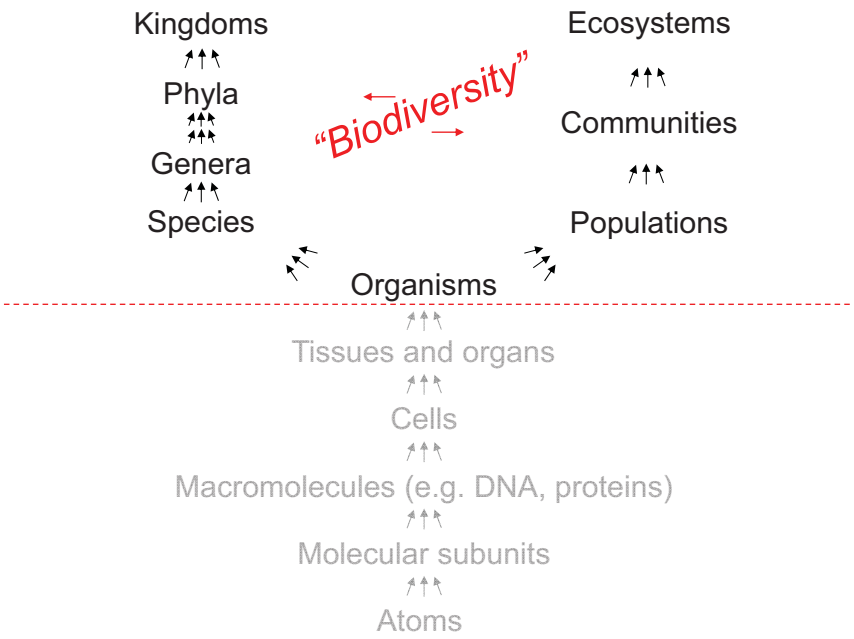
Biology is hierarchical



Levels in the biological hierarchy

Population: – *a group of individuals of one species in an area, potentially interacting (e.g., competition, reproduction)*

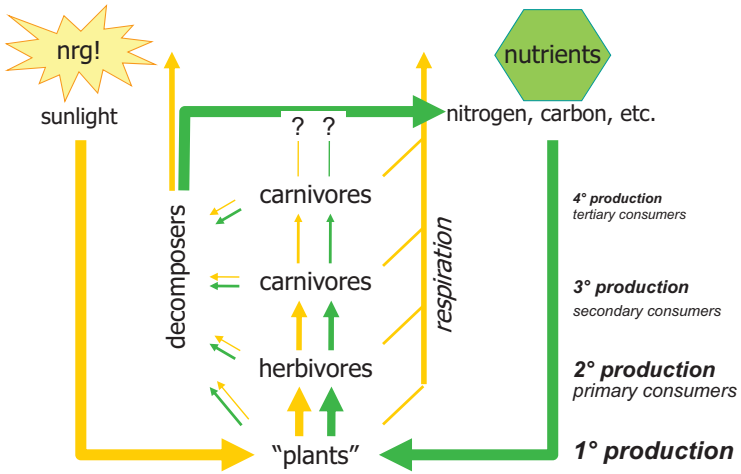
– *continuous through time*

Community: – *a group of populations of different species in an area, potentially interacting*

– *continuous through time*

Ecosystem: – a community (or group of linked communities), their physical environment, and their interactions

Ecosystems: pathways and magnitudes of flow in …



Trophic relationships govern energy and nutrient flow

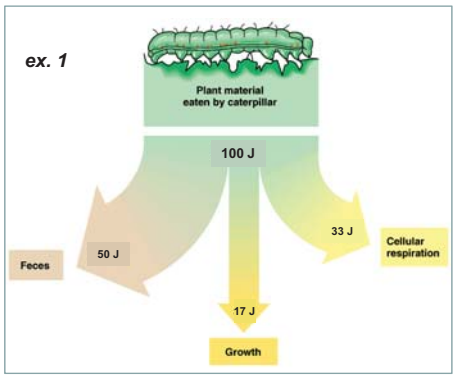
Organisms "produce" biomass at each step

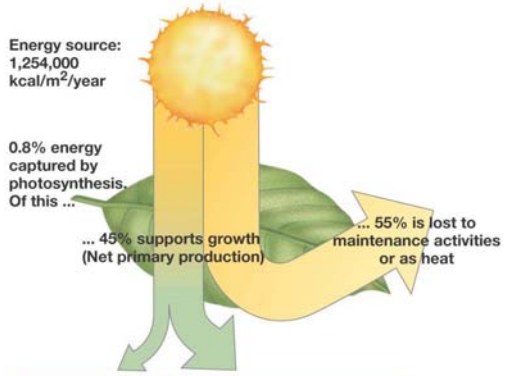
Q: Why is there loss at each step?

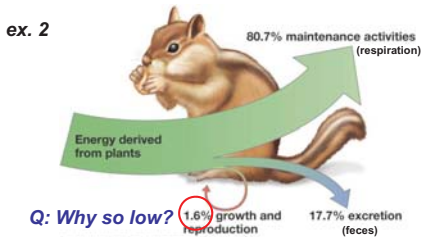
Q: Are nutrients and energy both recyclable?

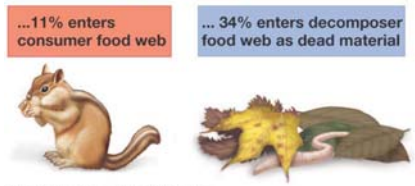
Energy "escapes" from production at each trophic level

➢ Where does the energy go? it depends on the consumer…



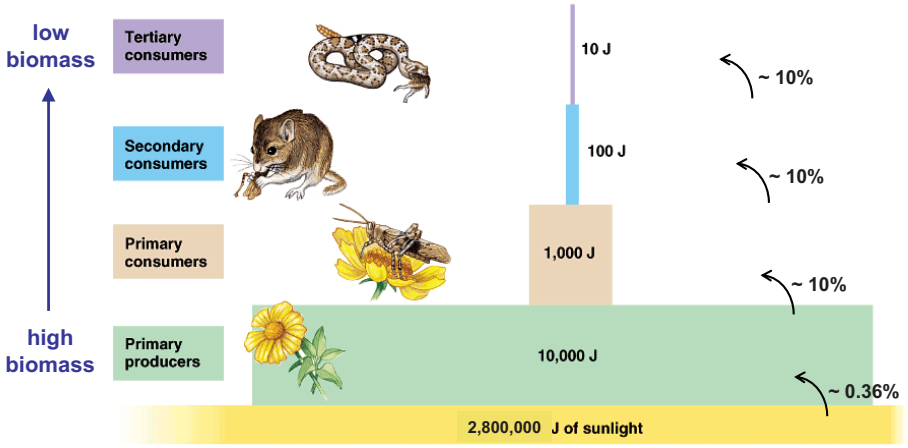






Energy "escapes" from production at each trophic level

➢On average, only ≈ 10% of energy is transferred to next level



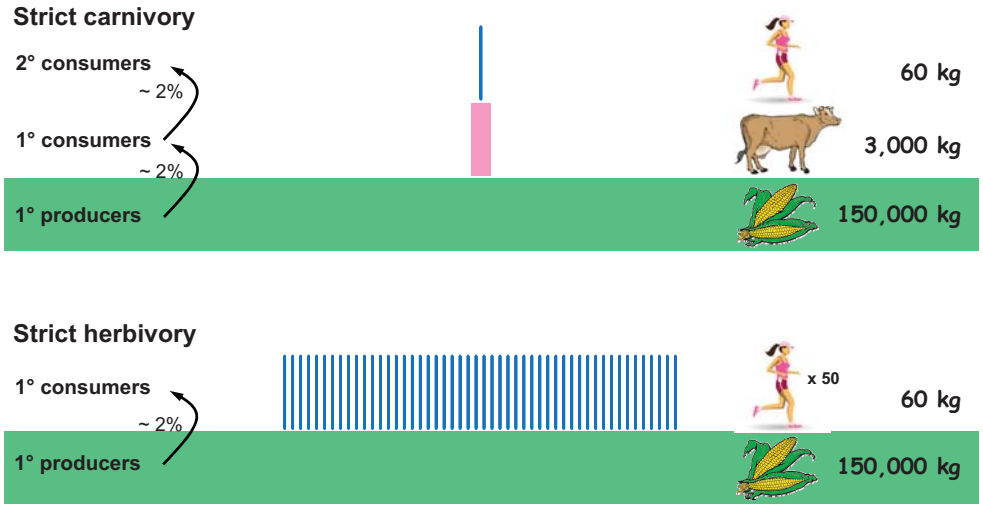
Q: Where does the rest of the energy go?

