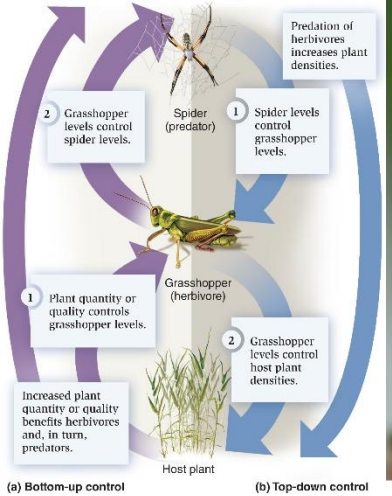
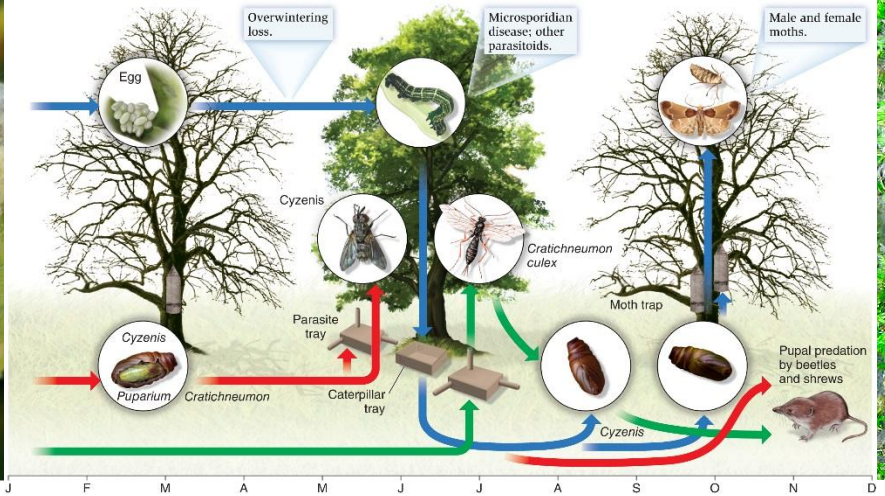








Population regulation

The ten principles of ecology

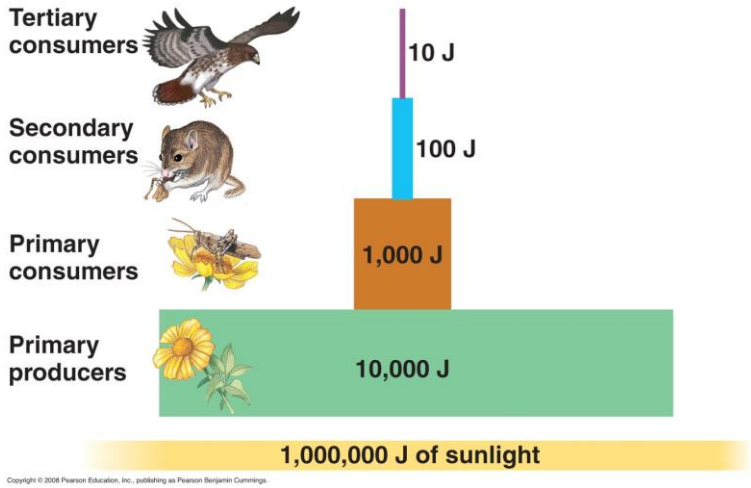
1. Evolution organizes ecological systems into hierarchies.
2. The sun is the ultimate source of energy for most ecosystems.
3. Organisms are chemical machines that run on energy.
4. Chemical nutrients cycle repeatedly while energy flows through an ecosystem.
5. dN/dt = B-X+I
6. dS/dt = D-X+I
7. Organisms interact – do things to each other - in ways that influence their abundance.
8. Ecosystems are organized into webs of interactions.
9. Human populations have an outsized role in competing with, preying upon, and helping other organisms.
10. Ecosystems provide essential services to human populations.

Topics for today

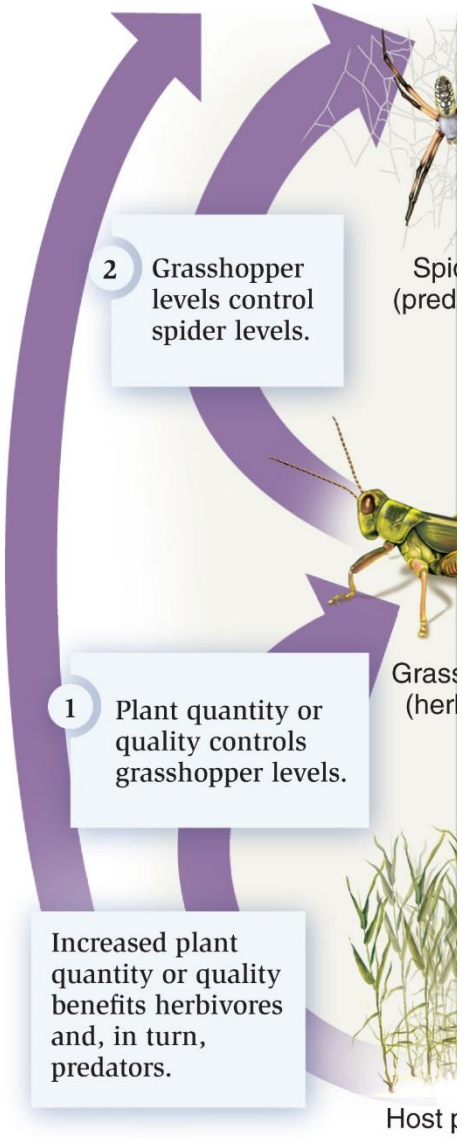
- Bottom-up model: predicts that food/prey resources regulate herbivore/predator abundances
- Top-down model: predicts that natural enemies are key constraint on prey abundances
- Trophic cascades

Bottom-up and top-down population regulation

- Trophic levels we will discuss today:
  - Predator (secondary, tertiary consumer)
  - Herbivore/Detritivore (primary consumer)
  - Plants/Organic matter (primary producers/basal resources)
  - Nutrients/Energy (usually from abiotic sources like the sun, soil, chemical weathering)



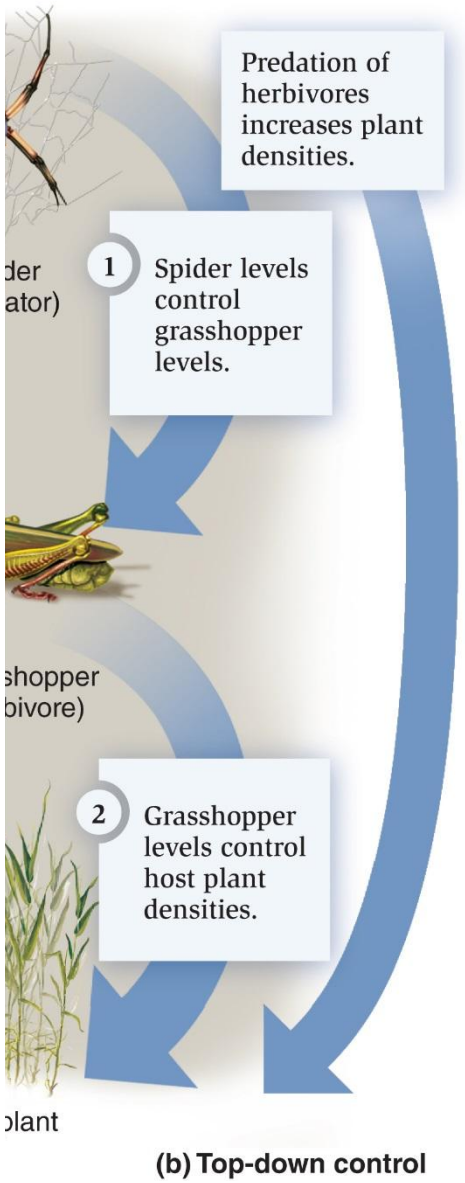
Bottom-up vs. top-down



(a) Bottom-up control

Bottom-up: The base of the food web controls the populations of higher trophic levels

Bottom-up vs. top-down



(b) Top-down control

Bottom-up: The base of the food web controls the populations of higher trophic levels

Top-down: Higher trophic levels control the trophic levels below

Topics for today

- **Bottom-up model: predicts that food/prey resources regulate herbivore/predator abundances**
- Top-down model: predicts that natural enemies are key constraint on prey abundances
- Trophic cascades

