Ecosystems: Nutrient ‘Cycles’

Earth's Life-Support Systems

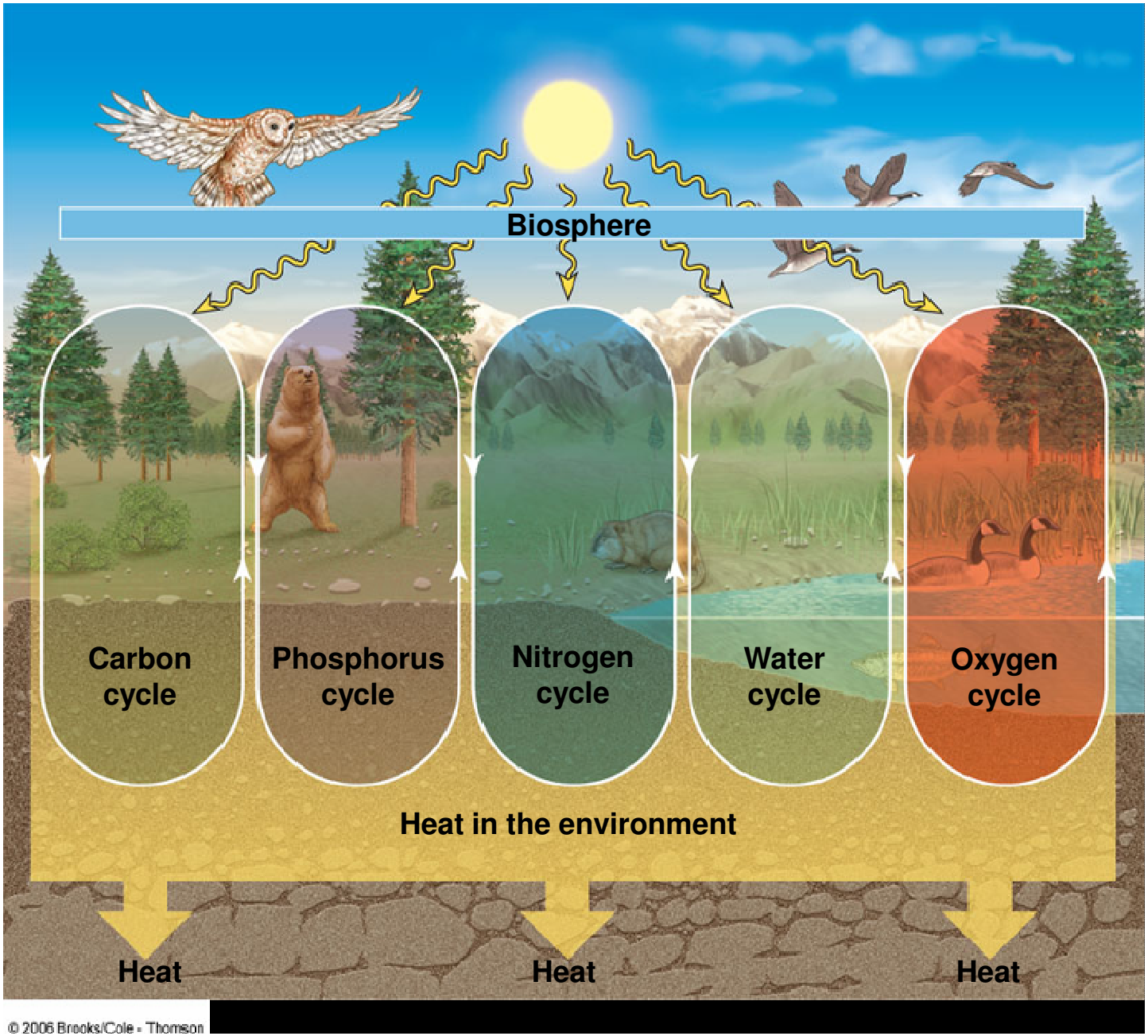
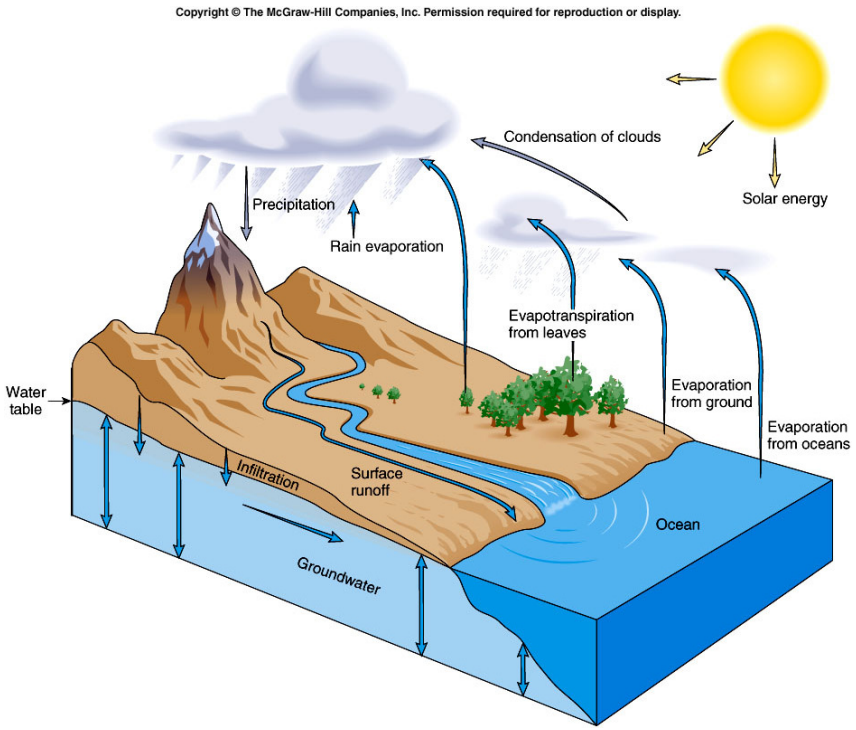


Fig. 3-6, p. 39

Greeks, Native Peoples, Buddhism, Hinduism use(d) Earth, Air, Fire, and Water as the main elements of their faith/culture

Cycling in Ecosystems – the Hydrologic Cycle

- What are the three forms of water?
- Processes
  - Condensation
  - Precipitation
  - Transpiration
  - Evaporation



What happens when water hits a surface?

Depends on: permeability of the surface

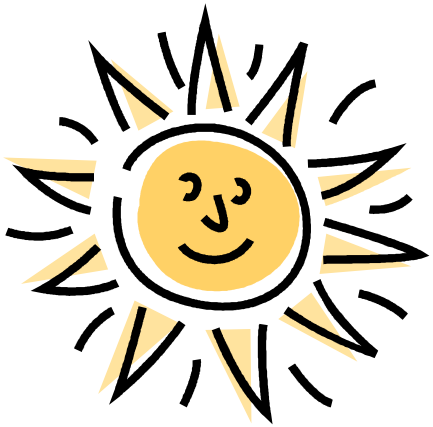
50% of water that falls on soil or vegetation runs off