Q: For what 2 reasons are top predators more vulnerable to extinction?

Q: What would be the ecosystem effects of removing top predators?

Energy "escapes" from production at each trophic level

➢Implications: where are YOU on the food chain?

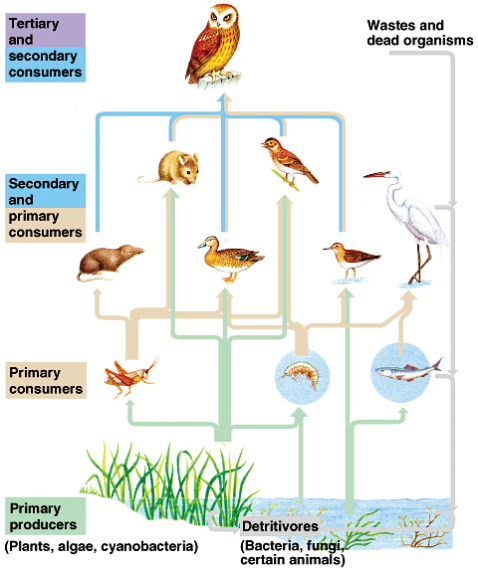


How would a change in your diet affect your ecological footprint?

Food web – major *trophic interactions* in communities

pathways of energy and nutrient flow

Ex. Aquatic-terrestrial trophic interactions



Energy follows a *one-way flow* through ecosystems

Nutrients can be *recycled* through ecosystems

Q: Which cannot be recycled?

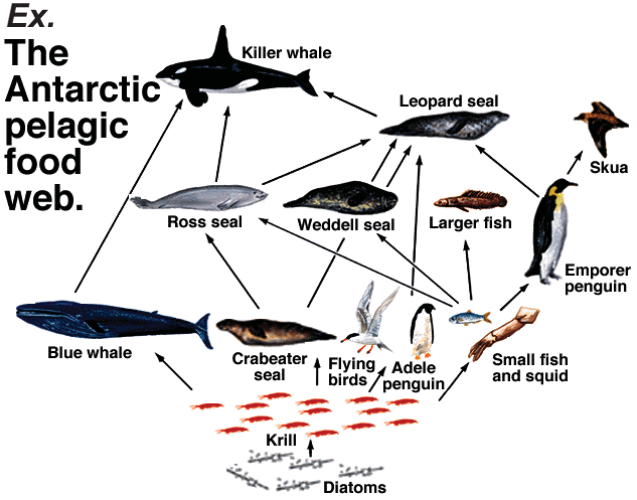
1. ***nitrogen***
2. ***calories***
3. ***water***
4. ***vitamins***

Q: Why are nutrients and energy different?

Food web – major *trophic interactions* in communities

pathways of energy and nutrient flow

***Ex.* The Antarctic pelagic food web.**



Energy follows a *one-way flow* through ecosystems

Nutrients can be *recycled* through ecosystems

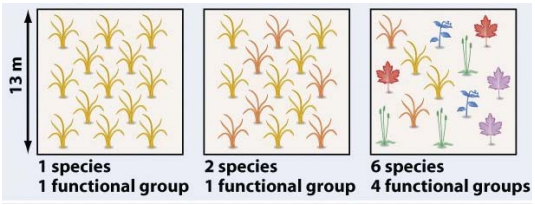
Q: What if orcas become extinct?

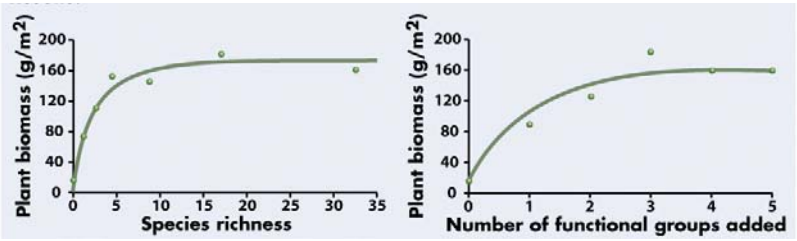
Implications for conservation: Why is diversity important for biological communities?

→ **higher productivity?**

Tropical rainforest

Experimental study



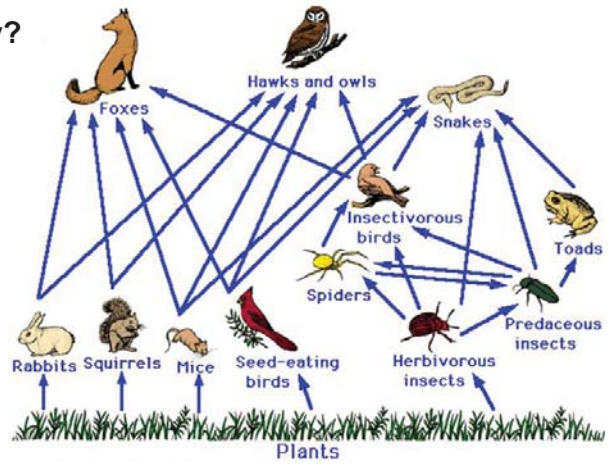


Implications for conservation: Why is diversity important for biological communities?

→ **higher productivity?**

→ **functional redundancy?**

→ **lower invasibility?**



Levels in the biological hierarchy

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Community: – *a group of populations of different species in an area, potentially interacting*

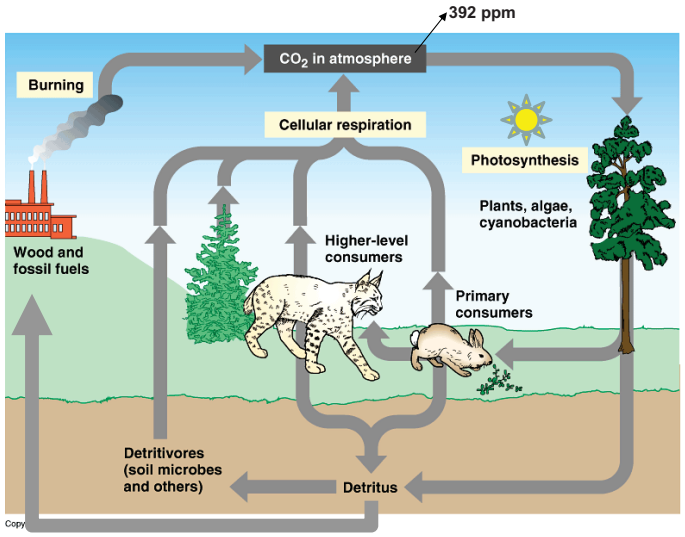
– *continuous through time*

Ecosystem: – a community (or group of linked communities), their physical environment, and their interactions

Biosphere: – all of Earth's ecosystems; the part of the planet capable of supporting life

