

# 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:

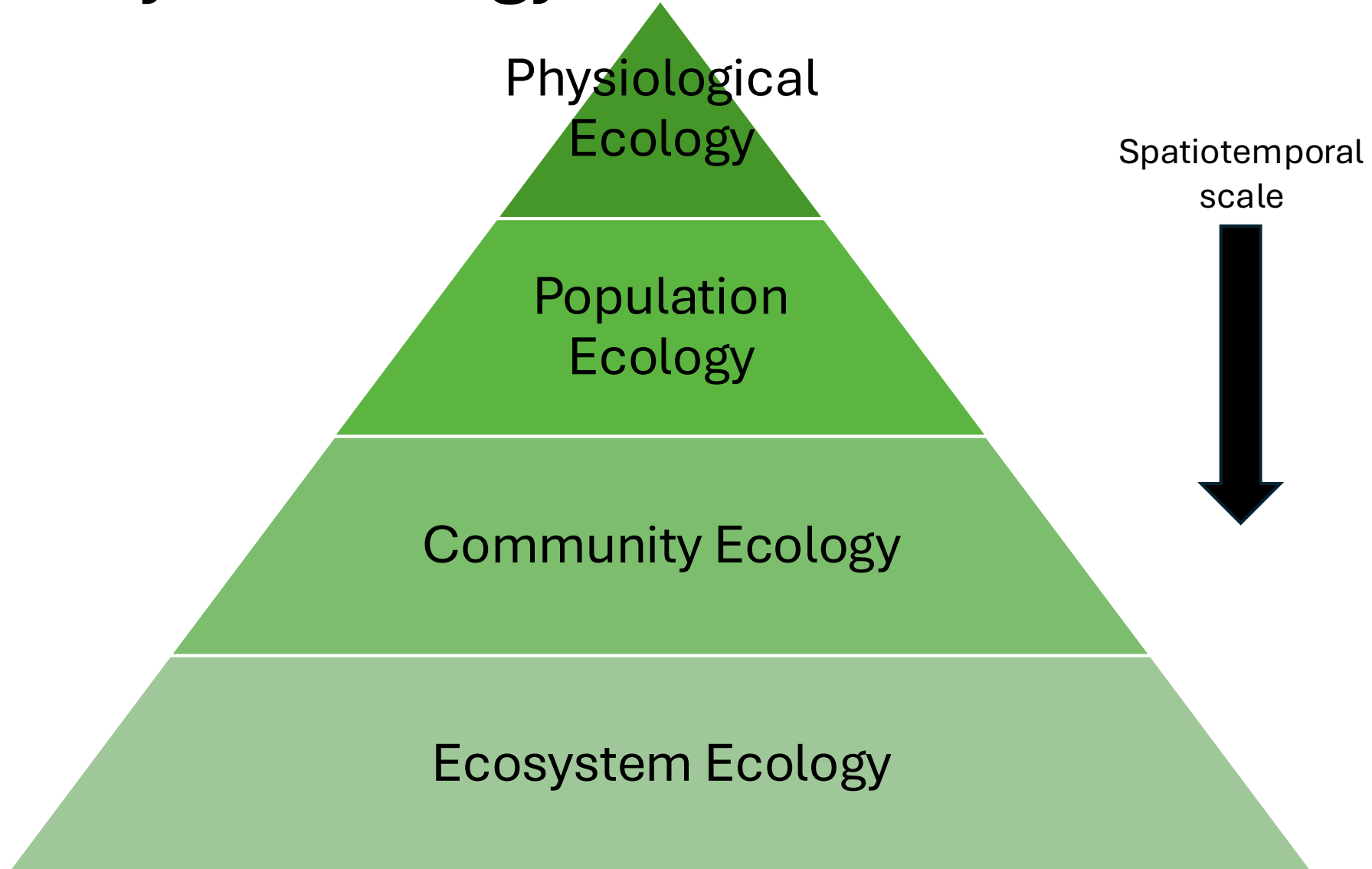
- (1) Each other (the biotic environment)
- (2) The environment (the abiotic environment)

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

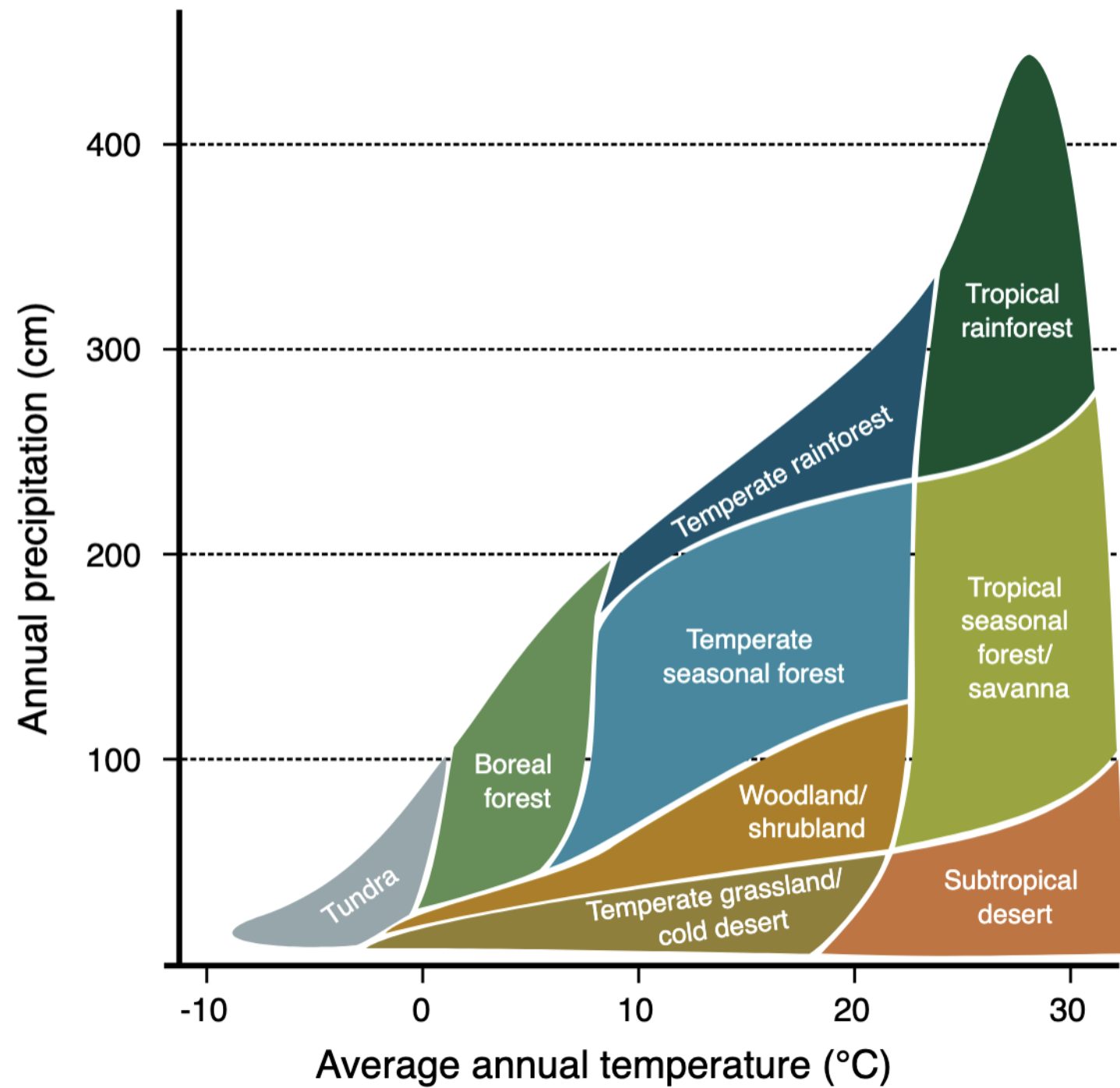




# What is **ecosystem** ecology?

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

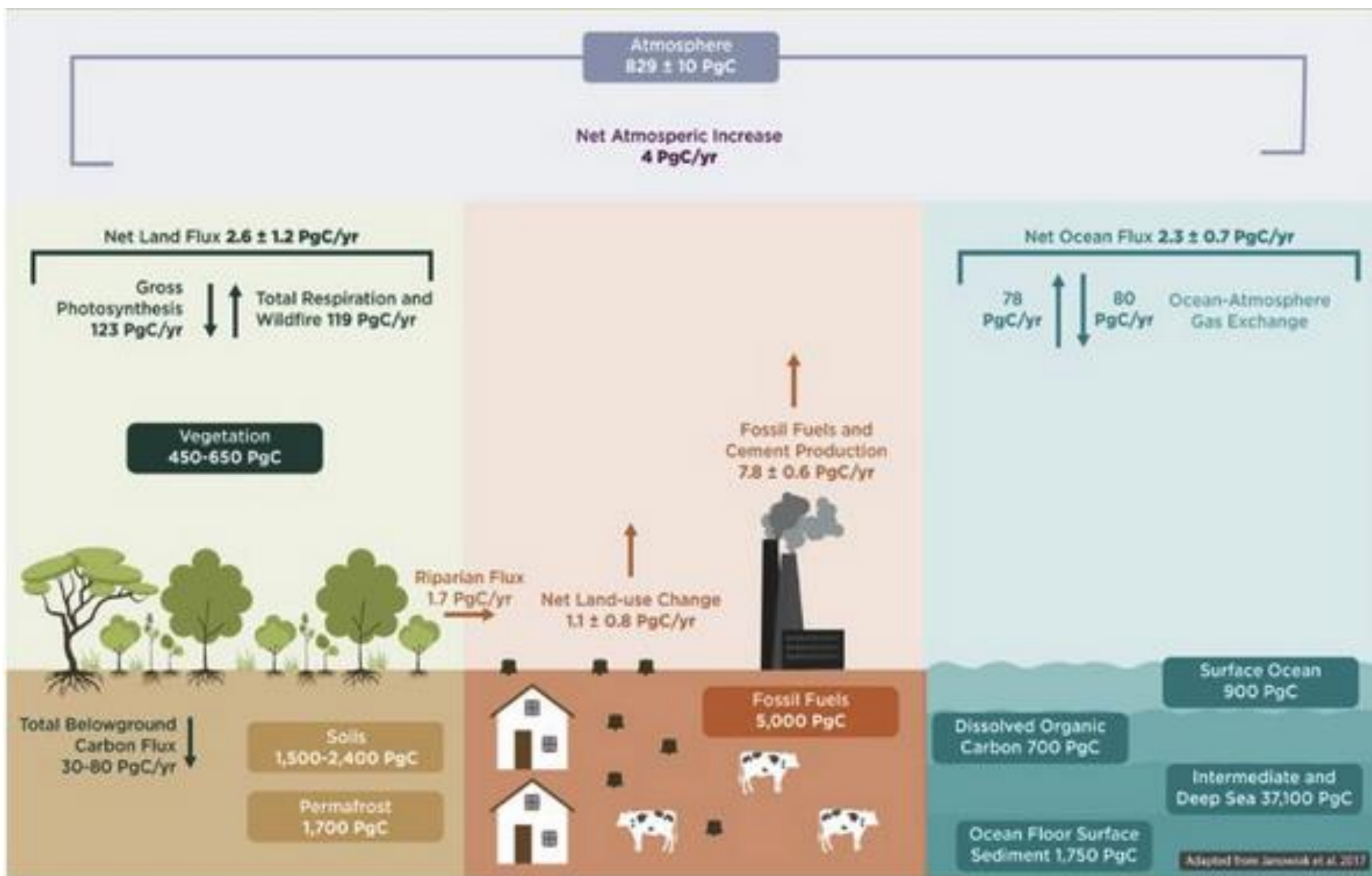
What are some examples of ecosystems?