Evidence for bottom-up control of herbivore populations

- Water hyacinth and weevils

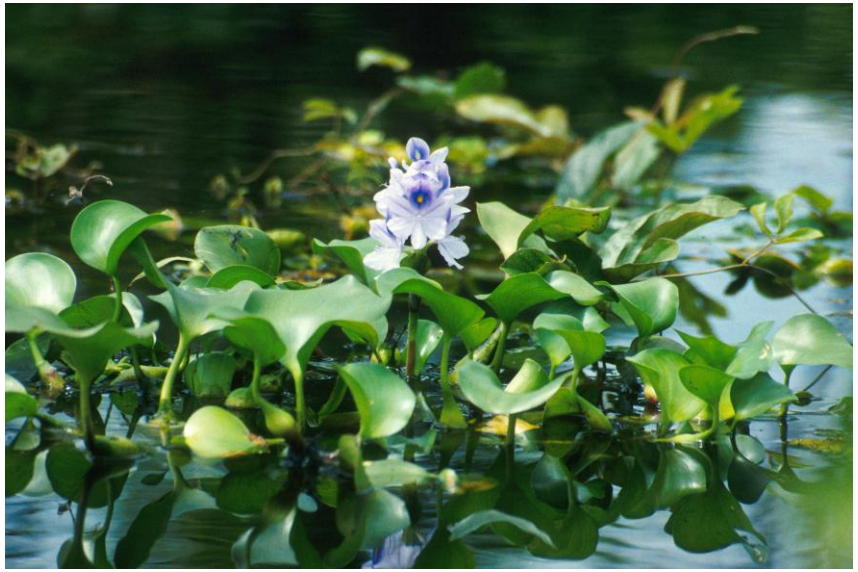


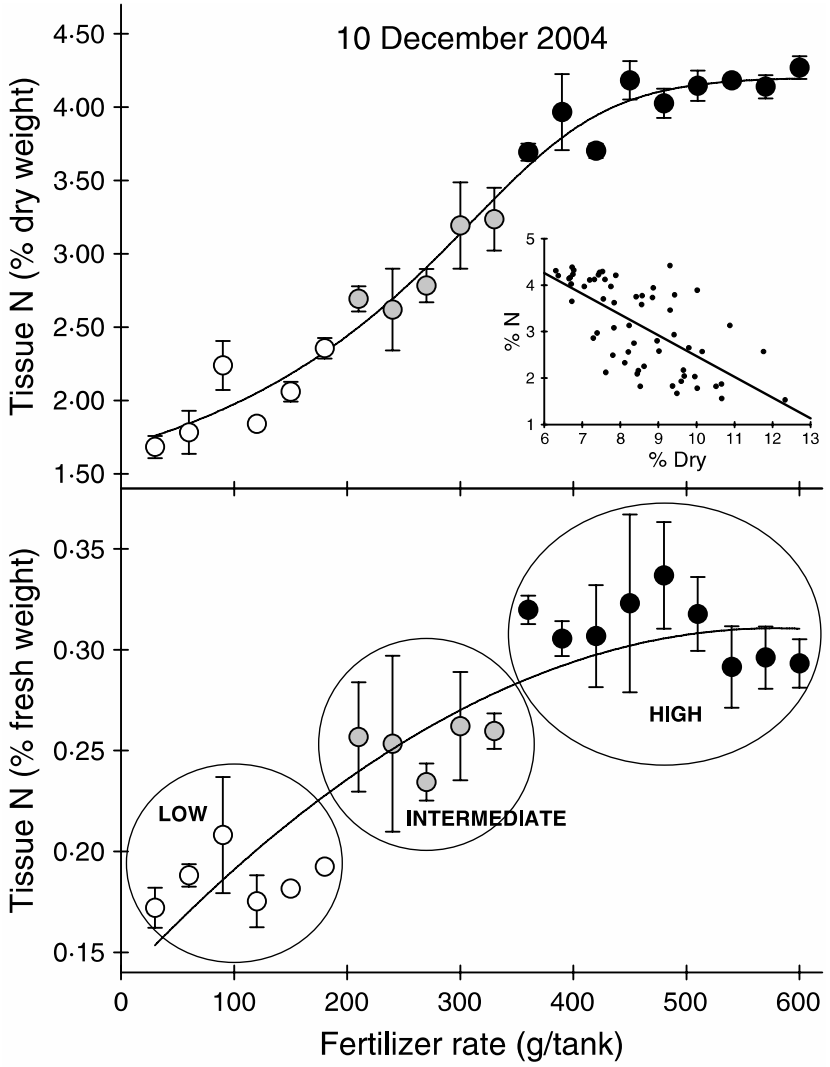
Neochetina bruchi
& Neochetina eichhoriniae



Evidence for bottom-up control

- Water hyacinth grown with fertilizer has higher Nitrogen in its tissues



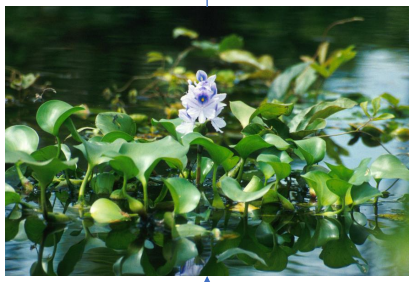


Center and Dray, 2010

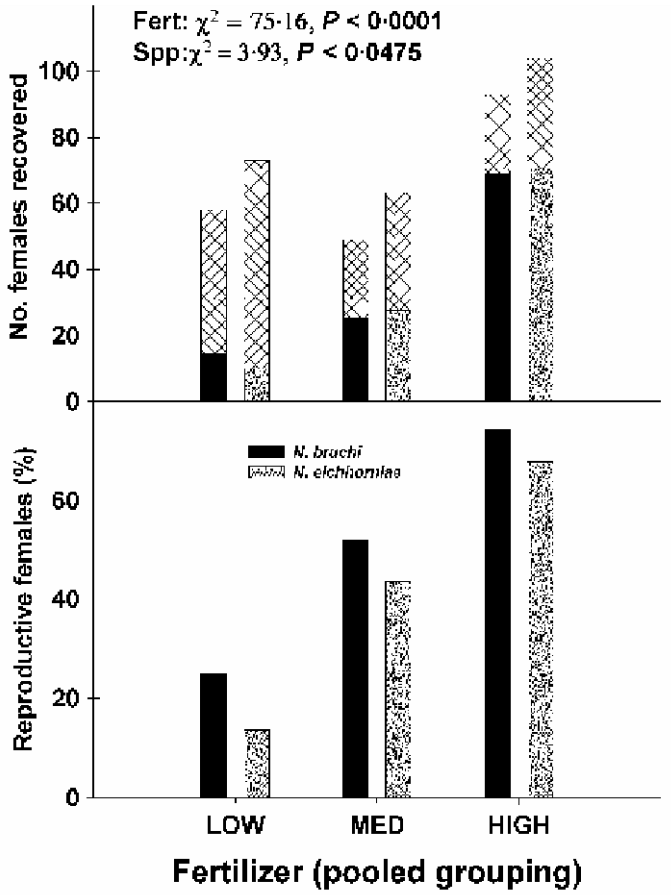
Evidence for bottom-up control

- Higher abundances of female weevils found in high fertilizer treatments
  - And a greater % were reproductive





