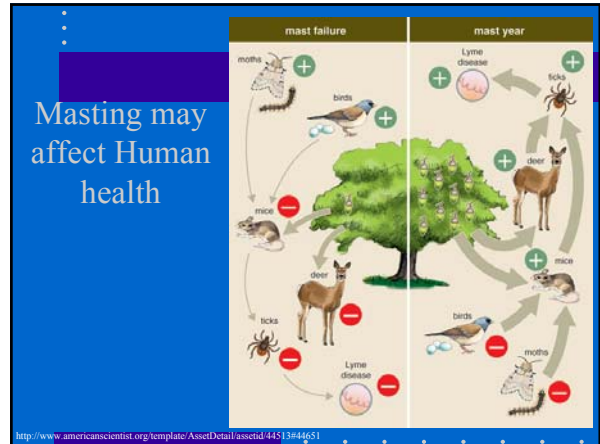
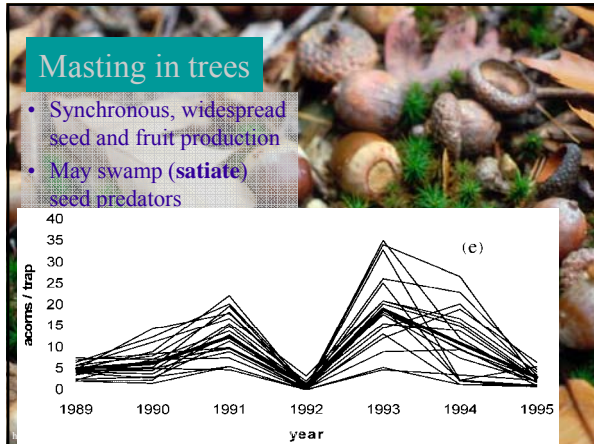
(Red for confirmed records, green for tentative)

## Cicada population density and their percent mortality due to predation.

Predators kill a significant percentage of cicadas emerging early when cicada density is low.

Then, as cicada density increases the percentage taken by predators declines markedly.

Finally, as cicada numbers decline at the end of the season, the percentage killed by predators again increases.



### Microparasites (Bacteria, Viruses)

- Basic Reproductive Rate:  $R_p$ 
  - $R_p = \#$  newly infected hosts per infected host
  - $R_p < 1$  Dies out
  - $R_p > 1$  Spreads
- $R_p = 1$  is the “Transmission Threshold” for spread of the disease

### Reproductive Rate of Infection

- $R_p$  Depends on:
  - $L$  = infectious period of host
  - $S$  = Size of susceptible host population
  - $\beta$  = Transmission coefficient (affected by contagiousness and host behavior)
- $R_p = LS\beta$

This is a molecular surface representation of the Human Immunodeficiency Virus Type 1 (HIV-1) Protease complexed with GR-37615 (a penicillin-derived inhibitor which shows retro-binding in this complex).

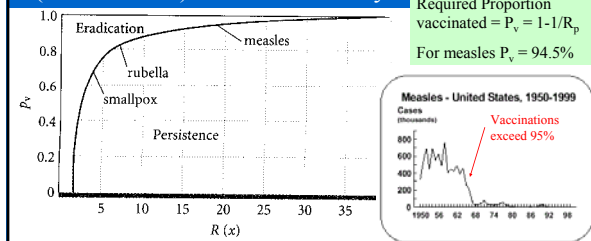
### Conditions for spread

$R_p = LS\beta$

- Disease will spread when  $R_p > 1$
- Threshold population size ( $S_t$ ) for spread of the disease:  $S_t = 1/\beta L$
- Disease dies out if  $S < S_t$
- Therefore small populations cannot support diseases that are:
  - Highly infectious (deplete population of susceptibles)
    - e.g., measles requires populations  $> 300,000$  to persist
  - Hard-to-transmit but with long infectious periods (high threshold populations)
    - e.g., HIV/AIDS

## Implications for Public Health

Immunization must reduce  $S$  (the susceptible population) below  $S_t$  (the threshold) -- "herd immunity"



## Animation about herd immunity

<http://www.immunisation.nhs.uk/article.php?id=78>

## Application to some common diseases

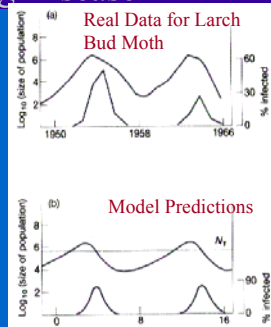
Disease	$R_p$	Vaccination level required for herd immunity ( $1 - 1/R_p$ )
AIDS	2 to 5	50 - 80%
Smallpox	3 to 5	66 - 80%
Measles	16 to 18	93 - 94%
Malaria	> 100	>99%

More accurate predictions require knowledge of how long vaccination lasts, population structure, etc.

<http://plg.maths.org/issue14/features/diseases/index-grid.html>

## Combating Disease

- Measurable parameters are important
- How to decrease  $\beta$ ?
  - Quarantine
  - Hygiene
  - Education
  - Vector control
- Models can predict outbreaks



## Conclusions

- Predators can lower prey density
- However, predators "control" prey only under certain circumstances
- Linked population cycles occur in practice and in theory
- Extinction of both species is common in the lab
- Diseases are a special form of predator-prey interaction



You are Here

Review Session

- Today, 2-3 room G01

G01

Biology Hallway

Biology Office

Greenhouse