

Quick icebreaker!

Sit in groups of three and introduce yourself. Please discuss the following:

- Name
- Major/Minor
- Year
- Favorite class taken so far
- Something interesting about you

Chapter 1: The Ecosystem Concept

Principles of Terrestrial Ecosystem Ecology

January 22, 2025

What is ecosystem ecology?

What is ecosystem **ecology**?

The study of relationships between organisms and:

- (1) Each other
- (2) The environment

What is ecosystem **ecology**?

The study of relationships between organisms and:

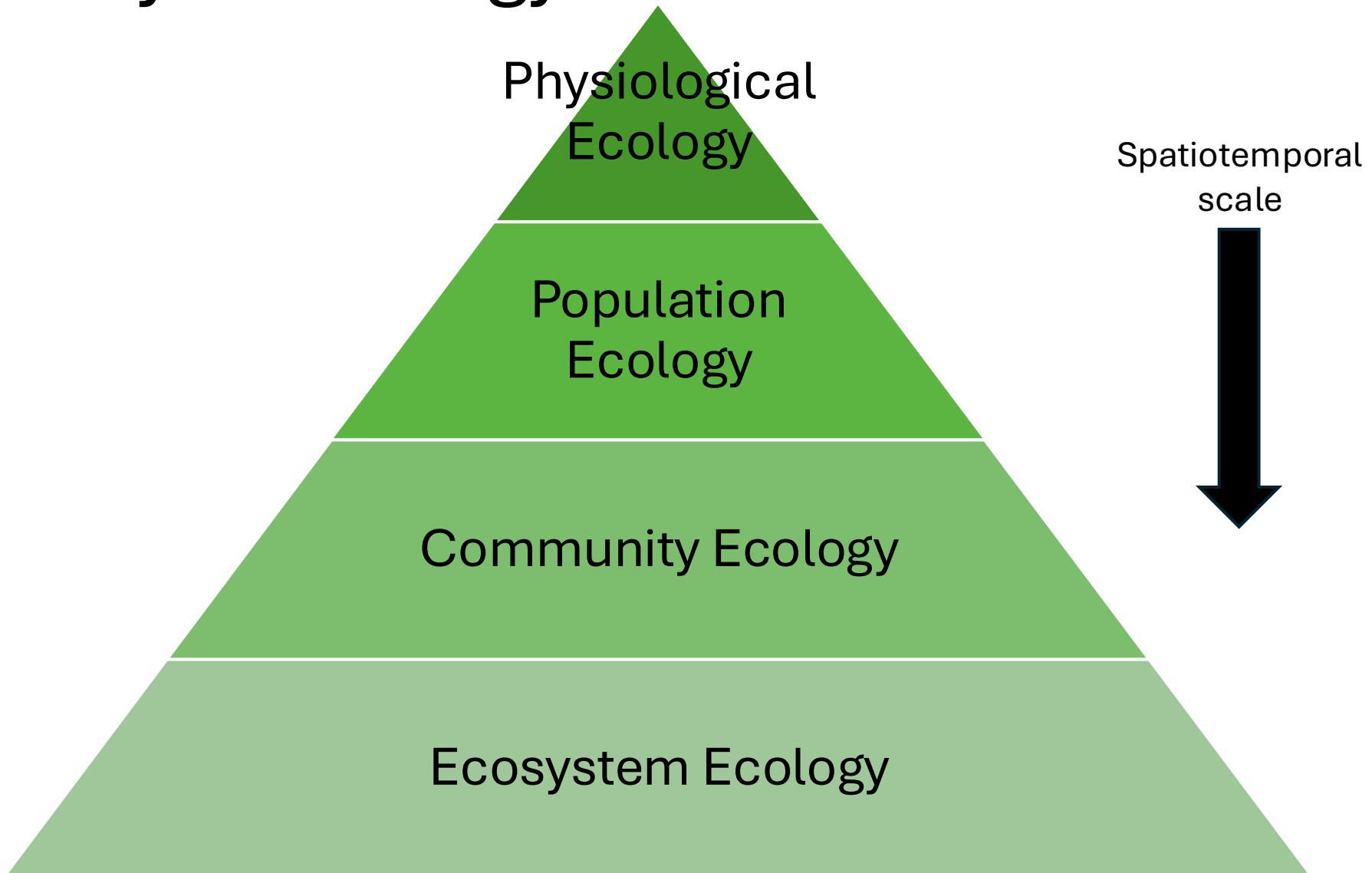
- (1) Each other (the biotic environment)
- (2) The environment (the abiotic environment)

What aspects of the **abiotic** and
biotic environment influence
organismal functioning?

What aspects of the **abiotic** and **biotic** environment influence organismal functioning?

Pick an organism (human, microbe, dog, etc.) and list a few abiotic and biotic factors that might influence how that organism functions in an environment

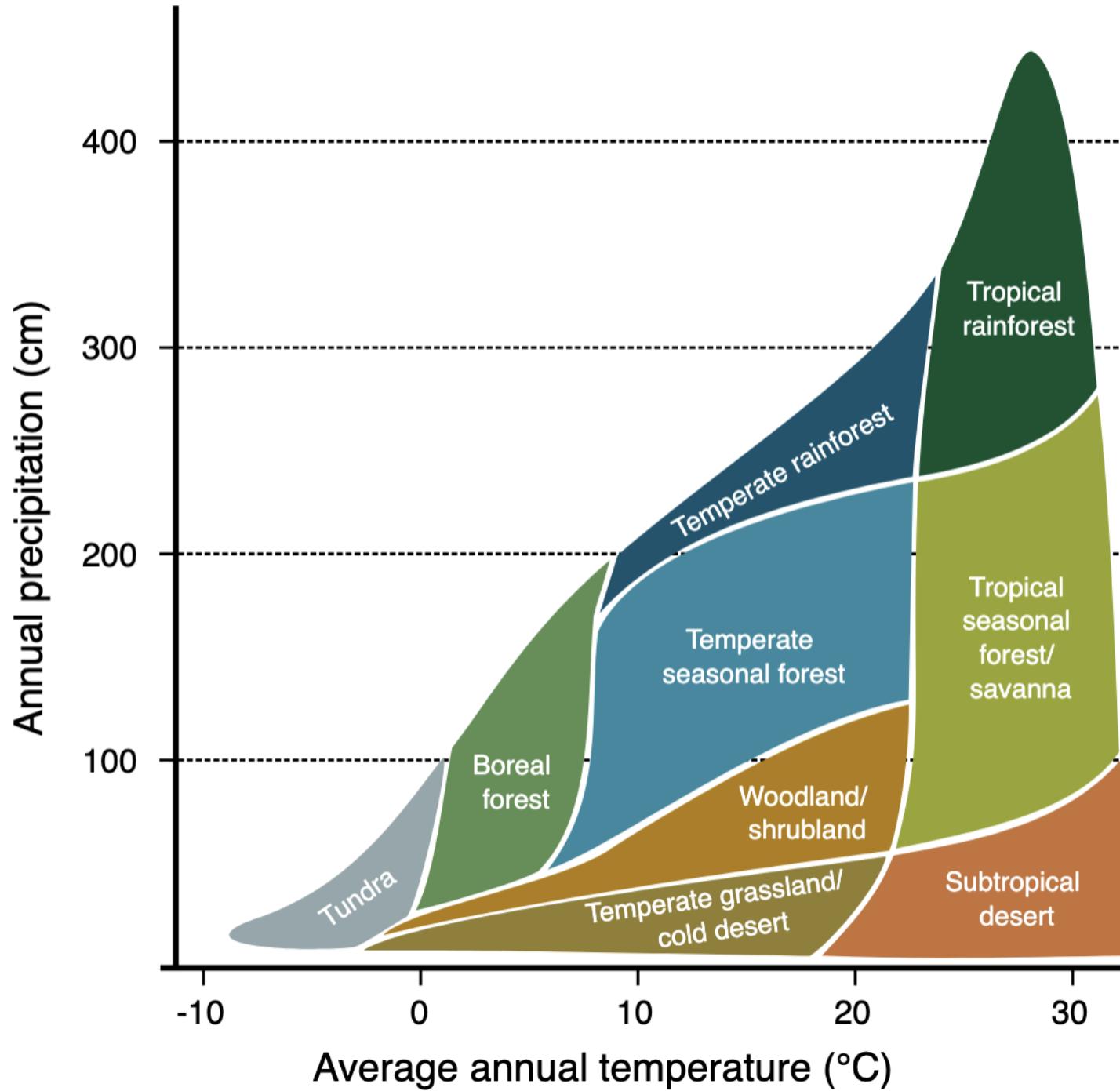
Hierarchy of Ecology



What is ecosystem ecology?

A system that includes all interactions among and between organisms and their environment.

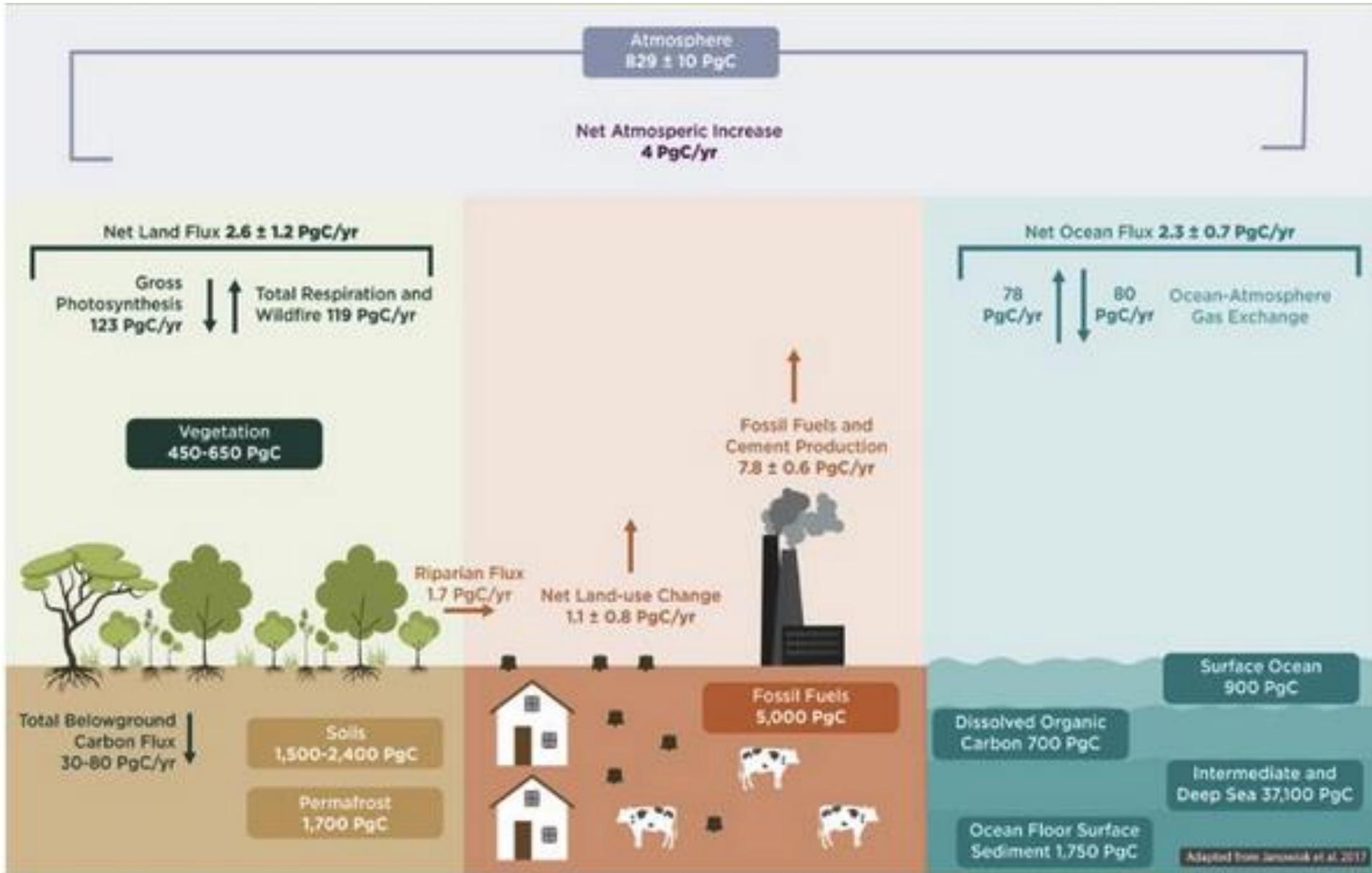
What are some examples of ecosystems?



Ecosystem ecology is the study of the interactions between organisms and their environment as an integrated system

Ecosystem ecology is a game of pools and fluxes

- Ecosystem ecologists seek to understand factors that regulate pools and fluxes of materials and energy through ecological systems
 - **Pools** – quantities of a given material/energy (e.g., carbon, water, nitrogen)
 - **Fluxes** – flows of a given material/energy (e.g., photosynthesis, respiration)
- **Ecosystem processes** describe the transfer of energy and materials from one pool to another (i.e., a flux)



Adapted from Janssens et al. 2017

Ecosystem ecology seeks to answer questions like:

- Why do tropical forests have large trees but accumulate only a thin layer of dead leaves at the soil surface, while the tundra supports small plants but an abundance of organic matter at the soil surface?
- Why does the concentration of carbon dioxide in the atmosphere decrease in the summer and increase in the winter?
- What happens to nitrogen fertilizer that farmers add to their fields but do not harvest with the crop?