100% of water that falls on asphalt runs off

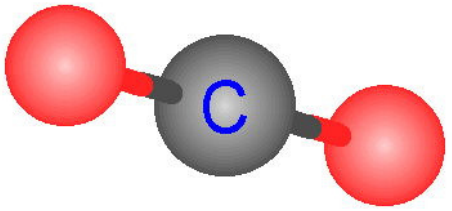
Carbon Cycle

Forms the basis of all living things

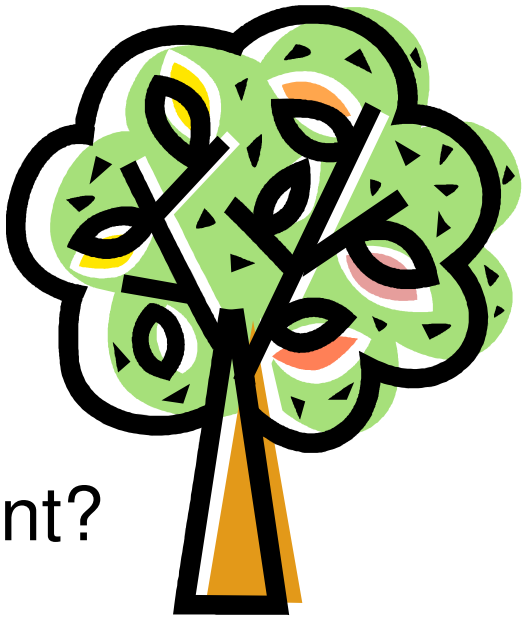
It all starts with…



and

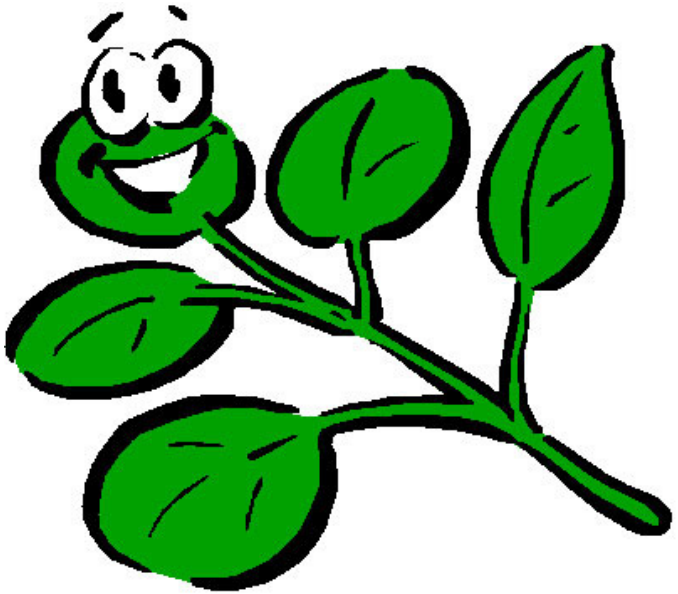


Which creates…



Why is this important?

Carbon Cycle



Does this plant contain carbon?

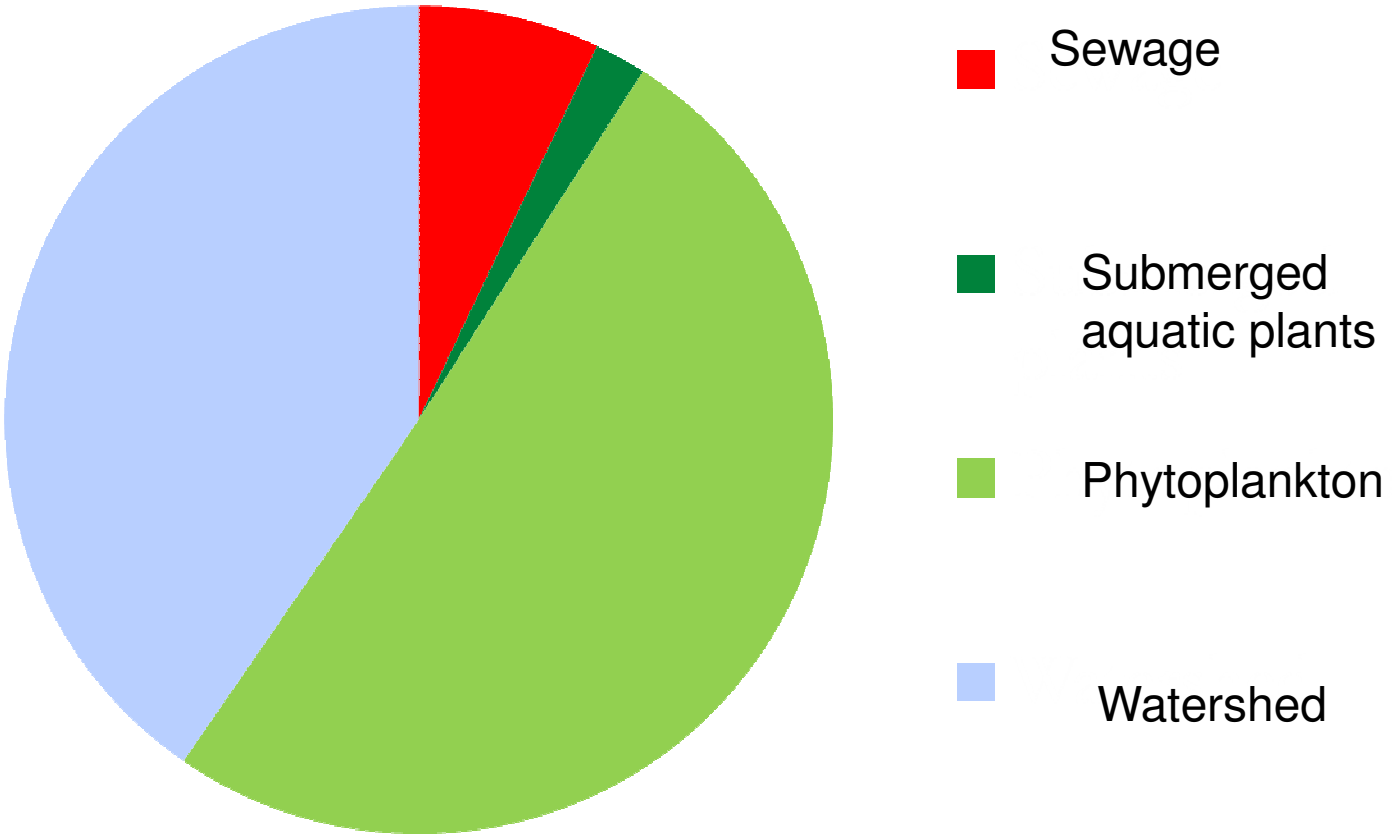
What happens when the plant dies? Does it release carbon?

Carbon Cycle

Does this wood contain carbon?

What happens when you burn wood? Do you release carbon?

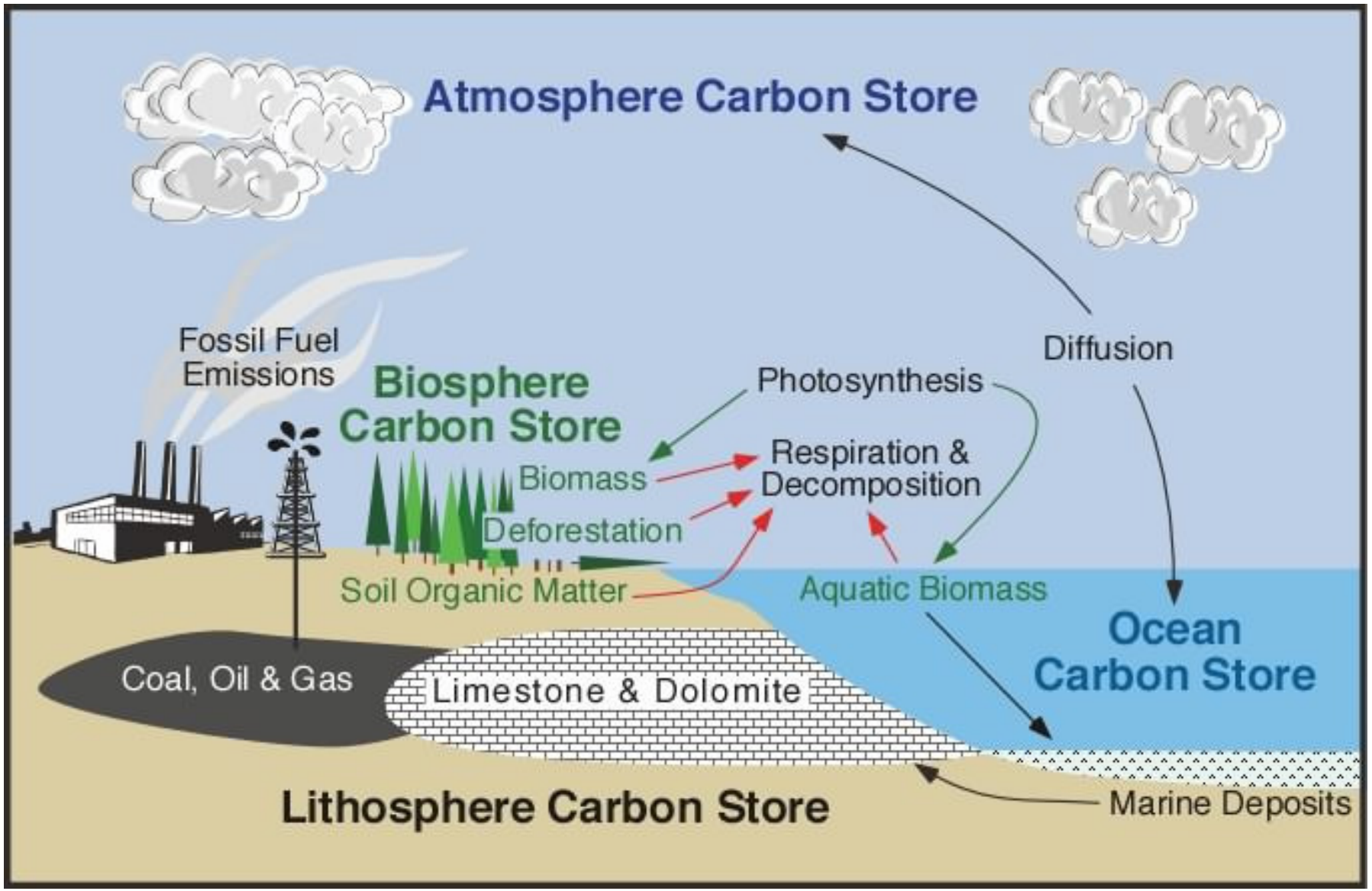
Sources of Organic Carbon in the Hudson River