**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)

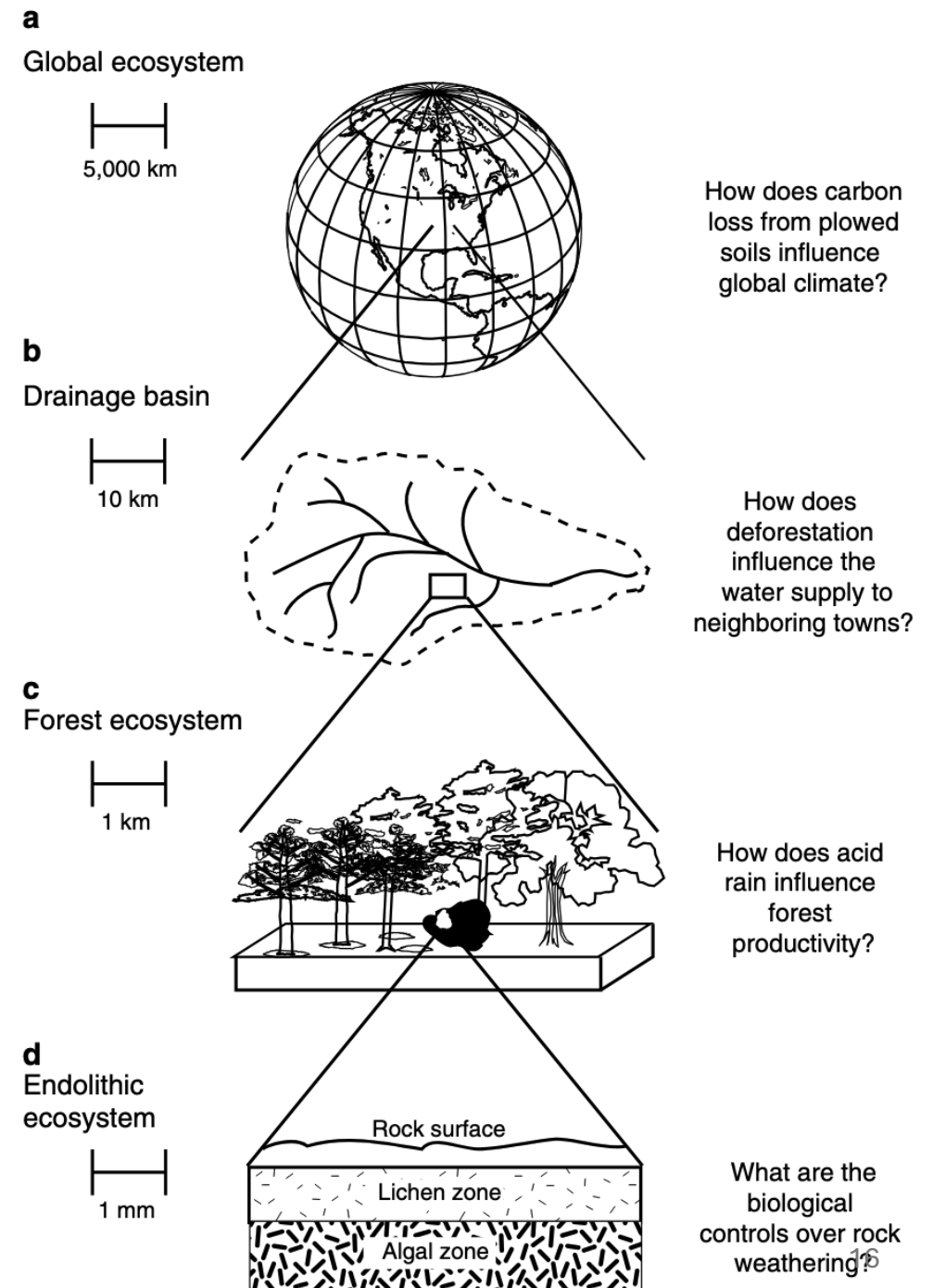


# Ecosystem ecology seeks to answer questions like:

- 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!

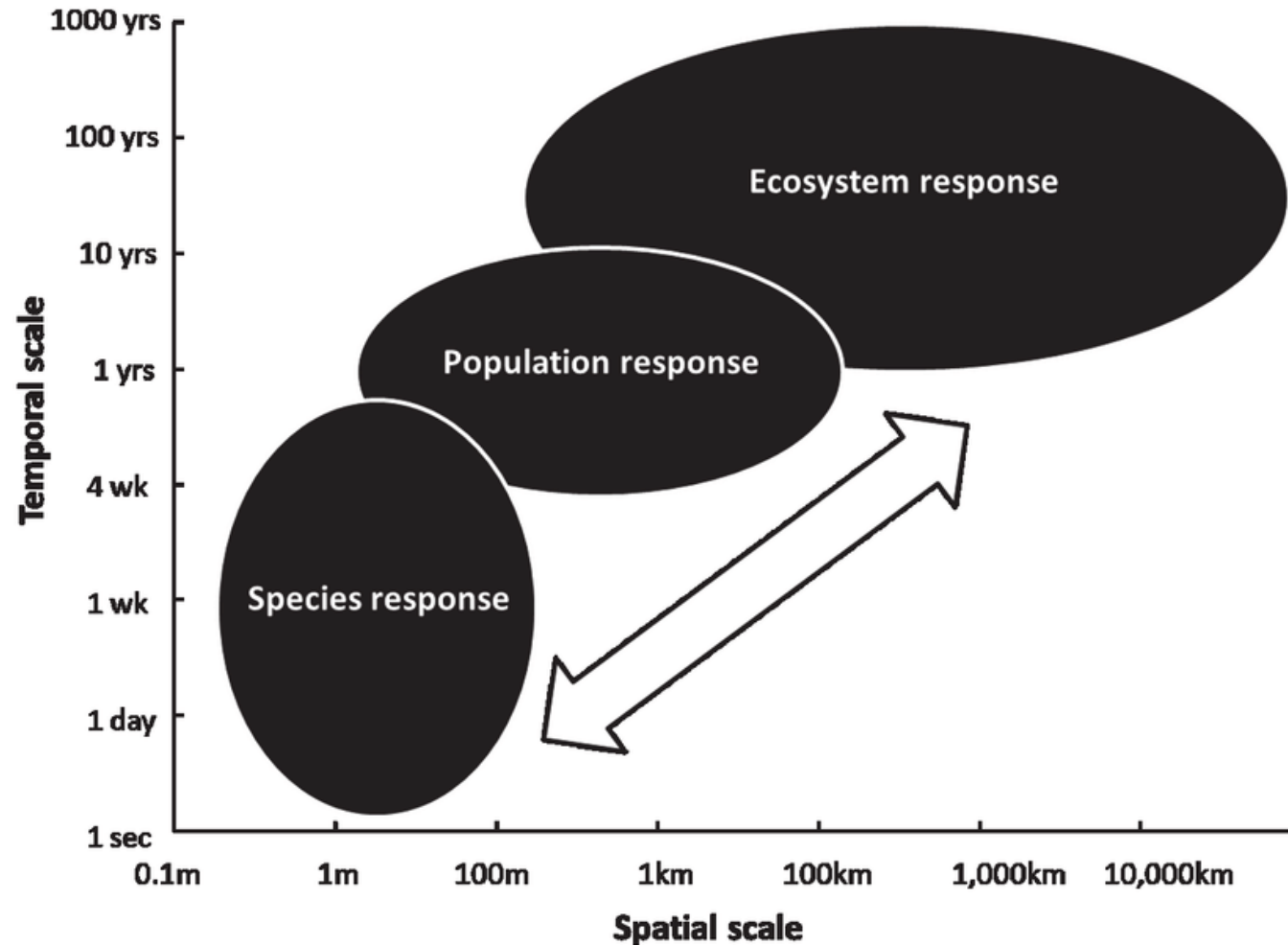




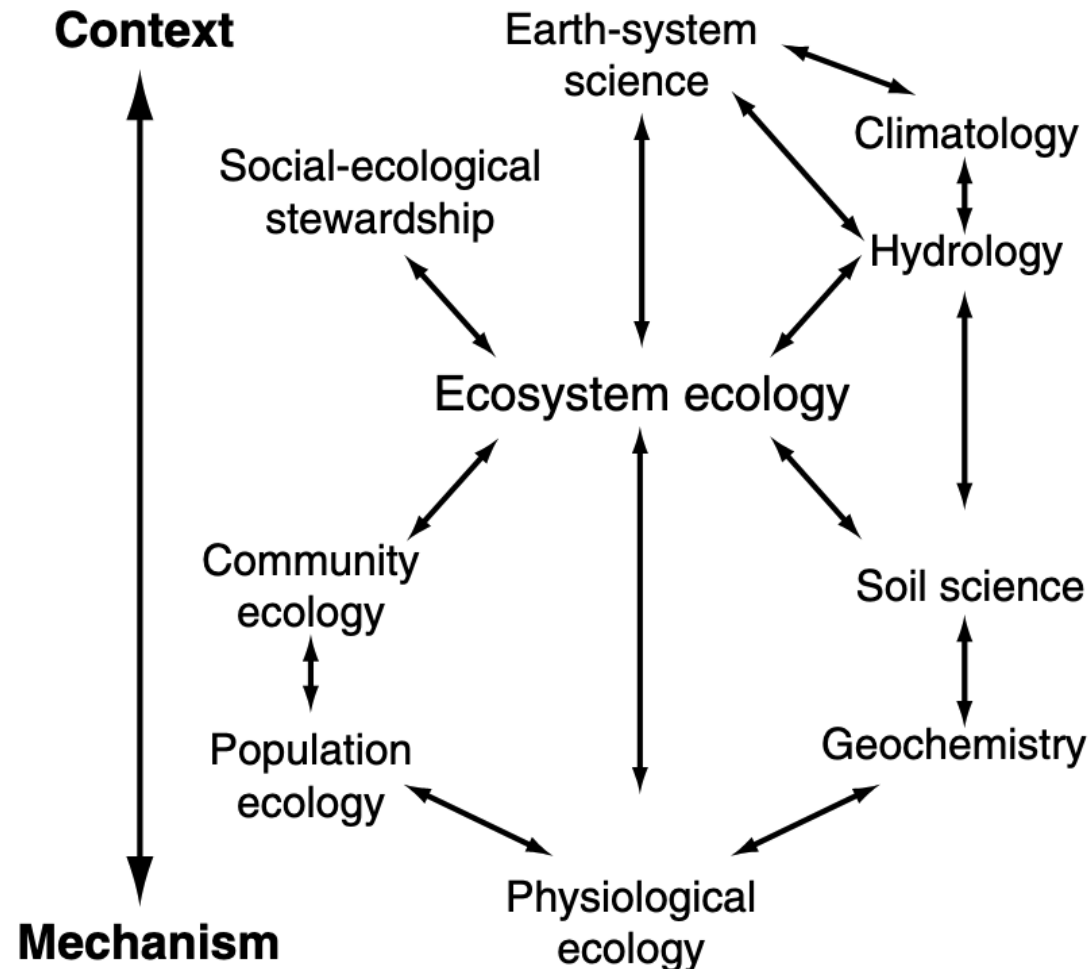
What are some examples of ecosystem processes?

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

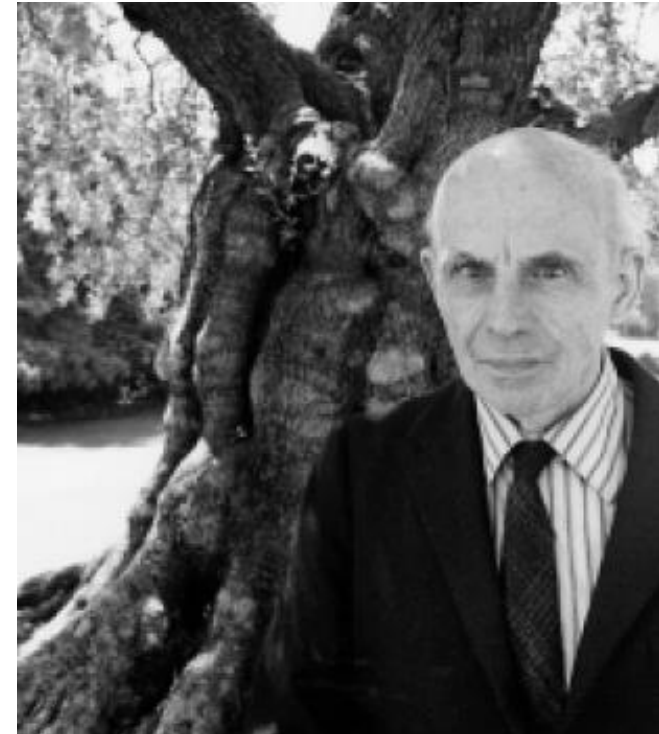


It also integrates several other study disciplines, including those from social sciences!