Ecosystem processes can be studied at many spatial scales

Scale is very important when considering certain questions in ecosystem ecology!

a

Global ecosystem

5,000 km



How does carbon loss from plowed soils influence global climate?

b

Drainage basin

10 km

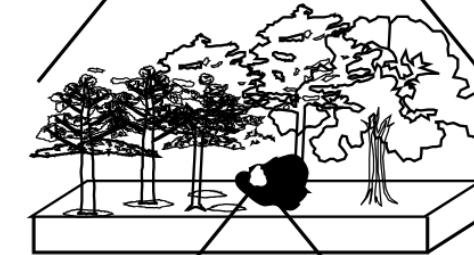


How does deforestation influence the water supply to neighboring towns?

c

Forest ecosystem

1 km

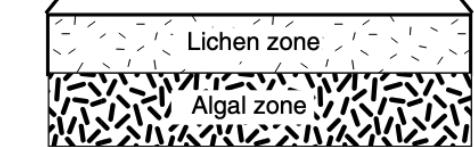


How does acid rain influence forest productivity?

d

Endolithic ecosystem

1 mm

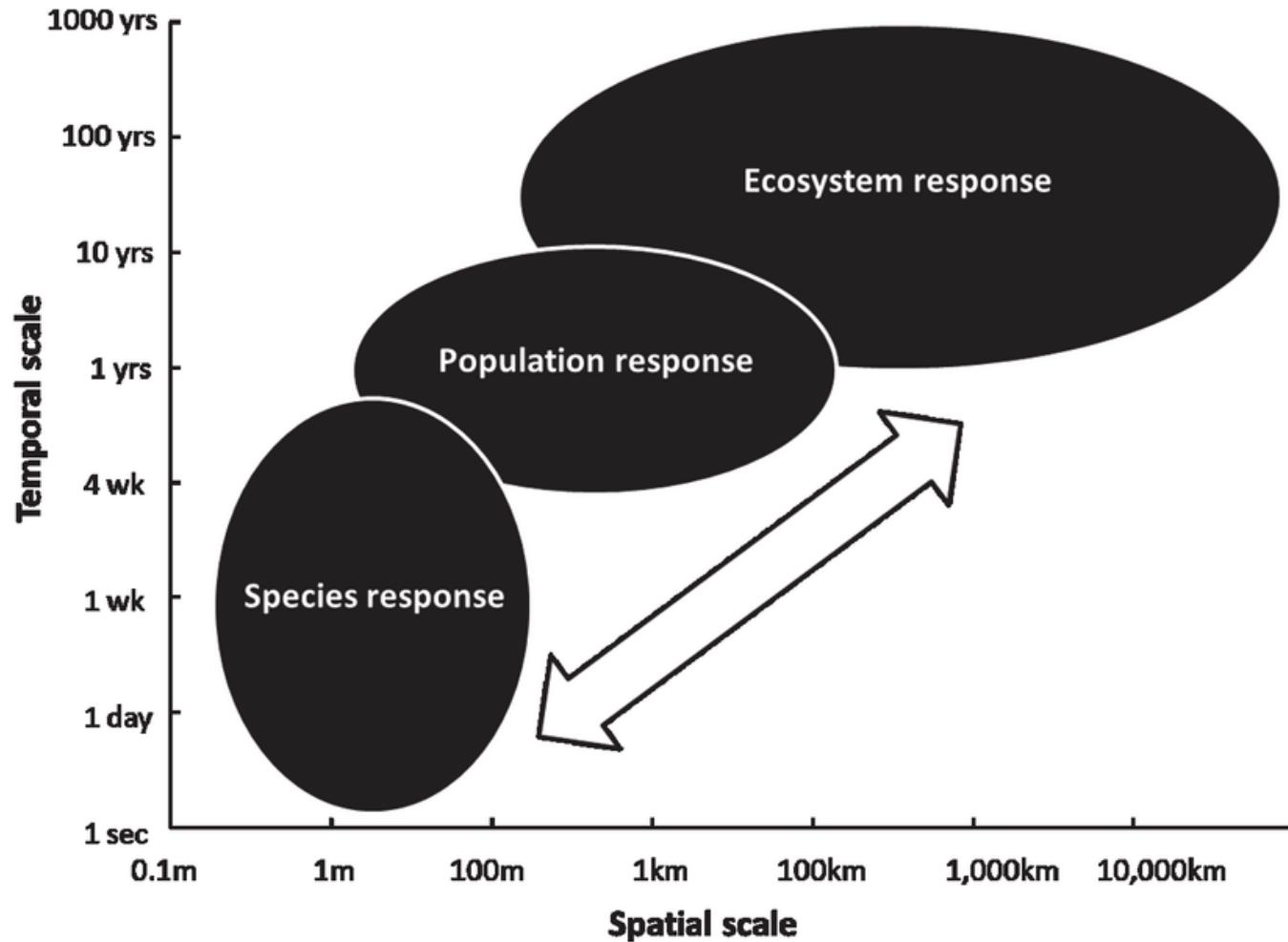


What are the biological controls over rock weathering? ¹²

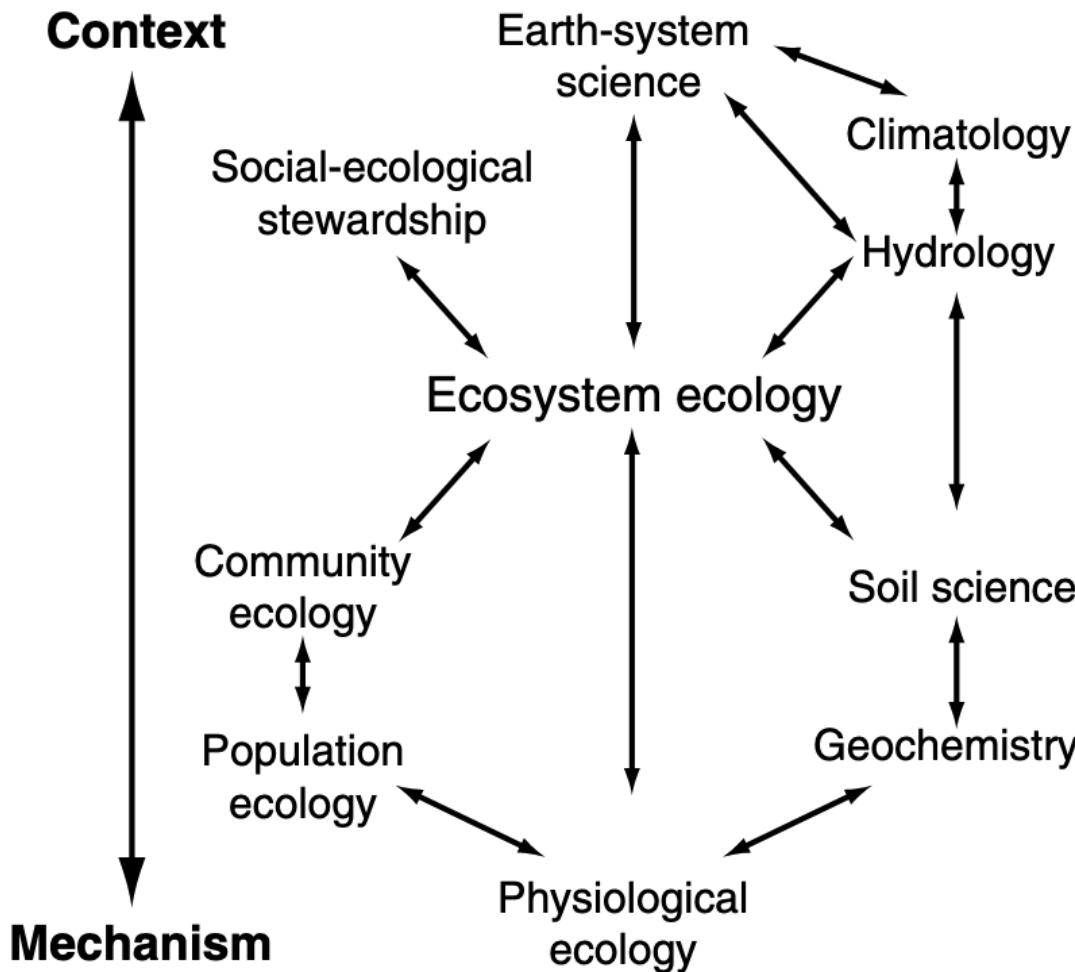
What are some examples of ecosystem processes?

What scale might these processes be measured?

Ecosystem processes are an **emergent property**
product of different ecological hierarchies



Given this, ecosystem ecology depends on information from physiological, population, and community ecology

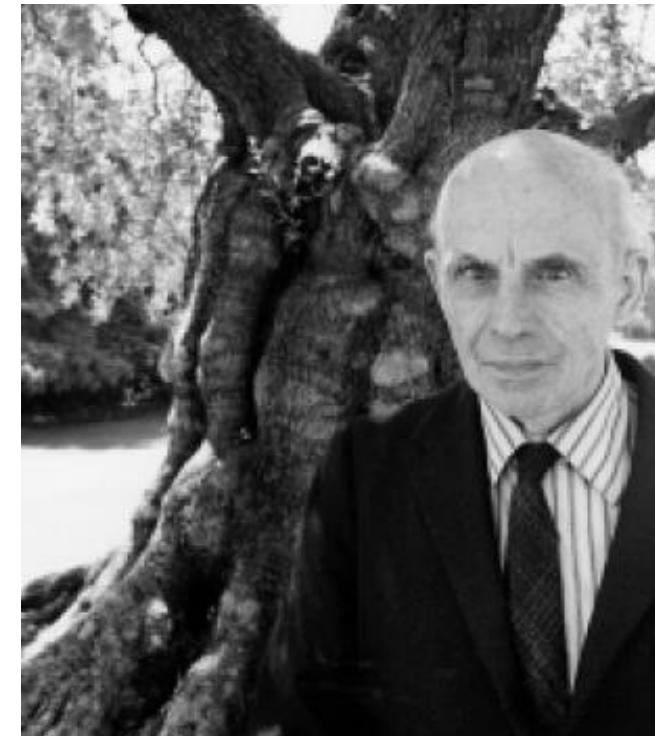


It also integrates several other study disciplines, including those from social sciences!

Ecosystem processes are regulated by several state factors

Hans Jenny (US soil scientist) in 1941 first to formalize a quantitative model of soil formation as well as the “state factors” that set the bounds for characteristics of an ecosystem:

**S = f (climate,
organisms,
relief/topography,
parent material, time)**



Climate



- * Precipitation
- * Temperature

Climate

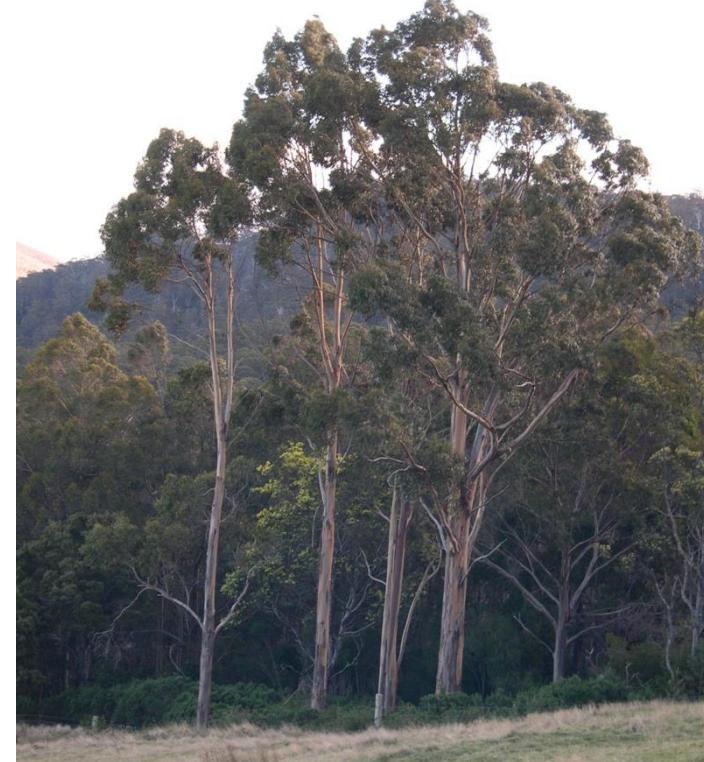


Wet ----- Dry

cl
O
R
P
T



Organisms



Organisms



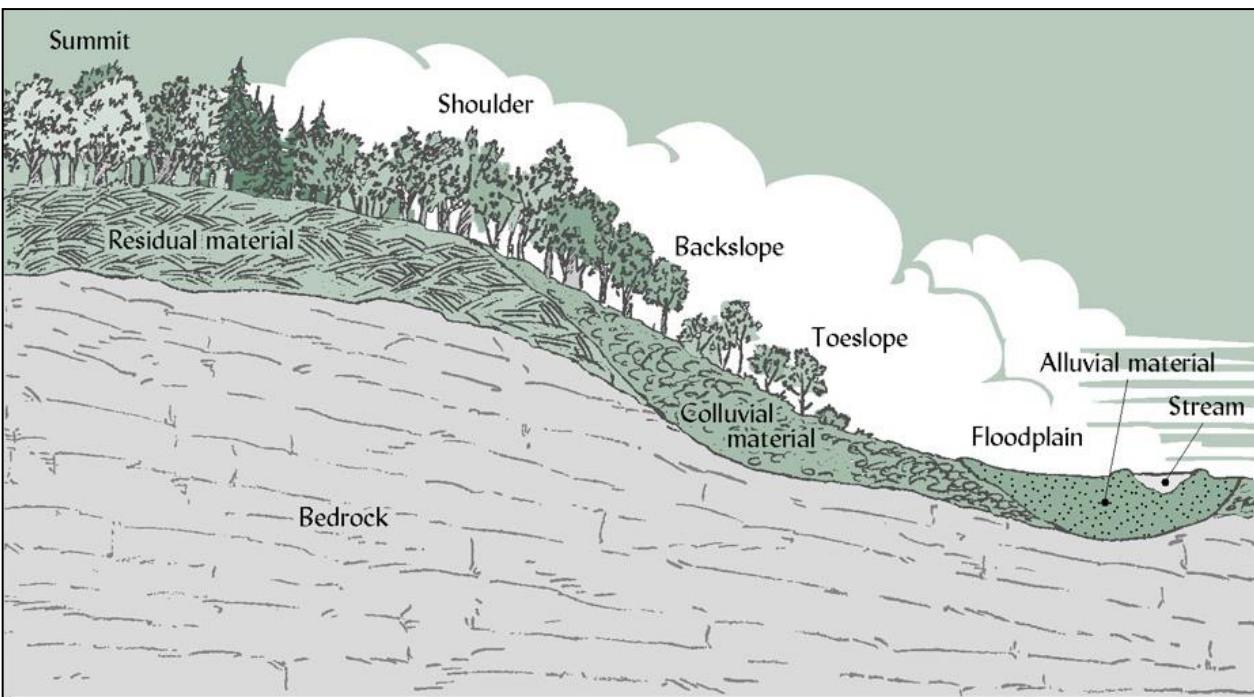
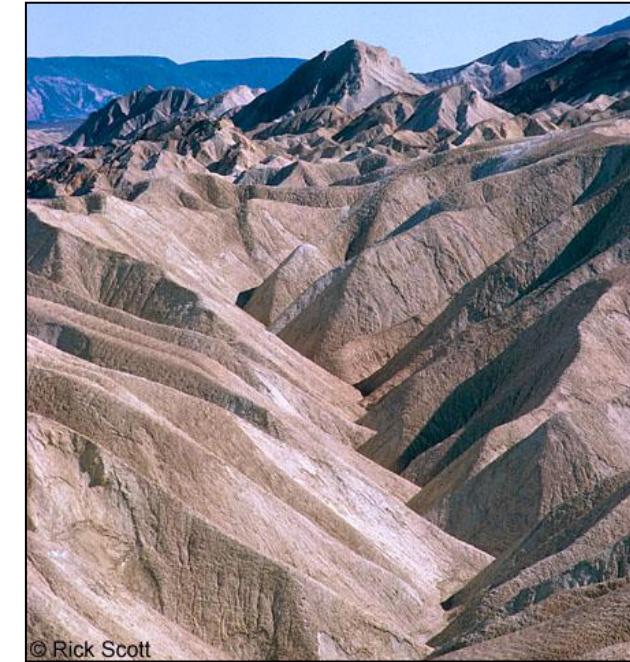
Diverse ----- Depauperate

cl

o

R Relief/Topography

P
T

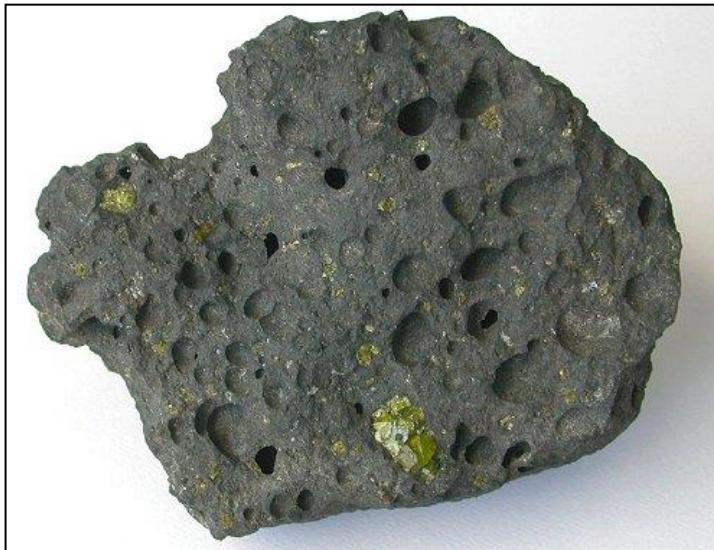


Topography



Steep ----- Flat

C
L
O
R



Igneous (basalt)



Metamorphic (schist)

P Parent Material

T

Sedimentary
(sandstone)



Parent Material



Igneous

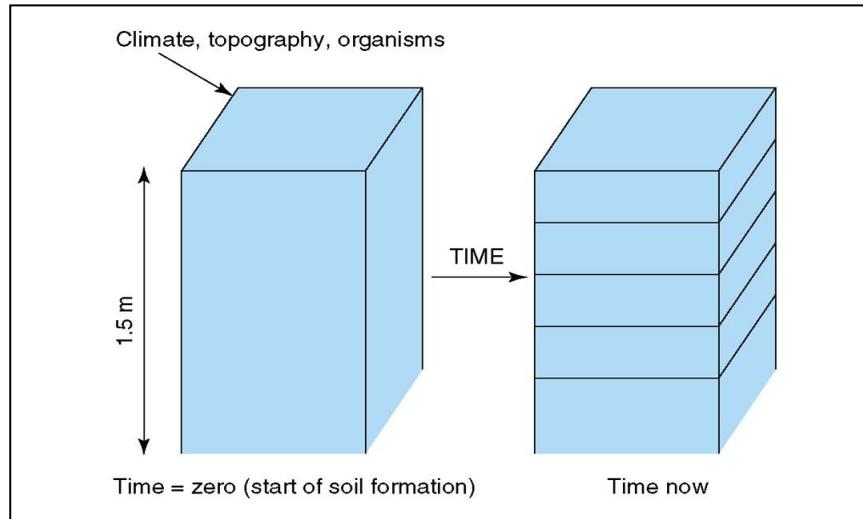
Sedimentary

Basalt

CL
O
R
P
T

Time

Development of Soil



Evolution



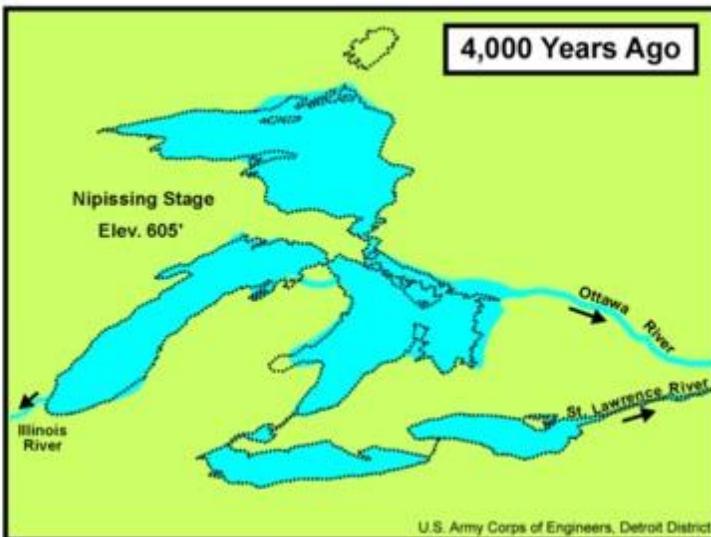
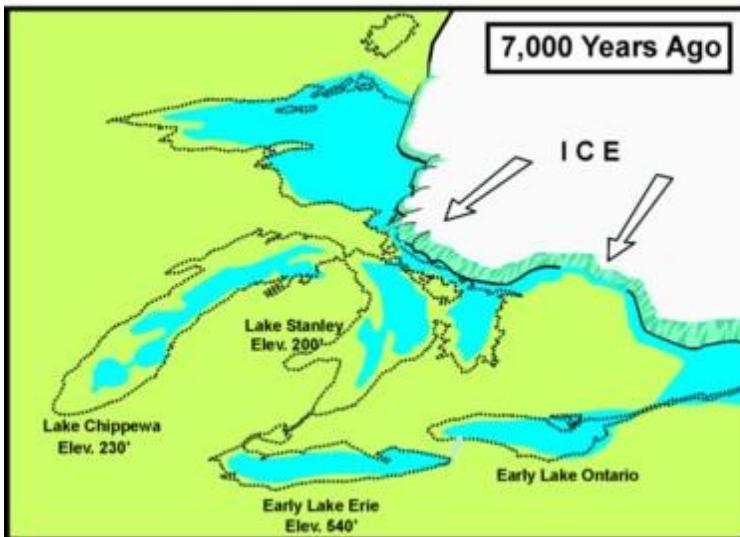
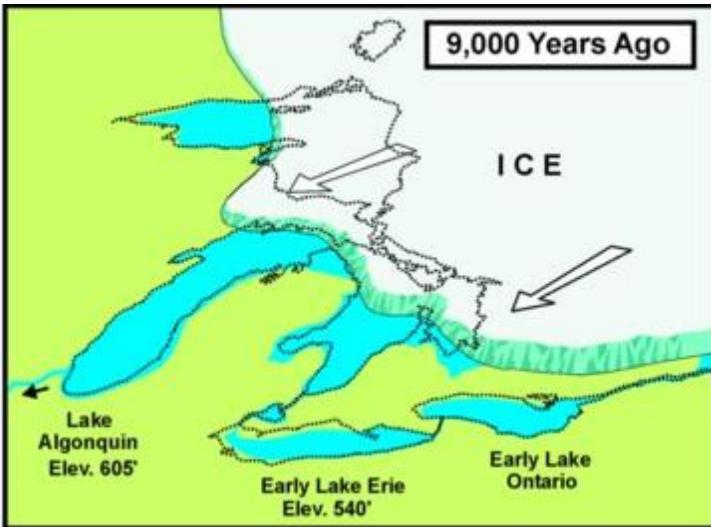
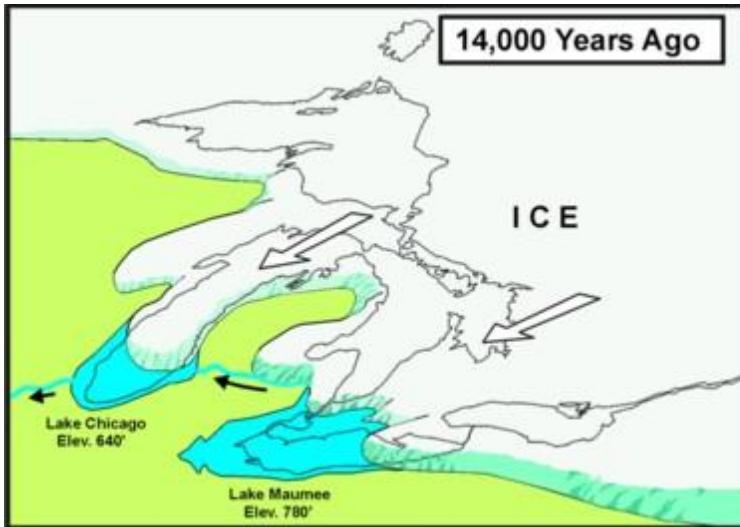
Time