Information taken from Stanne, Panetta, and Florist. 2007. The Hudson.

Carbon Cycle

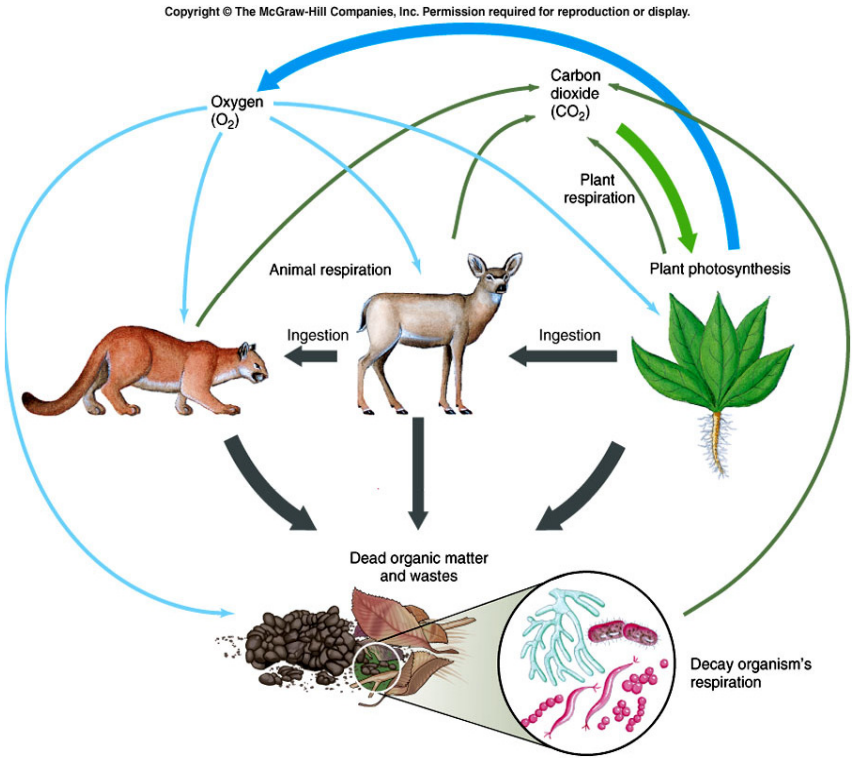
- Can be stored in five major areas:
  1. Living and dead organisms
  2. Atmosphere (carbon dioxide)
  3. Organic matter in soil
  4. Lithosphere as fossil fuels and rock deposits
  5. Oceans as dissolved CO2 and shells


Atmosphere Carbon Store
Fossil Fuel Emissions
Biosphere Carbon Store
Photosynthesis
Diffusion
Respiration & Decomposition
Biomass
Deforestation
Soil Organic Matter
Aquatic Biomass
Ocean Carbon Store
Coal, Oil & Gas
Limestone & Dolomite
Marine Deposits
Lithosphere Carbon Store

Estimated major stores of carbon on the Earth

Sink	Amounts in Billions of Metric Tons
Atmosphere	766
Soil Organic Matter	1500-1600
Ocean	38,000-40,000
Marine sediments and sedimentary rocks	66,000,000 to 100,000,000
Terrestrial plants	540-610
Fossil Fuel Deposits	4000

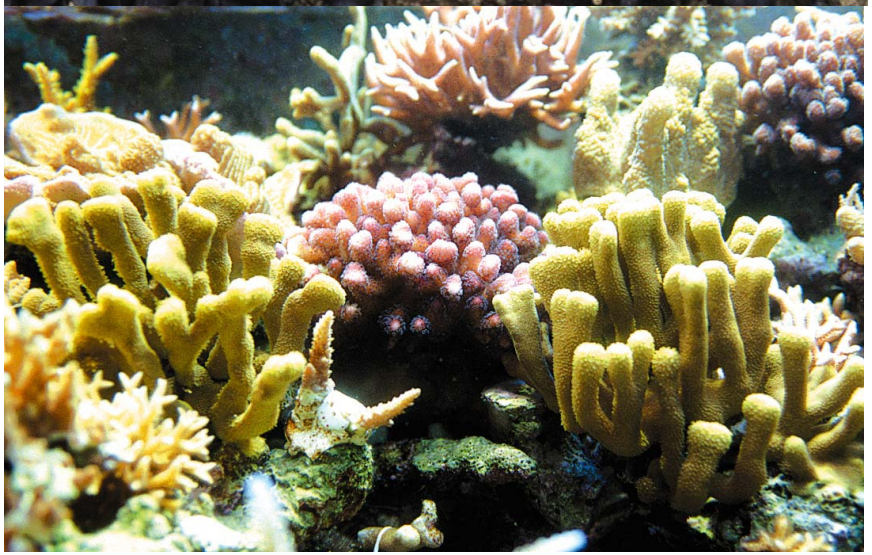
Carbon in Ecosystems: Photosynthesis and Respiration



- Forms of C: CO_2, organic C compounds like glucose
- Processes
  - Photosynthesis: Carbon dioxide + water + solar energy $\xrightarrow{\text{chlorophyll}}$ glucose (sugar) + oxygen
  - Respiration: Glucose + oxygen $\Rightarrow$ Carbon dioxide + water + E

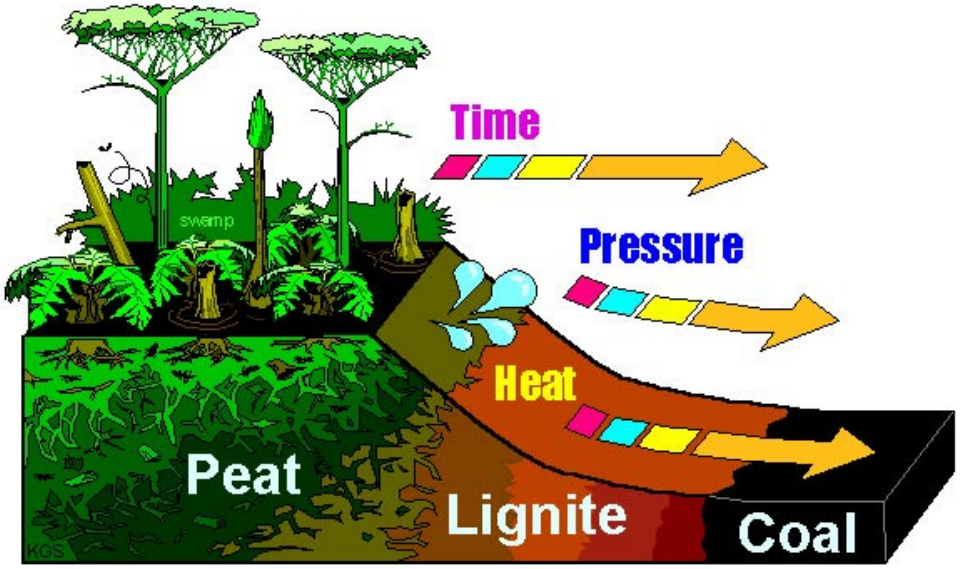
Carbon in Oceans

- Enters through diffusion (creates carbonic acid)
- Some sea life use bicarbonate to produce shells and body parts (coral, clams, some algae)