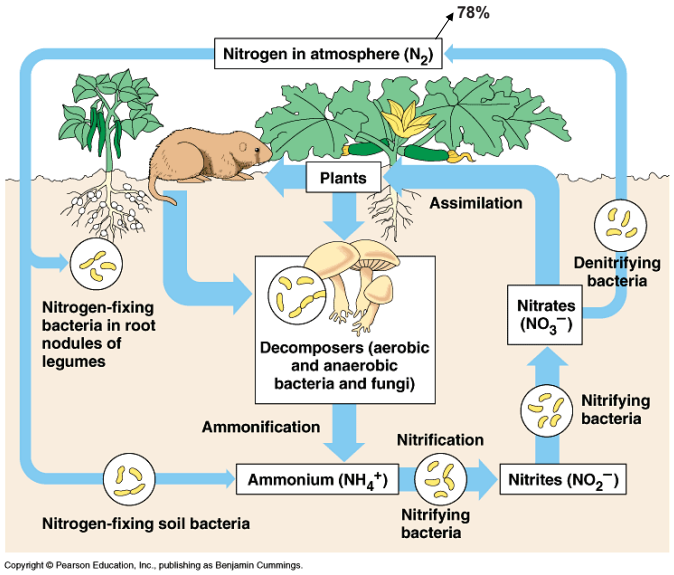
Biogeochemistry – nutrient cycling between *biotic* and *abiotic* parts of an ecosystem

Carbon cycle *in a terrestrial ecosystem*



Biogeochemistry – nutrient cycling between *biotic* and *abiotic* parts of an ecosystem

Nitrogen cycle *in a terrestrial ecosystem*



Biome: characteristic <u>community type</u> supported by particular combination of <u>physical conditions</u>

Q: Which physical conditions (abiotic factors) influence ecosystems?

- **temperature**
- **light**
- **water**

} ***"Climate"***

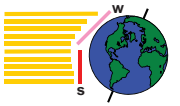
- salinity
- pH
- wind/turbulence
- nutrients
- etc.

<u>Macro</u>climate – regional/global patterns
- latitude, altitude, surface type, etc.

<u>Micro</u>climate – local patterns
- local vegetation, rocks, slope, etc.

Q: Which factors influence macroclimate?

Angle of the earth relative to the sun

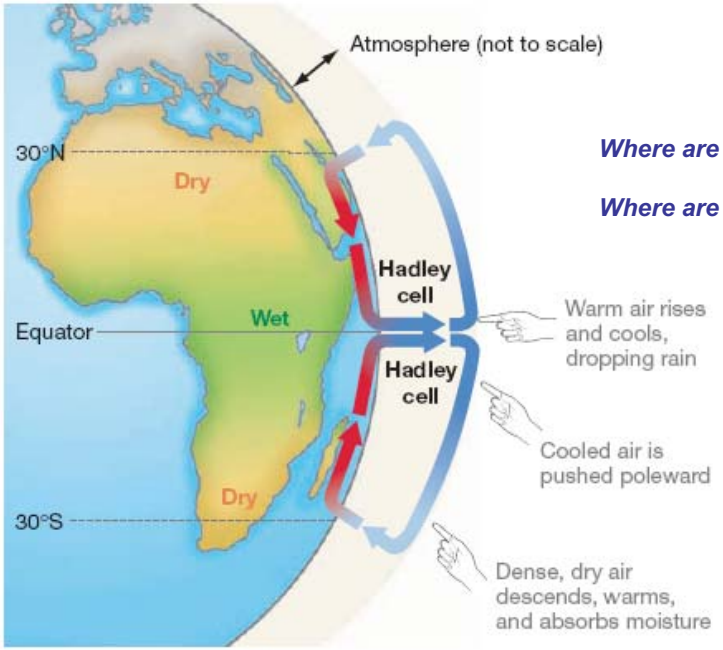


Q: Where is it summer? Why?

Intensity of **sunlight** → **temperature**, **rainfall**, seasonality, ocean currents, wind

support different **biomes**

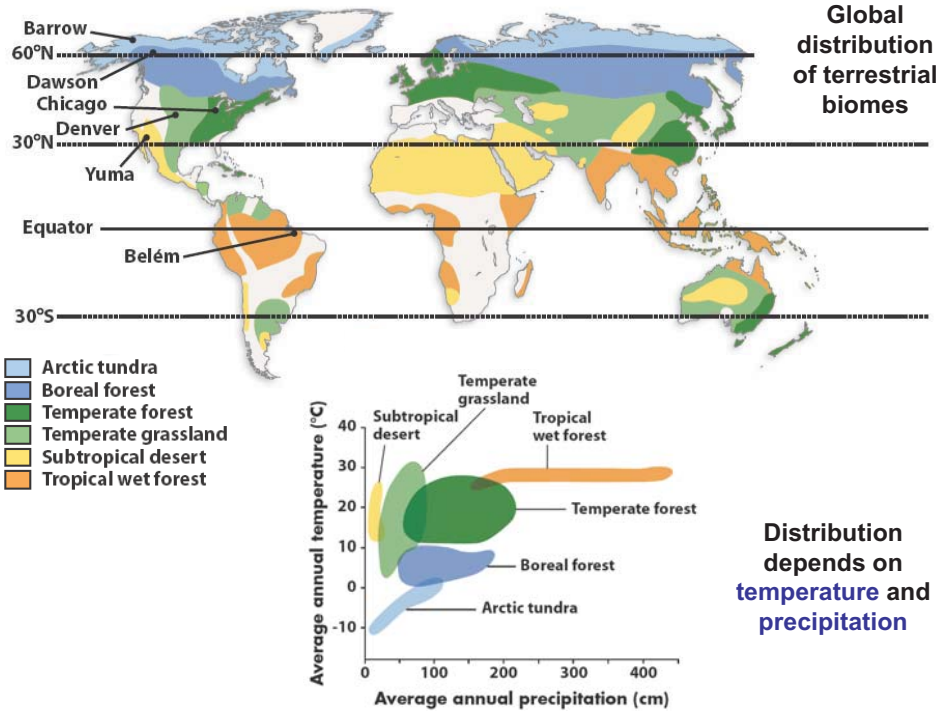
How does the intensity of sunlight affect precipitation?



Where are rainforests found?

Where are deserts found?

Biome: characteristic *community type* supported by particular combination of *physical conditions*