# 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)**



CL

# Climate

O

R

P

T



**\* Precipitation**

**\* Temperature**



# Climate



Wet ----- Dry



CL

O

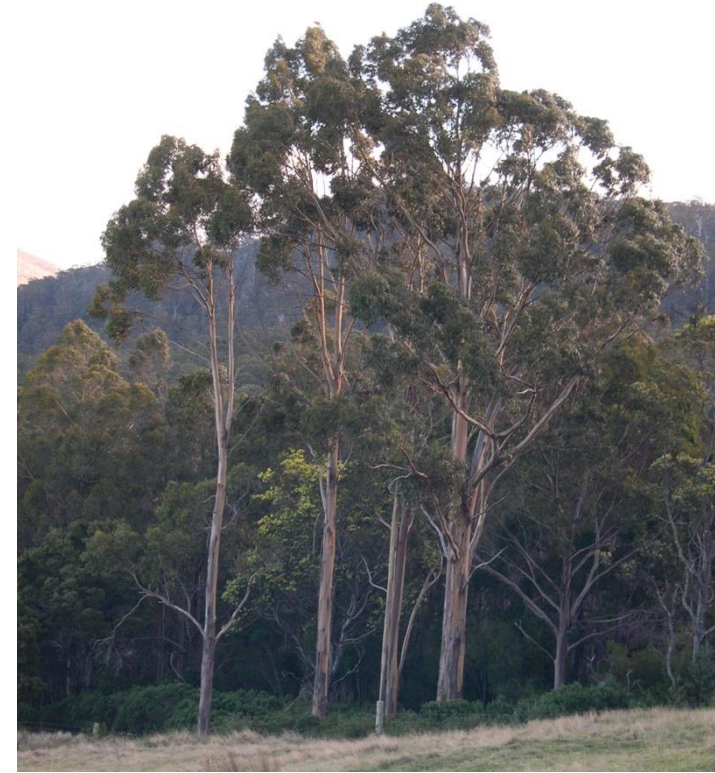
R

P

T



# Organisms





# Organisms



Diverse ----- Depauperate



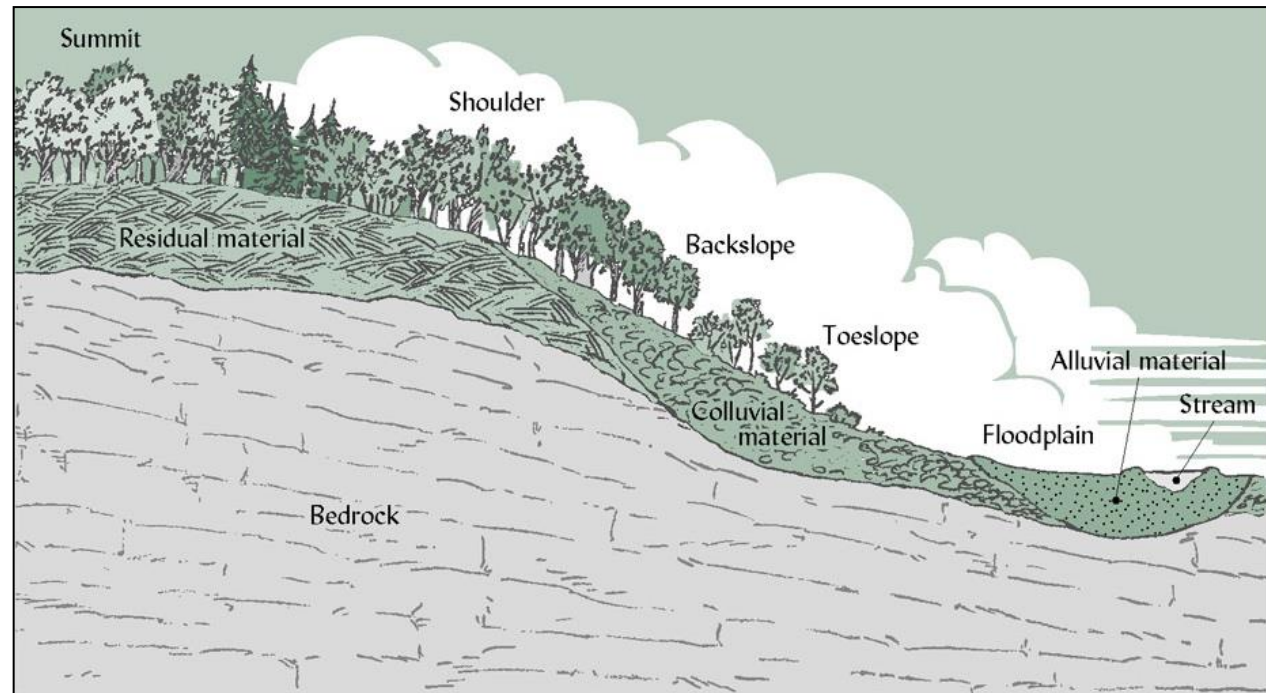
CL

O

# R Relief/Topography

P

T



# Topography



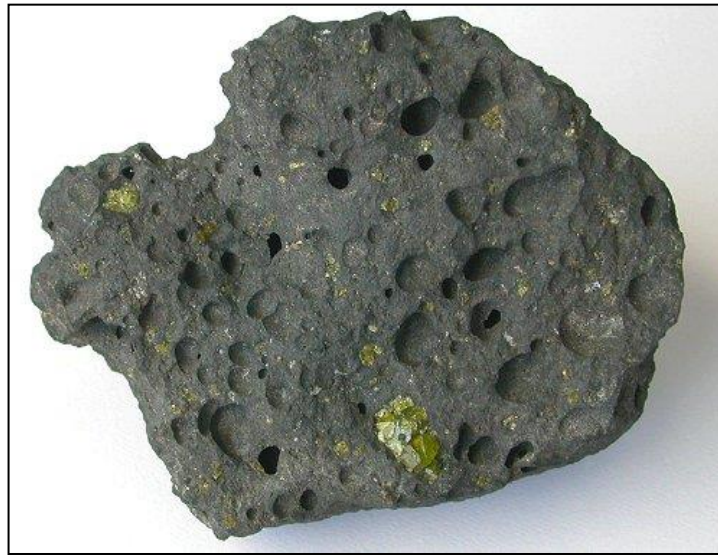
Steep ----- Flat



CL

O

R



**Igneous** (basalt)



**Metamorphic** (schist)

**P**

## Parent Material

T

**Sedimentary**  
(sandstone)



# Parent Material



Igneous



Sedimentary