Carbon cycle in the lithosphere

- Inorganic: coal, oil, natural gas, oil shale, limestone
- Created from organisms (both plant and animal) that died a long time ago and accumulated on the bottom of oceans or lakes

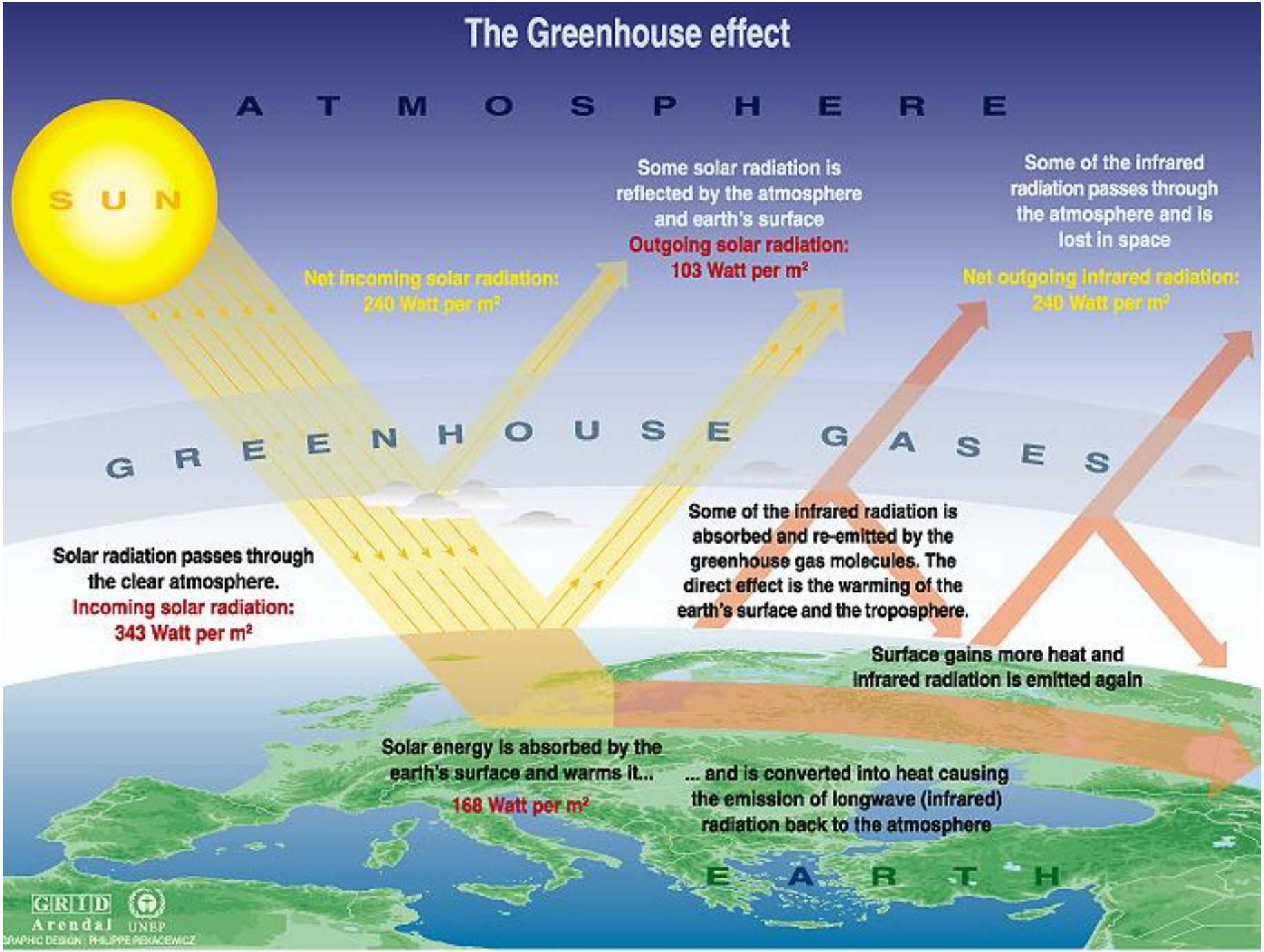


Carbon cycle in the soil

- Organic: litter, humic substances found in soil

Humans and the Carbon Cycle

- Until recently: none
- Now: 6.5 billion metric tons of carbon are transferred from fossil fuel storage pool to the atmosphere



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

Geologic Cycle

- Takes place over millions of years
- CO2 from the atmosphere combines with water to create a weak acid, which reacts with compounds in the earth's surface and eventually settles into the ocean floor
- This carbon is eventually released back into the atmosphere during volcanic eruptions
- What else might cause the carbon to be released back into the atmosphere?

Biologic Cycle

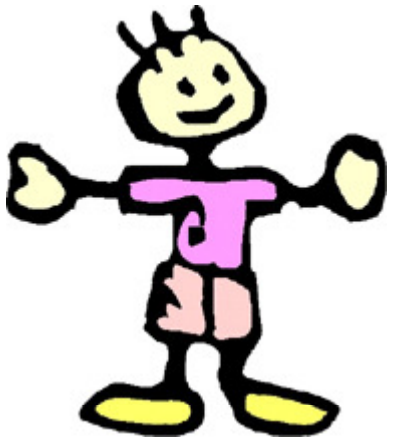
- Very rapid process: days to years
- Photosynthesis: makes carbohydrates and oxygen
- about half of the CO2 is released and half is stored in the plant biomass
- Biomass becomes part of the soil carbon cycle, which is ultimately released through erosion, fire, or decomposition
- Average residence time of carbon in soil is 20-30 years
- What are anthropogenic sources of CO2?

Nitrogen Cycle

- Why is nitrogen important?
- What uses can you think of for nitrogen?
- It is considered a ‘limiting’ factor in many ecosystems…without it, plants would not be able to grow
- Including phytoplankton

Nitrogen Cycle

Do you contain nitrogen?



Does the air contain nitrogen?