N, P, K fertilizer



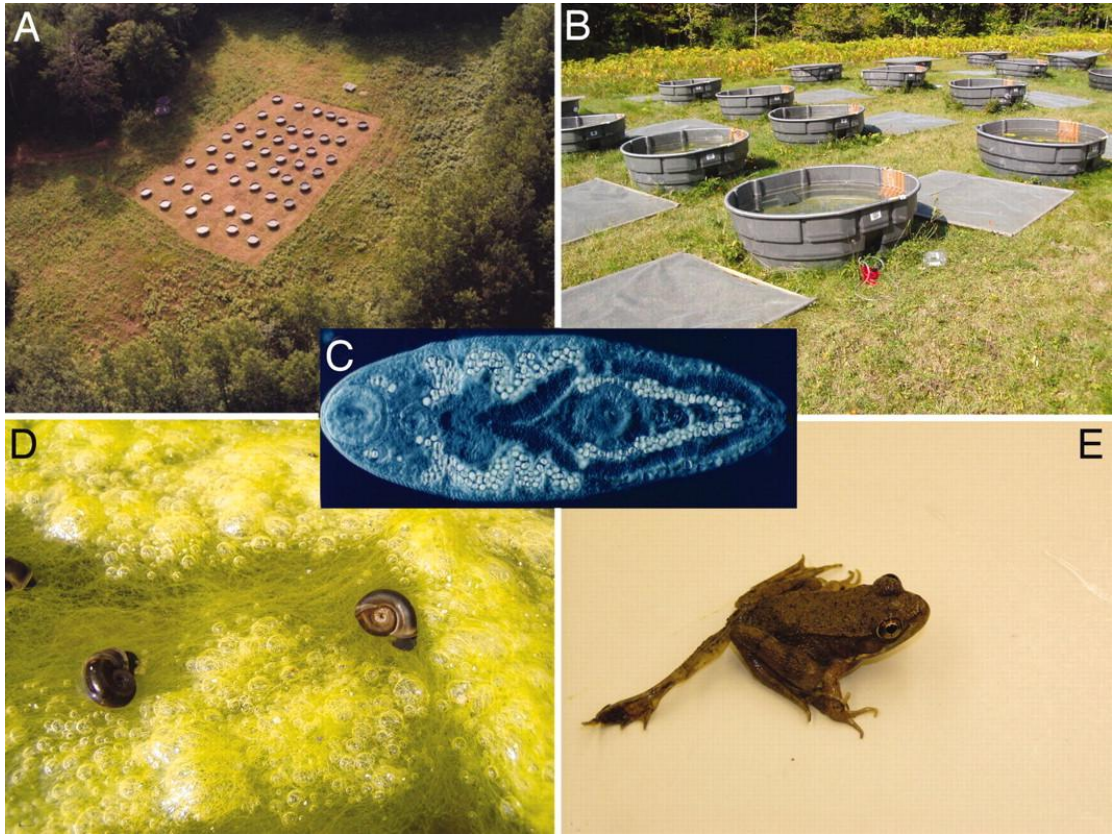
Center and Dray, 2010

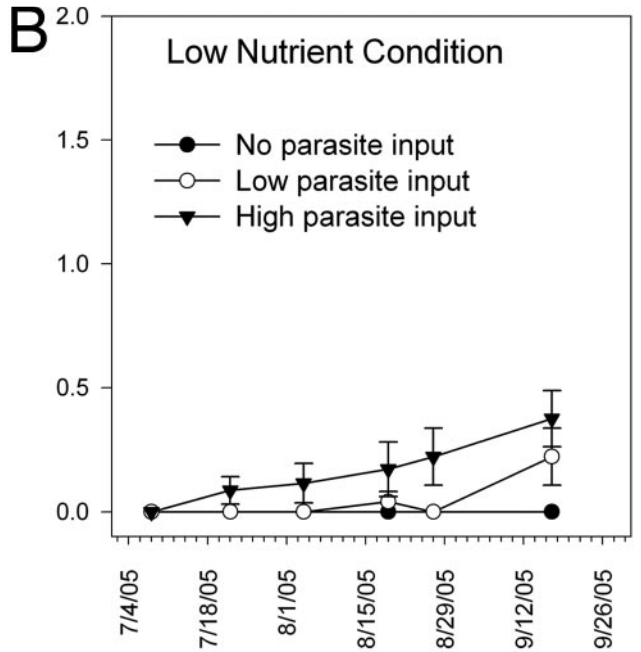
Back to parasitism for a minute:

- Can bottom-up effects influence pathogens?

Back to parasitism for a minute:

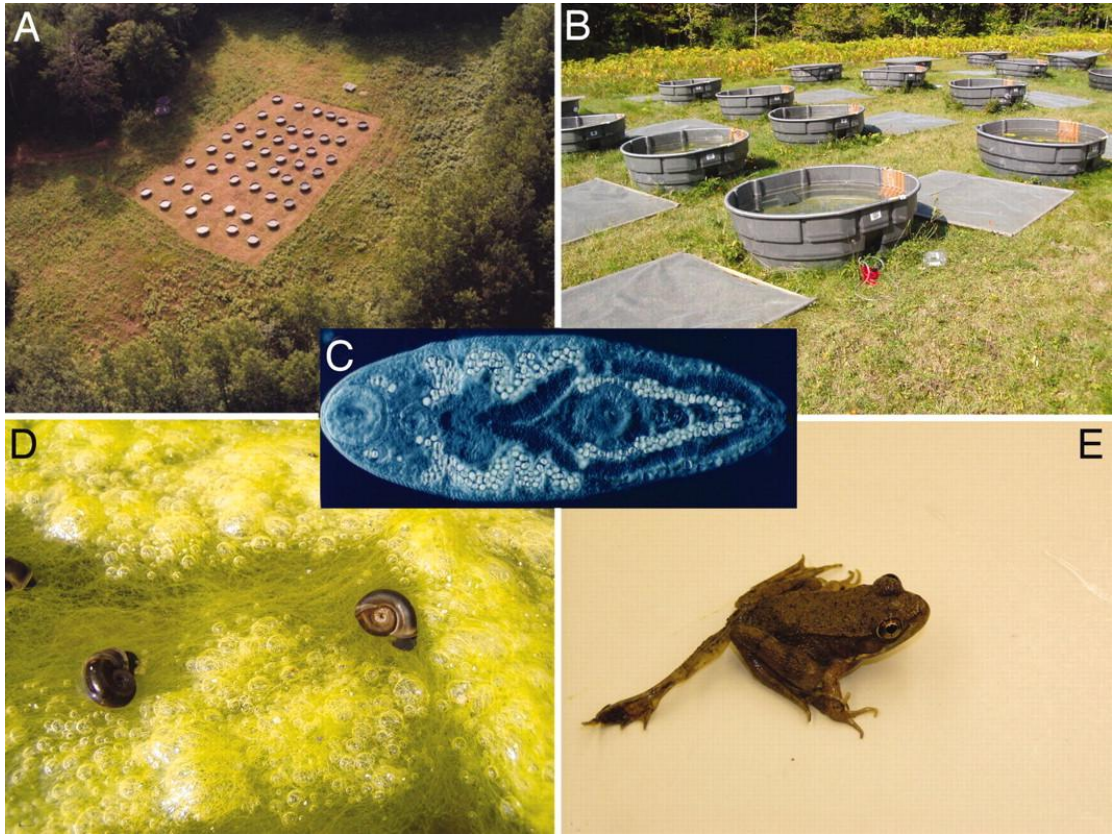
- Can bottom-up effects influence pathogens?

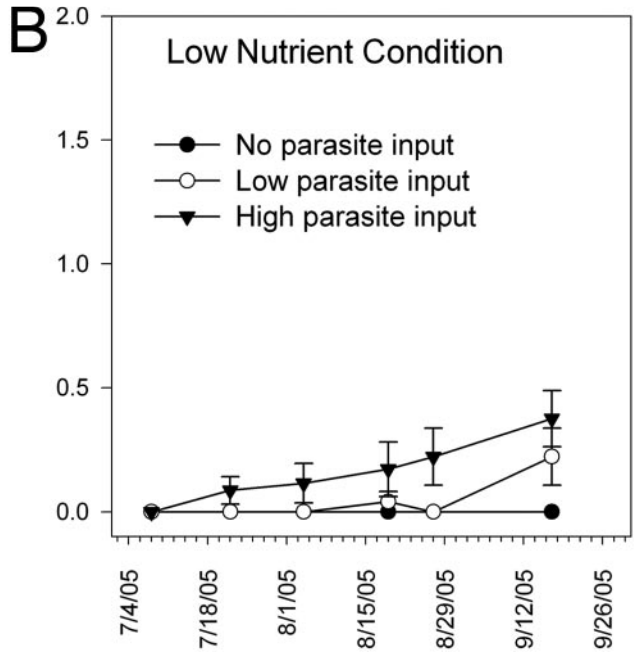




Back to parasitism for a minute:

- Can bottom-up effects influence pathogens?





Back to parasitism for a minute:

- Can bottom-up effects influence pathogens?



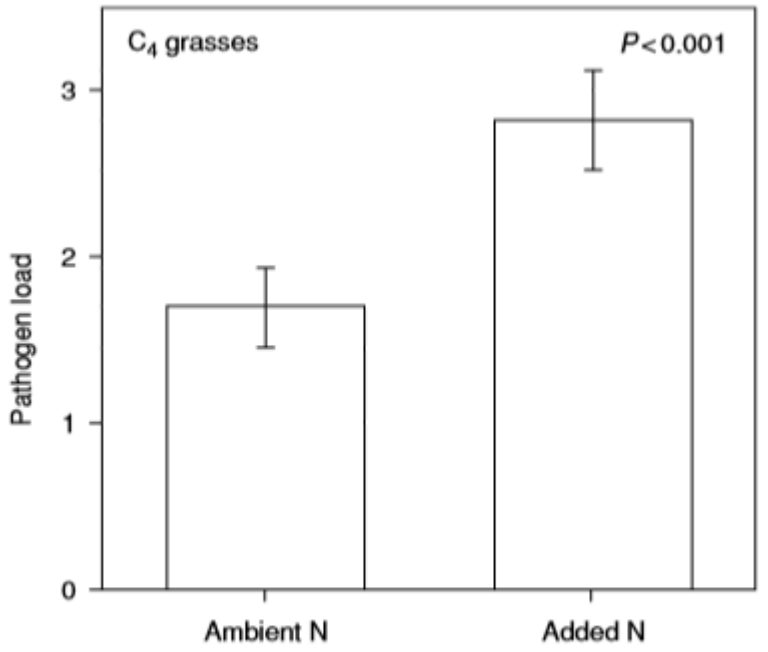
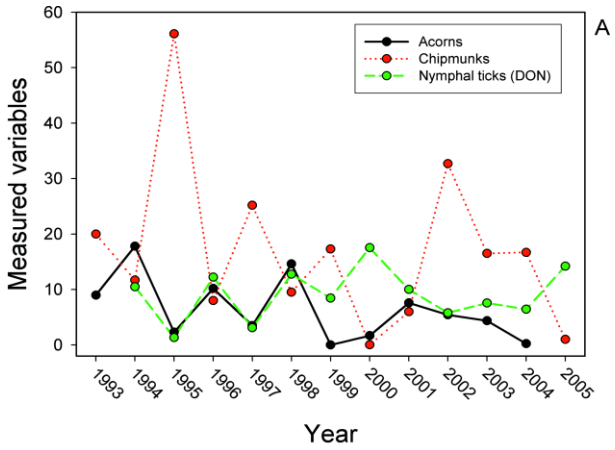