Basalt



CL

O

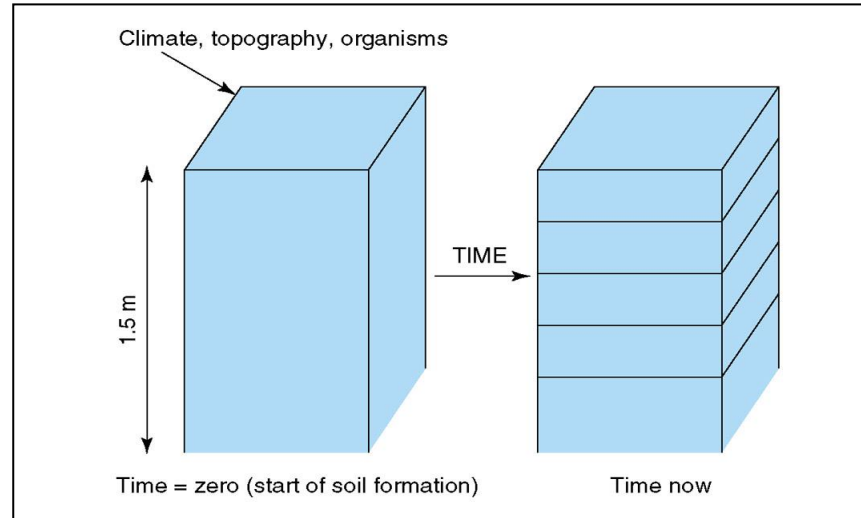
R

P

T

Time

## Development of Soil



## Evolution



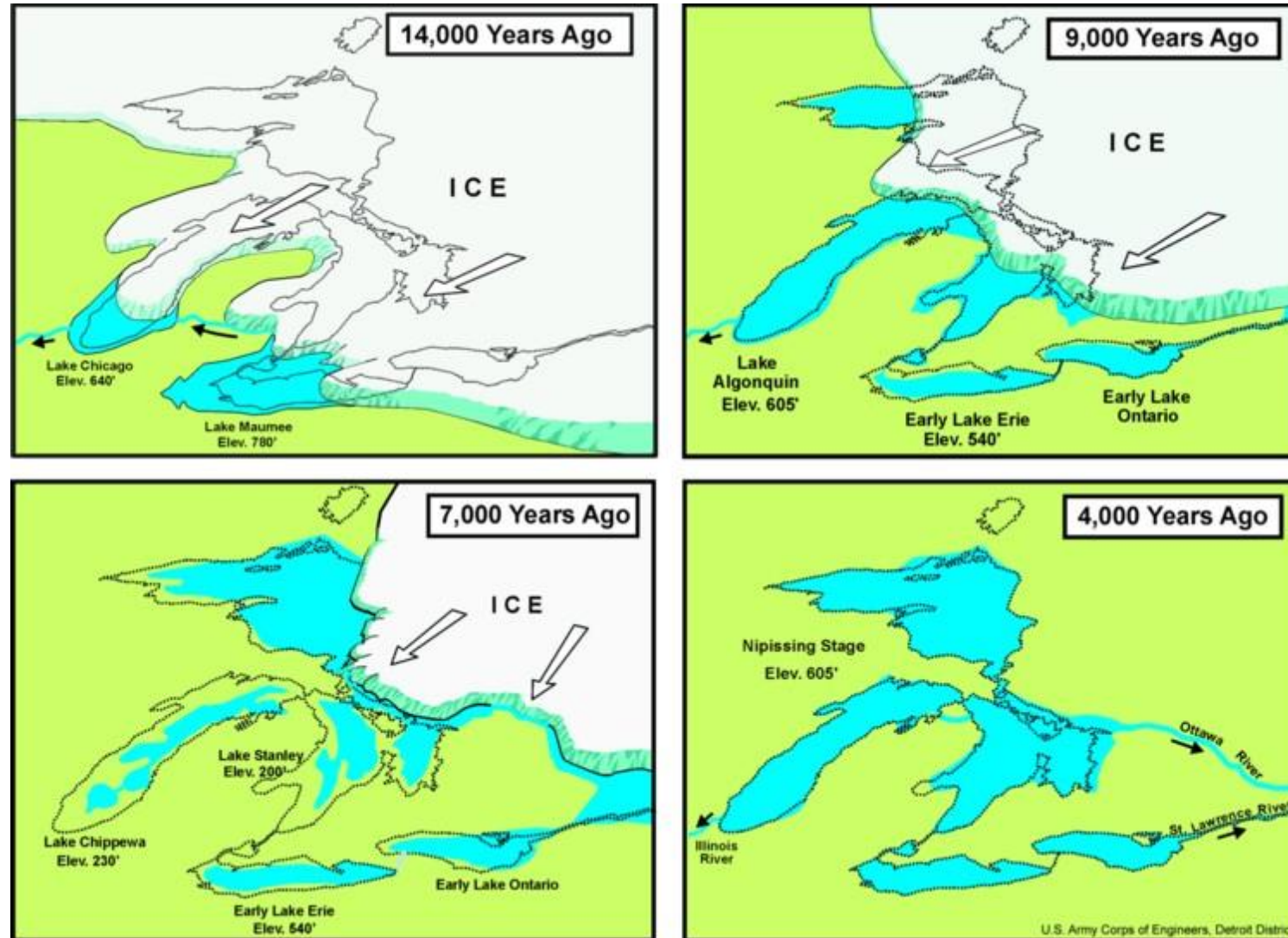
# Time



Old ----- Recent

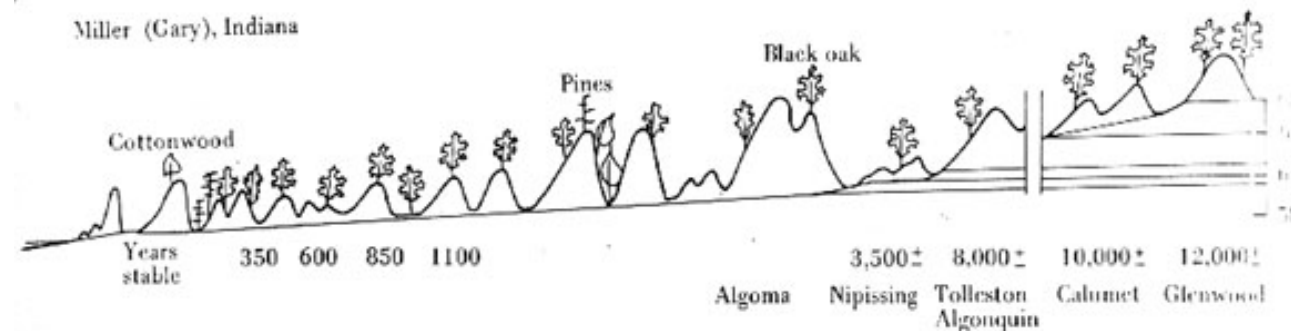
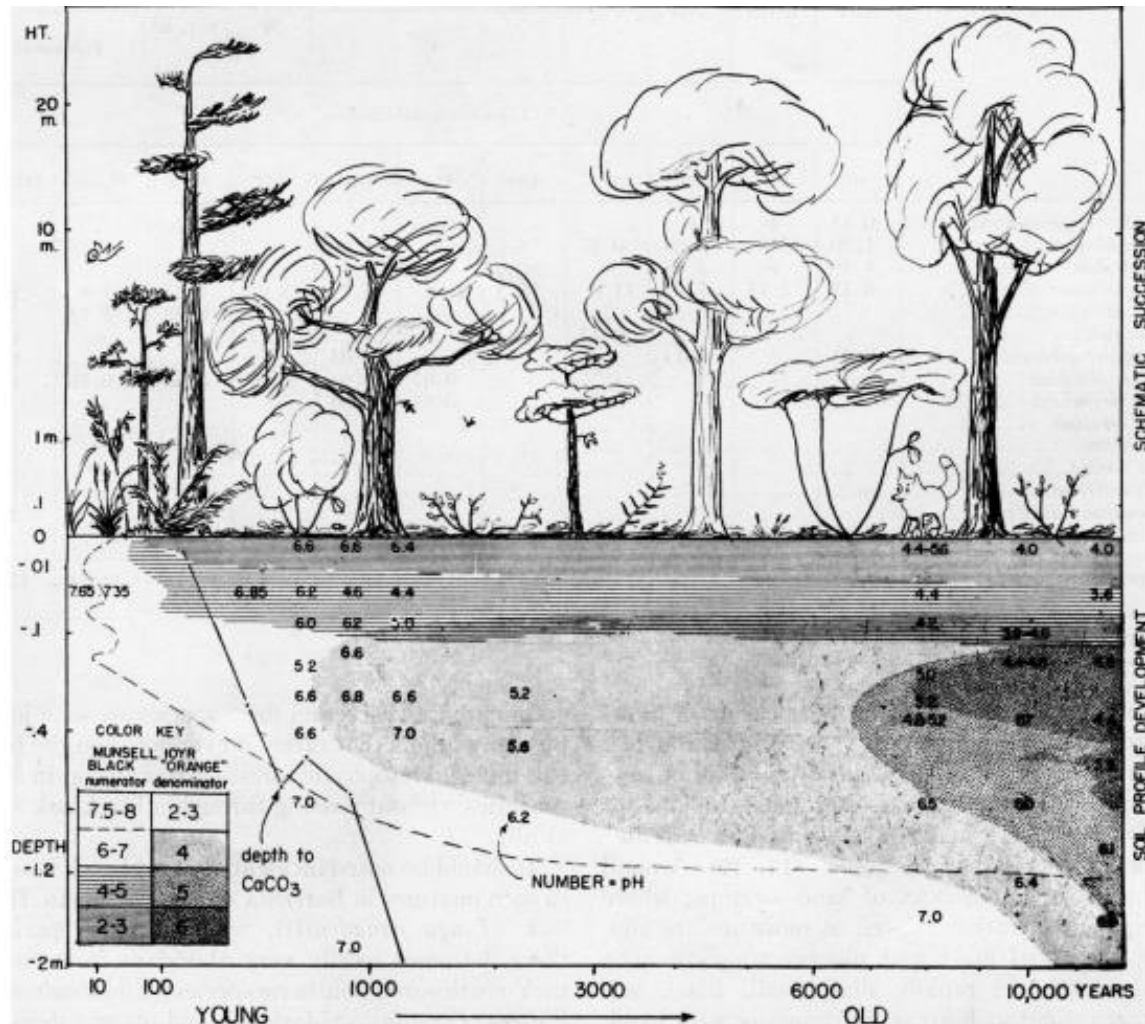
Example: succession is the result of state factor changes

# Lake Michigan dunes





# Lake Michigan dunes



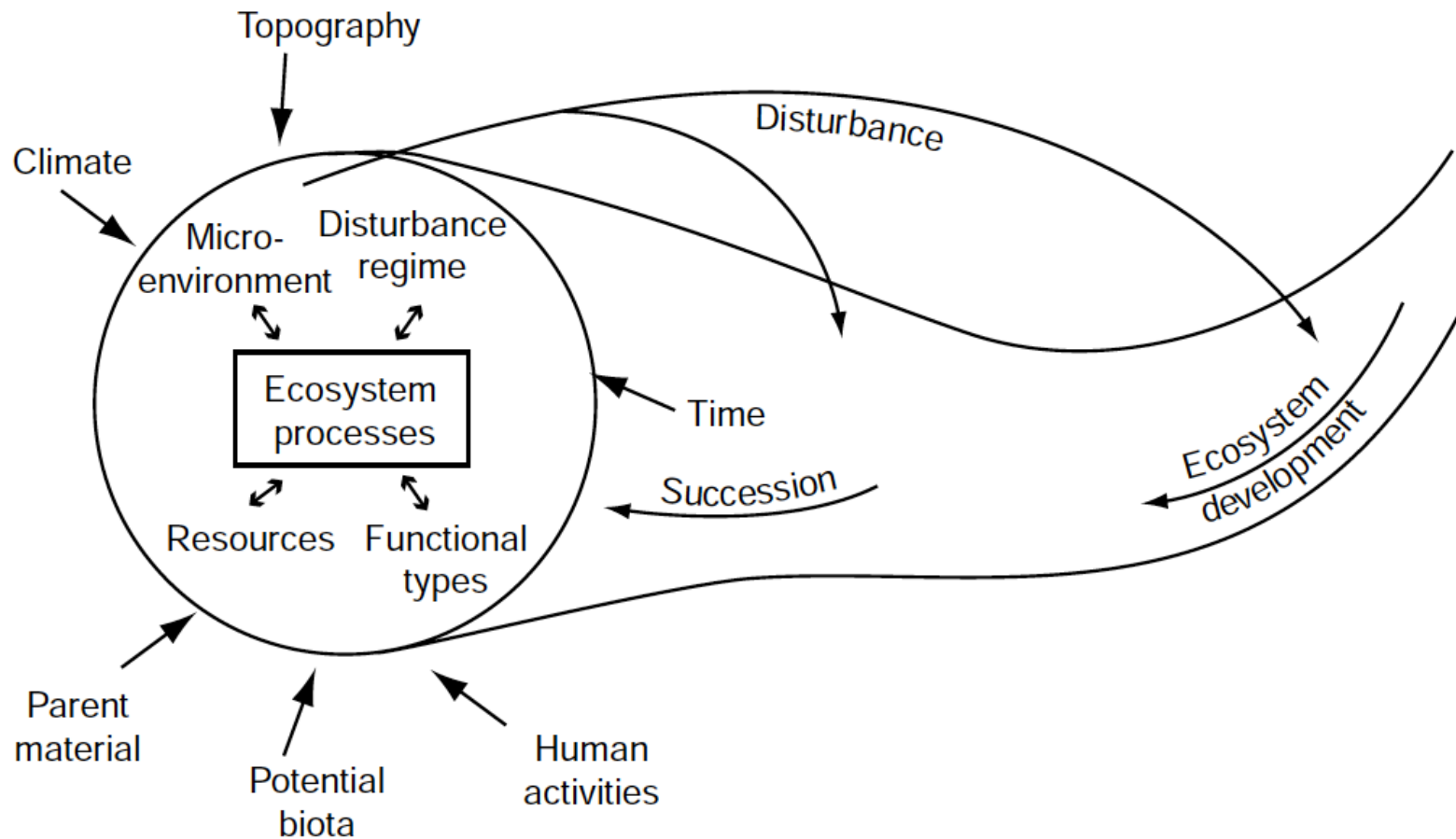
**Figure 22.4.** Diagrammatic profiles across Indiana sand dunes at the southern end of Lake Michigan. Successively older dune systems originated along earlier and higher beaches. (After Olson 1958.)

