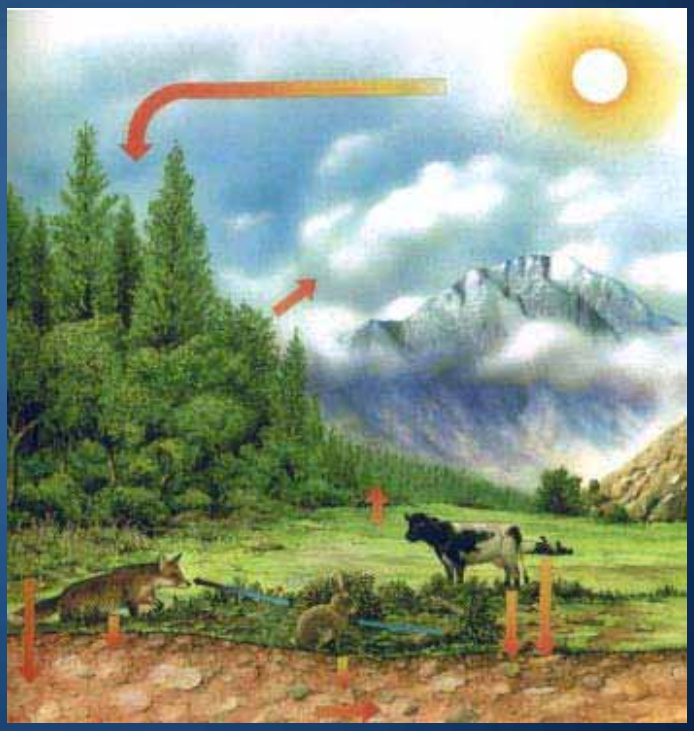
Biogeochemical Cycles



Biogeochemical Cycles

- Literal meaning:
  - Bio – "living"
  - Geo – "rocks and soil"
  - Chemical – "processes"
- 2 main types
  - Gaseous
    - Pools/fluxes
    - global
  - Sedimentary
    - Soil
    - Rocks
    - minerals
- Ok…so what does that mean?

Biogeochemical Cycles

- Gases important for life:
  - Nitrogen (78%)
  - Oxygen (21%)
  - Carbon Dioxide (0.03%)
- Gaseous and sedimentary cycles:
  - Involve biological and nonbiological processes
  - Driven by flow of energy through the ecosystem
  - Tied to the water-cycle
    - Water is how things move…without water, biogeochemical cycles cease!!!
  - All Biogeochemical Cycles have a common structure:
    - Inputs
    - Internal cycling
    - Outputs

Cycle Structure - Inputs

- Gaseous (N and C)
  - Via atmosphere
- Sedimentary (calcium and P)
  - Weathering of rocks/minerals
- Supplements
  - Precipitation (Wetfall)
  - Airborne particles and aerosols (Dryfall)
  - 70-90% of rainfall striking forest canopy reaches the forest floor
    - This contributes nutrients deposited on the leaves making water reaching the forest floor richer in calcium, sodium, potassium, etc. than rainfall in open areas

Cycling Structure - Outputs

- Exports must be offset by inputs to prevent a net decline
- Various exports:
  - Carbon (CO_2 into atmosphere via respiration)
  - Microbial and plant transformations of nutrients
- Organic matter
  - Can be transported through a watershed through surface flow (streams/rivers)
  - Majority of energy input in stream ecosystems
  - Can be transferred via herbivores
  - Organic matter prevents rapid loss from a system
    - Nutrients bound tightly together
    - Must be released by decomposers

Cycling Structure - Outputs

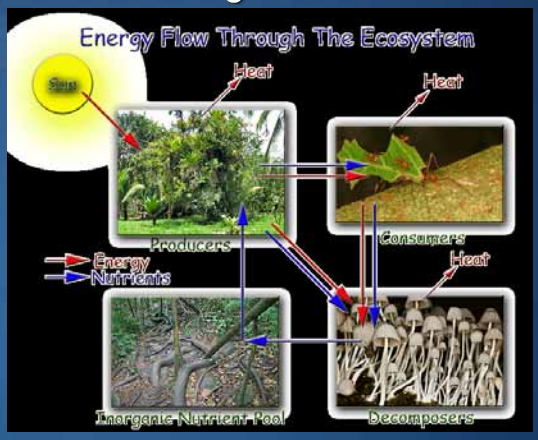
- Underground transport
  - Leaching
  - May be balanced by inputs (e.g. weathering)
- Harvesting
  - Farming
  - Logging
- So how do we replace losses caused by farming/logging?
- Logging can also alter processes involved in internal cycling…
- What about FIRE!!!???!!!
  - Read Ch. 19 (Ecological Issues: The Yellowstone Fires of 1988)