Old ----- Recent

Example: succession is the result
of state factor changes

Lake Michigan dunes



U.S. Army Corps of Engineers, Detroit District

Lake Michigan dunes

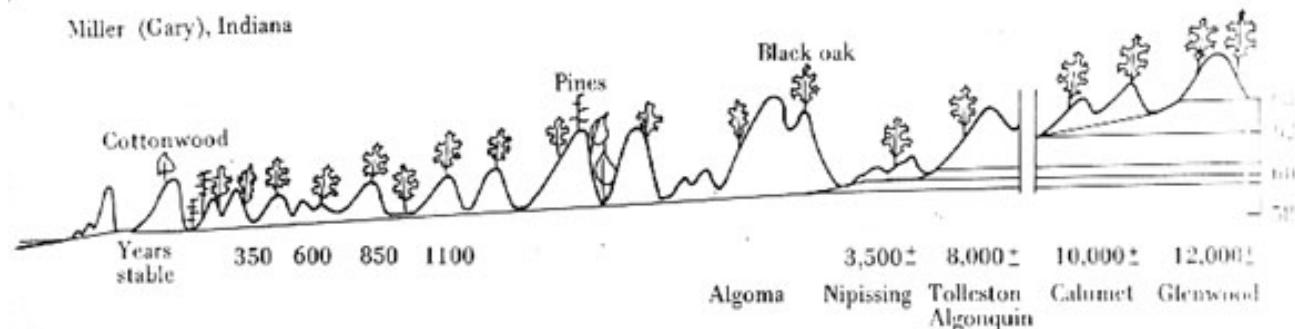
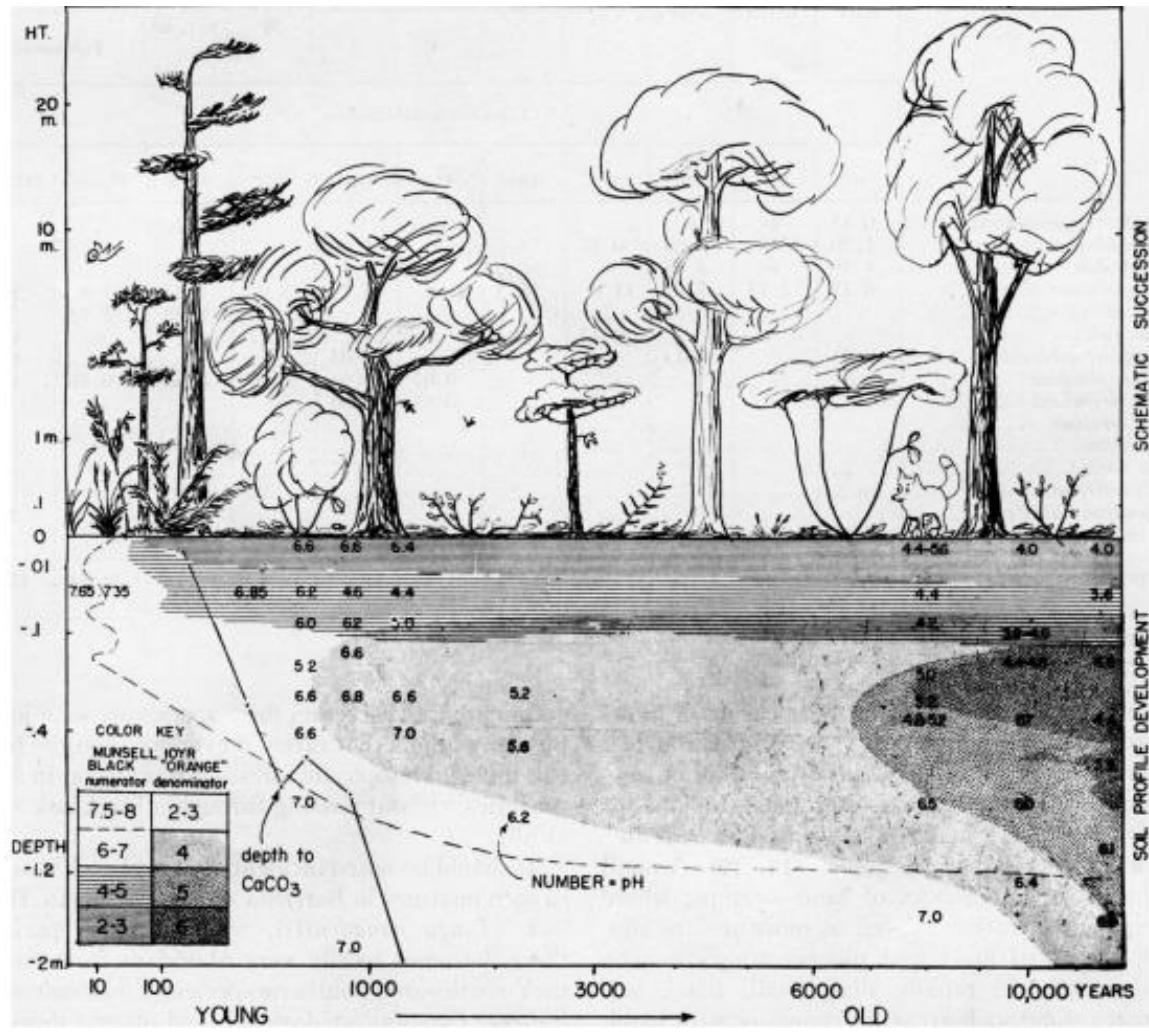
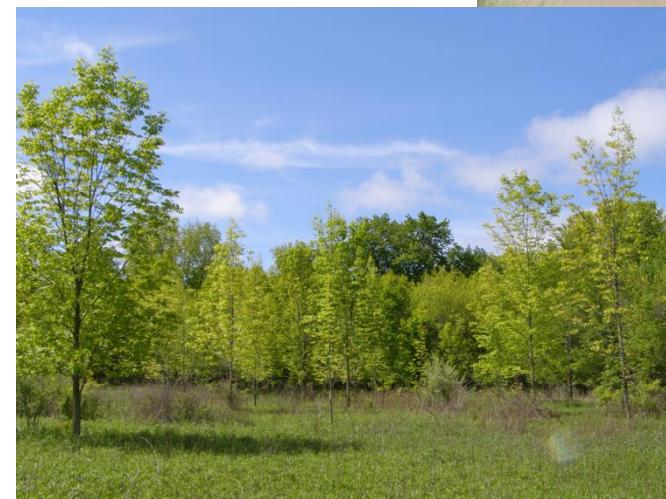


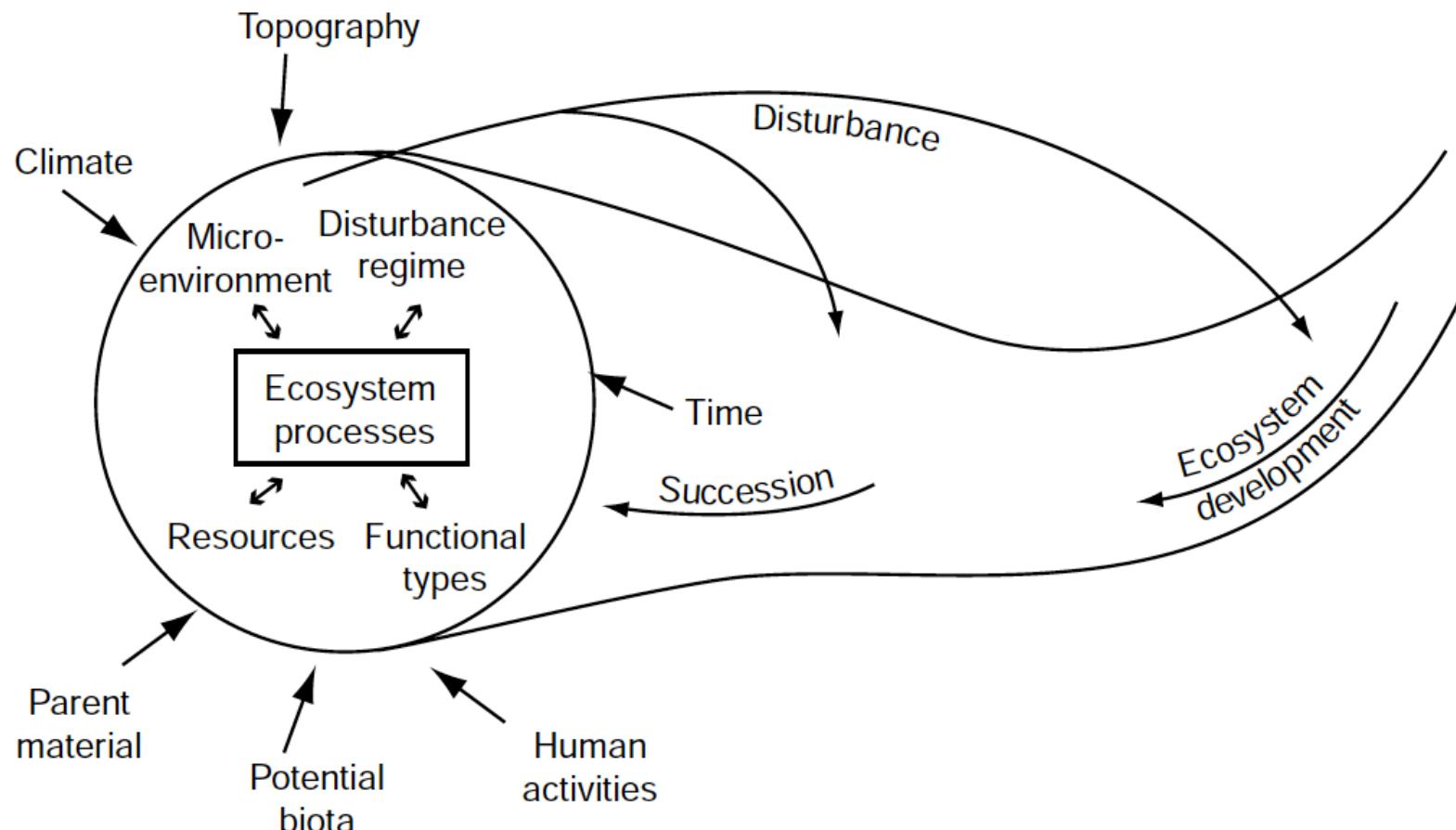
Figure 22.4. Diagrammatic profiles across Indiana sand dunes at the southern end of Lake Michigan. Successively older dune systems originated along earlier and higher beaches. (After Olson 1958.)

Lake Michigan dunes

- Beaches
 - Low nutrient environments
 - Unstable soils
 - Few plants (sea rocket)
- Foredunes
 - Soil stabilized by grasses
 - Low nutrient soils
 - Grasses and wildflowers
- Dune forests
 - Better soils
 - Competition is for light (tall plants)

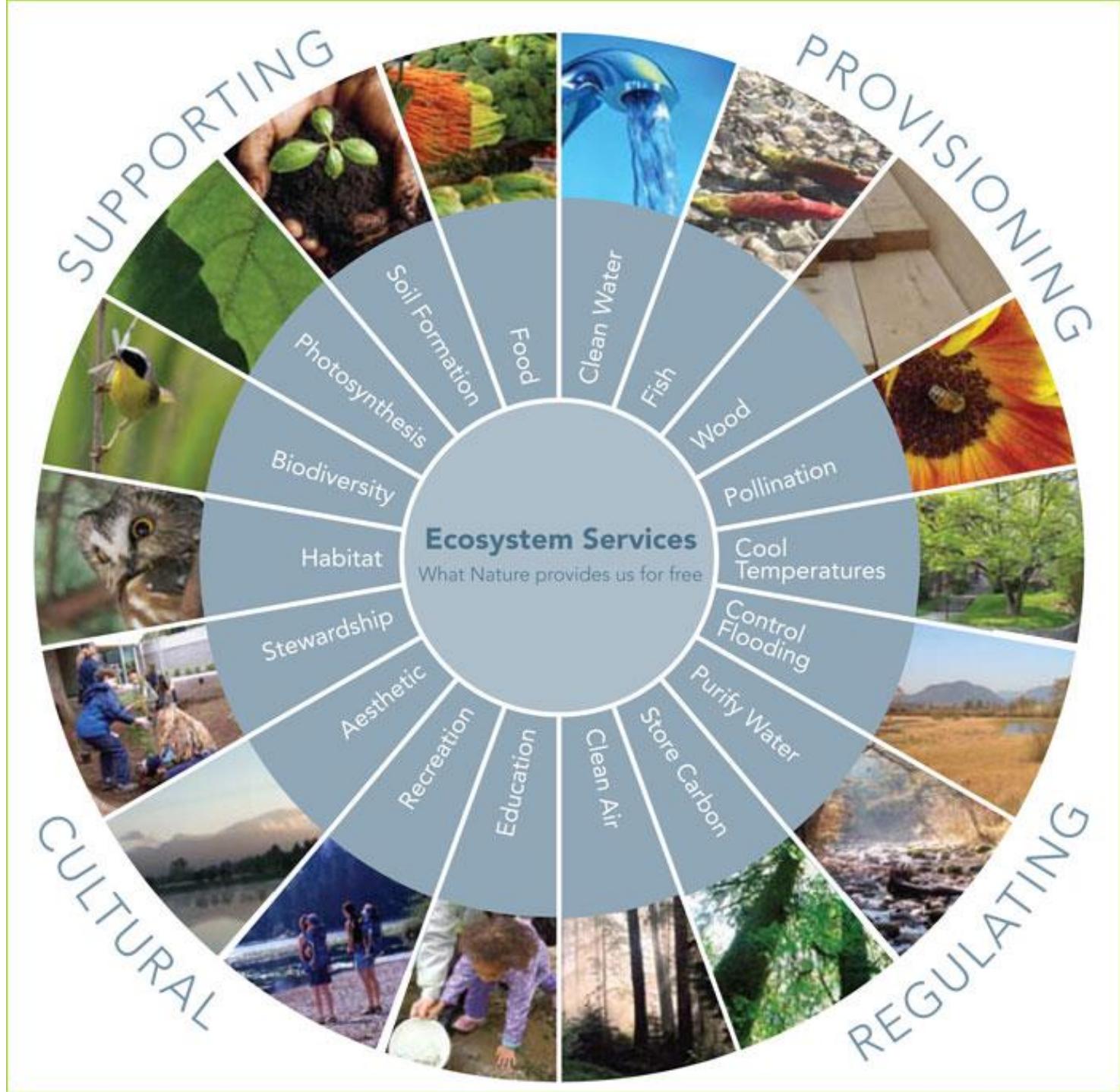


Ecosystem processes are driven by multiple interacting factors (including state factors)



Ecosystem services: “things an ecosystem provides”

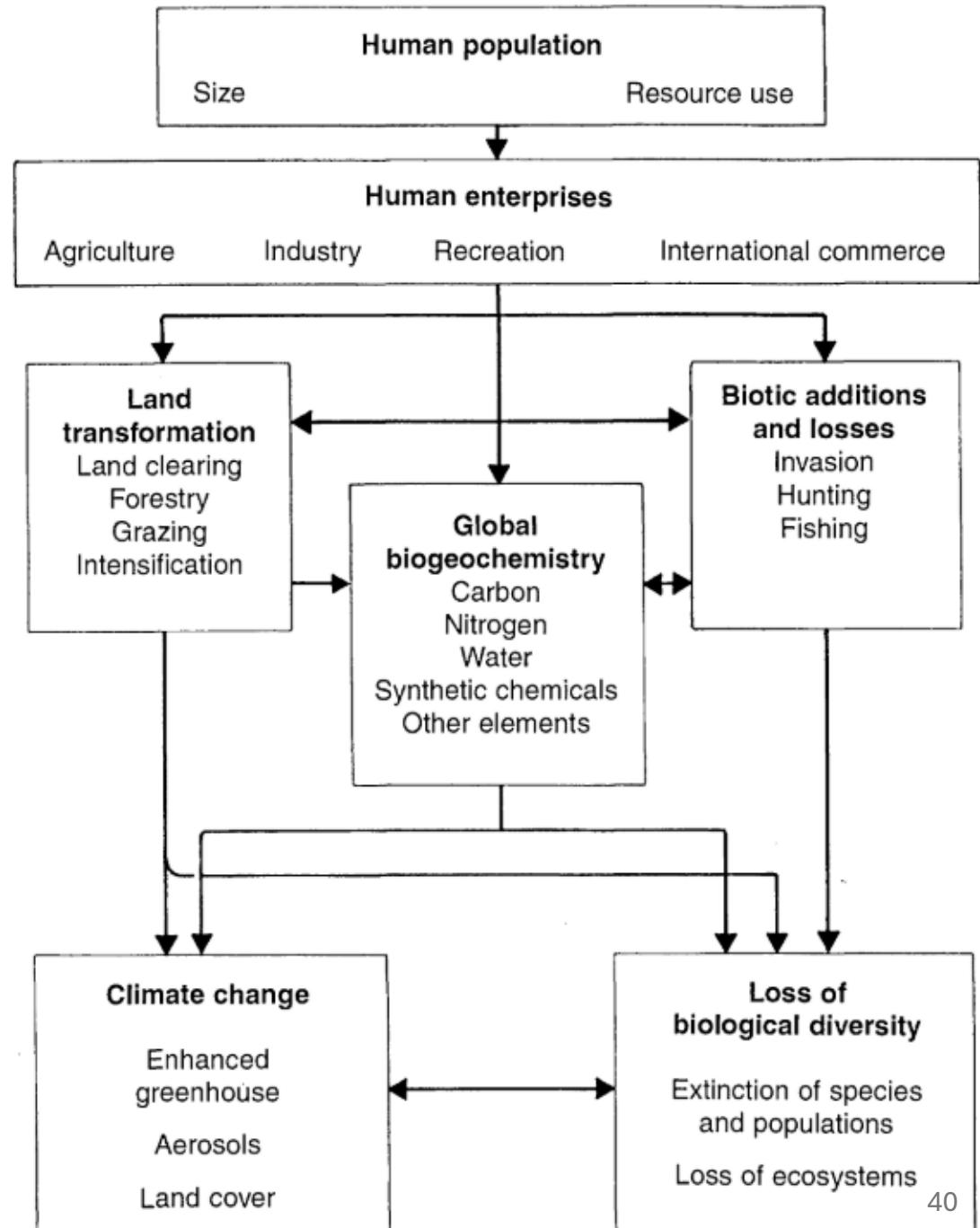
What “services” do humans get from ecosystems?