Nitrogen Cycle

- The atmosphere is made up of 79% N gas
- This gas is not useable by living things
- It must be converted to form compounds such as ammonia (NH_4) or nitrate (NO_3) which can be taken up by living things
- There is natural and human fixation of N_2

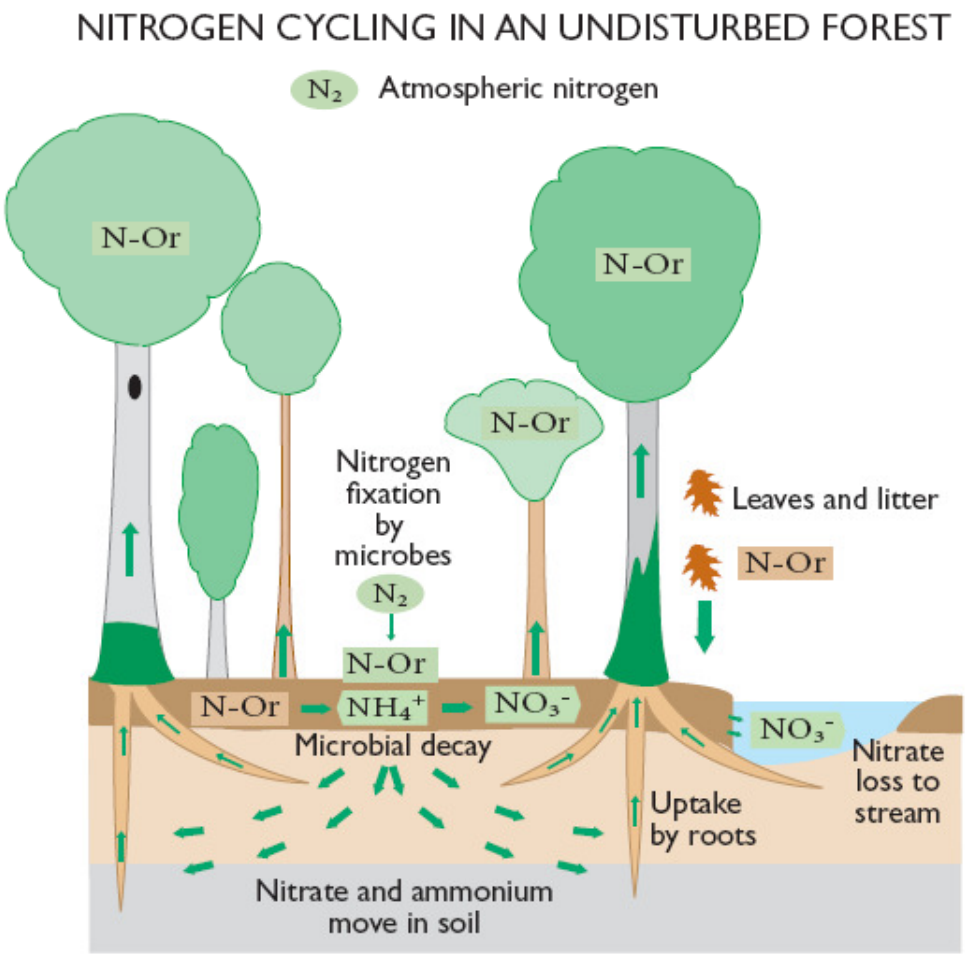
    Natural: lightning, bacteria

    Human: fossil fuel combustion, fertilizer manufacturing

Nitrogen Cycle

- Organisms cannot use N_2
- Nitrogen fixing bacteria
  - Root nodules of legumes (mutualism)
  - Soil
- Plants use nitrate (NO_3^-)-- FERTILIZERS

Nitrogen Cycle



N-Or Organic nitrogen in living tissue

N-Or Organic nitrogen in dead tissue

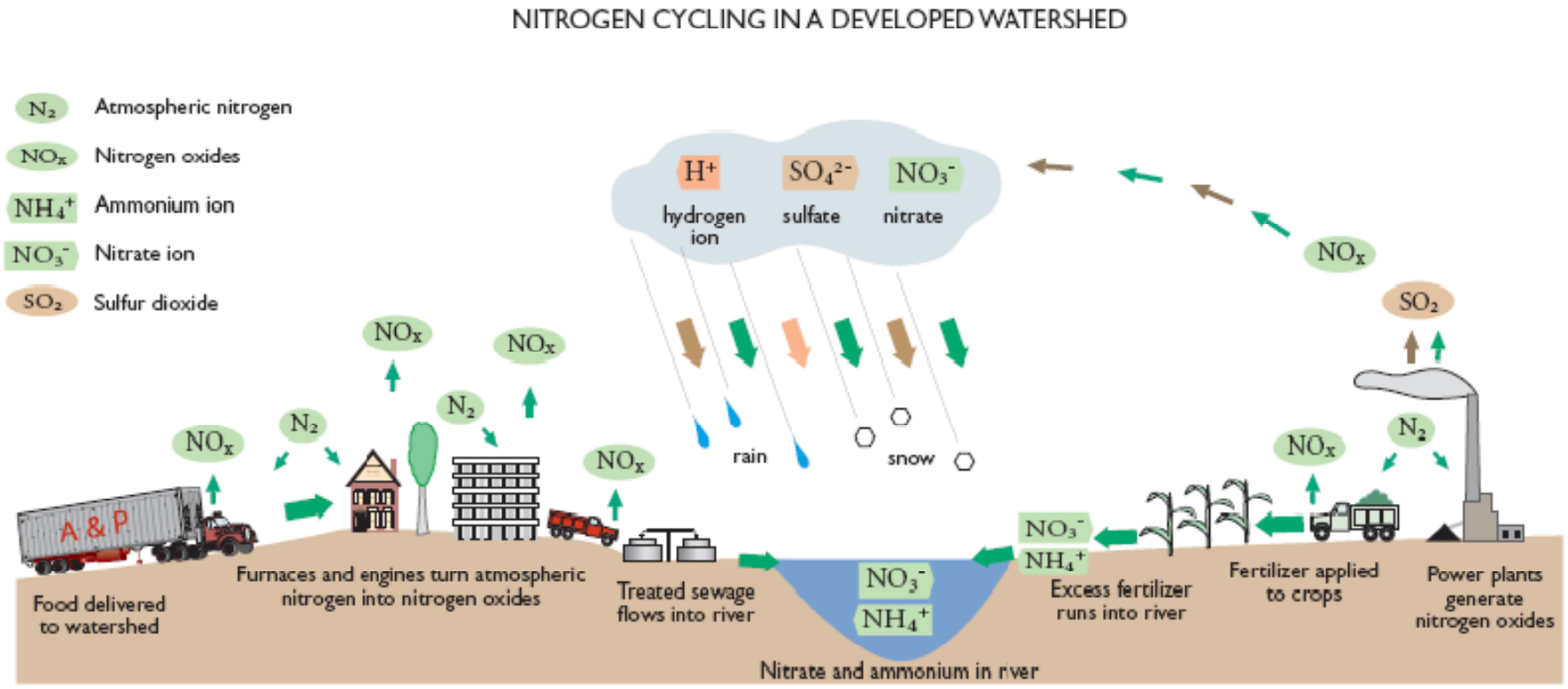
NH_4^+ Ammonium

NO_3^- Nitrate

Flow of nitrogen

In an undisturbed forest most of the nitrogen cycles between living plants and dead organic mater in the soil. Plants take up nitrogen through their roots; microbes release the nitrogenfrom dead leaves and branches to the soil. Small amounts enter the cycle through nitrogen fixation, and even smaller amounts leave in stream water.

Nitrogen Cycle



Developed watershed import nitrogen in food and fertilizer. They also receive nitrogen from acid rain, which in turn gets its nitrogen from the nitrogen oxides produced by furnaces, boilers, and engines. About half the nitrogen a watershed receives is stored in the soil or in trees or exported as crops. The flows into rivers.

Nitrogen cycle…so what?

- Plants and animals *need* nitrogen
- But…there can be too much of a good thing!
- Too much nitrogen results in: eutrophication of aquatic systems

There is both cultural (human) and natural eutrophication

Eutrophication: excess nutrients stimulate plant growth (algal bloom); when these plants die, decomposers use up the available oxygen during decomposition

Source: www.algae.info

Source: http://serc.carleton.edu

Nitrogen in the Hudson

Where does it come from?

