Ecological Cascades

“In light of recent events, I’m afraid I’m going to have to eat some of you.”
1. What is a trophic cascade? Give an example described in this paper.
Vocab: Estes et al., 2011

• Synergistically – so happy together
• Perturbation – small disturbance
• Motile - mobile but for single celled organisms
• Autotroph - self feeding, plants, phytoplankton
• Zooplankton – animal plankton
• Phytoplankton – plant plankton
• Photic/aphotic - light in ocean
• Diatom - silicate cell wall, phytoplankton
• Pelagic – coastal, surface water zone
Cascading Effects of Top-Predator Loss

- Predators control the populations of prey
- Without that top-down control, prey populations expand and in turn reduce populations of whatever they eat
- In terrestrial systems, top predator loss often leads to increased herbivory
Wolves in Yellowstone

https://www.youtube.com/watch?v=ysa5OBhXz-Q
Cascading Effects of Top-Predator Loss

Berger et al., 2001
Elk browse juvenile trees and strip bark from adult aspen
Yellowstone wolf re-introduction

1988 (no wolves)

2004 (10 years post wolf reintroduction)

Juvenile willow recruitment

Ripple & Beschta, 2006
Animal Behavior Changes with loss of Predators

Moose vigilance in response to sound

Berger et al., 2001
Cougar loss in Zion National Park

No juvenile cottonwood due to mule deer browse

Ripple & Beschta, 2006
Cougar loss in Zion National Park

Young cottonwood seedlings & saplings are absent with no top-down control on mule deer.

Tree recruitment date

Ripple & Beschta, 2006
Cougar loss in Zion National Park

Lack of riparian vegetation alters stream morphology (wider, shallower, more erosion)
Cougar loss in Zion National Park

Ripple & Beschta, 2006
Cascading Effects of Top-Predator Loss Addition (Invasive Mongoose)

Mongoose eats

Eaten by mongoose prey

Close to mongoose introduction
Loss of top predator sharks

1200 lb hammerhead caught off the coast of Australia
Ecological cascades: Loss of top ocean predators

Myers et al., 2007
Ecological cascades: Loss of top ocean predators

Major economic consequences on N. Carolina scallop fisheries

Myers et al., 2007
Losses of abundance also matter

Figure 3
Changes in average body size associated with five functional groups of fish species from the western Scotian Shelf during the past 38 years (1970–2008). Note the large declines in body mass among the heavily exploited piscivore and large benthivore functional groups. Adapted from Reference 112.

Strong & Frank, 2010
Big fish have higher reproduction

Long recovery time of fisheries lacking older, larger fish

Morita & Takashima, 1998
Berkeley et al., 2004
Megafauna Extinctions Revisited:
Massive trophic cascades began 20-50,000 years ago
Large megafauna loss in Pleistocene

N. America

S. America

Australia

Surviving

Extinct

Johnson, 2009
Consequences of loss of top predators

Red = extinct
Consequences of loss of top herbivores

• Conversion of vegetation from patchy savanna mosaics to closed forest
Historical view of European habitat prior to human alteration
Updated view of European habitat prior to human alteration?

Oostvaardersplassen

• Reintroduction (rewilding) of large herbivores in 1968
Consequences of loss of top herbivores

• Conversion of vegetation from patchy savanna mosaics to closed forest
• Increased fire frequency and extent
Fire frequency spikes after mega-herbivore loss

Gill et al., 2009
Fire frequency spikes after mega-herbivore loss

Human expansion in Australia

Rule et al., 2012
Consequences of loss of top herbivores

- Conversion of vegetation from patchy savanna mosaics to closed forest
- Increased fire frequency and extent
- Decline of co-evolved plants
Trees with giant fruits evolved for mega-herbivore dispersal

Figure 2. Fleshy fruited megafaunal-dependent species illustrating size, shape, and color variation. a, Attalea speciosa, Arecaceae; b, Mouriri elliptica, Melastomataceae; c, Hymenaea stigonocarpa, Fabaceae; d, Genipa americana, Rubiaceae; e, Salacia elliptica, Celastraceae; f, Annona dioica, Annonaceae. Black reference line is 2 cm length. Photos from Fazenda Rio Negro, Pantanal, Brazil; by PJ, MG, and Camila I. Donatti. doi:10.1371/journal.pone.0001745.g002

Guimaraes Jr. et al., 2008
Trees with giant fruits evolved for mega-herbivore dispersal

Guimaraes Jr. et al., 2008
Osage orange (*Maclura pomifera*)

- Native to N. America
- Giant seedy fruit
- Structural defenses
- Nothing eats them today
Pronghorn (*Antilocapra americana*)

- Fastest land animal in N. America (up to 60 mph)
- Likely hunted by extinct N. American cheetah
Challenges

• Trophic cascades are hard to predict

Estes et al., 2011
Challenges

• Trophic cascades are hard to predict

• Many ecosystems lost top predators or herbivores thousands of years ago
Challenges

• Trophic cascades are hard to predict
• Many ecosystems lost top predators or herbivores thousands of years ago
• How do we restore ecosystems with trophic downgrading?

Bolson tortoise, poster child of rewilding
Discuss remaining questions from Estes et al., 2011

2. What is a ‘natural experiment’? Why does much of our knowledge about trophic cascades stem from natural experiments?

3. Losses of top herbivores are thought to have led to an increase in wildfire globally. Explain why.

4. Why is the loss of a species of plant or phytoplankton less likely to create an ecological cascade than the loss of a top predator?

5. Describe one other piece of information you thought was interesting in this paper.