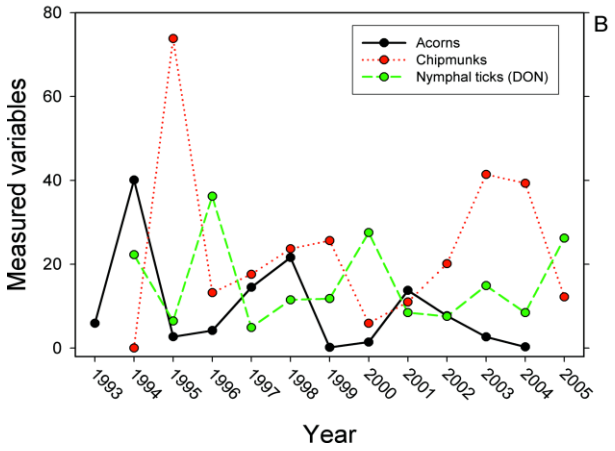
Fig. 5 The effect of nitrogen addition on C_4 grass pathogen load. Data shown are means ± SEM.

Back to parasitism for a minute:

- Can bottom-up effects influence pathogens?



Henry Farm plot



Teahouse plot



1-year lag



2-year lag

1-year lag



Bottom-up control in stream food webs

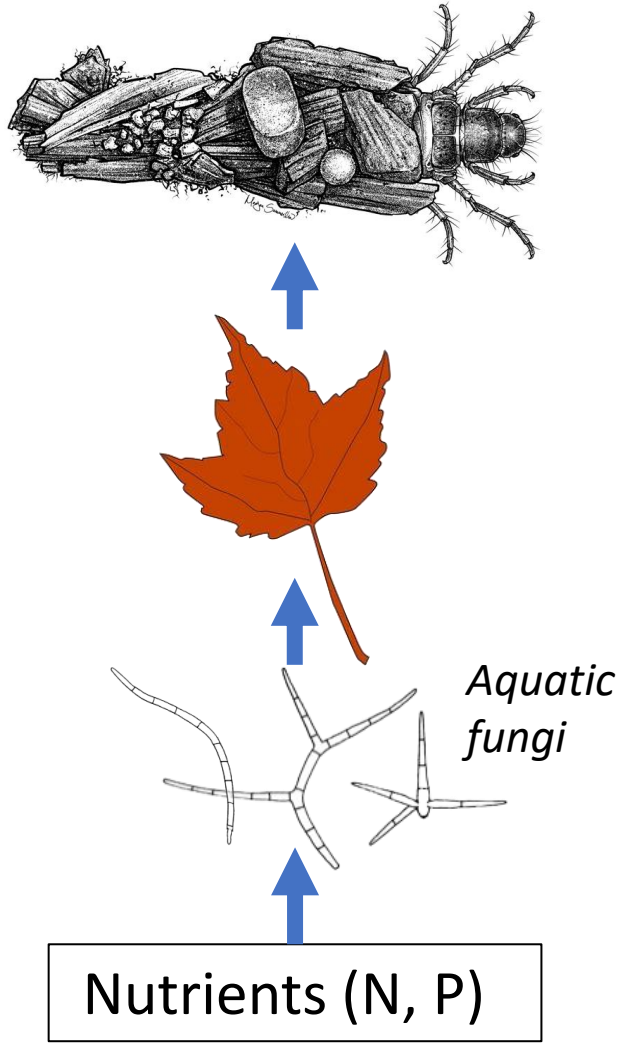
- Added nutrients (N, P) to 5 headwater streams
- Measured effects on organic matter (leaf litter), aquatic insects



Rosemond et al. 2015

Bottom-up control in stream food webs

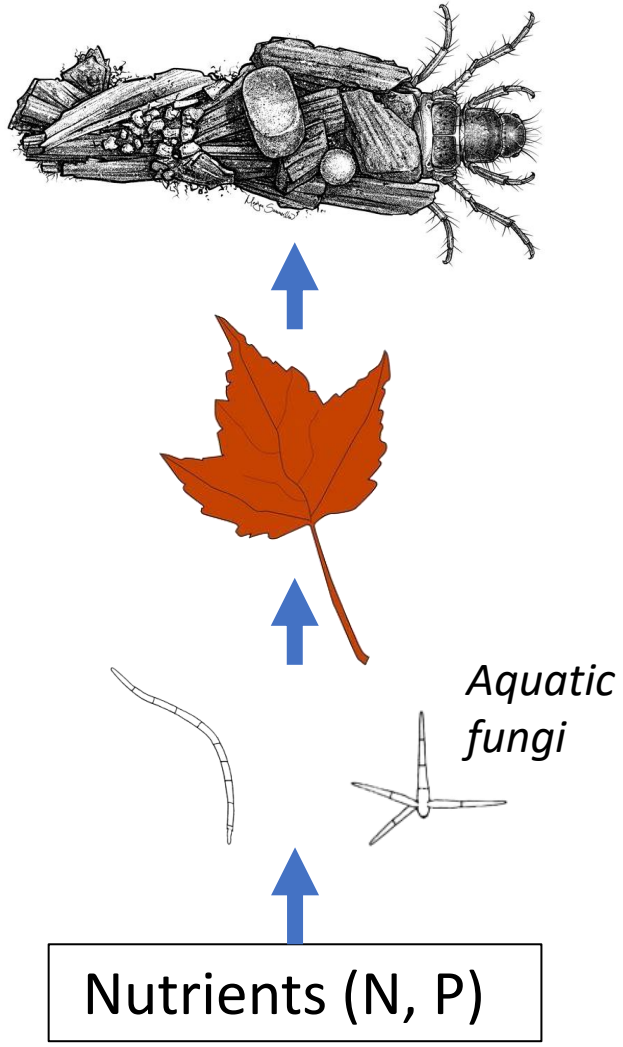
- Nutrients stimulated aquatic fungi from the bottom up.
- Increased organic matter nutrient content
- Increased populations of aquatic detritivores.



Rosemond et al. 2015

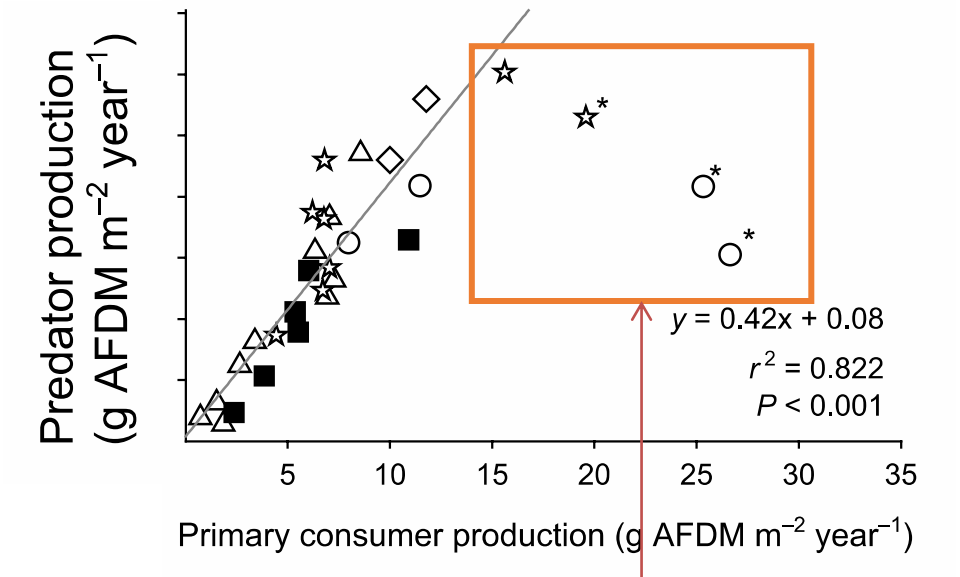
Bottom-up control in stream food webs

- An important detritivore consumer in these systems is *Pycnosyche* spp. A case-building caddisfly that consumes dead organic matter.
- These populations increased dramatically with nutrient addition.