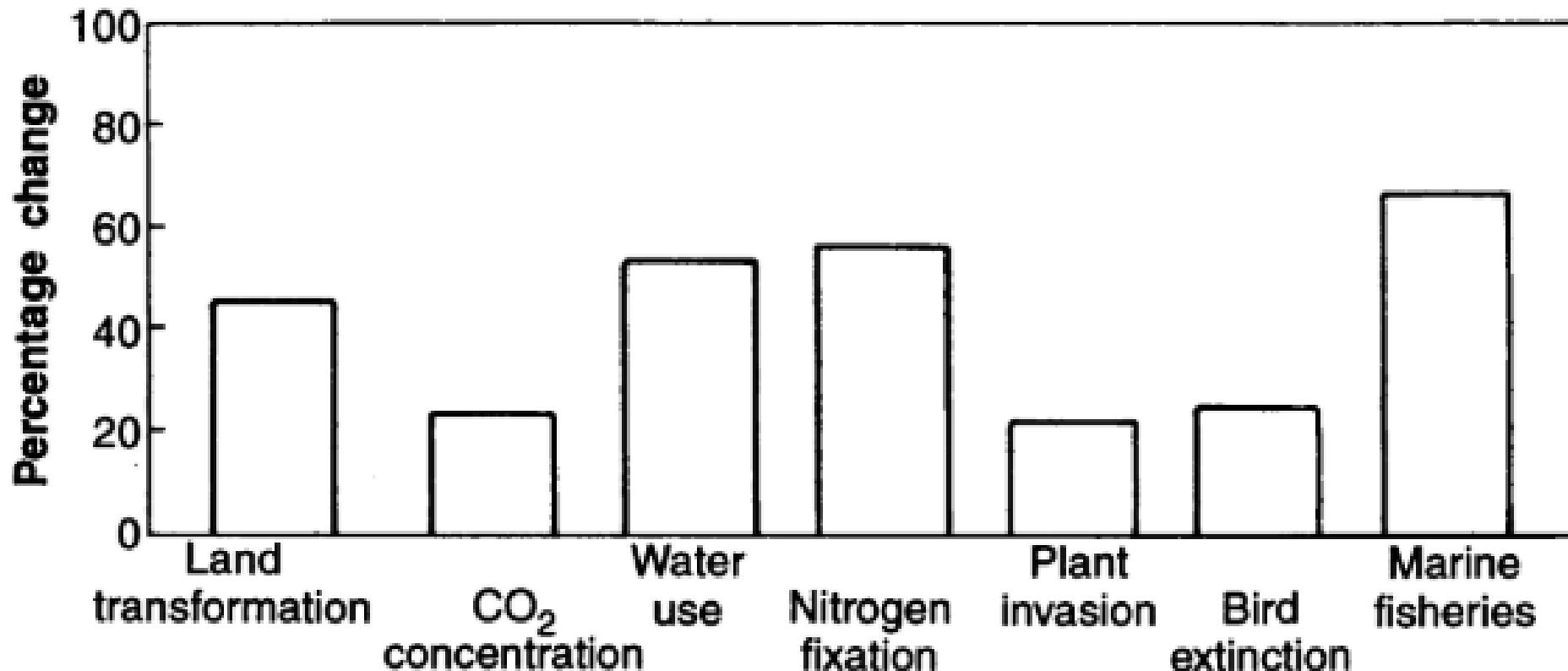
Human Domination of Earth's Ecosystems

Vitousek PM, Mooney HA, Lubchenco H, Melillo JM. 1997. Human domination of Earth's ecosystems. *Science* 277(5325):494-499.

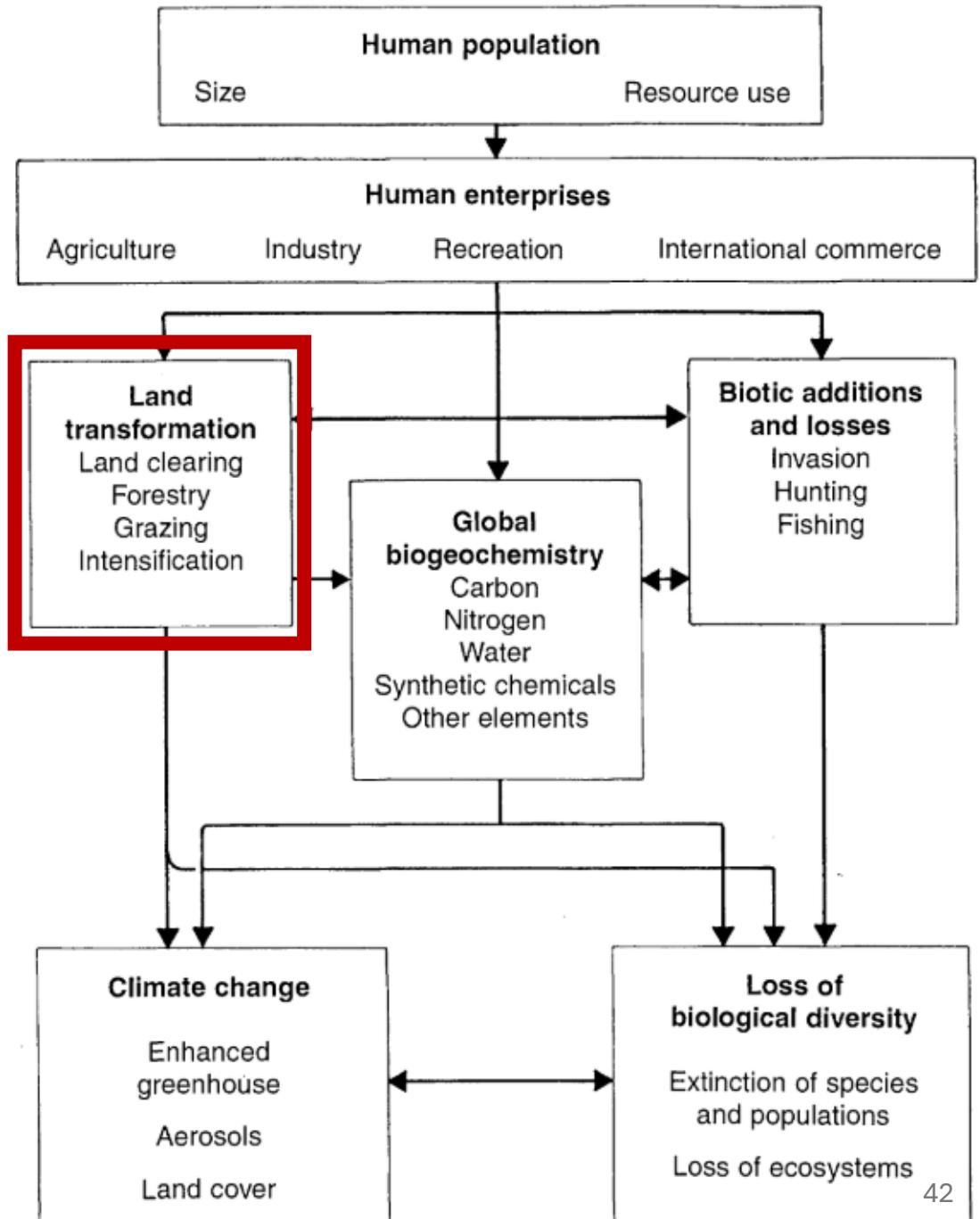
Humans have many direct and indirect effects on the Earth system



Humans have altered several major components of the Earth system



Humans have many direct and indirect effects on the Earth system

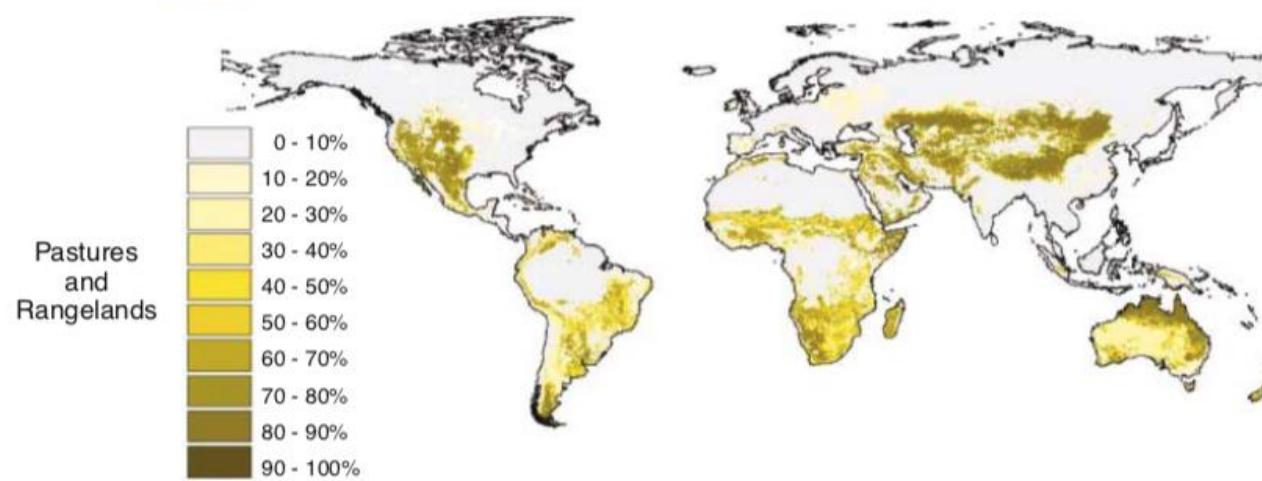
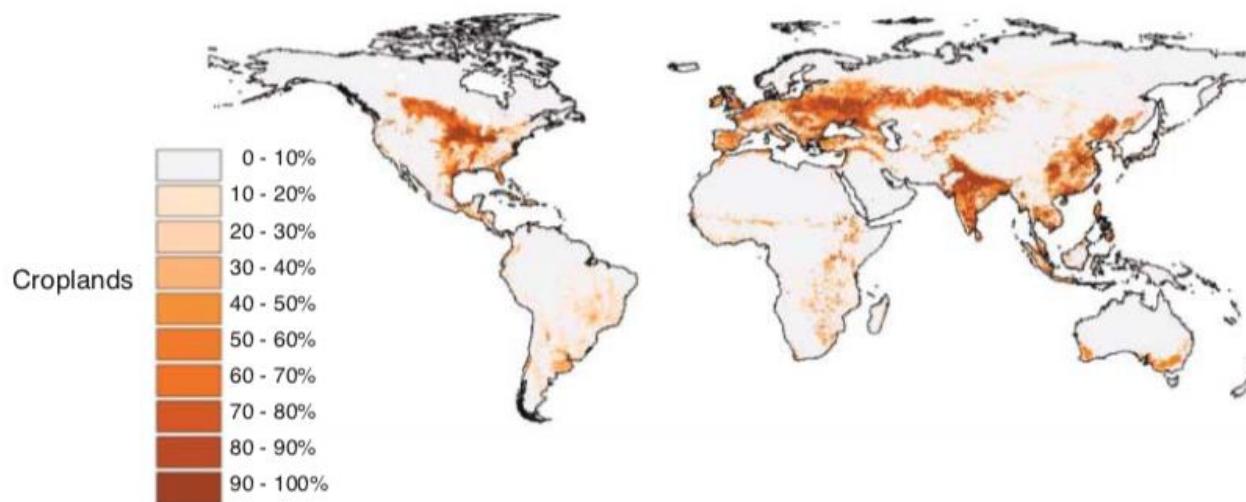
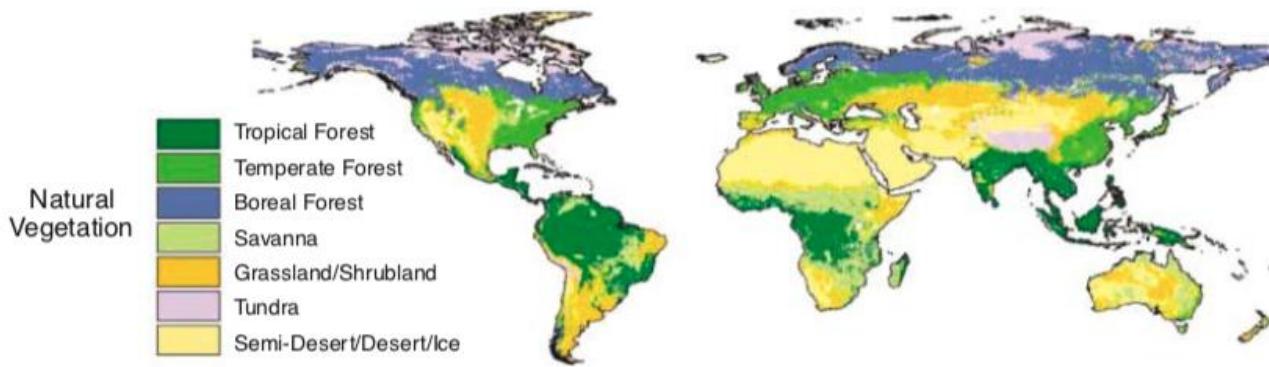