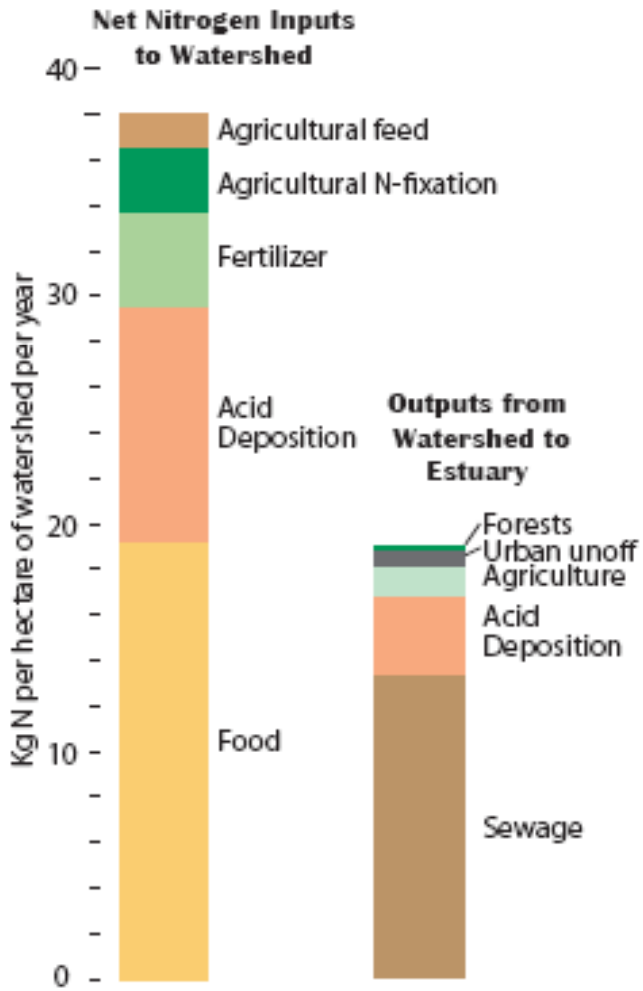
-human waste

-acid deposition

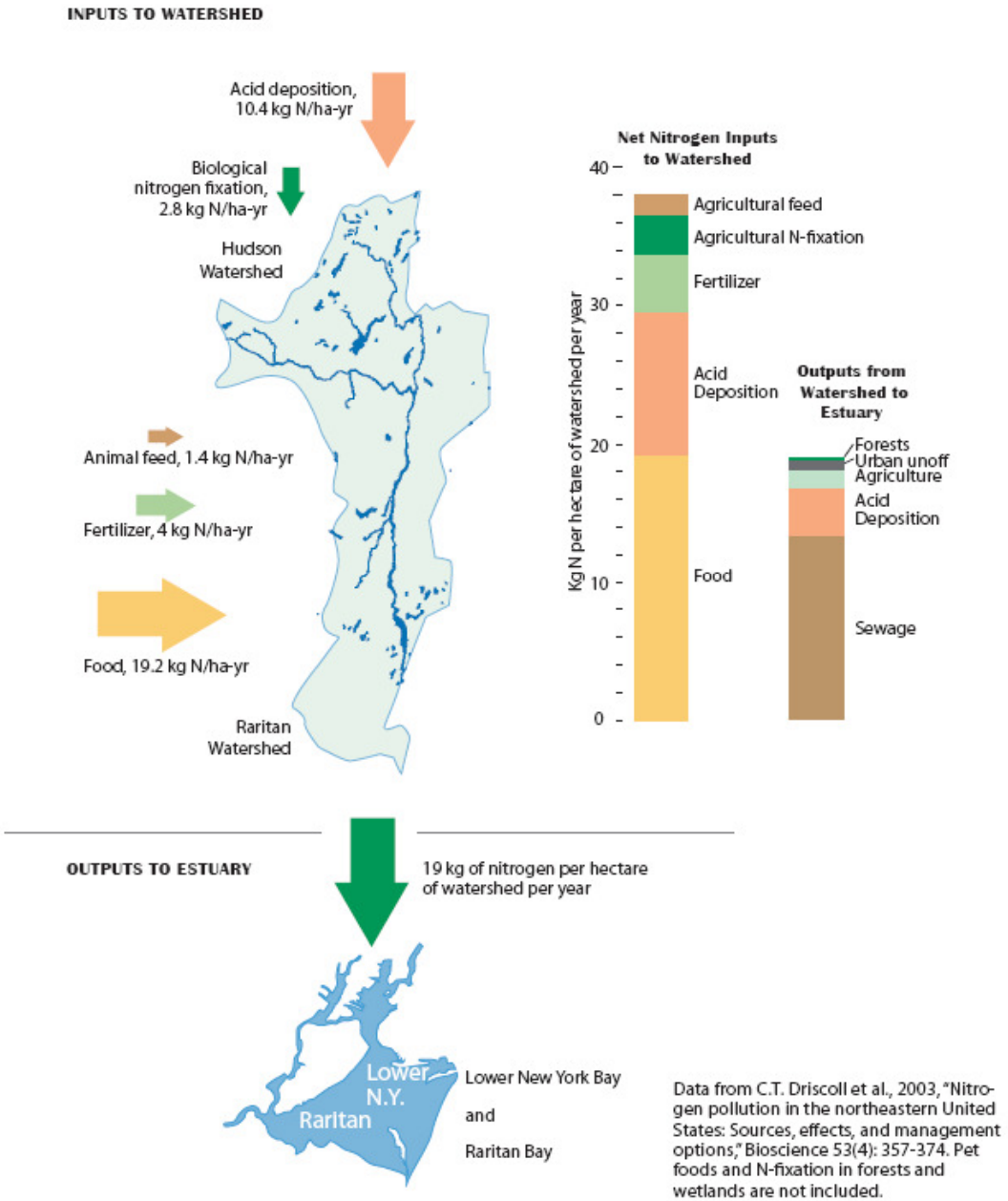
-fertilizer

-agriculture: fixation and feed

Where does it go?