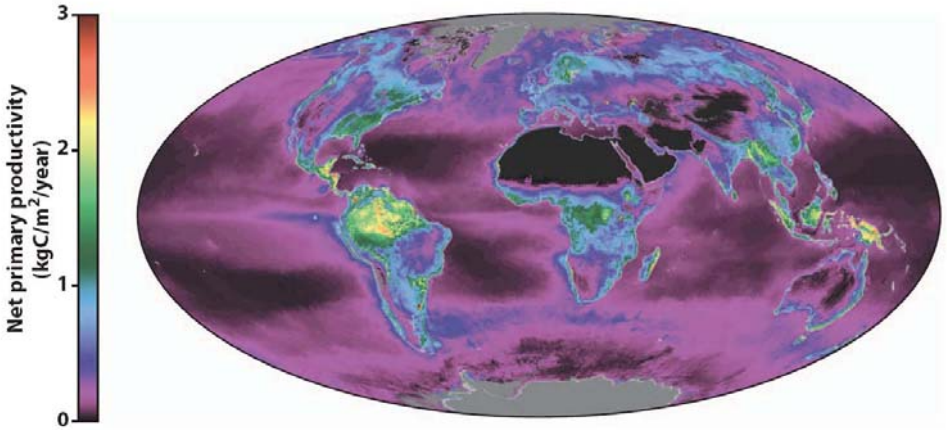


Global distribution of terrestrial biomes

Distribution depends on temperature and precipitation

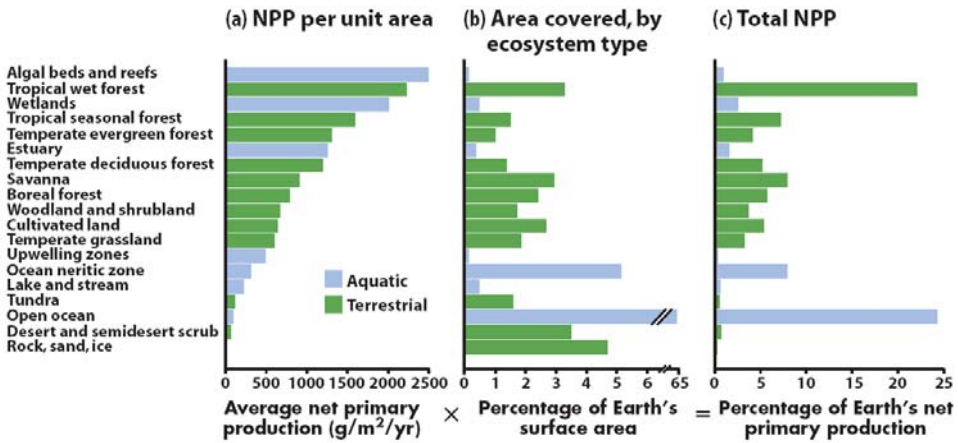
Which biomes are most productive?

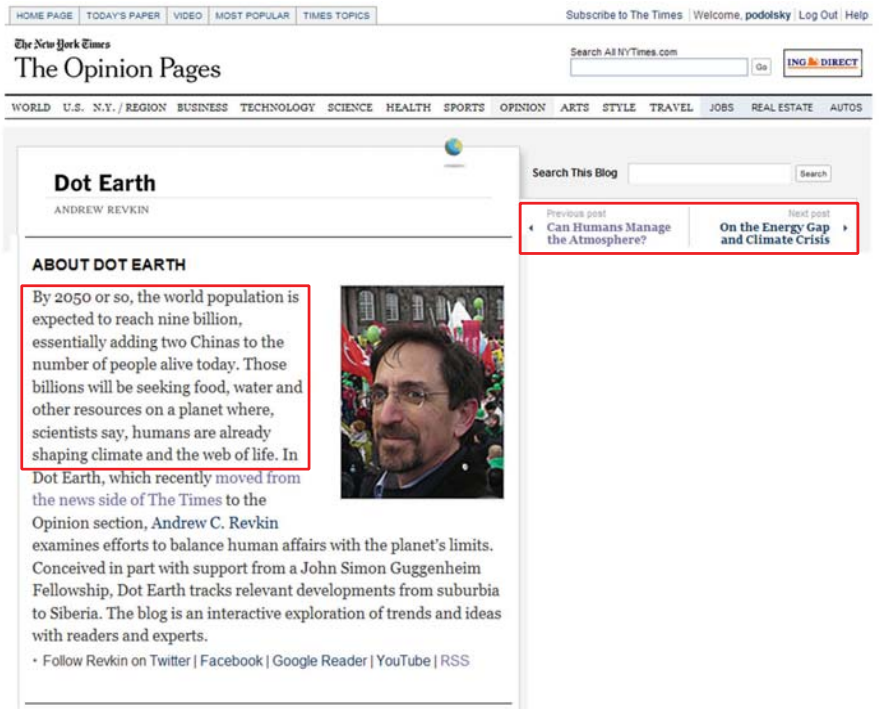
Net primary productivity (NPP) – energy invested in new plant biomass



How do abiotic factors limit NPP in terrestrial ecosystems? in marine ecosystems?

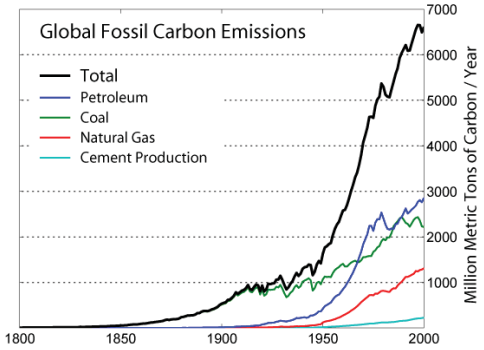
Which biomes are most productive?