Land transformation

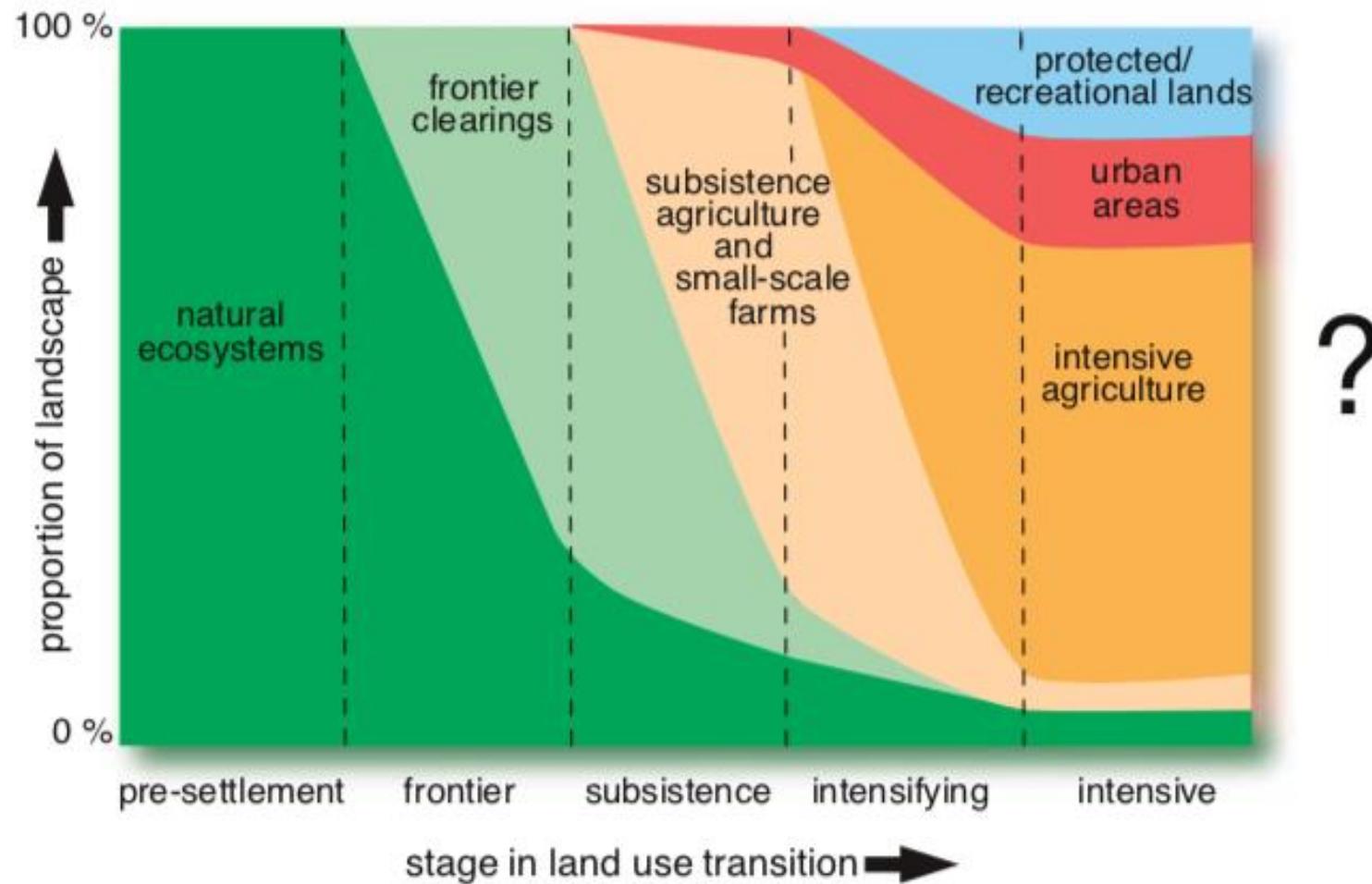
- Nearly 50% of all land has been transformed by humans
- Primary driver of species loss
- 20% of all CO₂ emissions



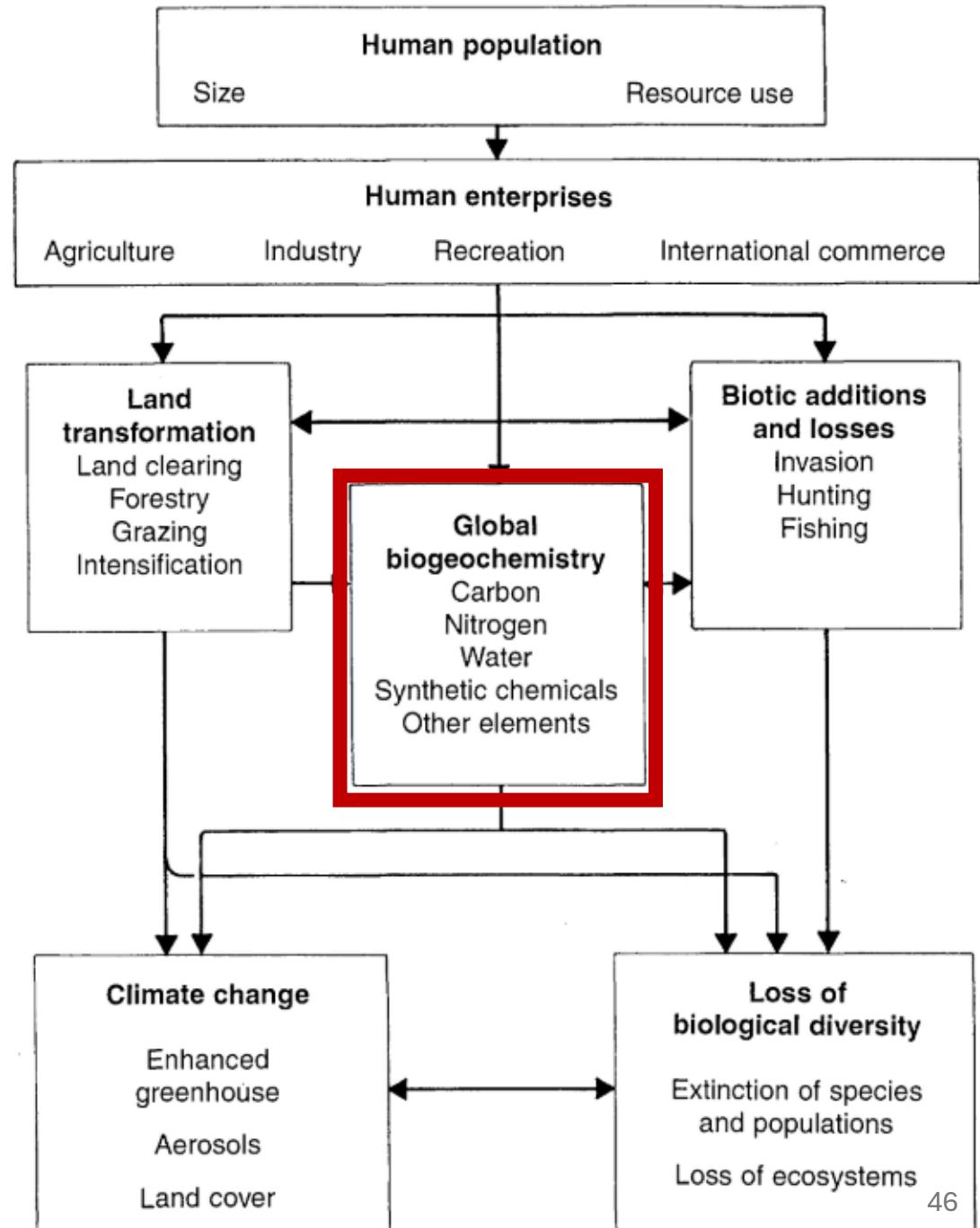
Border between Haiti (left) and Dominican Republic (right)



Progressive land transformation (Foley et al. 2005)

