Overview of Lecture: Ecology: Communities & Ecosystems
see the schedule for reading and watching assignments

THE FOLLOWING PREVIEW HAS BEEN APPROVED FOR ALL AUDIENCES

Bullet Points:
• community ecology
• interspecific competition
• the Lotka-Volterra model
• competitive exclusion
• character displacement
• predators & parasites
• keystone species
• the loss of large predators
• Spaceship Earth – is tiny and under great stress
• local & global biodiversity – why sustain biodiversity?
• climate change – the public good & the tragedy of the commons

Don’t forget to complete the MSU online SIRS form: https://sirsonline.msu.edu
Learning Goals:

1. Be able to use examples from lecture and/or the text & videos to explain the Lotka-Volterra competition model and what additional ecological and demographic processes it incorporates beyond the logistic model. Be able to use examples to help explain competitive exclusion. What, in general, tends to lead to coexistence rather than competitive exclusion in competitive interactions.

2. Be able to explain the keystone predator hypothesis and how predators or parasites can increase biodiversity. Use examples from the studies by Ripple et al. and by Estes et al. to help explain why the disruption of trophic cascades that results from the extirpation of top predators creates such concern for the maintenance of biodiversity and ecosystem function.

3. Be able to explain in what sense is the anthropogenic forcing of global climate change similar to the public goods game know as the tragedy of the commons?

Don’t forget to complete the MSU online SIRS form.
Earlier: Unlimited **populations** grow exponentially.

**Density-dependent regulation** of demographic rates (b & d) limits pop growth (\(\lambda\) or \(r\)); if pop growth rate is low but “+” (\(\lambda >1 \text{ or } r >0\)) , 
N approaches a carrying capacity \(K\); if pop growth rate is high, dynamics cyclic or chaotic.

A biological community is

Multispecies communities w/ complex food webs are very complex systems with many positive and negative indirect interactions! ex: “my enemy’s enemy is my friend”
The exponential growth model: \( \frac{dN}{dt} = N \cdot r \)

The logistic growth model: \( \frac{dN}{dt} = N \cdot r_{\text{max}} (1 - \frac{N}{K}) \)

How can we add a little more realism to this model by incorporating **Interspecific Competition**?

Suppose we can measure the impact of one individual of species 2 on the pop growth rate of species 1 relative to the impact of one additional individual of species 1?

Call this rate of substitution the ‘interspecific competition coefficient’ \( a_{12} \) (the intraspecific coefficients \( a_{11} \) & \( a_{22} \) are implicitly = 1)

**The Lotka-Volterra interspecific competition model:**

\[
\begin{align*}
\frac{dN_1}{dt} &= \quad \quad \\
\frac{dN_2}{dt} &= 
\end{align*}
\]

If we ‘do the math’ we find **stable coexistence** of both species 1 & 2
**Competitive exclusion** is often found in simple lab experiments where 2 diff species are forced to scramble for one limiting resource. (it’s difficult to maintain stable pairs in simple environments w/ exploitation competition).

A classic illustration is from **Gause’s exp’s w/ paramecia** (see Fig 39.3) competing for bacteria = food in chemostats (w/ fixed input of food).

When grown separately each species does fine (note: P. aurelia has smaller r but larger K)

**Competitive exclusion** is expected from details of L-V competition model, but there is a simple verbal interpretation (from D.Tilman):

Note that P. aurelia has a bigger carrying capacity K than P. caudatum.
Prospects for 'competitive exclusion' treatment to control salmonellas and other foodborne pathogens in poultry.

Lactobacillus ... a competitive exclusion agent against bacterial pathogens in poultry.

Lactobacillus as a probiotic for preventing urogenital infections
Andreu A Reviews in Medical Microbiology 15 (1): 1-6 JAN 2004

This article discusses the role of Lactobacillus as a probiotic agent for the maintenance of vaginal microflora and the prevention of urogenital infections. Lactobacillus protects the vagina from colonization by pathogens by ... blocking their attachment to the vaginal epithelium and producing substances that inhibit their multiplication.