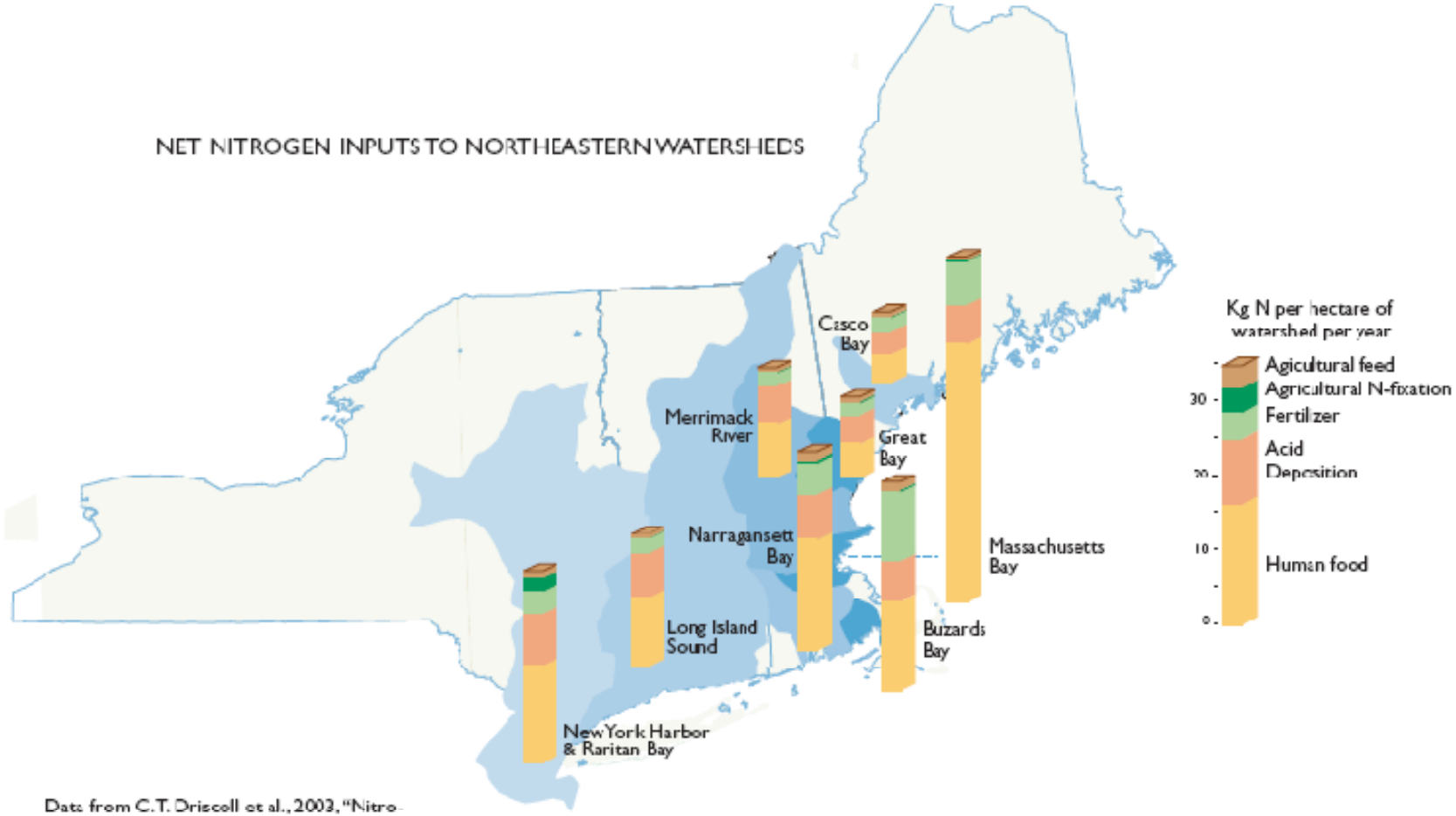


THE NITROGEN BALANCE OF THE HUDSON - WATERSHED



Data from C.T. Driscoll et al., 2003, "Nitrogen pollution in the northeastern United States: Sources, effects, and management options," Bioscience 53(4): 357-374. Pet foods and N-fixation in forests and wetlands are not included.

Nitrogen Cycle



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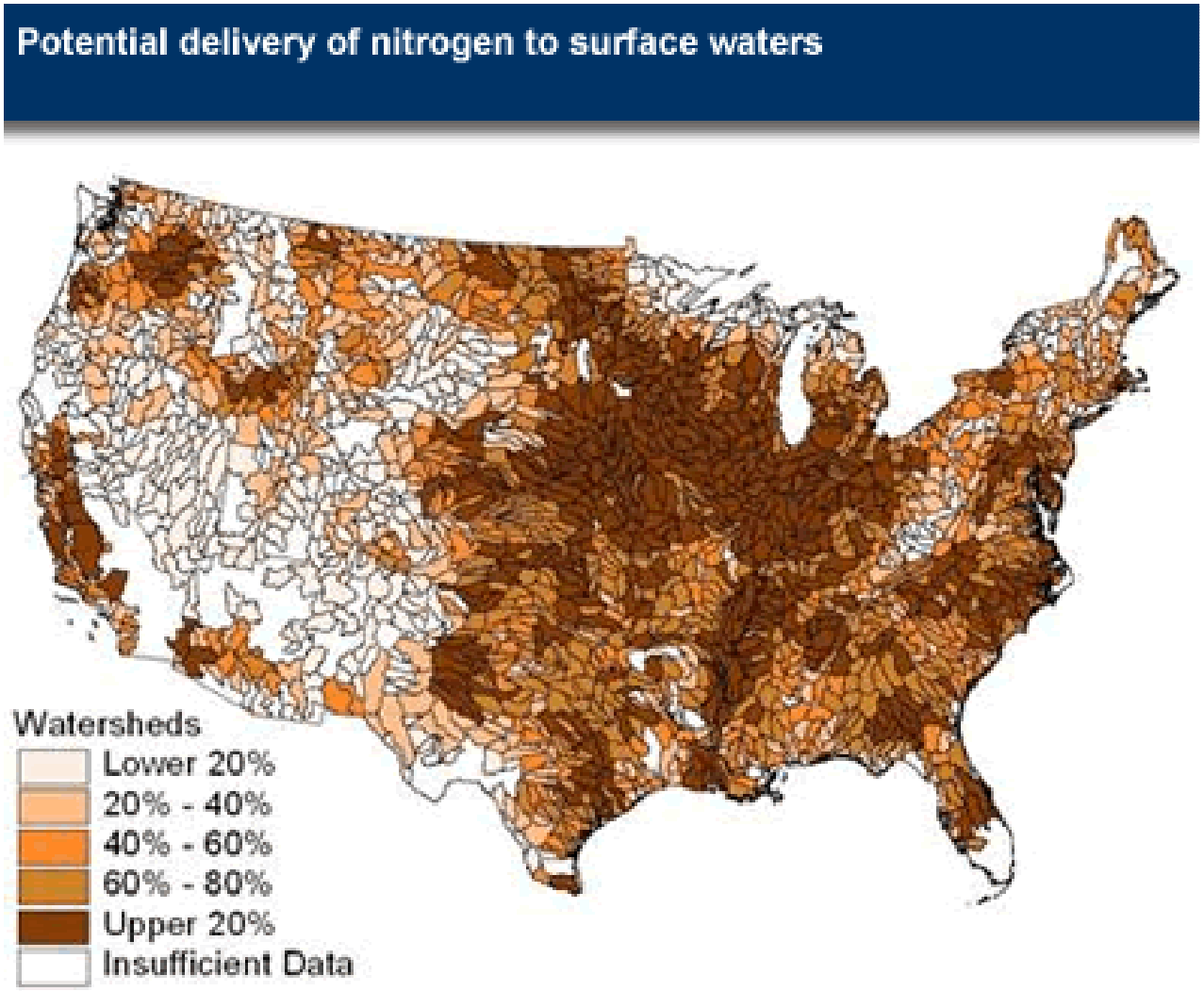
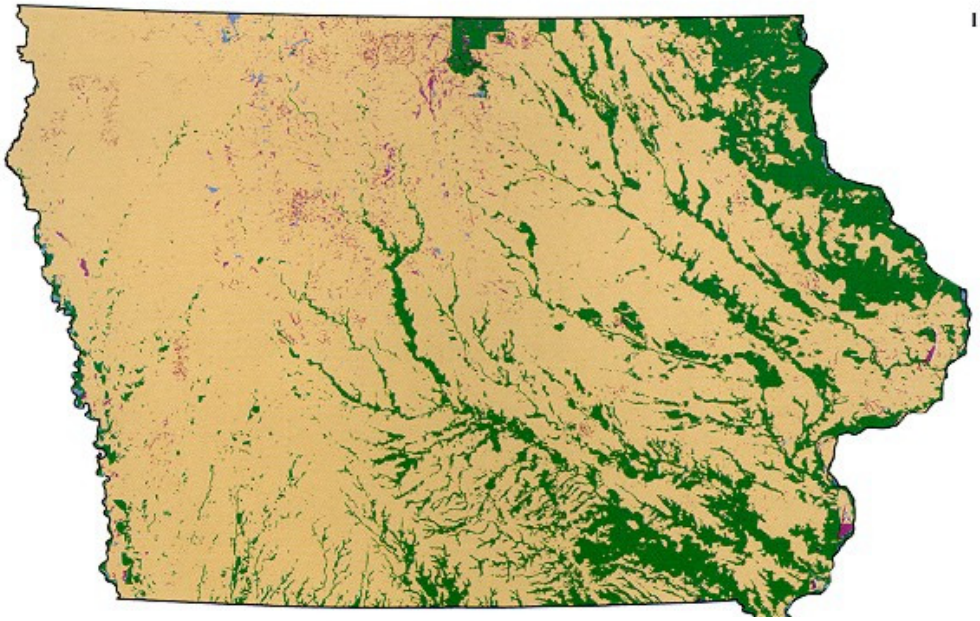
Nitrogen: Why so much from the middle of the USA?