# 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?

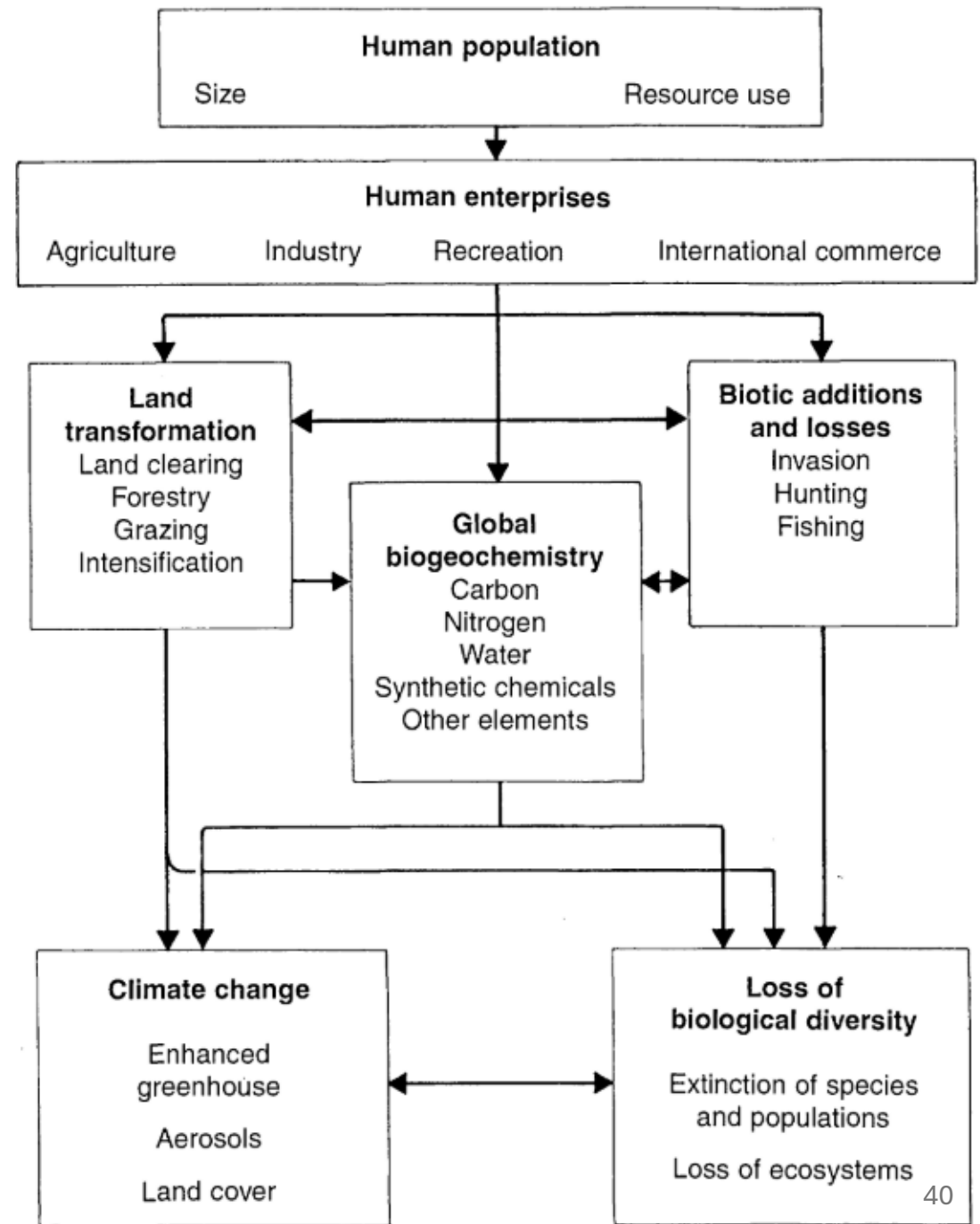




# Human Domination of Earth's Ecosystems

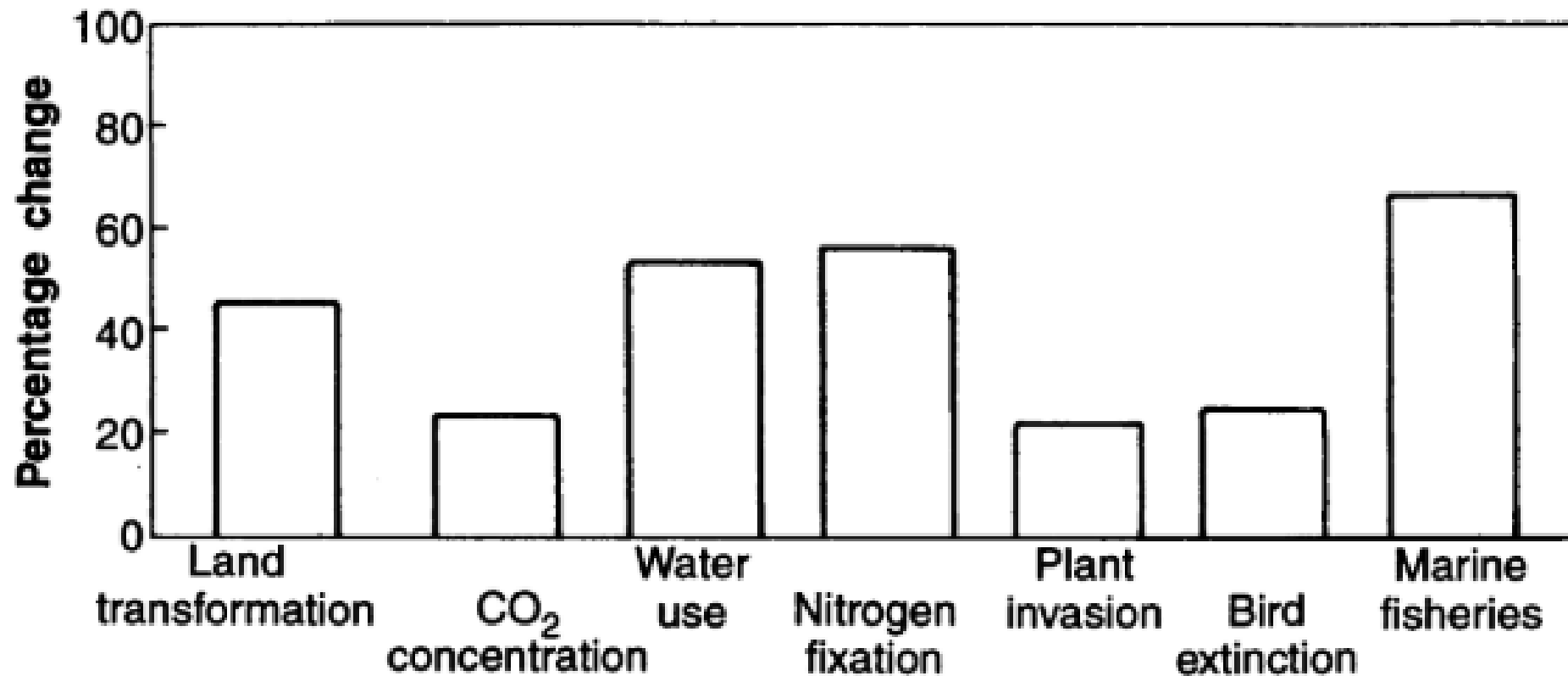
Vitousek PM, Mooney HA, Lubchenco H, Melillo JM. 1997. Human domination of Earth's ecosystems. *Science* 277(5325):494-499.

Humans have many direct and indirect effects on the Earth system

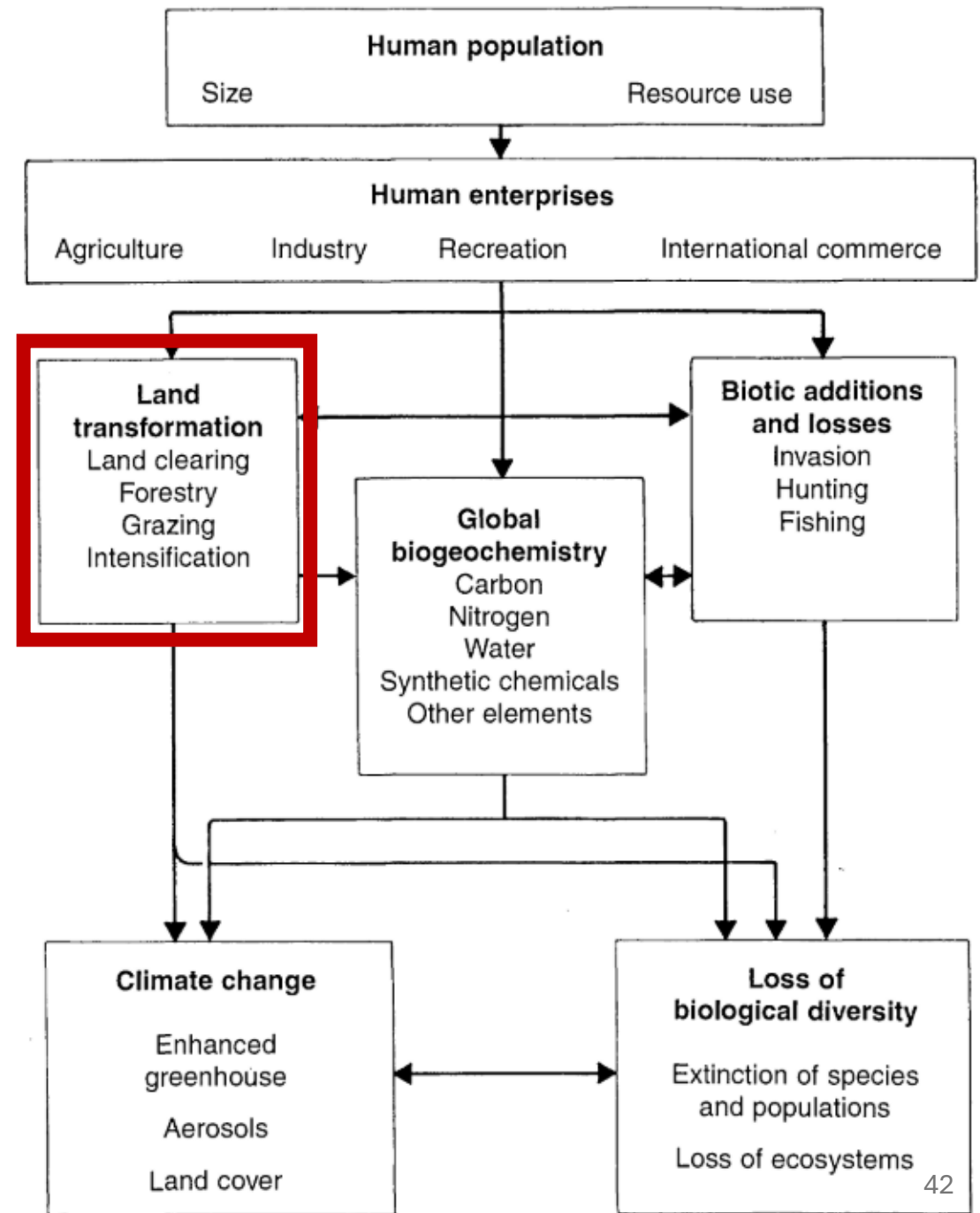




# Humans have altered several major components of the Earth system



Humans have many direct and indirect effects on the Earth system

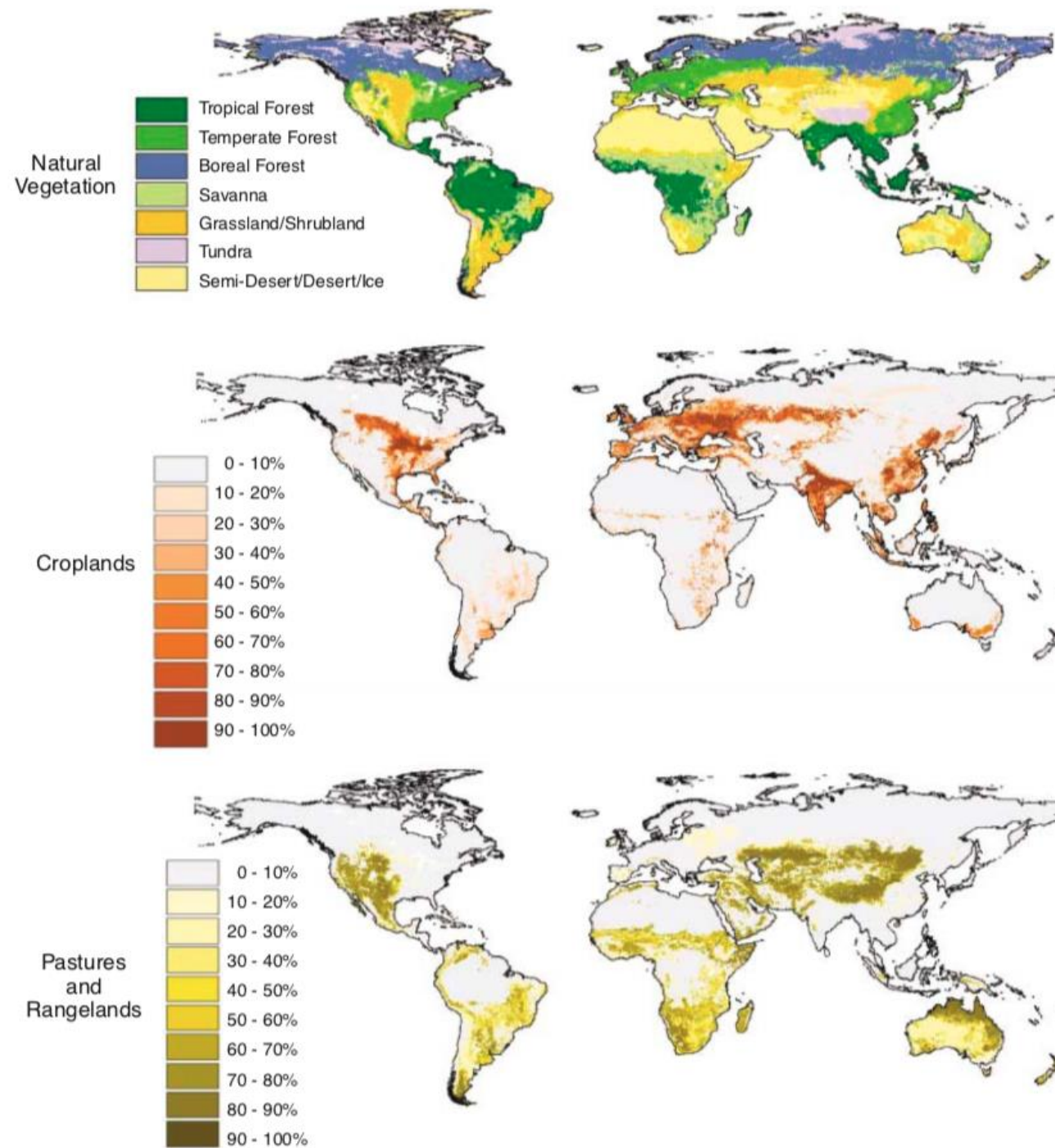


# Land transformation

- Nearly 50% of all land has been transformed by humans
- Primary driver of species loss
- 20% of all CO<sub>2</sub> emissions