Rosemond et al. 2015

Bottom-up control: trophic “dead ends”



Nutrients added to headwater stream: stimulates primary consumers, but <u>not</u> predators

Predation resistant taxa within a trophic level that cannot be used by higher trophic levels.

Pycnopsyche spp.



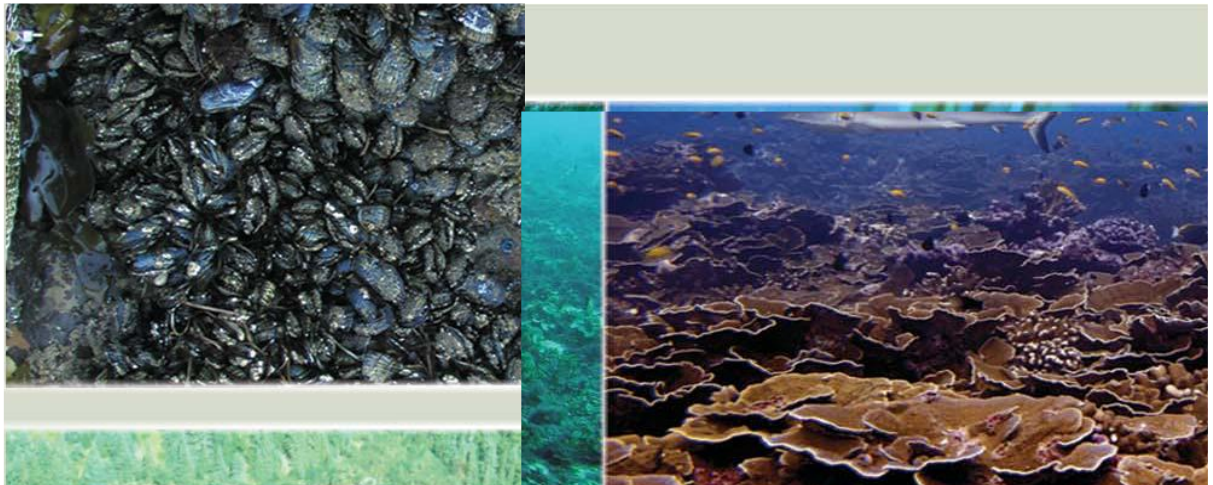
Johnson et al. 2013, Cross et al. 2006, Davis et al. 2010

Topics for today

- Bottom-up model: predicts that food/prey resources regulate herbivore/predator abundances
- **Top-down model: predicts that natural enemies are key constraint on prey abundances**
- Trophic cascades

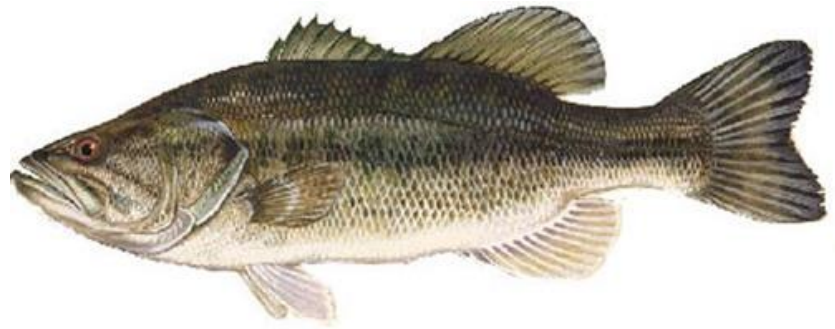
A top-down example from an experimental lake system

- One side of the lake had largemouth bass removed. Which one?



Carpenter et al. 2001

A top-down example from an experimental lake system



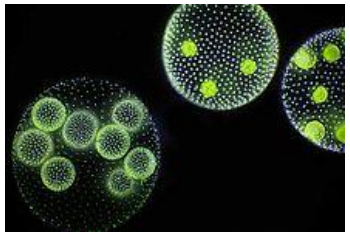








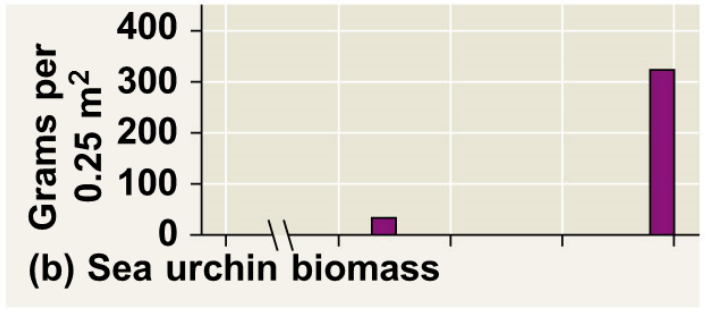


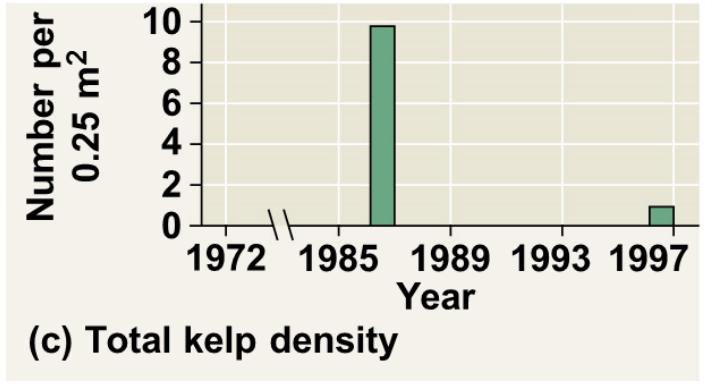


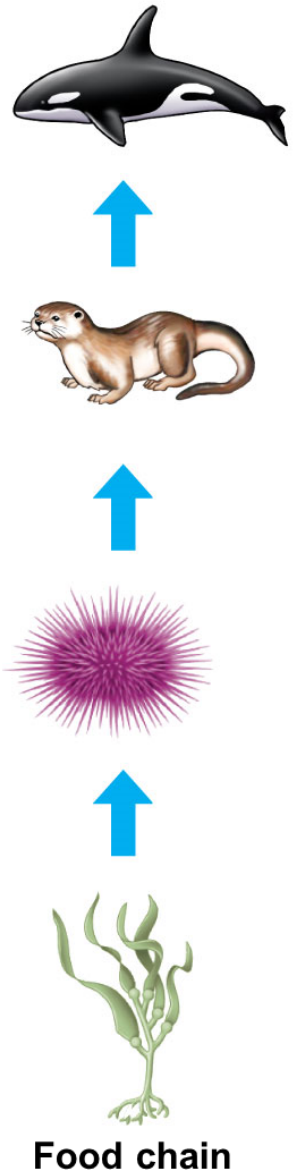
Carpenter et al. 2001

A marine top-down example







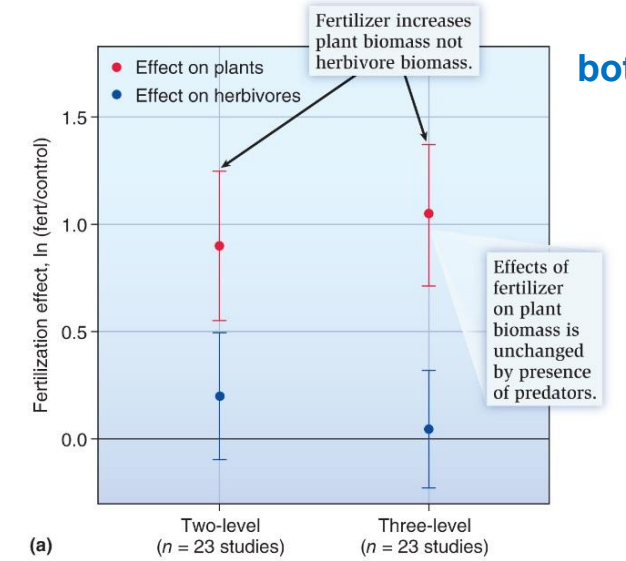


Increasing predation from killer whales (top predators) decreased otters, increased sea urchins, and decreased kelp (*enemy of my enemy is my friend*)