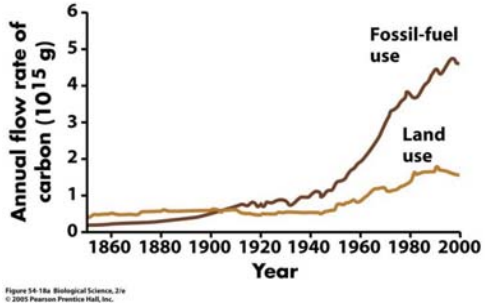


Humans are altering global biogeochemistry…

- pollution



Rising rates of CO_2 release from various anthropogenic sources

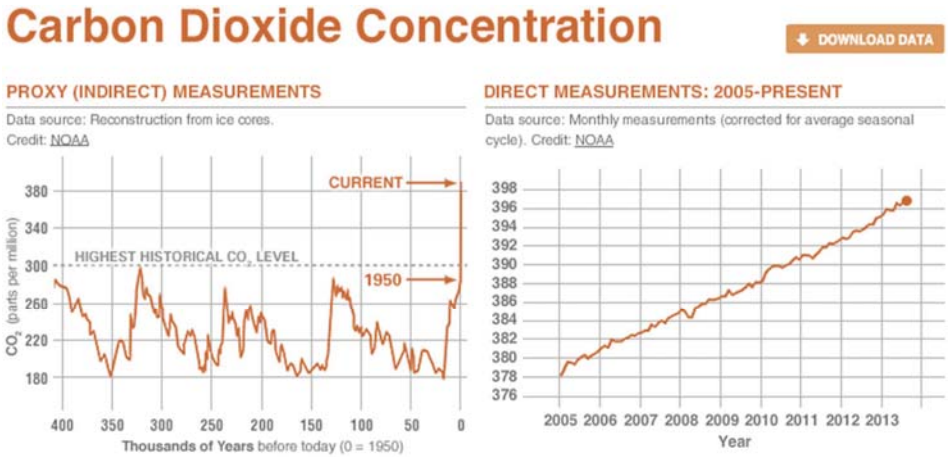


Increases in CO_2 emissions due to fossil fuel use and forest destruction

http://www.globalwarmingart.com/wiki/Carbon_Dioxide_Gallery

Humans are altering global biogeochemistry…

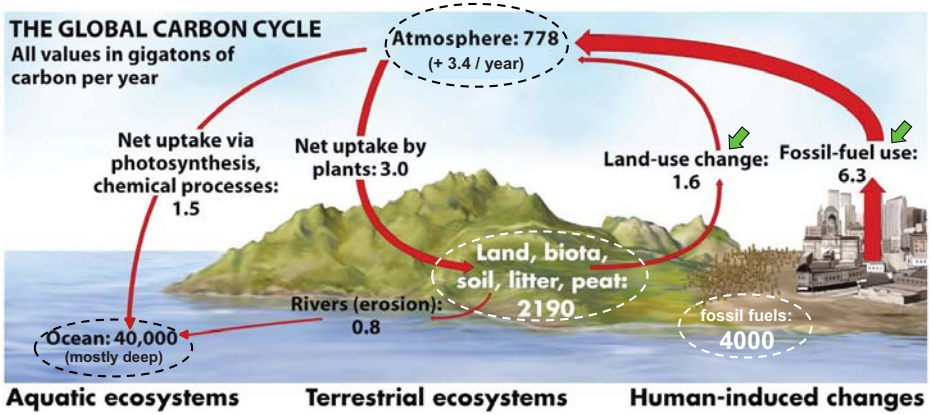
- pollution
- atmospheric CO_2



http://climate.nasa.gov/keyIndicators/

Humans are altering global biogeochemistry…

…and changing the carbon cycle



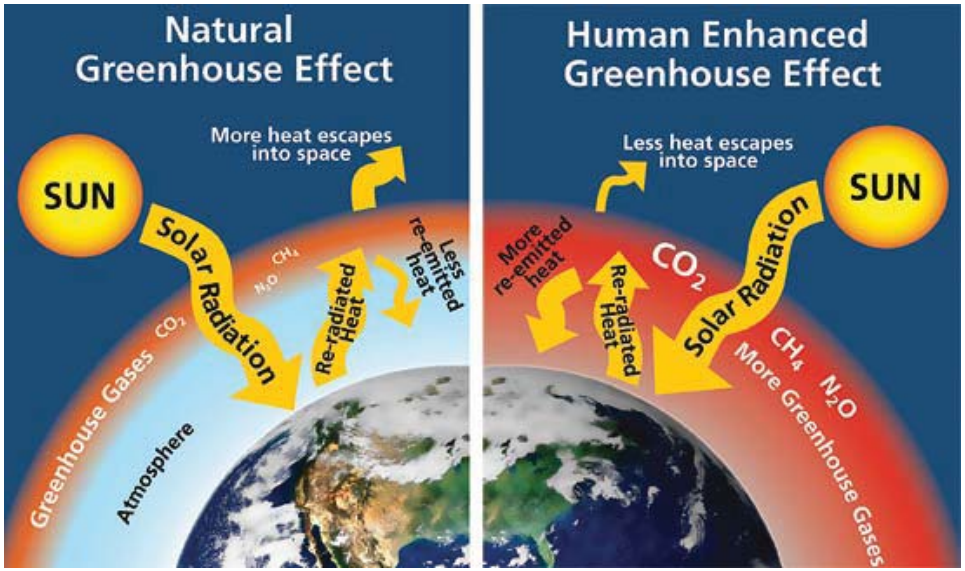
major reservoirs

major anthropogenic changes

How do these changes influence carbon reservoirs?

Humans are altering global biogeochemistry…

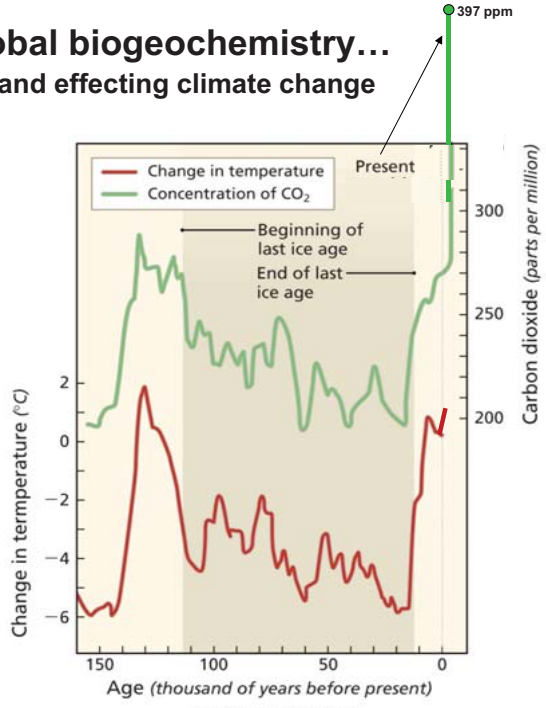
…and enhancing the greenhouse effect



http://www.nps.gov/goga/naturescience/climate-change-causes.htm

Humans are altering global biogeochemistry…

…and effecting climate change



Changes in atmospheric CO_2 and temperature over previous 150,000 years

Humans are altering global biogeochemistry…

…and effecting climate change

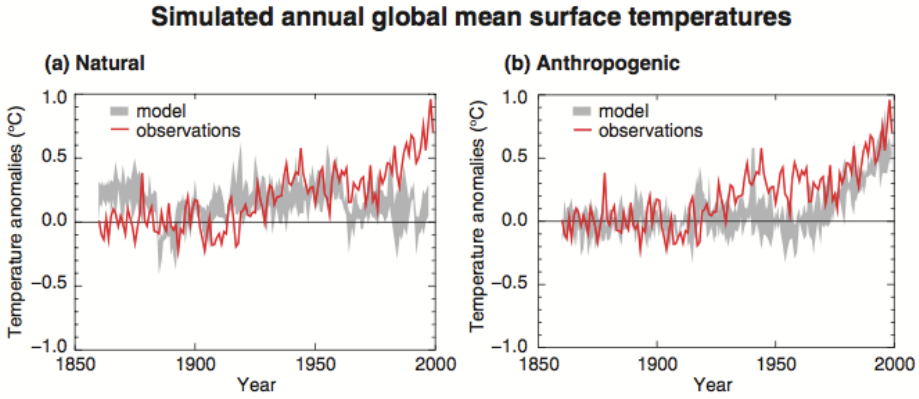
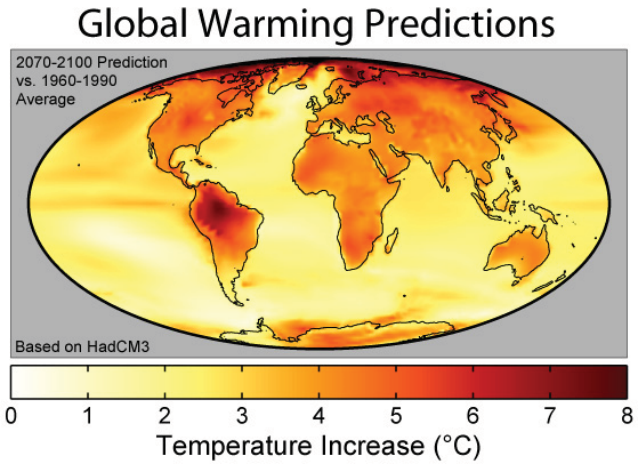


Figure 1: Comparison of climate model predictions with observations. (a) represents simulations done with only natural forcings: solar variation and volcanic activity. (b) represents simulations done with anthropogenic forcings: greenhouse gases and sulphate aerosols (IPCC).

Humans are altering global biogeochemistry…

…and effecting climate change



The predicted warming over the 21st century due to business as usual greenhouse gas emissions scenario (IS92a) as reported by the HadCM3 climate model. The average warming in this model is 3.0 °C.