My enemy’s enemy is my friend!
There are two possible outcomes of competition between species with identical niches: either the less competitive species will be driven to **local extinction**, or the species may evolve to use a different set of resources. This **differentiation of niches** is called **resource partitioning**.

We can think of resource partitioning as "**the ghost of competition past**" - circumstantial evidence of earlier interspecific competition resolved by the evolution of niche differentiation.

**Niche differentiation** is often evident from morphological **character displacement**. The Galápagos finches provide a good example of **character displacement** in beak sizes & in the seeds that they can eat most efficiently.
It is apparent that **predation** influences the distribution and abundance of prey species - most obviously by **killing** some and **scaring** the rest.

*Just fyi - there is a Lotka-Volterra model for for predators and prey, but not today!*

Predators & parasites can actually increase **biodiversity**, by preventing competitive exclusion:

![Graph showing the impact of Pisaster on species diversity](a)

![Biomass data](b)
Large-bodied animals play essential roles in ecosystem structuring and stability through both indirect and direct trophic effects.

Humans have disrupted this trophic structure through both habitat destruction and active extirpation of large predators, resulting in large declines in numbers and vast contractions in their ranges. Consistent with theory, empirical studies increasingly show that large carnivores have substantial effects on the structure and function of diverse ecosystems. Significant cascading trophic interactions, arise when some of these carnivores are extirpated from or repatriated to ecosystems. [as with wolves in N. Am. and Yellowstone]

Trophic Downgrading of Planet Earth

Ecological theory has long predicted that major shifts in ecosystems can follow changes in the abundance and distribution of apex consumers. Although such losses are widely viewed as an ethical and aesthetic problem, recent research reveals extensive cascading effects of their disappearance in marine, terrestrial, and freshwater ecosystems worldwide. These findings emphasize the urgent need for interdisciplinary research to forecast the effects of trophic downgrading on process, function, and resilience in global ecosystems.
Status and Ecological Effects of the World’s Largest Carnivores
WJ Ripple et al. Science 10 Jan 2014 343,1241484.

“My enemy’s enemy is my friend”

\((-\cdot\cdot) = +\)

Consider:
wolves, moose, plants
on Isle Royale
Trophic Downgrading of Planet Earth JA Estes et al.

(A) Shallow seafloor community at Amchitka Island after and before the collapse of sea otter populations. Sea otters enhance kelp abundance (right) by limiting herbivorous sea urchins.

(B) The rocky intertidal zone of central California after (left) and before seastar exclusion. Pisaster increases species diversity by preventing competitive dominance of mussels.

(D) Fished (left) and unfished (right) coral reefs. Fishing lowers the competitive advantage of reef-building corals by removing large predators of small coral eating fish.

(E) Pools in a prairie margin stream lacking (left) and with (right) bass. The bass extirpate herbivorous minnows, promoting the growth of benthic algae.
Population trends of grassland birds in North America are linked to the prevalence of an agricultural epizootic [disease] in Europe.

JJ Nocera & HM Koslowsky PNAS March 22, 2011 vol. 108 no. 12 5122-5126

We present a striking illustration of a [global ecological] cascade in which bovine spongiform encephalopathy (BSE; “mad cow disease”) outbreaks in Europe exerted pressure on global beef markets, [European beef inedible – buy US instead] subsequently affecting North American hayfields and grassland bird populations.

We found that:

1. Imports of beef from North America increased 1 y after BSE outbreaks in Europe.
2. Probably because fewer cattle remained, the hay harvest in North America was reduced 2 y after the outbreak.
3. The reduced hay harvest yielded a positive response in grassland bird populations 3 y after the outbreak.