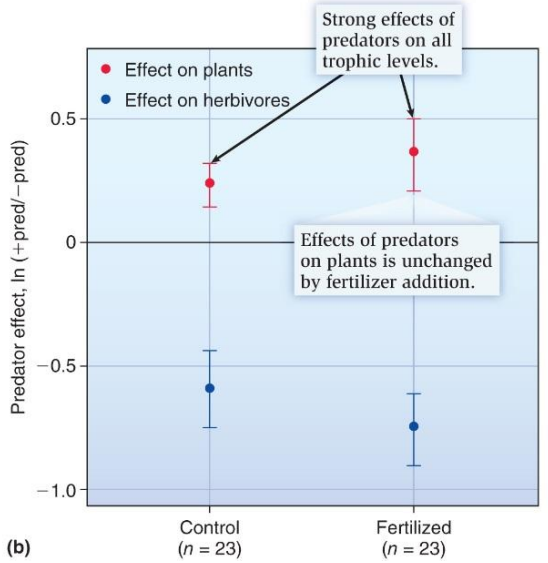
The average strength of bottom-up and top-down effects

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The graphs show the average results across 23 different studies.
(a) Effects of fertilizers in systems with and without predators.
(b) Effects of predator removal with and without fertilizer. (After Borer, et al., 2006)



bottom-up effects



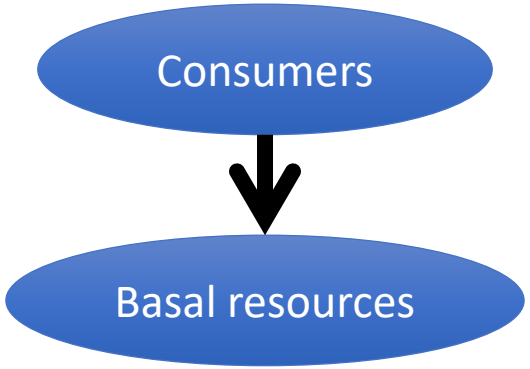
top-down effects

- Effects of predator removal **(top-down) has a stronger effect** on herbivores than fertilizer effects (bottom-up)
- Adding predators decreases herbivores and increases plants, while adding fertilizer does not significantly increase herbivores, <u>ON AVERAGE</u>

Trophic cascades –top-down effects ‘cascade’ to lower trophic levels

Top-down effects of predators typically reduce abundances of their prey, which benefits the next trophic level down the food chain.

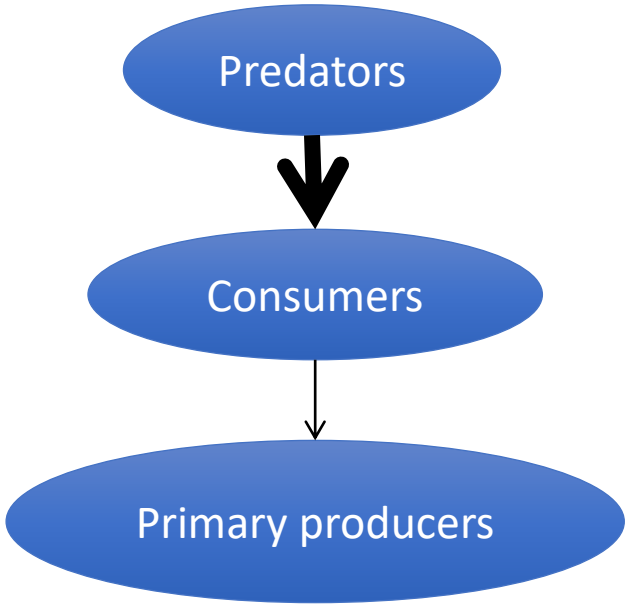
Or more simply: consumer effects on resources at the food web base (basal resources)



Trophic cascades – indirect control of lower trophic levels by top-down effects

Top-down effects of predators typically reduce abundances of their prey, which benefits the next trophic level down the food chain.

Predation reduces consumers, which allows plants to increase in biomass/abundance

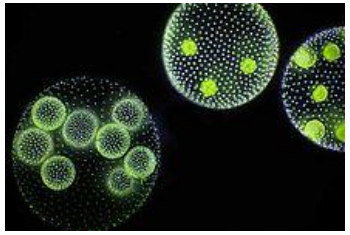


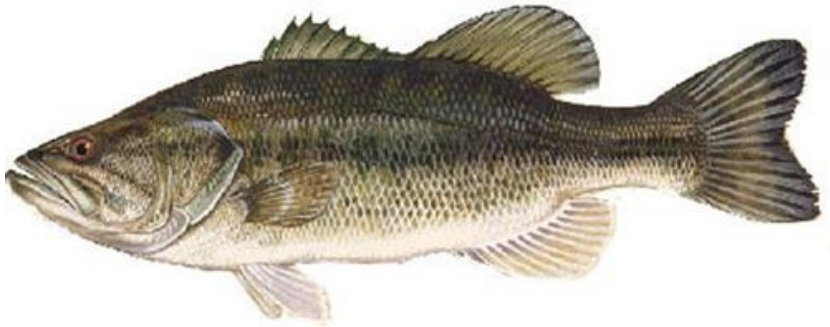
Explain the differences between top-down effects with and without a secondary consumer (top predator)

Explain the differences between top-down effects with and without a secondary consumer (top predator)