http://www.globalwarmingart.com/wiki/Predictions_of_Future_Change_Gallery

Humans are altering global biogeochemistry…

- pollution
- atmospheric CO_2
- oceanic CO_2

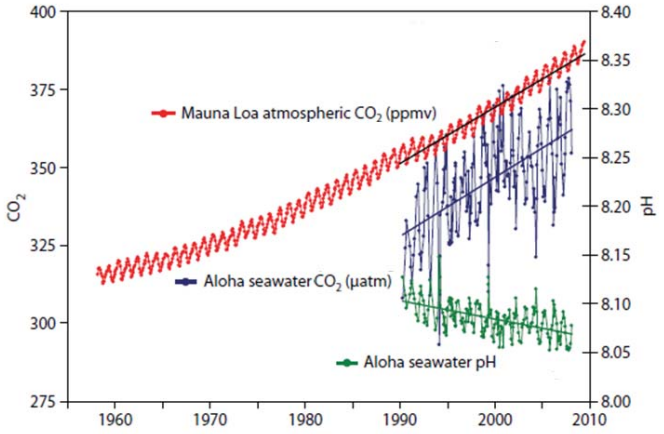
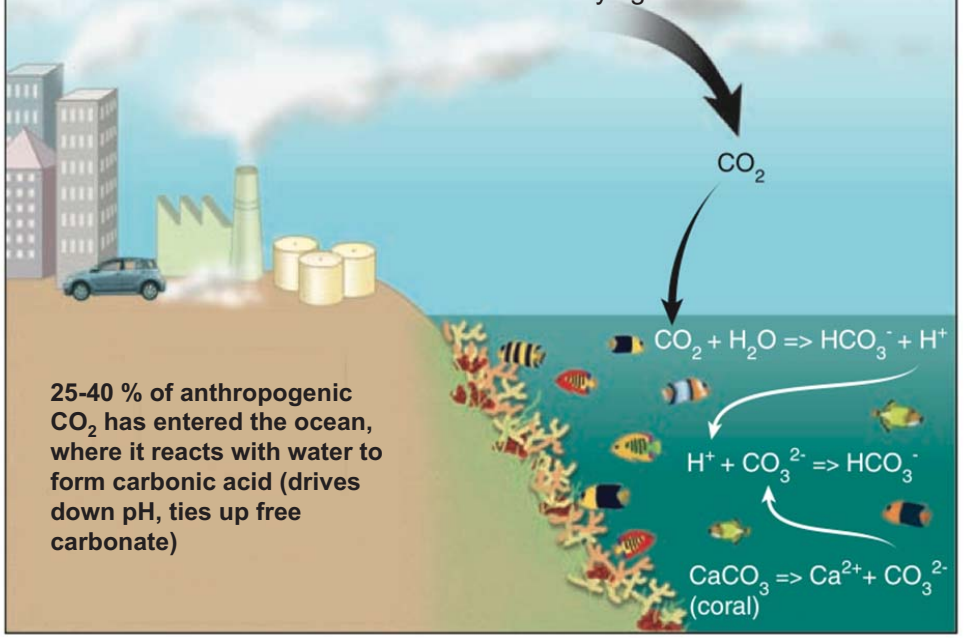


*Fig 1. Changes in atmospheric CO2 (**red**), seawater CO2 (**blue**), and seawater pH (**green**) over the last 50 years. The ocean has absorbed about 40% of atmospheric increases in CO2.*

Humans are altering global biogeochemistry…

- and acidifying the world's oceans



25-40 % of anthropogenic CO_2 has entered the ocean, where it reacts with water to form carbonic acid (drives down pH, ties up free carbonate)

Humans are altering global climate…

…and affecting biodiversity

Population effects, 1982-2006

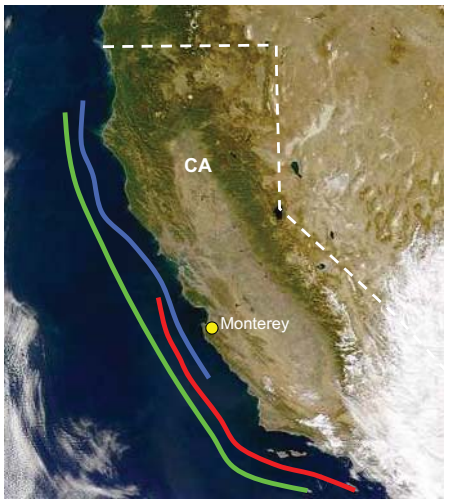
- decreased body size
- fewer cubs born
- fewer cubs survive
- reduced juvenile growth

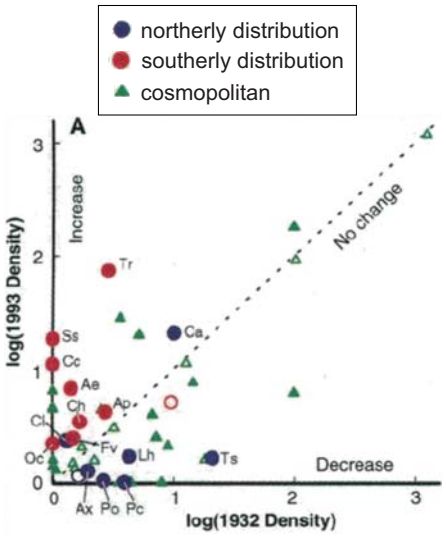
The First-Ever Bulk Freighter To Pass Through The Arctic Was Carrying Coal

BY ARI PHILLIPS ON SEPTEMBER 26, 2013 AT 1:44 PM

Humans are altering global climate…

…and affecting biodiversity

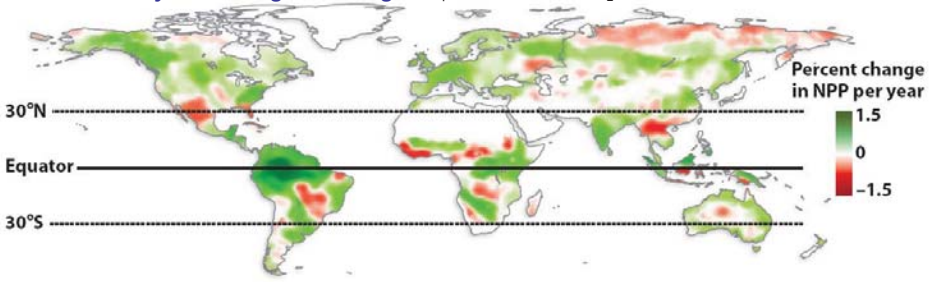




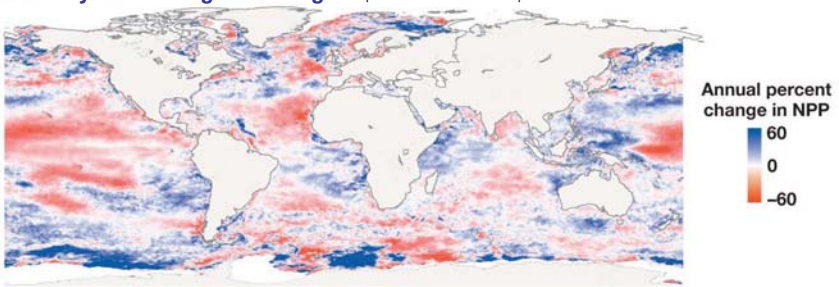
Humans are altering climate & biogeochemistry…