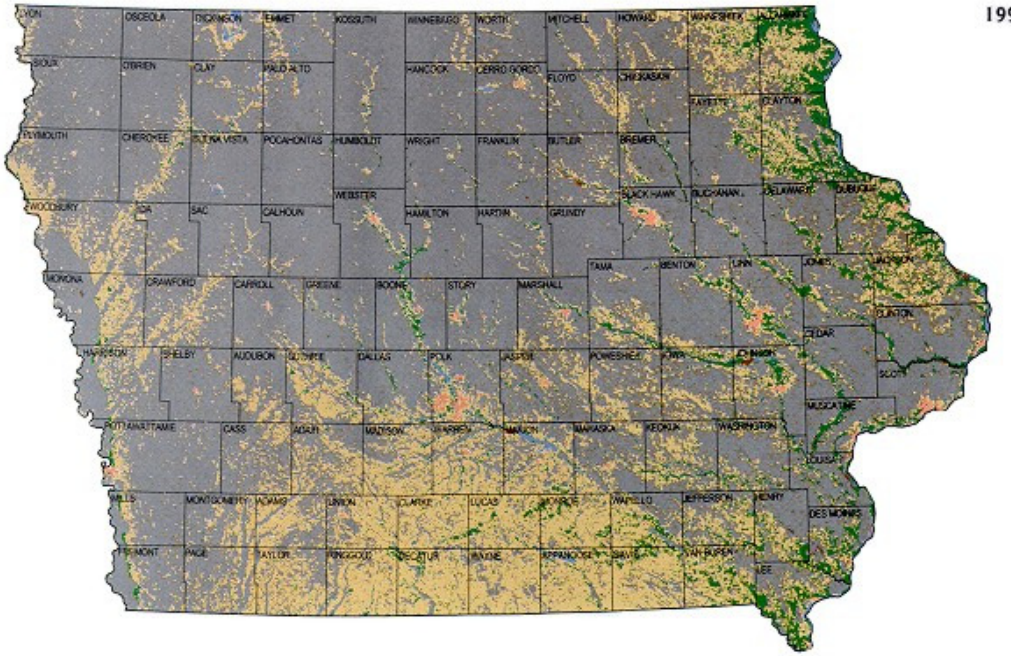
Note: The potential for cropland within a watershed to discharge nitrogen in surface water is determined by runoff factors (climate, distance from water, erosion) and nitrogen source factors (total inorganic and organic fertilizer applications), which are influenced by the economic choices farmers make.

Source: Economic Research Service, USDA. Nitrogen data from Association of American Plant Food Control Officials (1998) and Kellogg et al. (2000).



1850s Landcover Map of Iowa

- Prairie
- Forest
- Wetland
- Water



1990s Landcover M of Iowa

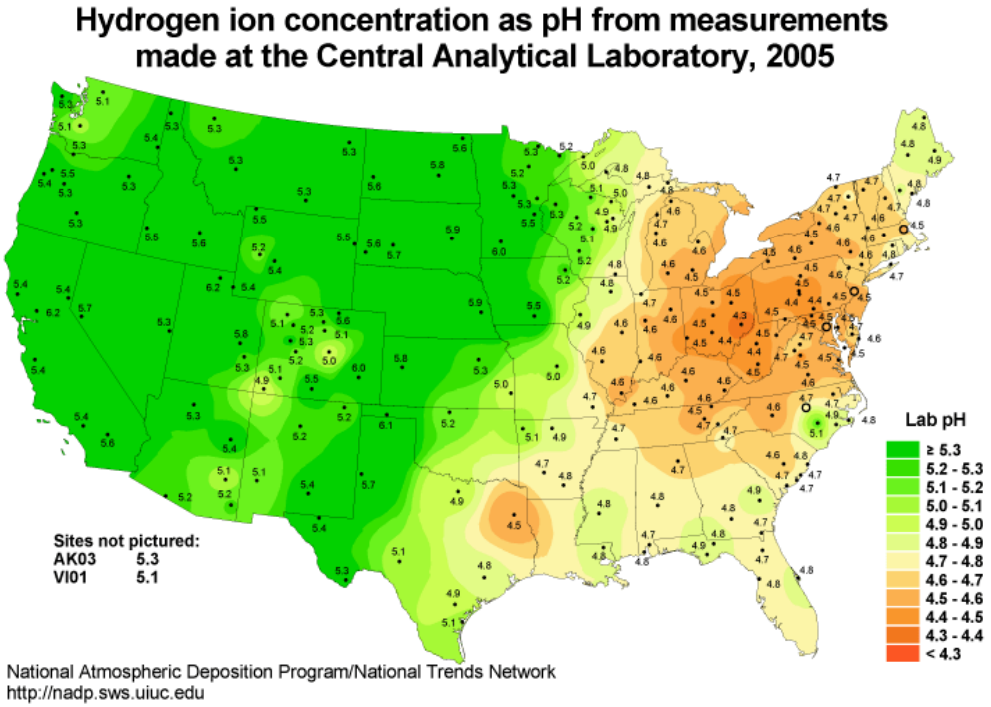
- Urban / r
- Grassland
- Forest
- Row crop
- Barren
- Water

Source: Compiled from Landsat Thematic Mapper satellite imagery, Iowa Dept. of Natural Resources.

Humans and the Nitrogen Cycle

Last 100 years: humans have more than doubled the amount of fixed nitrogen that is pumped into the atmosphere every year.

Consequences: acid rain, creation of ground level ozone, groundwater contamination, and eutrophication



Phosphorous

- Where does it come from?

  -not a gas

  -weathers from rock

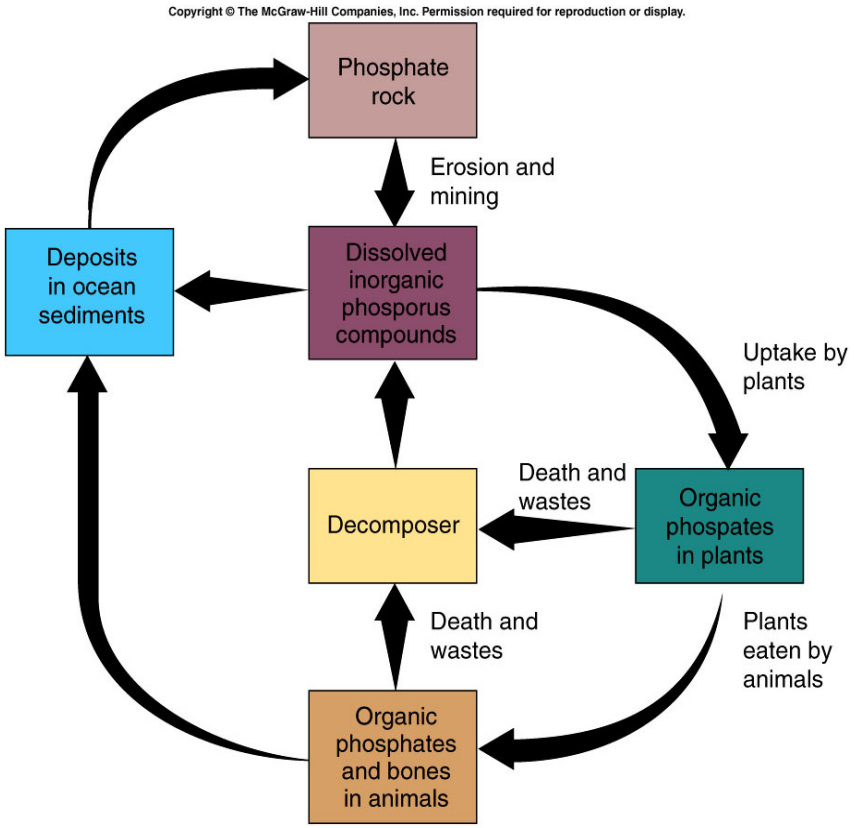
  -reuse from already present phosphorous in detritus
- Why is it important?

  -less abundant and available than N

  -often the limiting nutrient in freshwater ecosystems

Phosphorus Cycle

- Inorganic phosphate in rocks
  - Dissolves in water
  - Plants take up inorganic phosphate
  - FERTILIZERS
- Converted to organic phosphates found in organisms
- Decomposers convert organic waste back to inorganic P in the soil



Phosphorous in the Hudson

- Main source: detritus
- Used by plants during the growing season
- Some P is lost to the ocean and some becomes buried in sediment

Summary: Humans, Nutrients, and the Hudson

- Sewage: contributes nitrogen, phosphorous, and carbon
- Fertilizer runoff
- Laundry water that contains phosphates
- Deposition of nitrogen from acid rain
- Consequences for the New York Harbor

Q: Why doesn't the Hudson have more algal blooms?