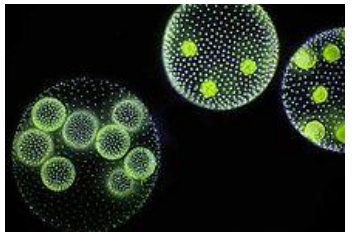






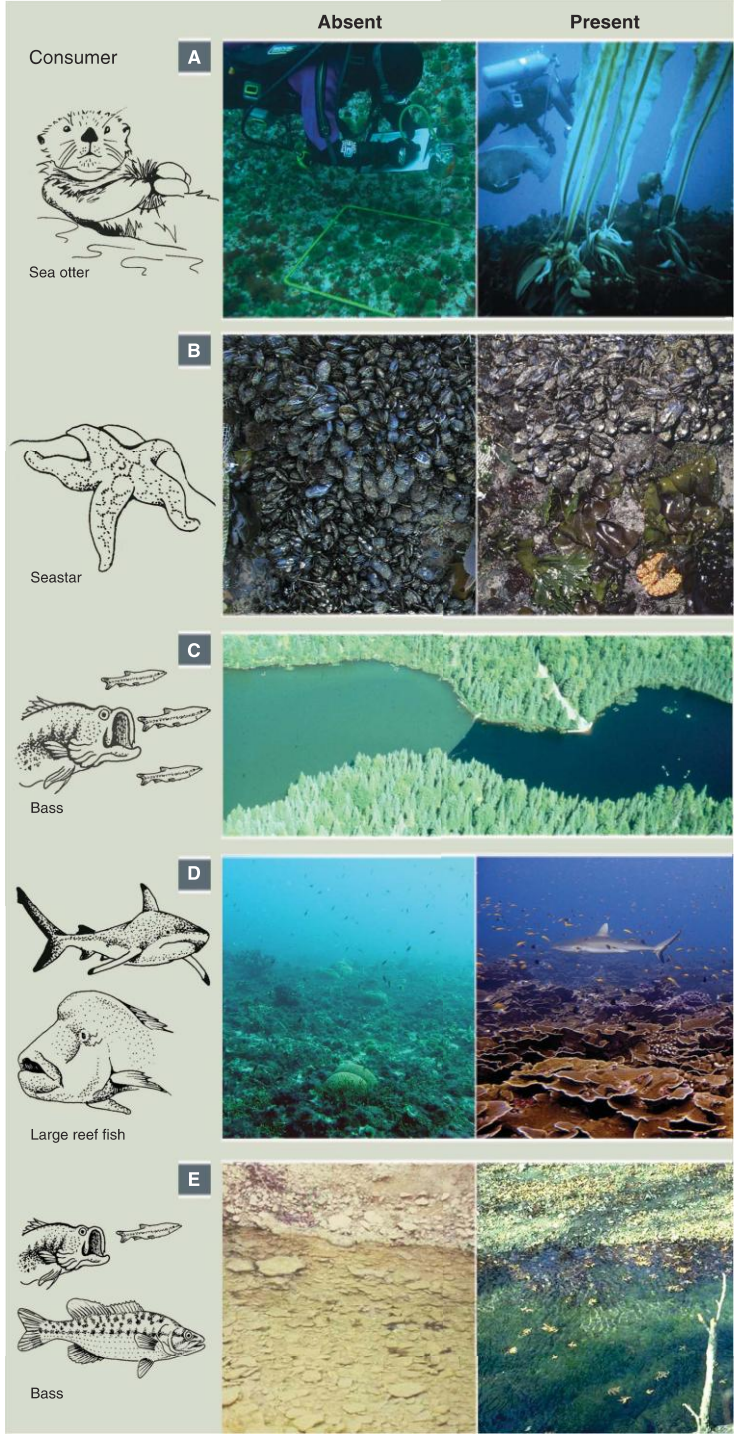






Top-down interactions are becoming less common

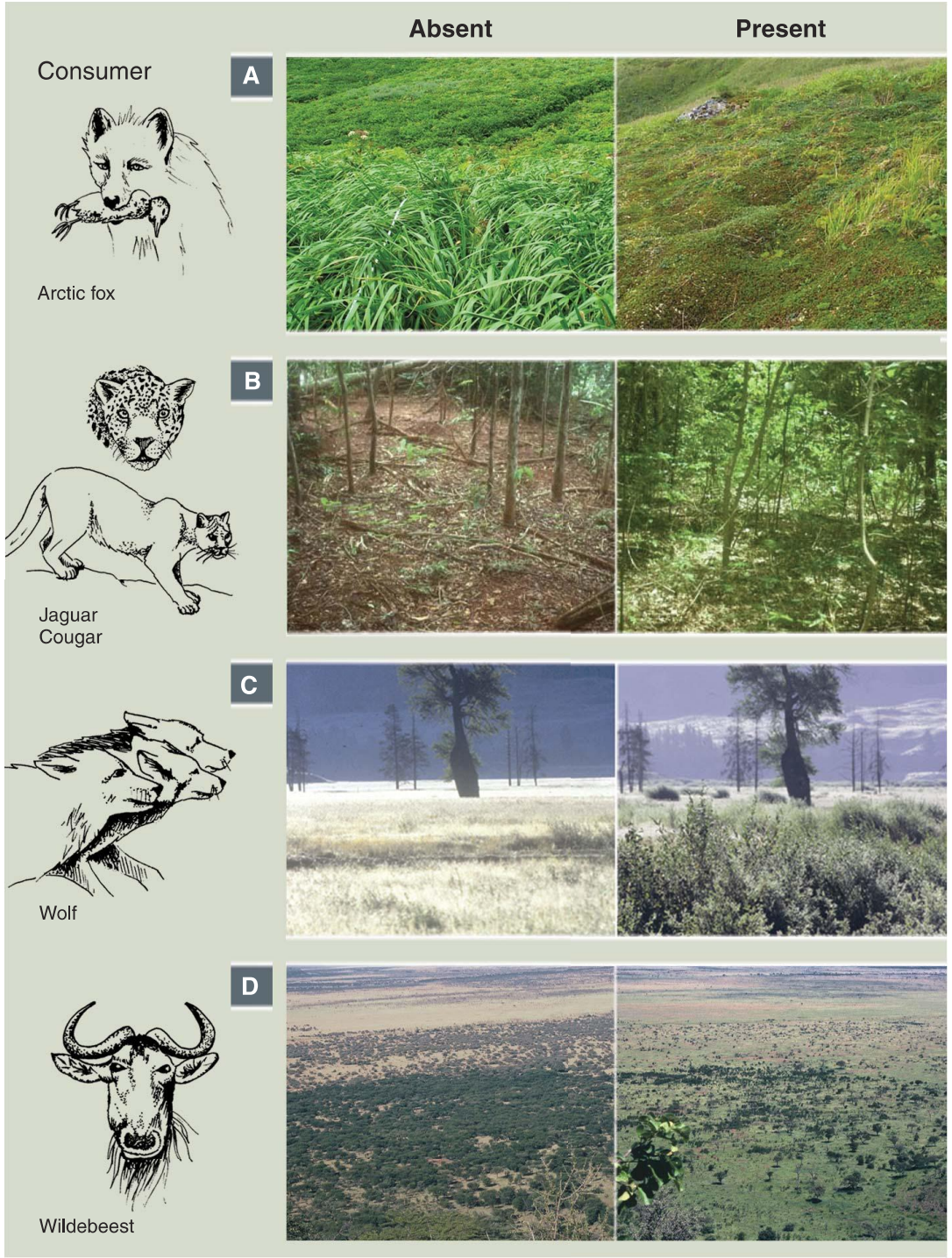
- Trophic “downgrading” of earth
- Loss of key ecological interactions from top-down completely changes ecosystem structure
  - A) sea otter and kelp
  - B) *Pisaster* and mussels
  - C) bass-zooplankton-phytoplankton
  - D) sharks



Estes et al. 2011

Top-down interactions are becoming less common

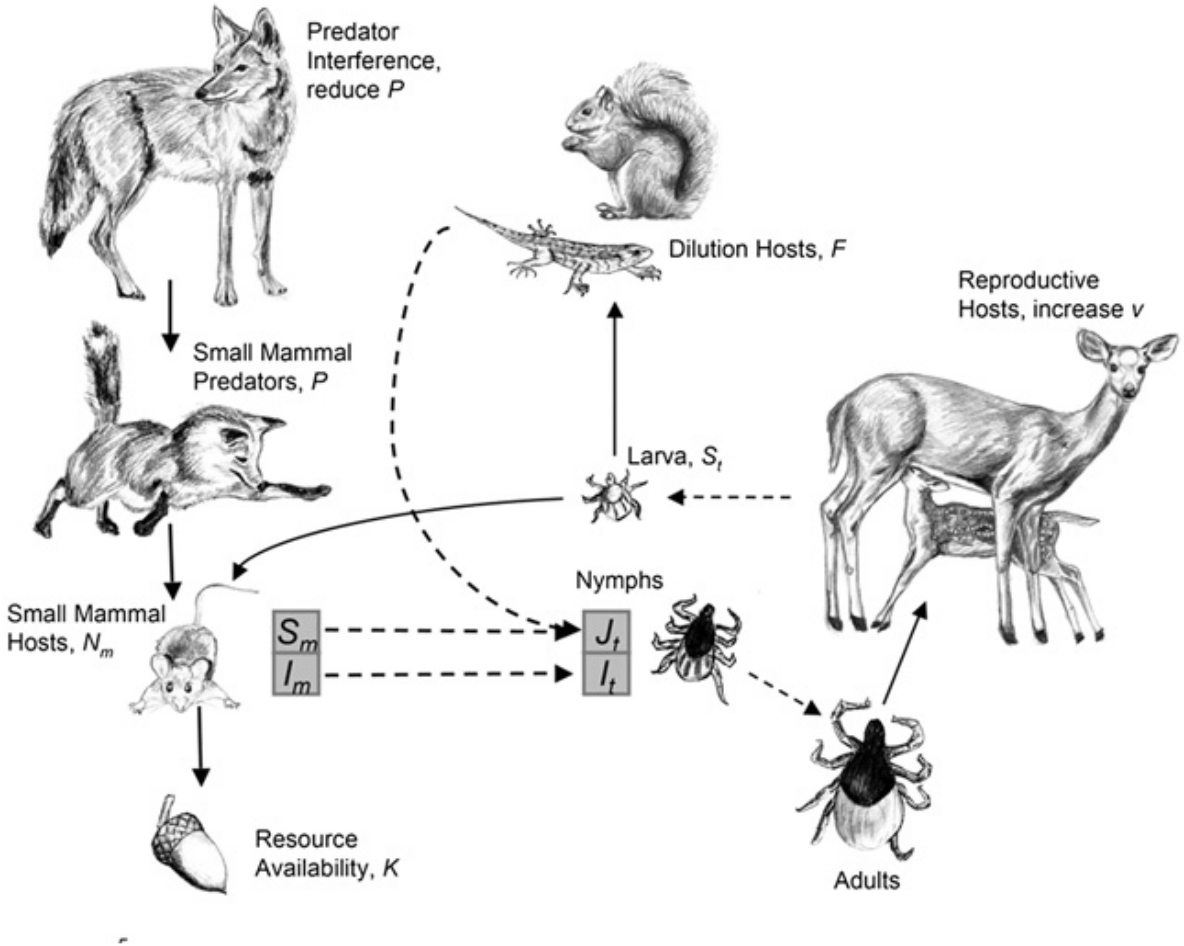
- Trophic “downgrading” of earth
- Also occurs on land
  - A) arctic fox and seabirds
  - B) jaguar and rainforest herbivores
  - C) wolves and elk
  - D) Woody vegetation, wildebeest and rinderpest.