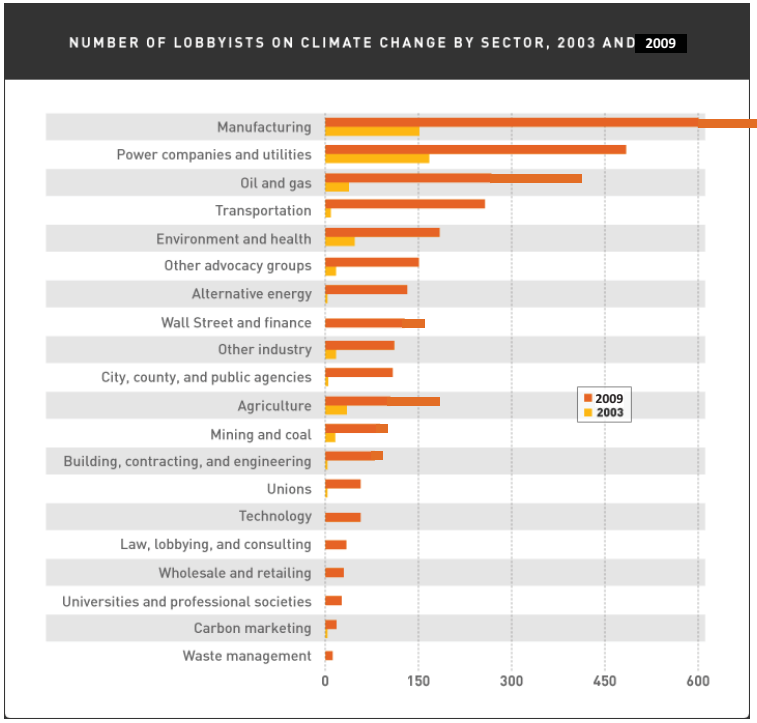
…and affecting global 1° productivity

Terrestrial: why increasing on average? ↑ *temperature, CO_2, nitrification*

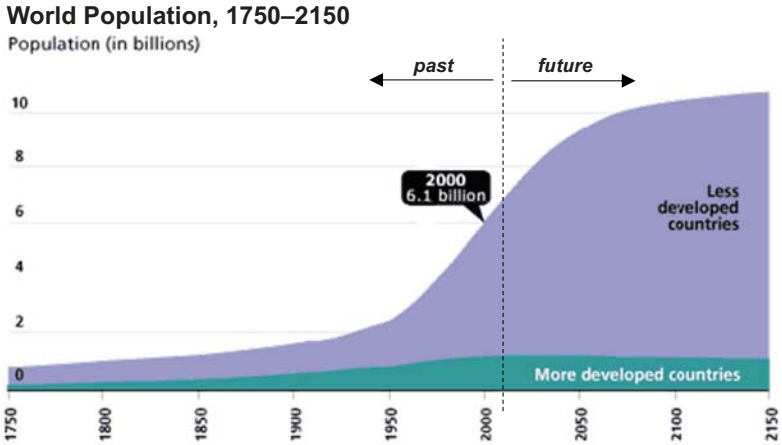


Oceanic: why decreasing on average? ↑ *stratification* ↑ *acidification*





Human population growth & resource use

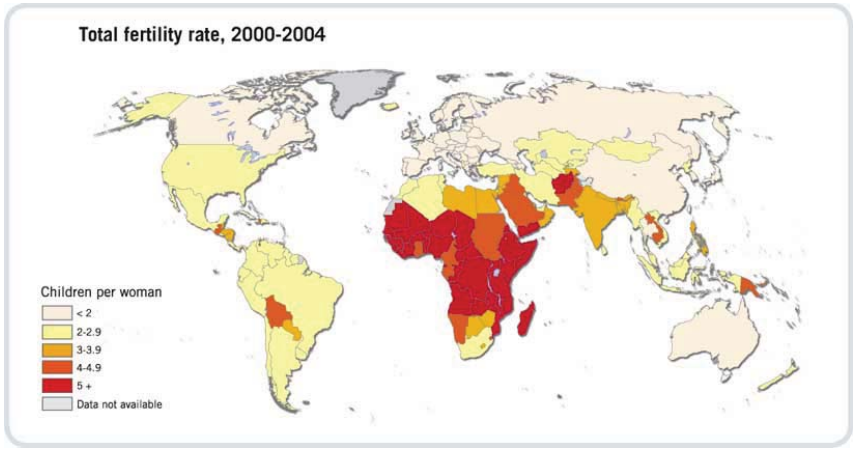


Source: United Nations, *World Population Prospects, The 1998 Revision*; and estimates by the Population Reference Bureau.

Vitousek PM, Mooney HA, Lubchenco J, Melillo JM. 1979.
Human Domination of Earth's Ecosystems. *Science* 277 (5325): 494 – 499.

Human population growth & resource use

Geographic variation in birth rates



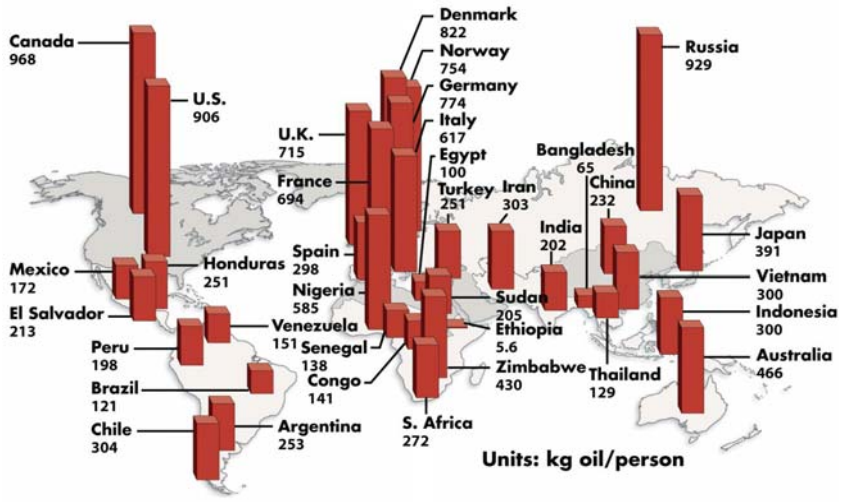
Source: World Health Organization

Are less developed countries to blame for the world's ecological problems?

Is human population growth the major issue?

Human population growth & resource use

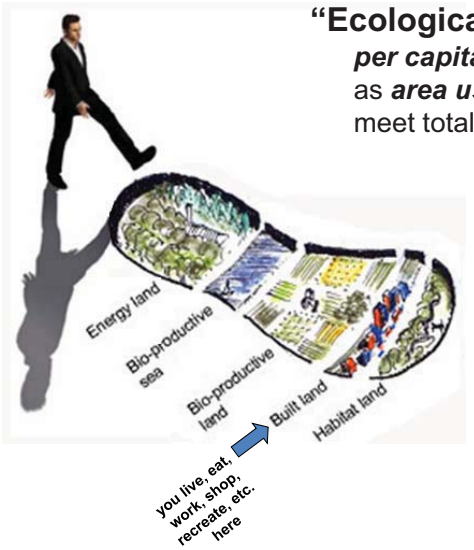
Geographic variation in resource use



Human population growth & resource use

"Ecological footprint"

per capita demand on resources, measured as ***area used*** to regenerate resources to meet total needs

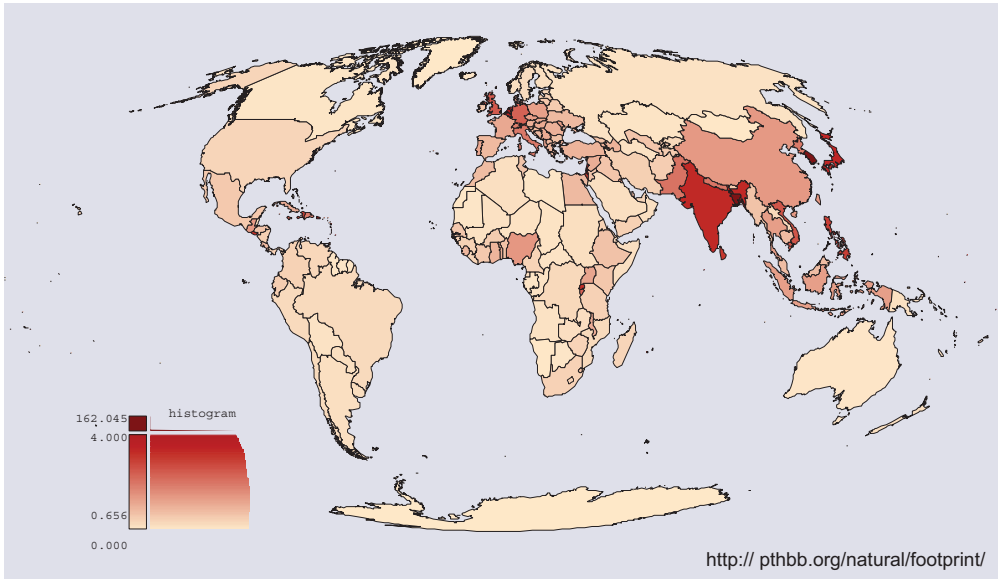


Is there enough land on earth to meet these demands?

Has the human population reached carrying capacity?