The Global Perspective

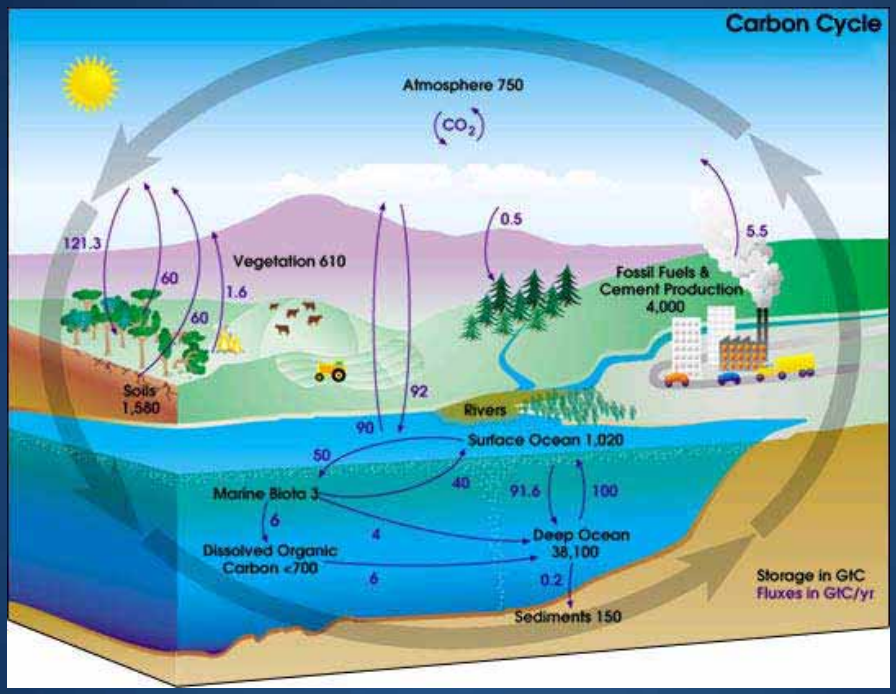
- Usually biogeochemical cycles are studied at a local scale
- However, exchanges are linked and
  - The output from one ecosystem represents an input to another
- This requires study at a broad spatial framework
  - Particularly true with nutrients in a gaseous cycle
- Gaseous cycles
  - Main pools are oceanic and atmospheric
  - Global circulation patterns
- Now to more specifics…

The Carbon Cycle

- Why is productivity often expressed in terms of grams of carbon fixed per square meter per year?
- CO_2: The source of all carbon
- Carbon "flows"
  - Photosynthesis
  - Herbivores
  - Carnivores
  - Released by?
  - Or? And is released by?

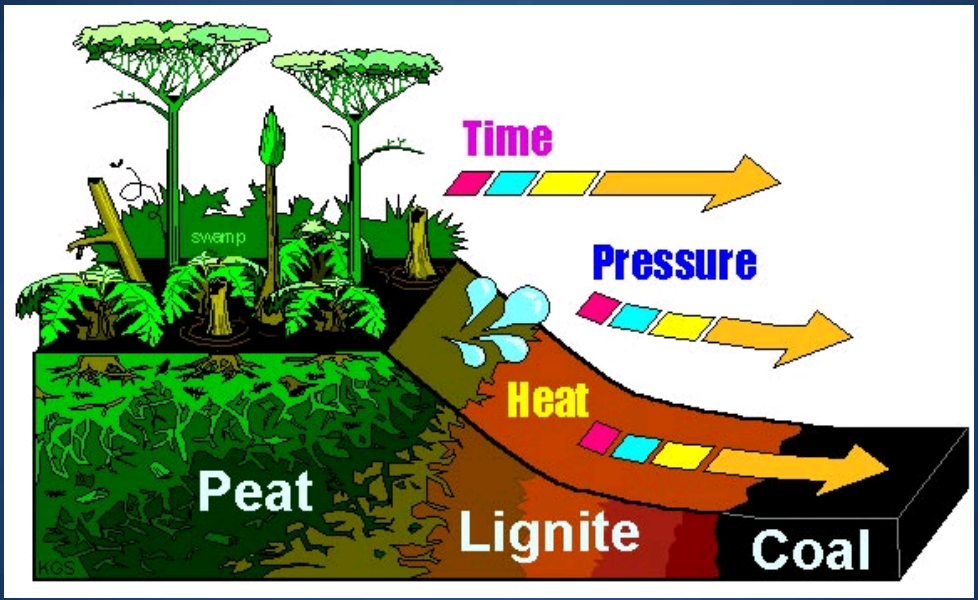


- Difference in ? And ? Is net primary productivity (in units of carbon), but
- Difference in ? And ? Is **net ecosystem productivity**!