Estes et al. 2011

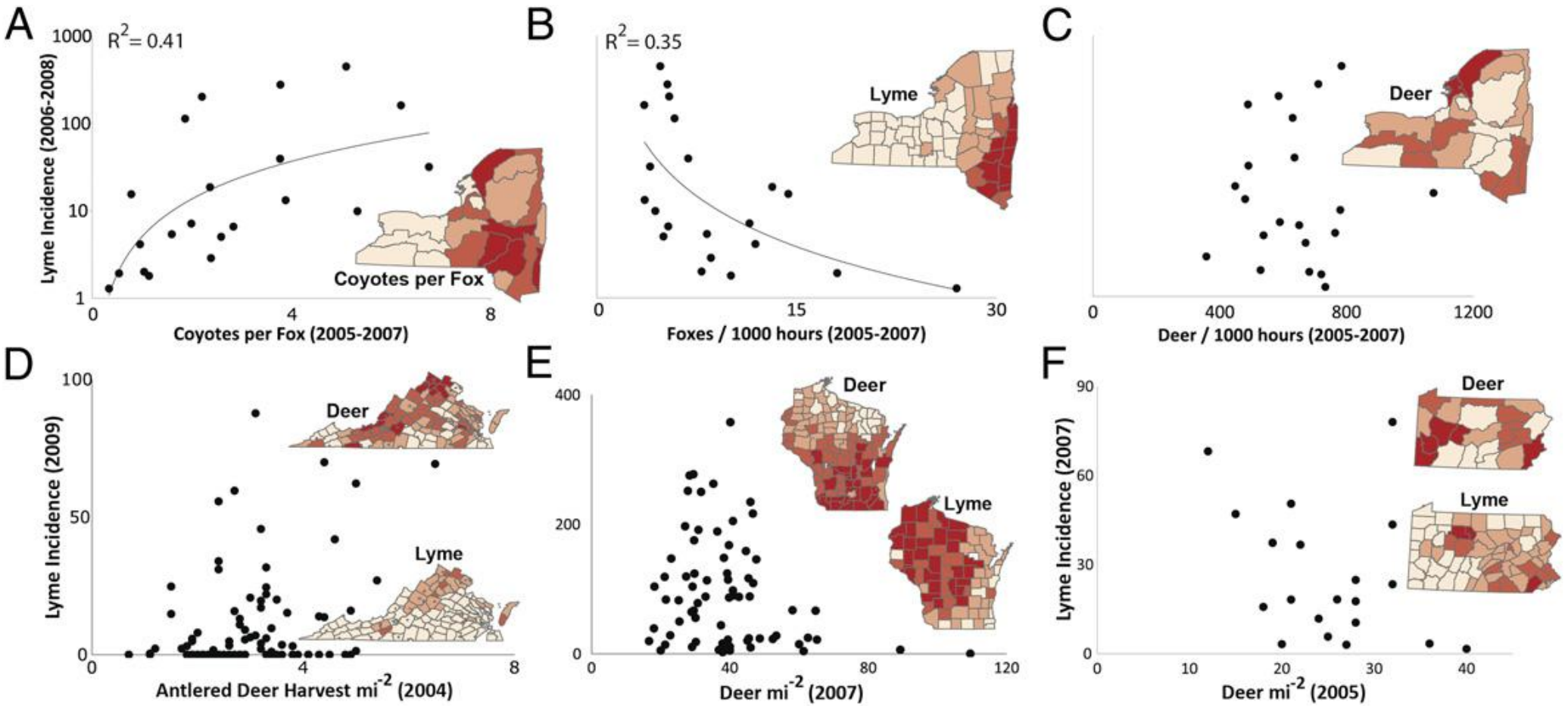
Top-down control and zoonotic disease: the Lyme disease example

Restructuring of predator communities across the globe may have unintended consequences for human disease risk.



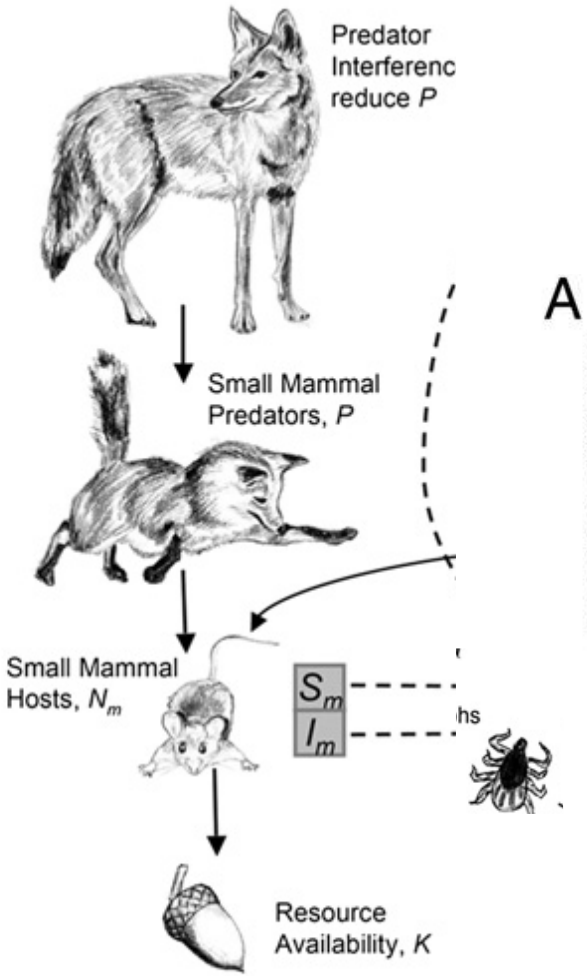
Levi et al. 2012

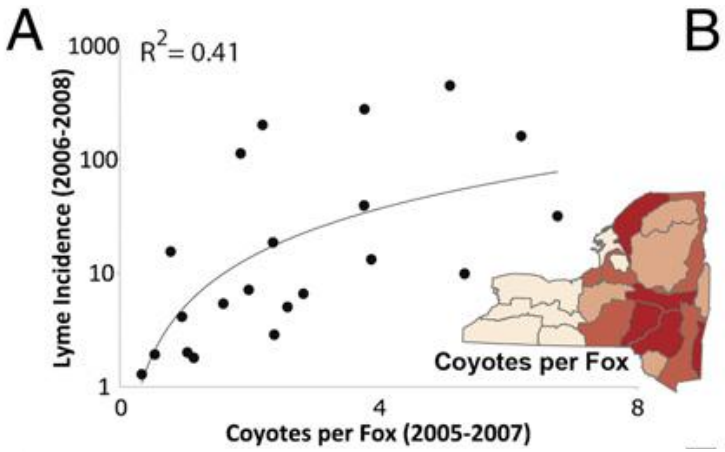
Top-down control on land: effects on zoonotic diseases

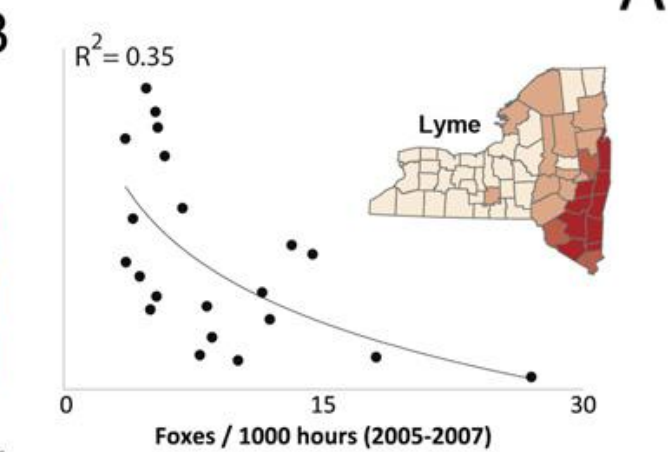


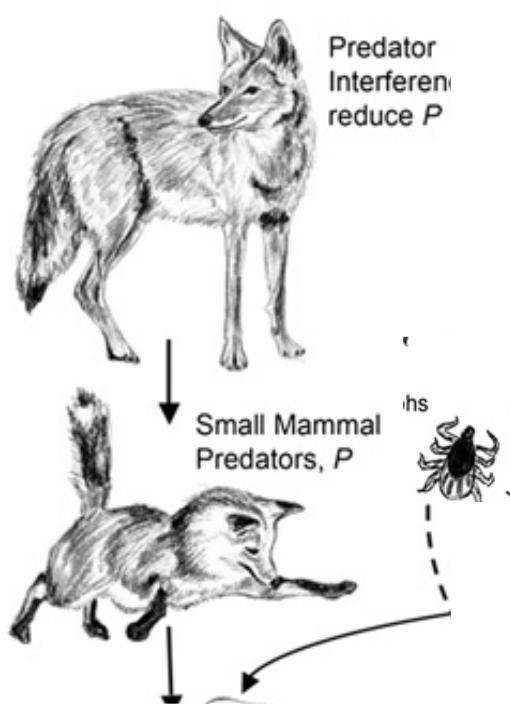
Levi et al. 2012

Top-down control and zoonotic disease: example of a trophic cascade?









Review

- Discuss your favorite example of a trophic cascade. Think about what will happen at each trophic level if a top predator is removed (in terms of abundance/biomass).
- Which tends to have a stronger response for population regulation: top-down or bottom-up?
- Discuss two differences between parasite-host and and predator-prey interactions?
- True or False? Frog malformations are caused by increased contaminants in ponds.