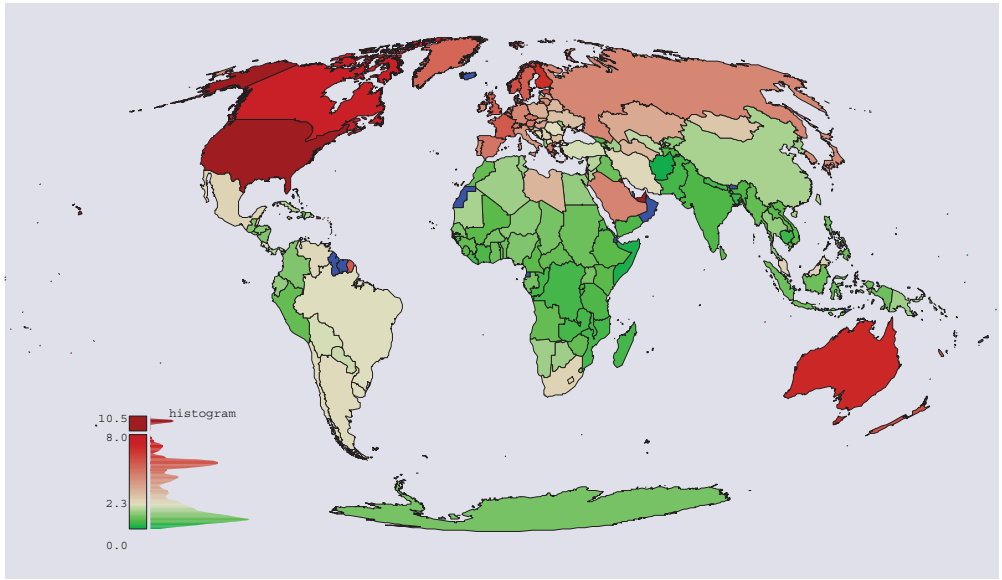
Human population growth & resource use

Population density (people per hectare)



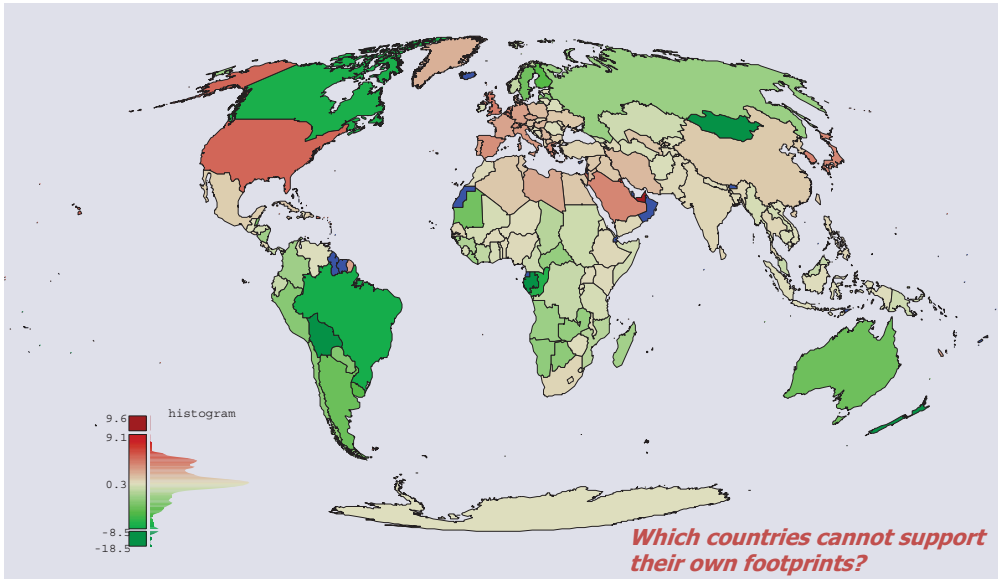
Human population growth & resource use

Ecological footprint (ecological hectares per person)



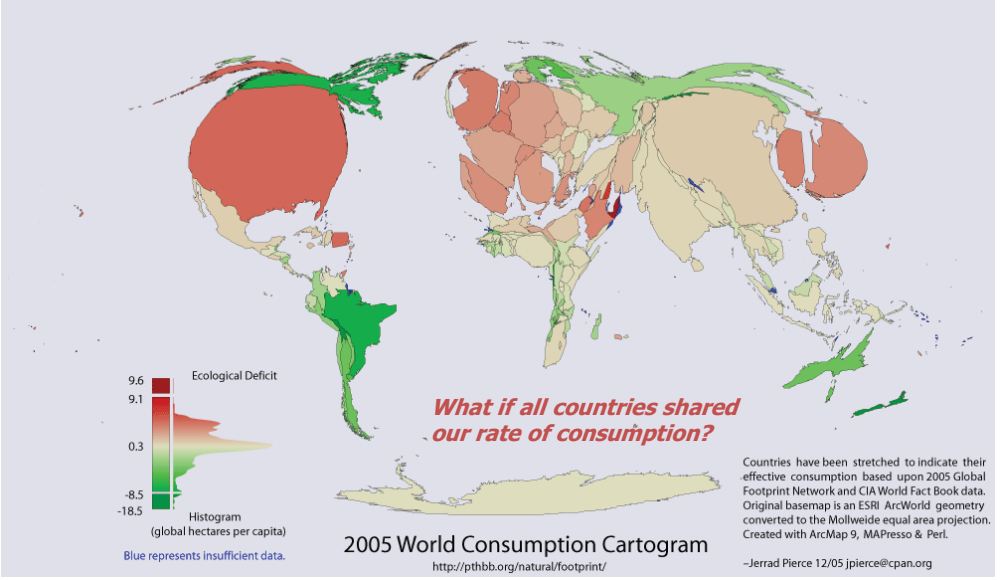
Human population growth & resource use

Ecological deficit (ecological / actual hectares per person)

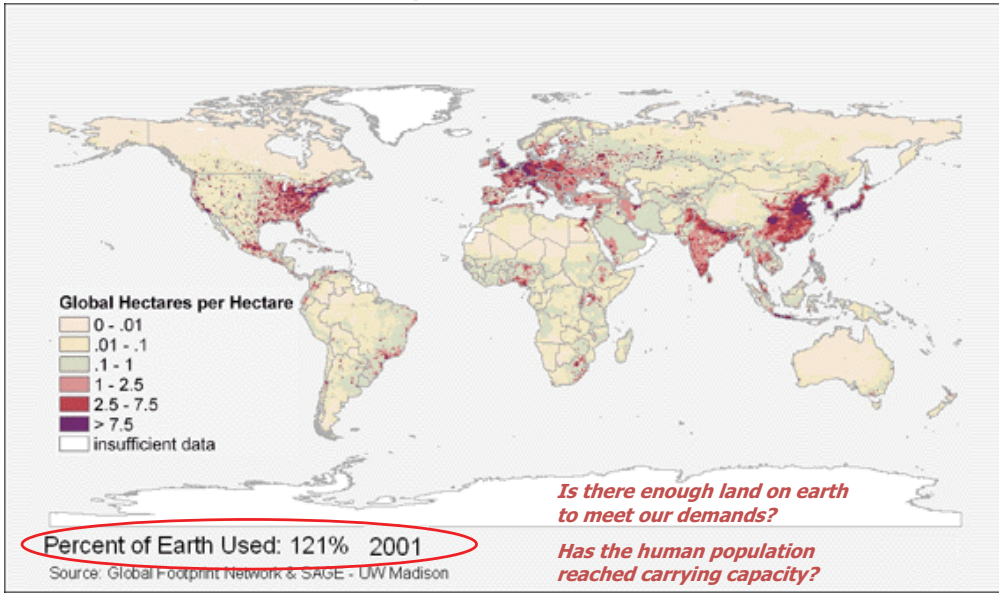


Human population growth & resource use

Ecological deficit adjusted (ecological / actual hectares = 1)



Human population growth & resource use



130% 2005
200% 2030

Human population growth & resource use

So, what is <u>your</u> ecological footprint?

http://footprintnetwork.org > Footprint for you

Extra credit: ***Calculate your ecological footprint. Identify two ways you could reduce it, recalculate each. Explain which change would have a greater impact.***