Indirect effects can be projected globally by global markets

More BSE in Europe, more meadowlarks in Kansas 3 years later

(From left to right) the Eastern Meadowlark, Grasshopper Sparrow, and Sedge Wren are among the birds most sensitive to changes in hay production.

Framing ecosystem services in the telecoupled Anthropocene


We are on a very tiny Spaceship Earth and the support systems are being stressed.
The biomass distribution on Earth
Yinon M. Bar-On, Rob Phillips, and Ron Milo
http://www.pnas.org/content/115/25/6506?etoc=

Humans just 0.01% of all life [biomass] but have destroyed 83% of wild mammals.

The biomass of
All life on Earth is made up of ...

82% plants
13% bacteria
5% everything else

Humans make up 0.01% of Earth’s total biomass

Guardian graphic.
Why is Biodiversity Important?
The complex web of inter-dependent ecosystems which constitute life on Earth includes us. We are part of that web and are entirely dependent on clean air, fresh water and healthy food for our survival.

Scientists have been working on the development of clear and transparent ways of assigning a monetary value to some of the ecosystem functions on which we depend, such as the activity of bees and other pollinators, …

These are known as 'ecosystem services'

[this is pretty risky – what if the monetary value of polar bears is too low?]
Climate change is already causing more frequent and severe weather across the U.S., and the country is poised to suffer massive damage to infrastructure, ecosystems, health and the economy if global warming is allowed to continue, according to the most comprehensive federal climate report to date.

The fourth National Climate Assessment is the culmination of years of research and analysis by hundreds of top climate scientists in the country. The massive report details the many ways in which global climate change is already affecting American communities, from hurricanes to wildfires to floods to drought.

"Climate change is already affecting every part of the United States, almost every sector of the United States, be it agriculture or forestry or energy, tourism," says George Mason University professor Andrew Light, who is one of the report's editors.

"It's going to hurt cities, it's going to hurt people in the countryside, and, as the world continues to warm, things are going to get worse."
Climate Change Is Victim Of 'Tragedy Of The Commons'
November 27, DAVID KESTENBAUM

One reason it is so hard to slash carbon emissions is that climate change occurs globally. [the benefits of it are global]

The countries that produce the most greenhouse gas all need to take action to fix the problem. [the costs to reducing it are local]

That raises a classic economic dilemma called the tragedy of the commons. [the tragedy results when]

selfish individuals or countries over-exploit the public good or common resource: if I show restraint or invest in the future, you might cheat: “free ride” on my investment]

Can humankind escape the tragedy of the commons?
Stephen Battersby
Proc Natl Acad Sci U S A.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5224396/

[fairness and trust are critical]
“It is difficult to imagine the world coordinating when the most important country refuses even to play the game.”
Mike Collins, Apollo 11 astronaut:
“Oddly enough the overriding sensation I got looking at the earth was, my god that little thing is so fragile out there.”
The Great Acceleration

Population "carrying capacity"?

Carbon dioxide

Nitrous oxide

Methane

Urban population

Stratospheric ozone

Surface temperature

Ocean acidification

Primary energy use

Marine fish capture

Shrimp aquaculture

Nitrogen to coastal zone

Water use

Tropical forest loss

Domesticated land
‘Bleak’ Report on a Planet in Peril Looms Over New Climate Talks

Somini Sengupta Nov. 26, 2019

With world leaders gathering in Madrid next week for their annual bargaining session over how to avert a climate catastrophe, the latest assessment issued by the United Nations said that greenhouse gas emissions are still rising dangerously.

“The summary findings are bleak,” said the annual assessment, which is produced by the United Nations Environment Program.
“I wish it need not have happened in my time," said Frodo. "So do I," said Gandalf, "and so do all who live to see such times. But that is not for them to decide. All we have to decide is what to do with the time that is given us.” — J.R.R. Tolkien, The Fellowship of the Ring
I hope we've done a good job of moving you along on your adventure and that this leg of the journey was interesting and useful.