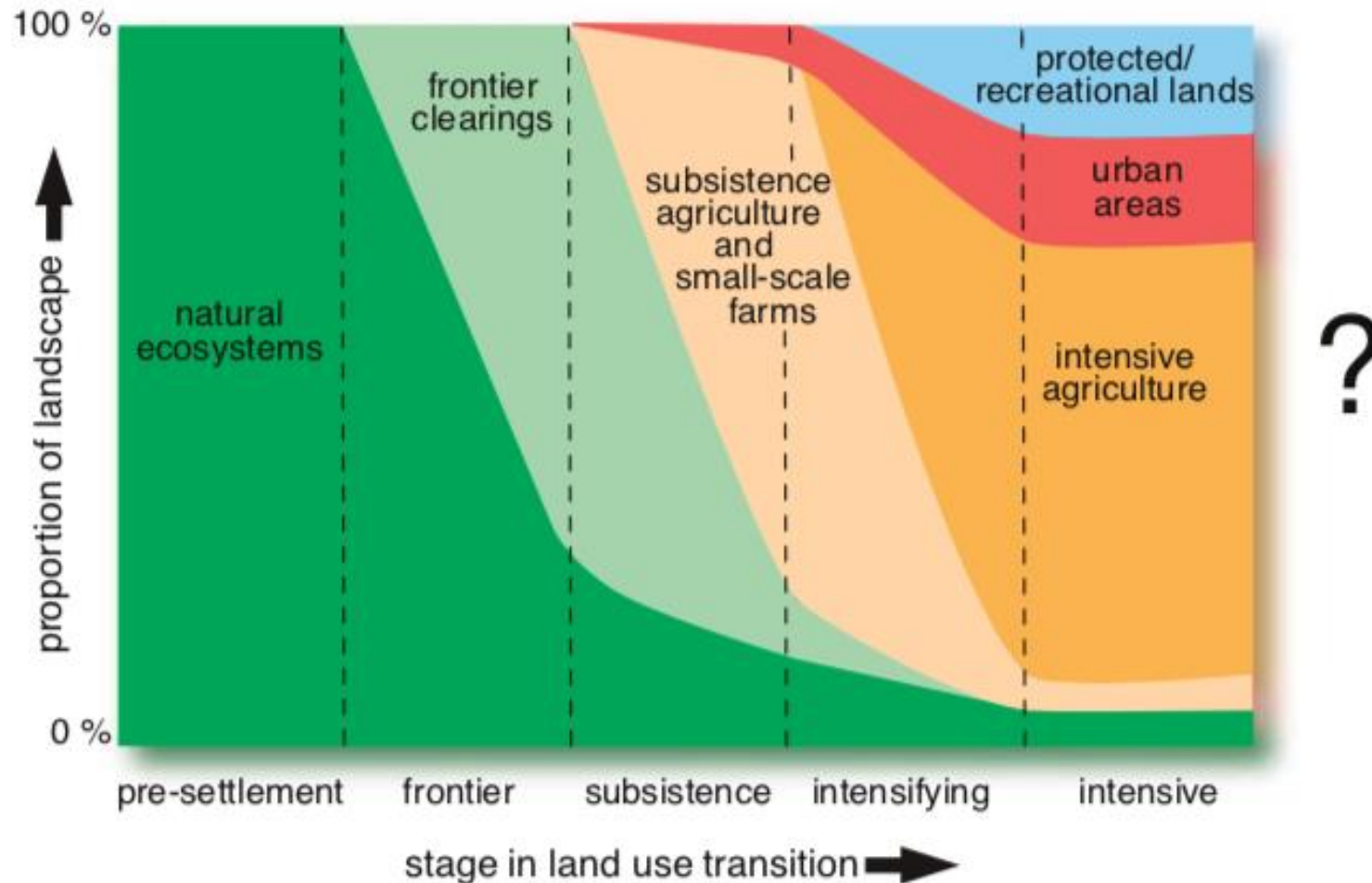


Border between Haiti (left) and Dominican Republic (right)