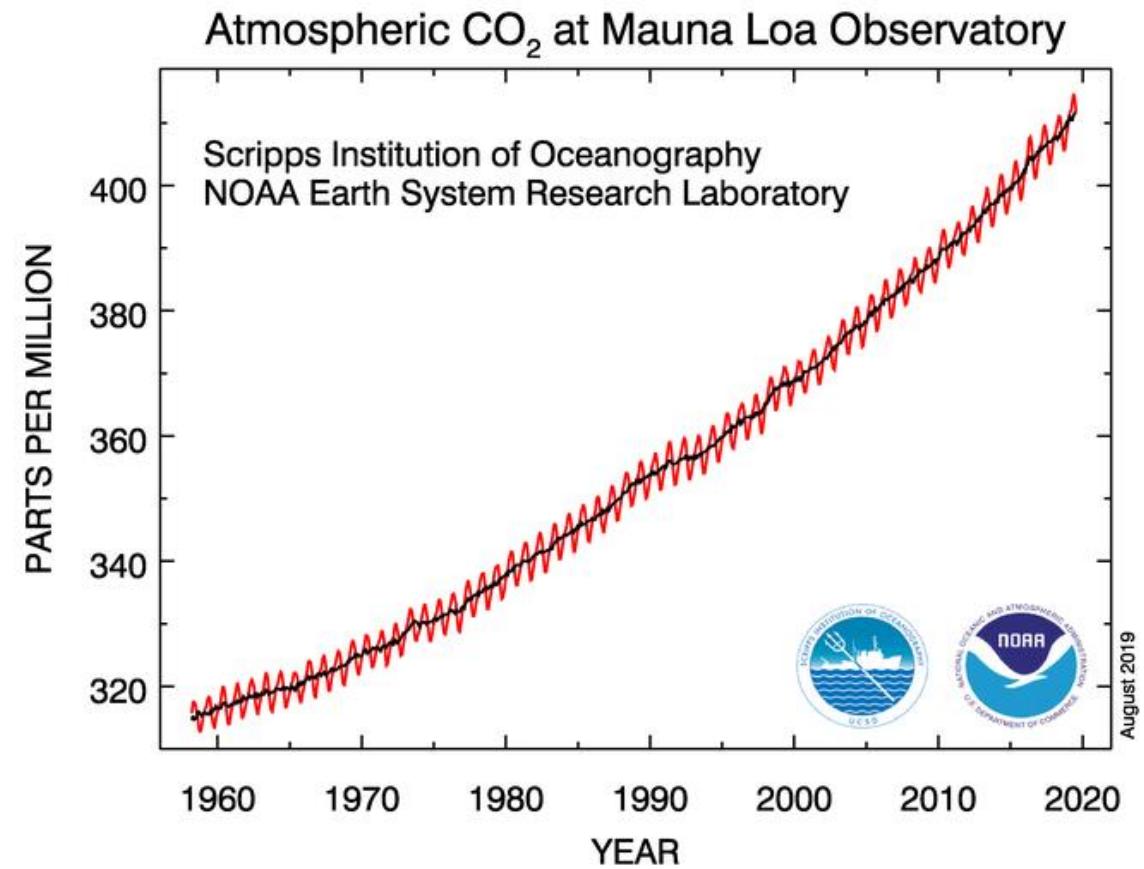


Humans have many direct and indirect effects on the Earth system

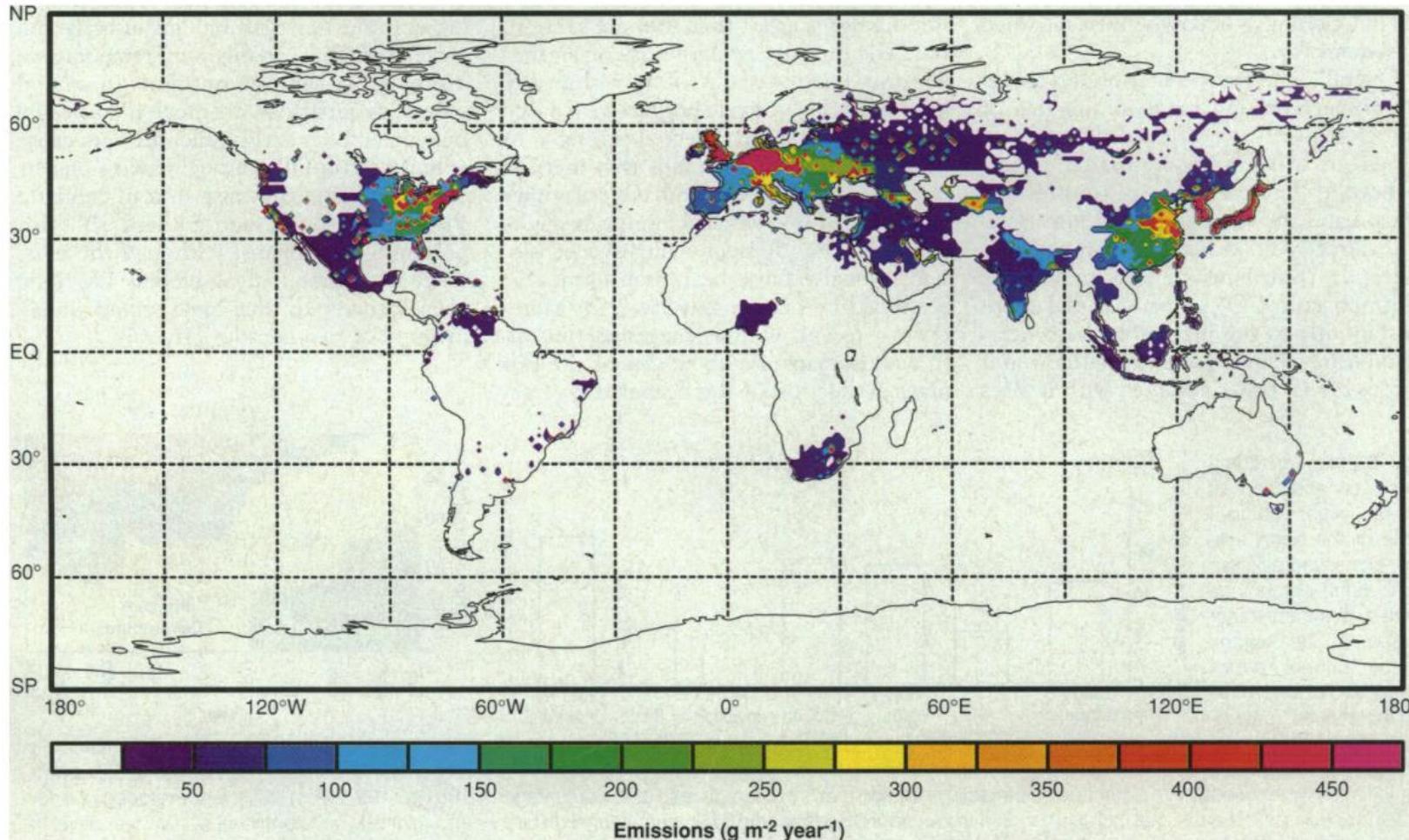


Biogeochemistry - Carbon

- Humans emit 5,500,000 tons of carbon per year
- Ecosystems take up only 2,300,000 tons per year
- Impacts
 - Climate change
 - Ocean acidification
 - Decreased food quality

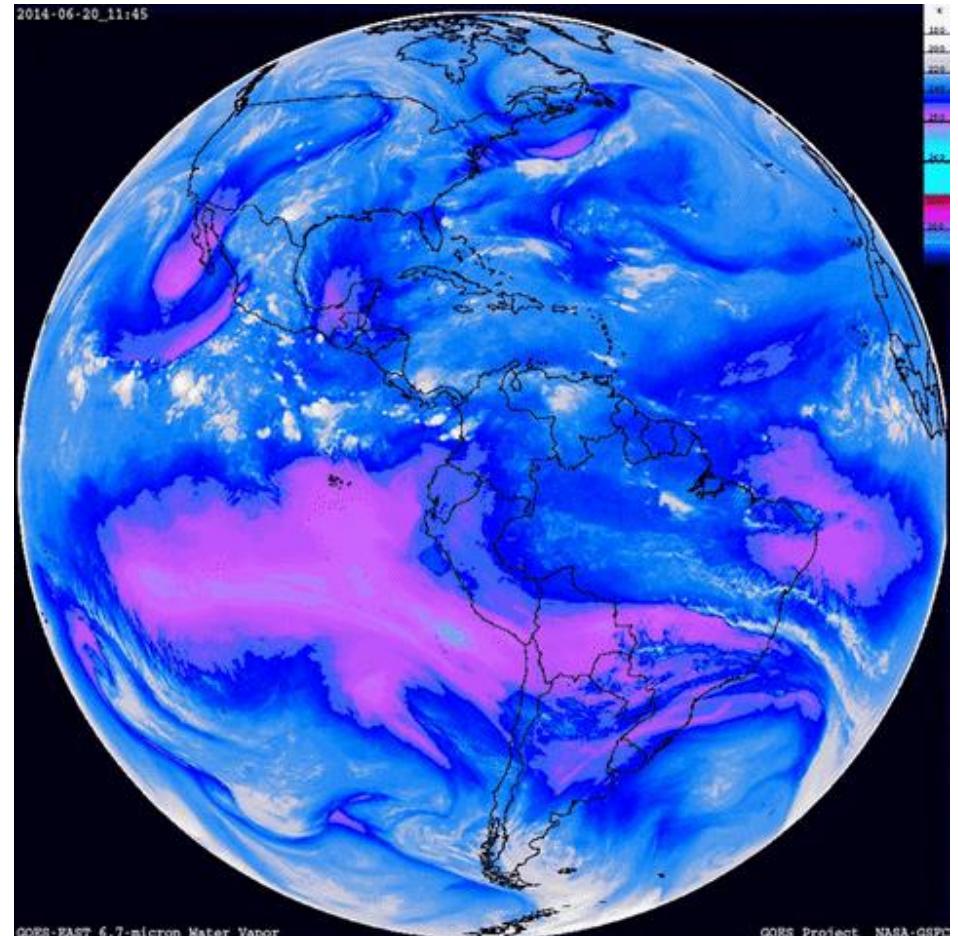


Geographical distribution of fossil fuel CO₂ emissions is highly correlated with urban hubs



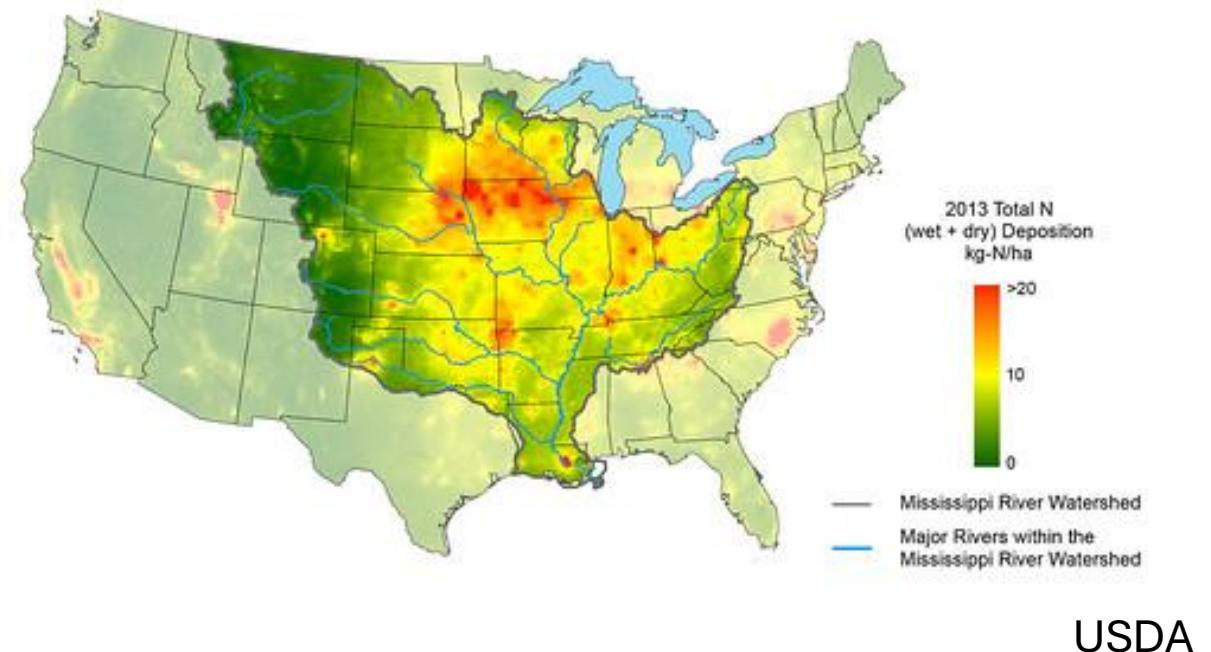
Biogeochemistry - Water

- Humans use 50% of accessible freshwater
 - 70% of that in agriculture!
- Water travels long distances
 - Water use can impact climate locally and far away

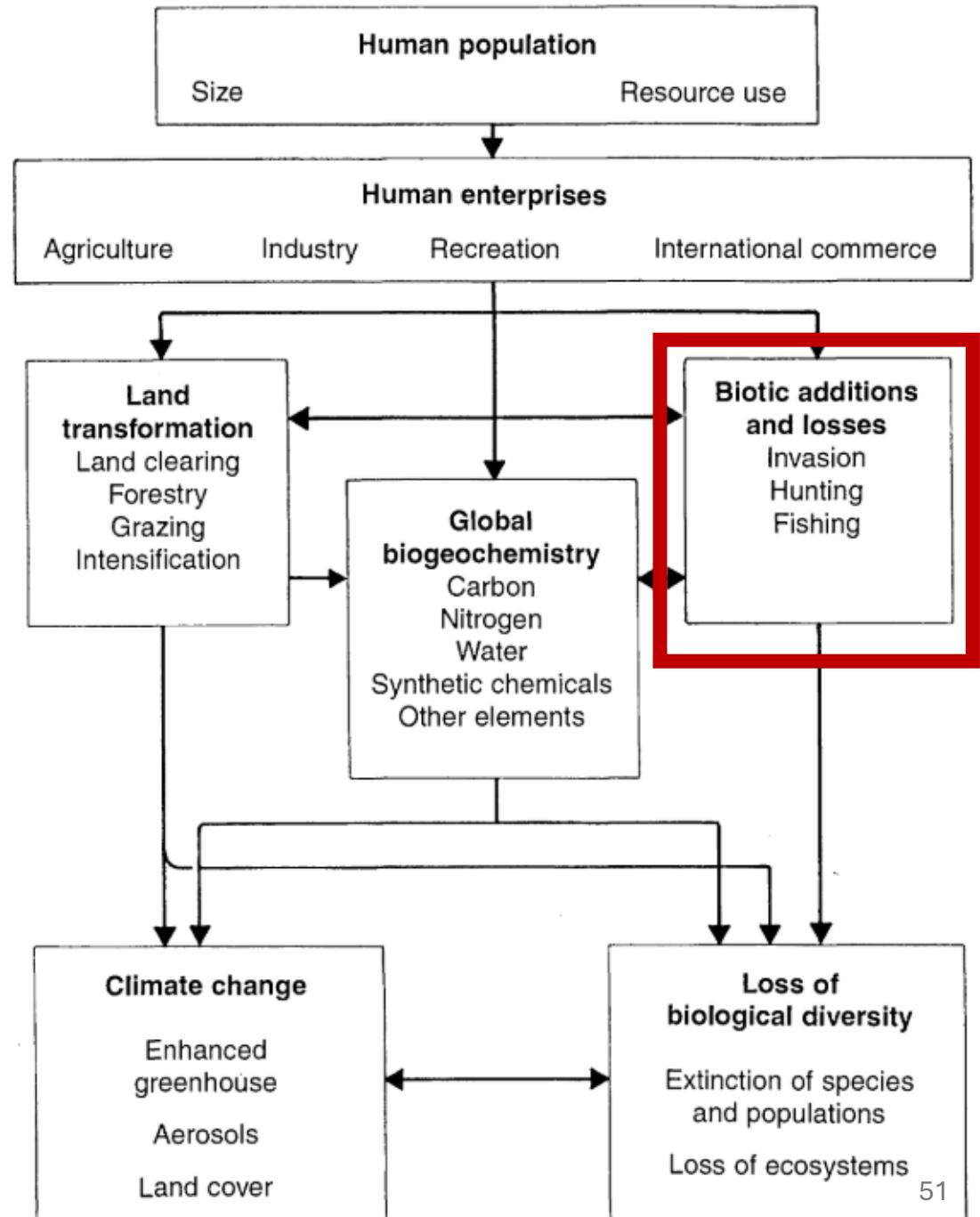


Biogeochemistry - Nitrogen

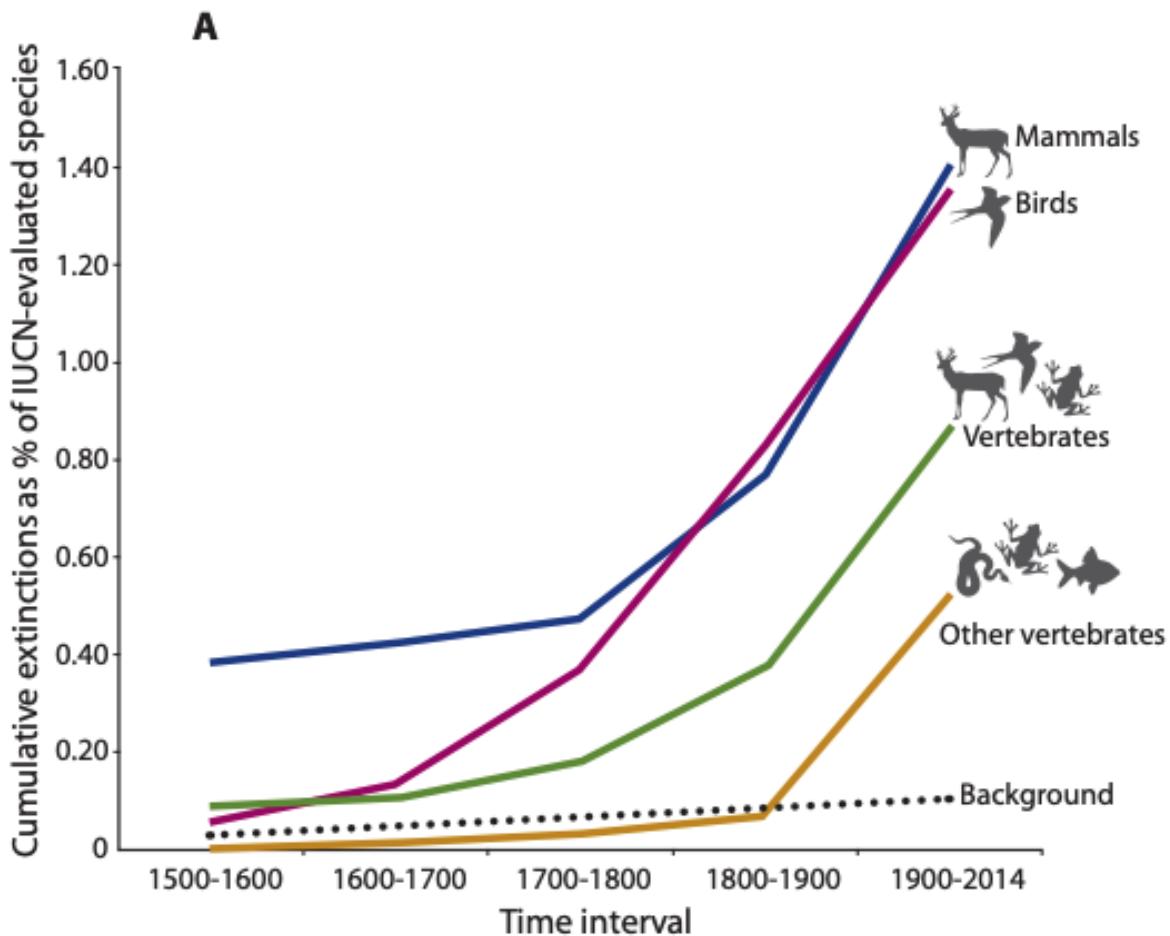
- Human activities add as much fixed N to terrestrial ecosystems as all natural sources combined!
 - Where does it come from?
- N saturation – not all N can be taken up
 - Where does it go?



