Week 9 Ecosystems Biology
Experimentation and Modeling
Today:

Problem: How can you do an experiment on a large-scale ecosystem?

Find an experiment that is naturally occurring:
- ocean acidification
- trophic downgrading

Use mathematical modeling (systems biology):
- lynxes and hares
- homework problems
Acidification affects carbonate concentration

Log scale!
We know what will happen *chemically*, but what will happen *biologically* when the ocean is increasingly acidified? How do we know? How can we test this?

(there is a clue in this picture)

...what kind of rocks are these?
...those were volcanic rocks
Volcanoes release CO$_2$
Causing a localized change in pH

This is in Hawaii, an extreme example. We don’t want to test the effect of magma, just CO$_2$, so we need a “milder” setting.
Castello D'aragonese, Ischia
An island in Italy: CO₂ vents from an ancient volcano

Calcareous algae – rigid, the “cement” of coral reefs, critical for structural integrity of reef ridges, which break waves and prevent coastal erosion.
Calcium carbonate exoskeleton

pH = 8.2  pH = 7.3
Get energy from the sun, and what other sources?

Are these important?

The Trophic Pyramid

~ 90% energy loss for each level up

A Hypothetical Biomass Pyramid

Primary Producers (Phytoplankton)
1,000,000 kg

Herbivores (Zooplankton)
100,000 kg

Mid-level Carnivores (Large Fish)
1,000 kg

Lower-level Carnivores (Shrimp)
10,000 kg

Top Carnivore (Shark)
100 kg
Discuss:

Where do microbes fit in the trophic pyramid?

Are apex predators important?

What effects could they have on an ecosystem? How? How can we test this?
“Trophic downgrading of planet Earth.”

Otters eat urchins
Urchins eat base of plants

Remember from lecture?
“Trophic downgrading of planet Earth.”
Capturing the big picture: Modeling (systems biology)

1. Use known interactions to build a model
2. Use model to make predictions
3. Test predictions (in lab and in the field)
4. Refine model based on outcomes
For your homework...

You will use a simple systems modeling program, Powerplay
You will express models as **signed digraphs**

Powerplay Java Applet (works in browser, recommended method)
http://www.ent.orst.edu/loop/pplay.aspx

Powerplay Download (not for Mac):
Allows you to save models
http://esapubs.org/Archive/ecol/E083/022/suppl-1.htm

Detailed instructions for Powerplay can be found on the Bi1 website
What is a signed digraph?

Positive (sunlight, cyanobacteria)

Negative (oceanic CO2, urchins)

Symbiosis/Mutualism

Predator/prey

competition

Is this an oversimplification?

Density dependence
Powerplay demonstration

Vegetation, hare, lynx with closed loops on vegetation and lynx

What happens if there is more vegetation?
Hypothesis: Planting seeds will increase both hare and lynx population

This was actually tested experimentally!

Found that more plants $\neq$ more hares

Model needs to be revised
Vegetation might help predators conceal themselves
Powerplay demonstration

Add in a vegetation positive effect on lynx
Increased vegetation

Community Matrix:

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<th>lynx</th>
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1. Brainstorm, as a class, components of the pond ecosystem (what makes up the microbial community? Remember: stromatolites)

2. Discuss in small groups how different organisms interact with each other (OK to use outside sources, but you could design a model solely by integrating lecture material)

3. Individually, design your model, including 4 or 5 components

Note: You will need to test the stability of your model using Powerplay. If it is not stable, you will need to revise your model
   - Add closed loops (self-regulation)
   - May have to play around with the model to find a constrained system