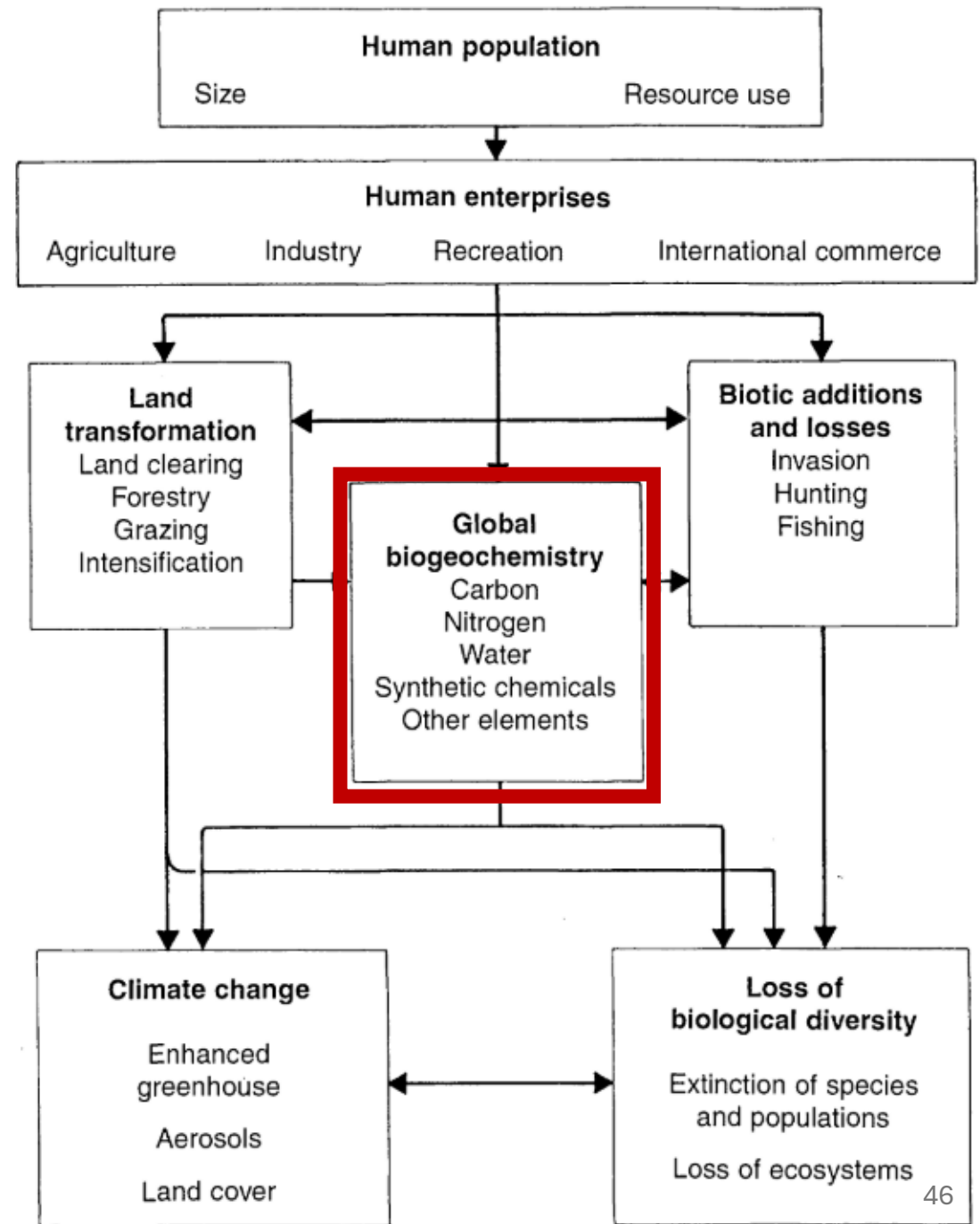




# Progressive land transformation (Foley et al. 2005)

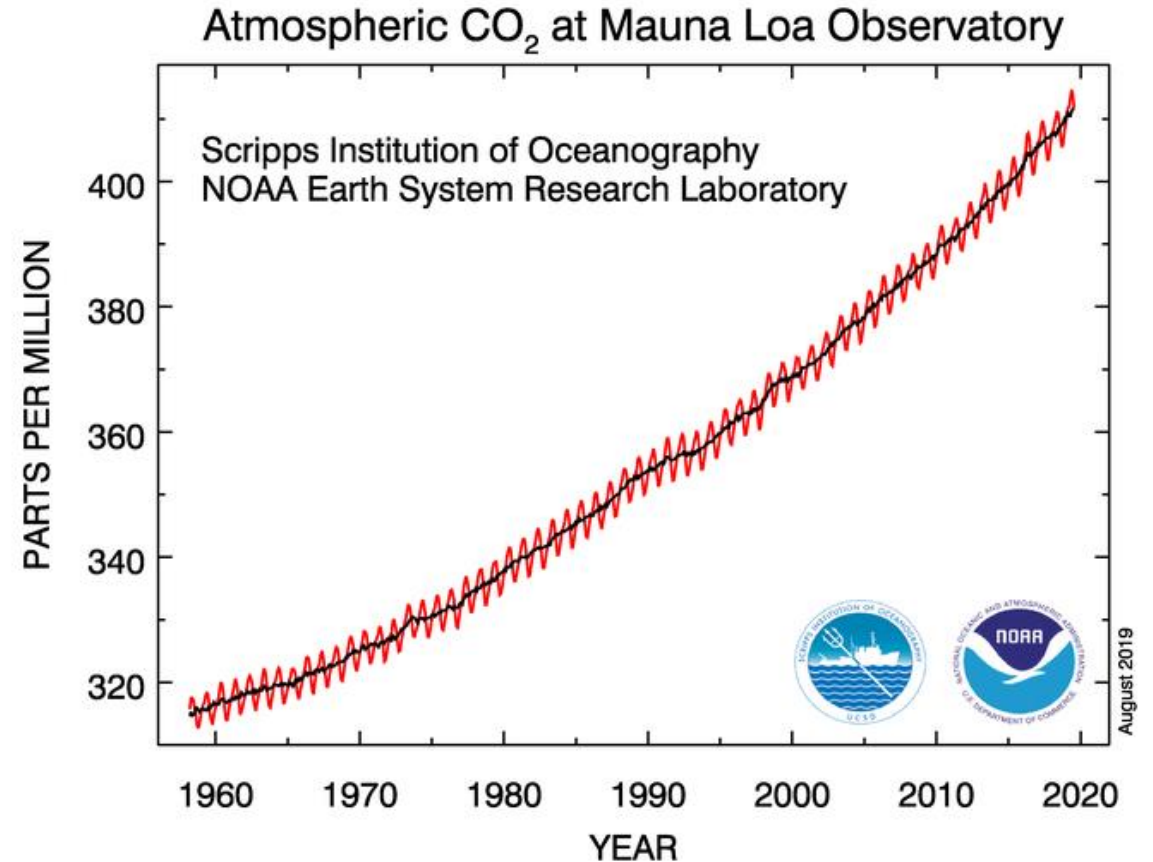


Humans have many direct and indirect effects on the Earth system



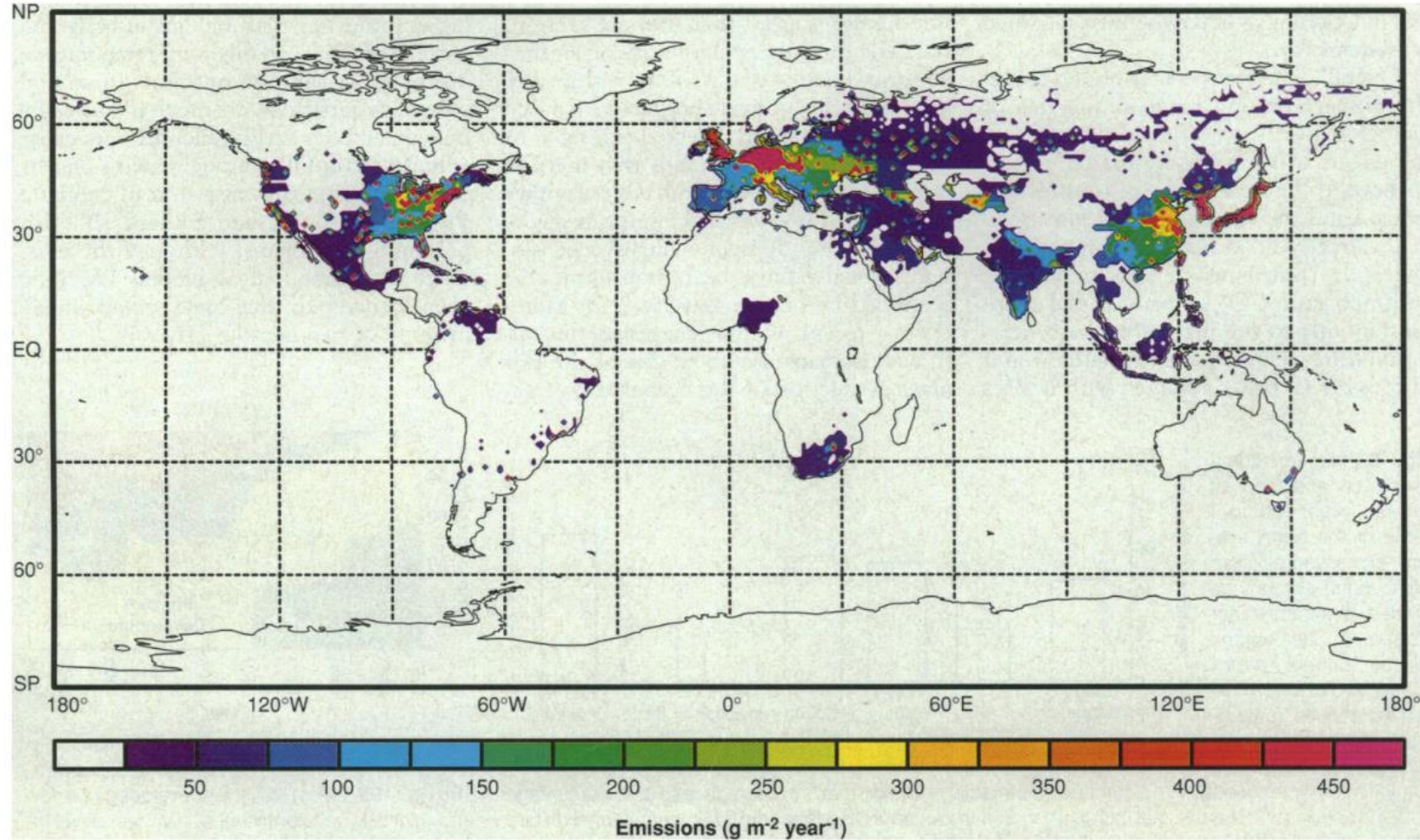
# Biogeochemistry - Carbon

- 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



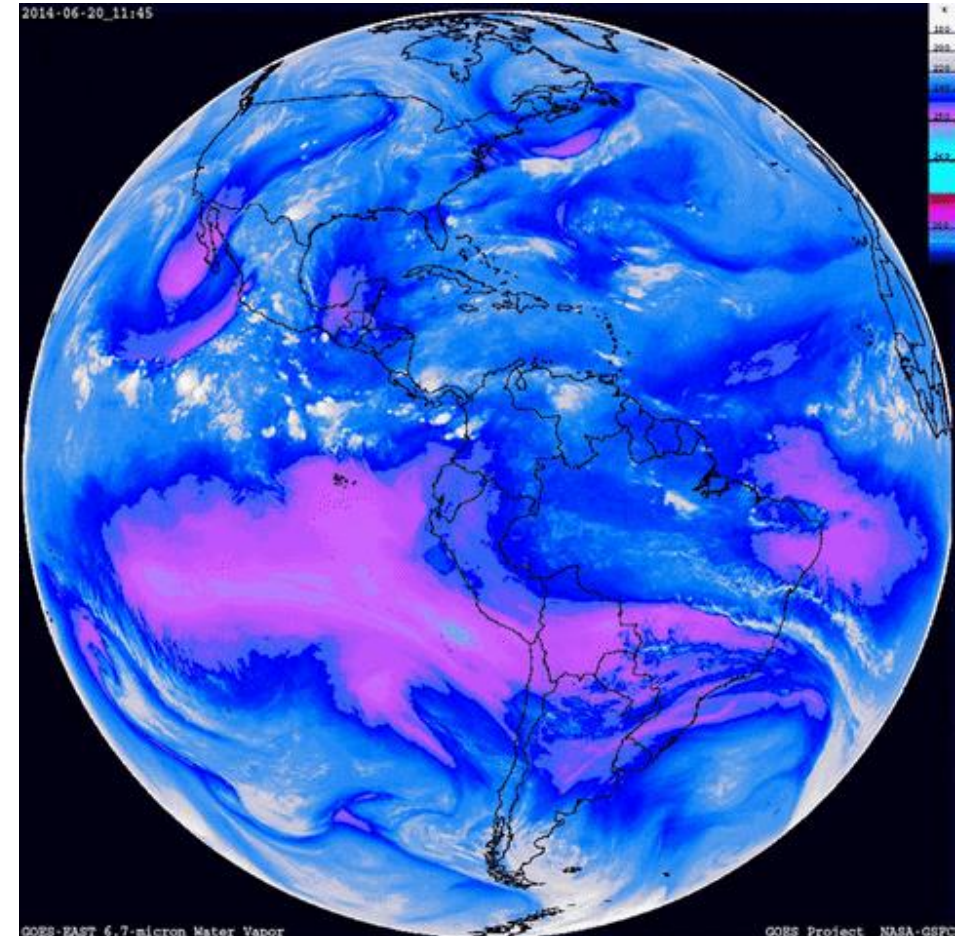


# Geographical distribution of fossil fuel CO<sub>2</sub> emissions is highly correlated with urban hubs



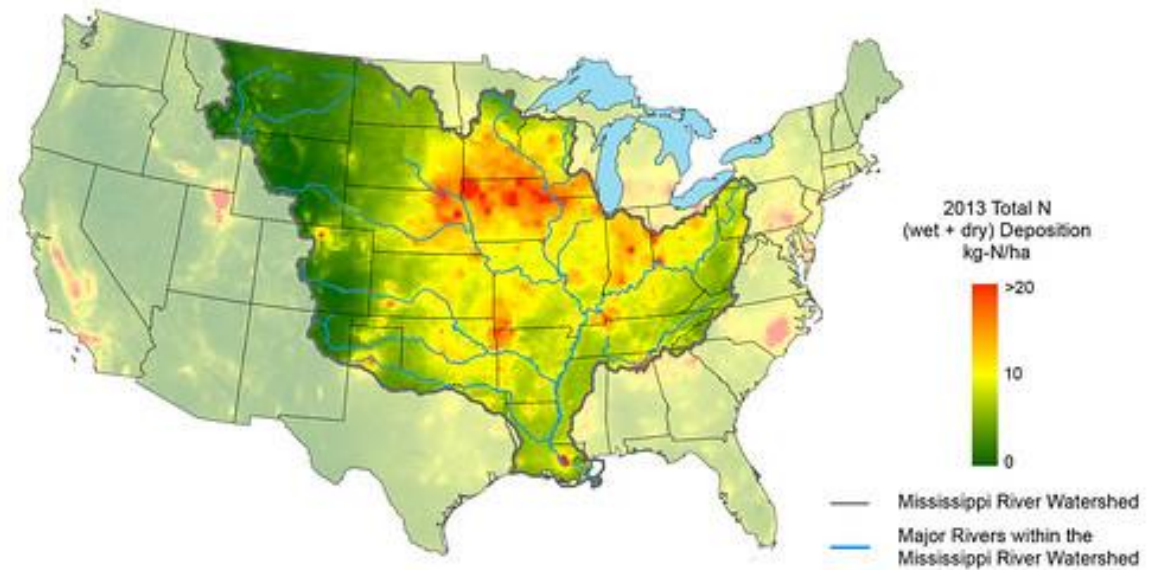
# Biogeochemistry - Water

- 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

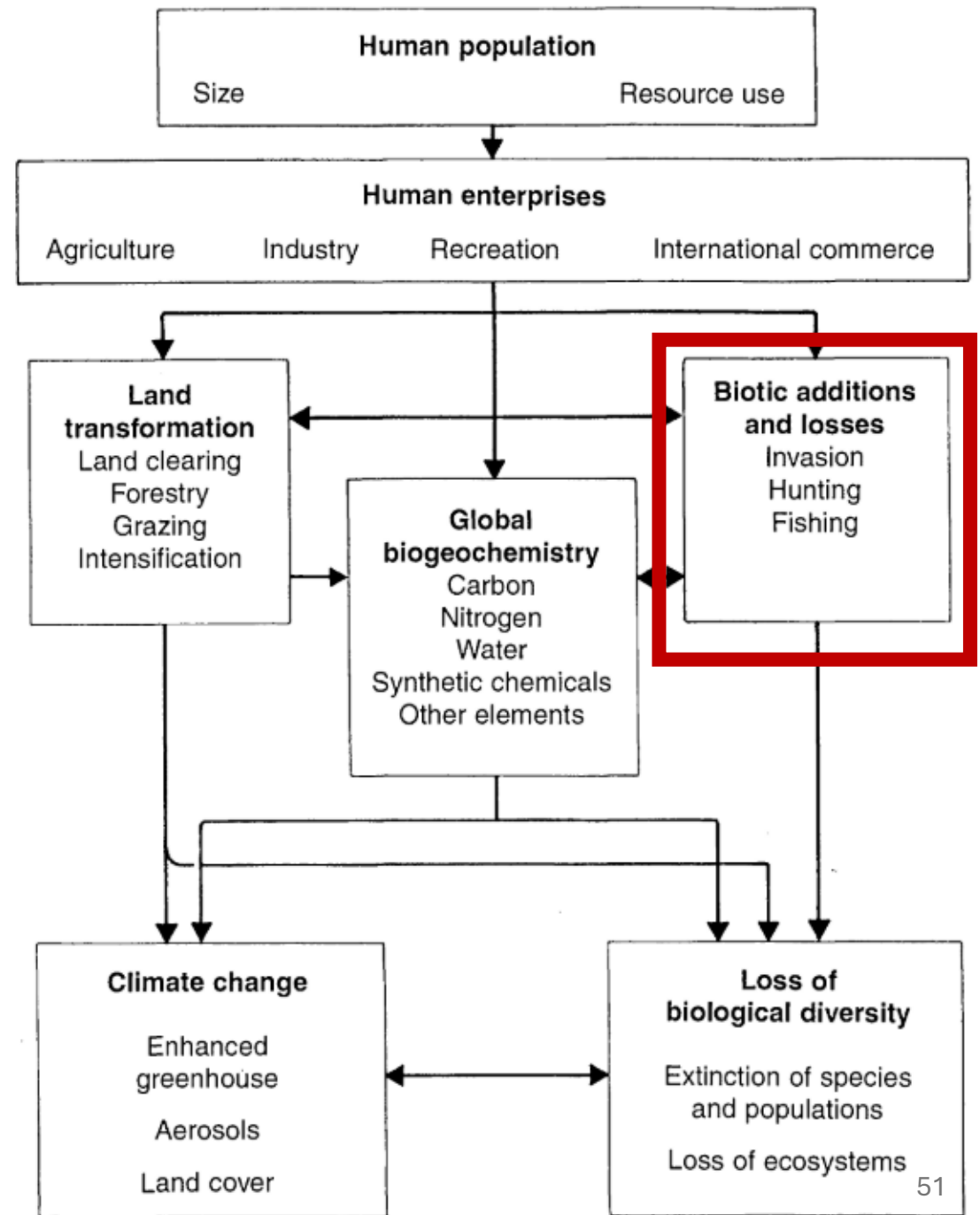
- Human activities add as much fixed N to terrestrial ecosystems as all natural sources combined!
  - Where does it come from?
- N saturation – not all N can be taken up
  - Where does it go?