Humans have many direct and indirect effects on the Earth system

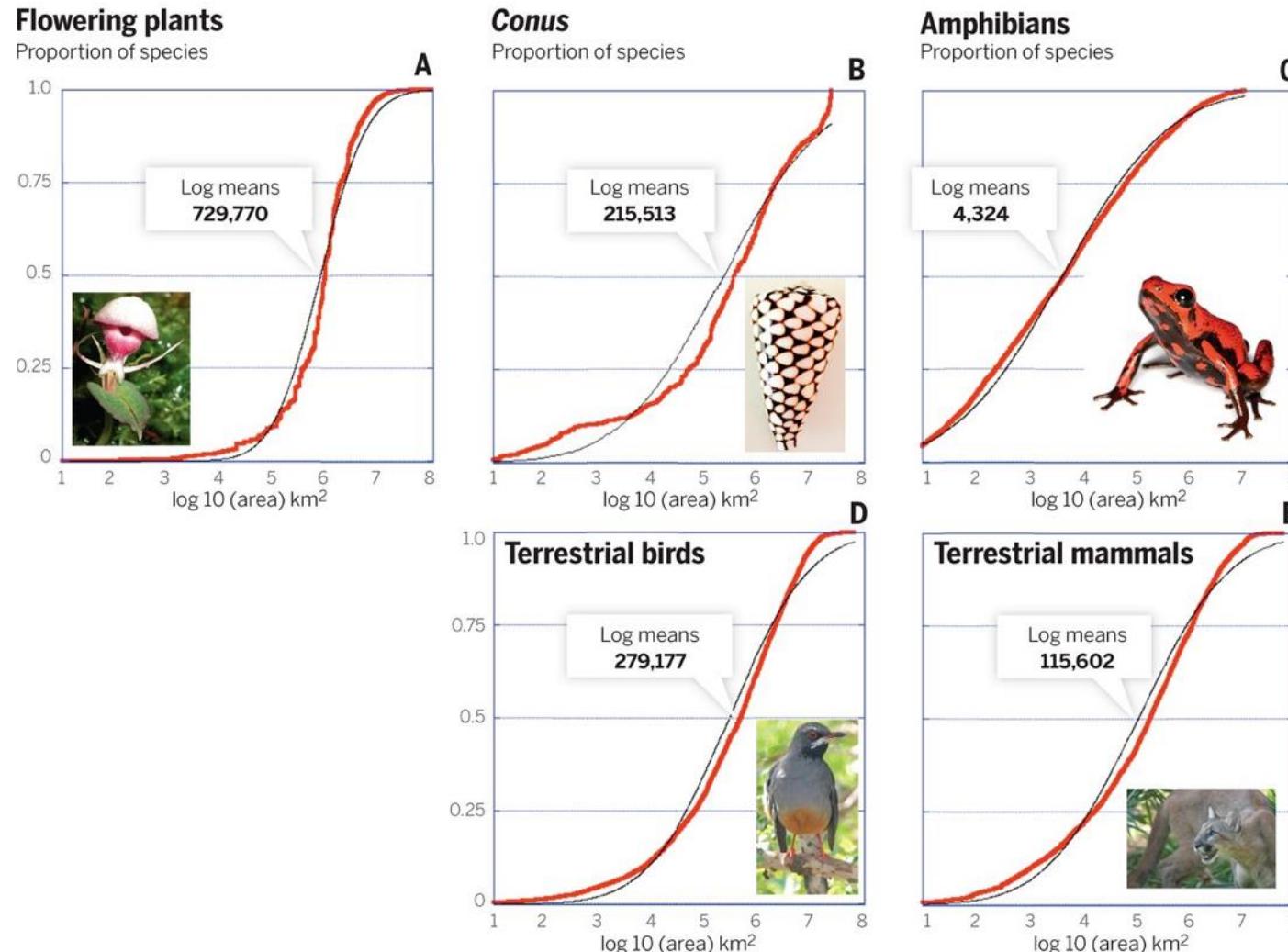


Biotic change – Species loss



Percent of extinct species
(note the background rate)

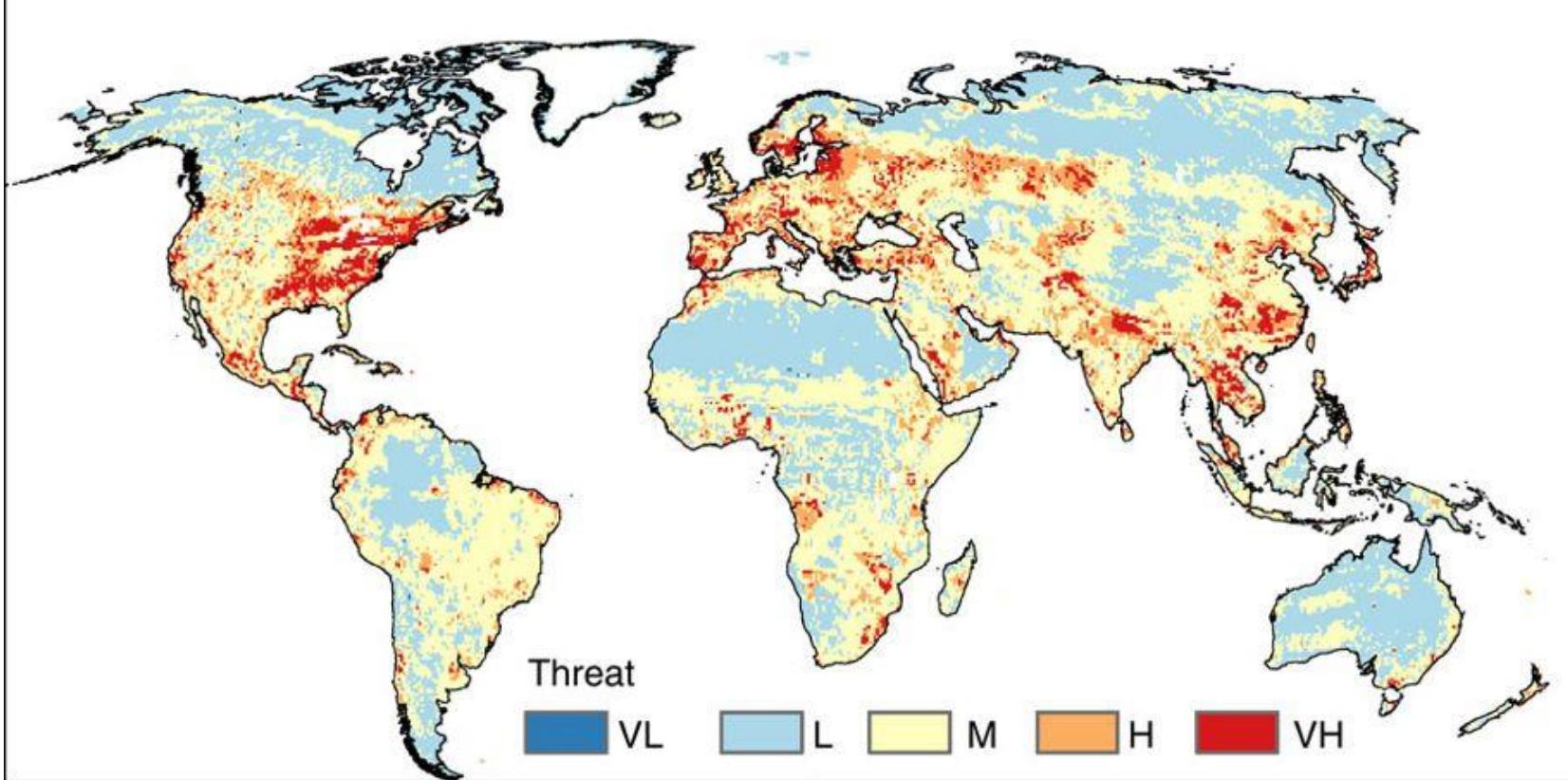
Biotic Changes – Species Loss



The number of species increases with space

Biotic Changes - Invasion

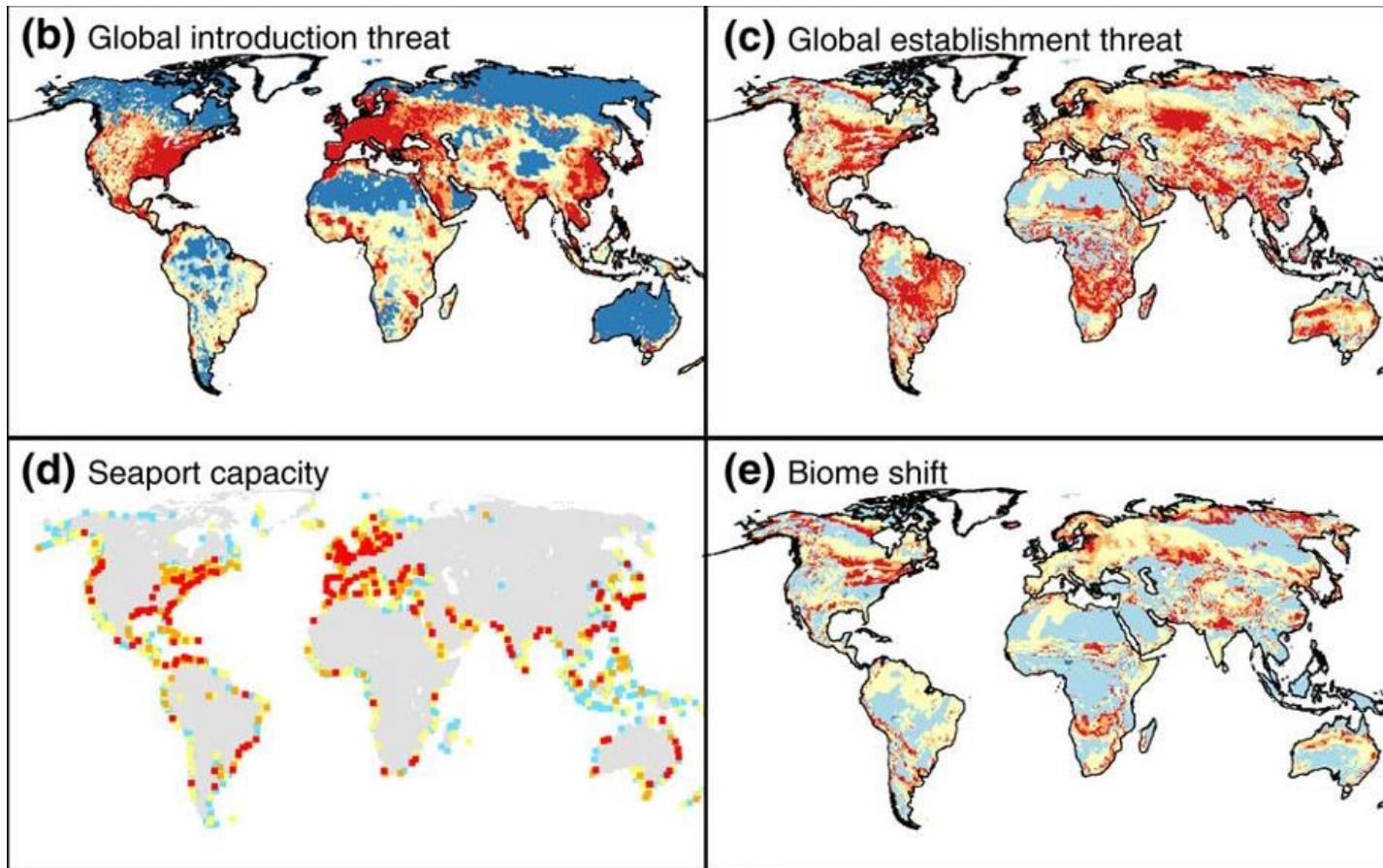
(a) Invasion threat



Invasive species
are threatening all
across the globe.

What might
explain these
patterns?

Biotic Changes - Invasion



Biotic Changes - Invasion