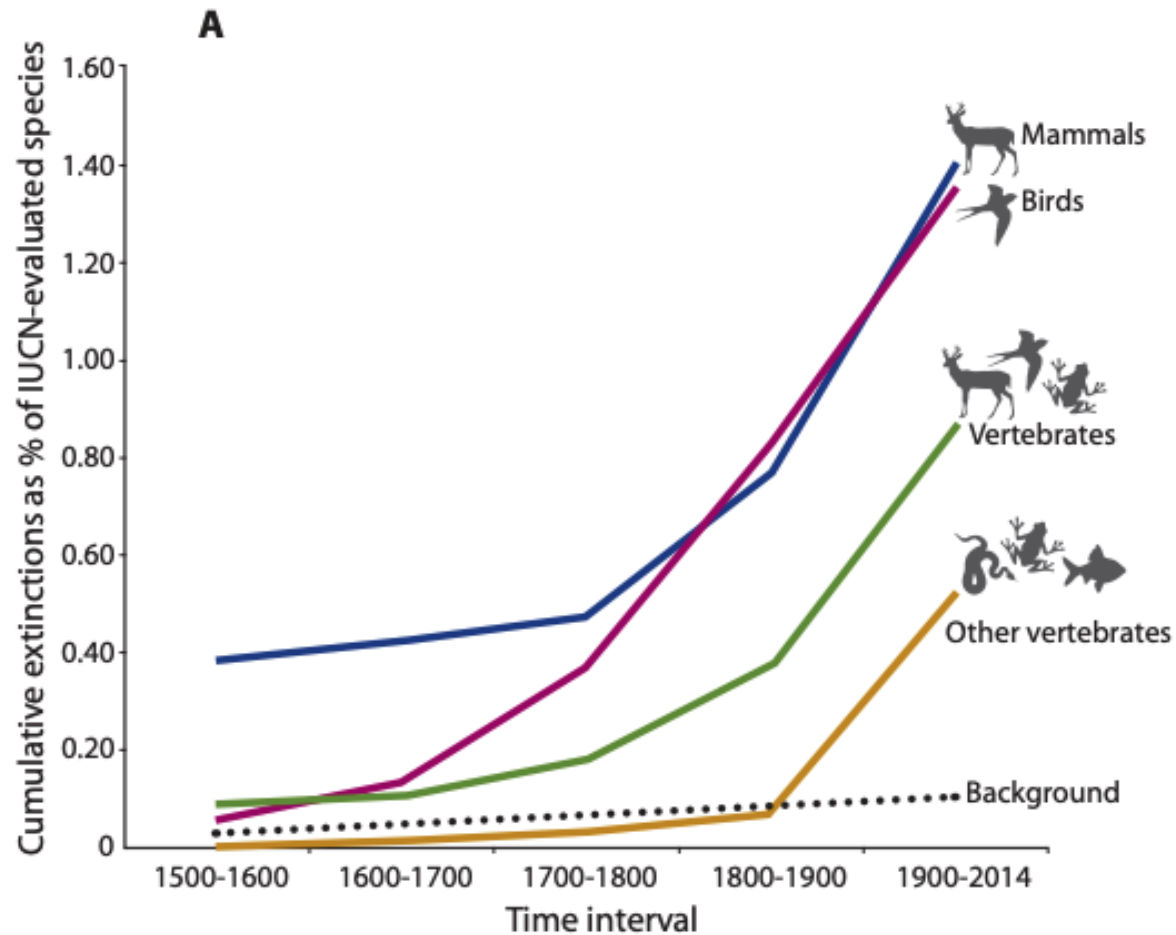
USDA



Humans have many direct and indirect effects on the Earth system



# Biotic change – Species loss

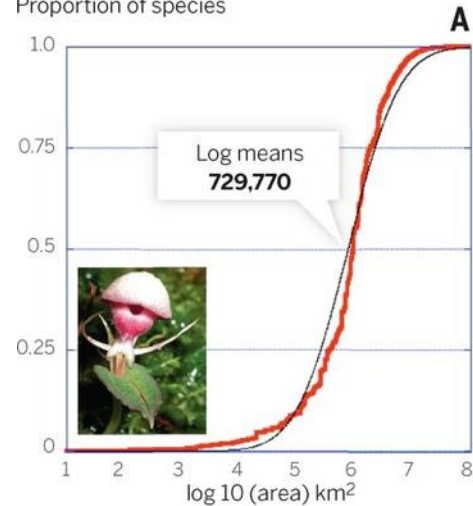


Percent of extinct species  
(note the background rate)



# Biotic Changes – Species Loss

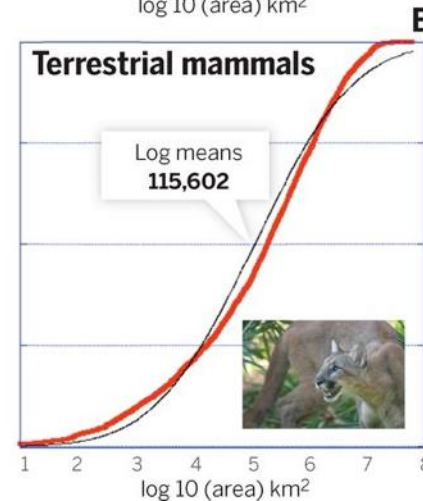
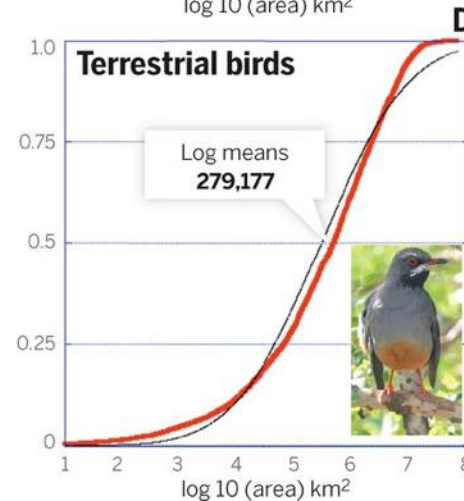
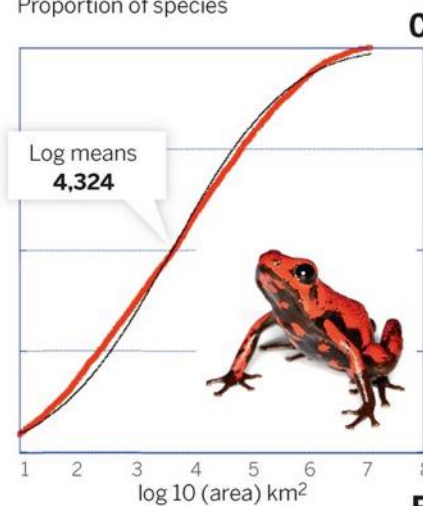
**Flowering plants**  
Proportion of species



**Conus**  
Proportion of species

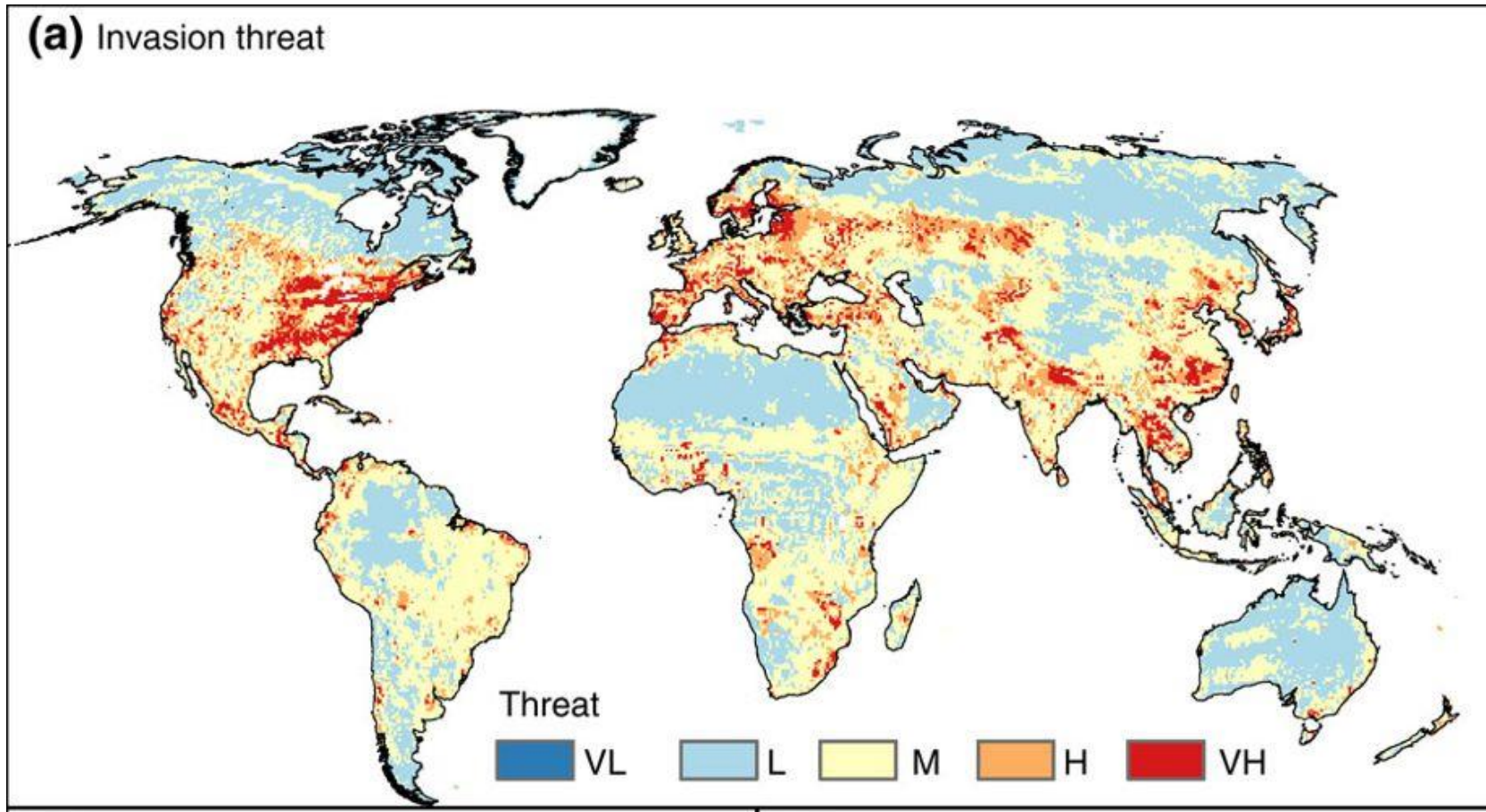


**Amphibians**  
Proportion of species



The number of  
species increases  
with space

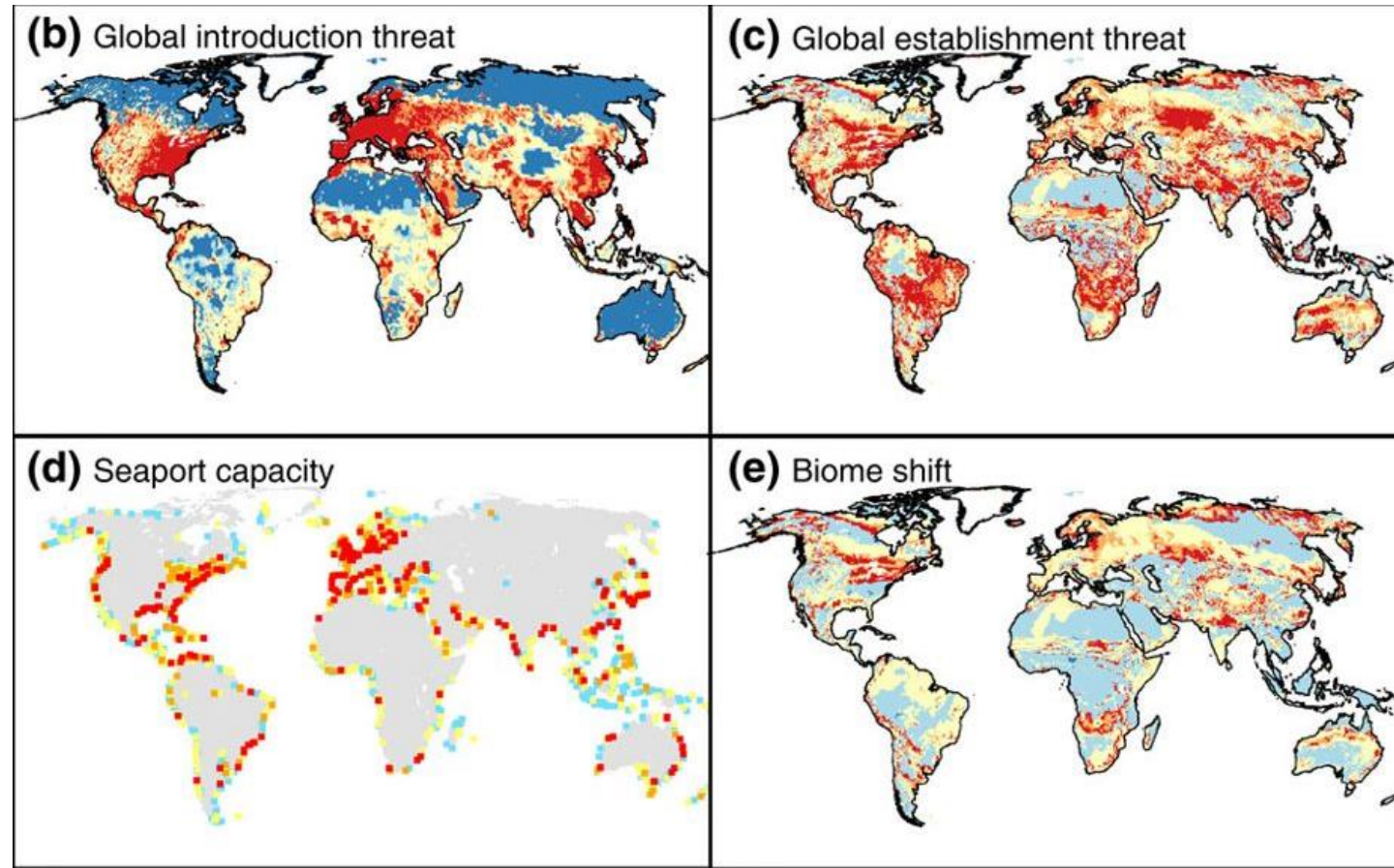
# Biotic Changes - Invasion



Invasive species are threatening all across the globe.

What might explain these patterns?

# Biotic Changes - Invasion





# Biotic Changes - Invasion