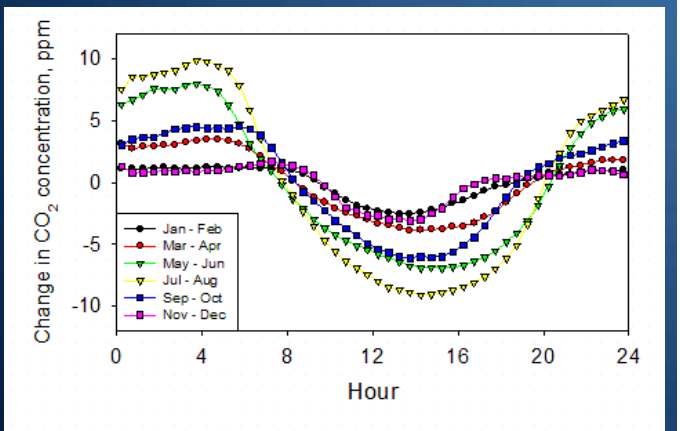
The carbon cycle

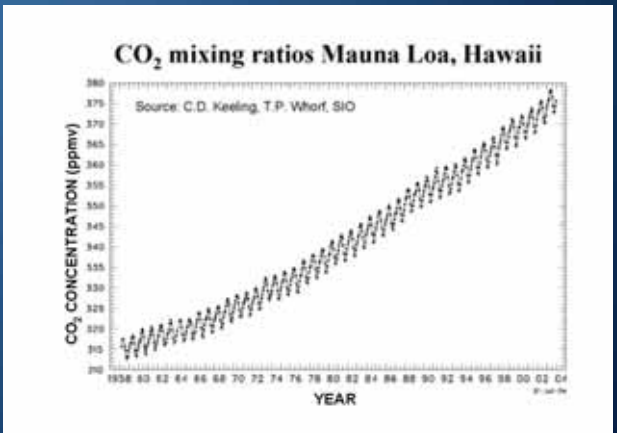
- At what rate does this happen (cycling through the ecosystem)?
  - Depends on a number of processes…
  - Particularly: primary productivity, and
  - Decomposition
  - Both of these are influenced by environment
    - Temperature
    - Precipitation
  - Warm/wet (example?) = high
  - Cool/dry (example?) = low
  - What about a swamp?
- Aquatic systems?



Carbon cycle fluctuations:

- Varies daily and seasonally…Why?
- Where does all this carbon come from?
  - Buried in sedimentary rocks
  - Fossil fuels
  - Oceans (bicarbonate and carbonate ions)
  - Terrestrial systems (biomass)
    - Believed now to be a sink which means what to us?





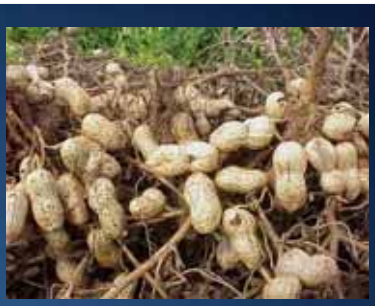
The Nitrogen Cycle

- Essential constituent of protein (the building block of all living tissue)
- Available to plants in 2 forms:
  - Ammonium (NH_4^+)
  - Nitrate (NO_3^-)
- Atmospheric N is in the form N_2
  - Not available for assimilation
- So how does N enter the ecosystem?
- 2 ways:
  - Atmospheric deposition (wetfall/dryfall)
  - Nitrogen fixation (much more interesting)

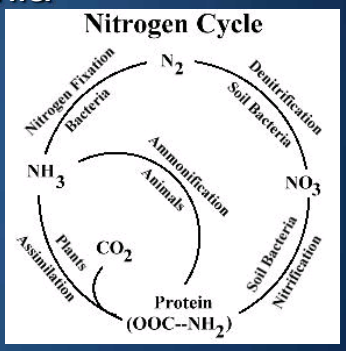
Nitrogen Fixation

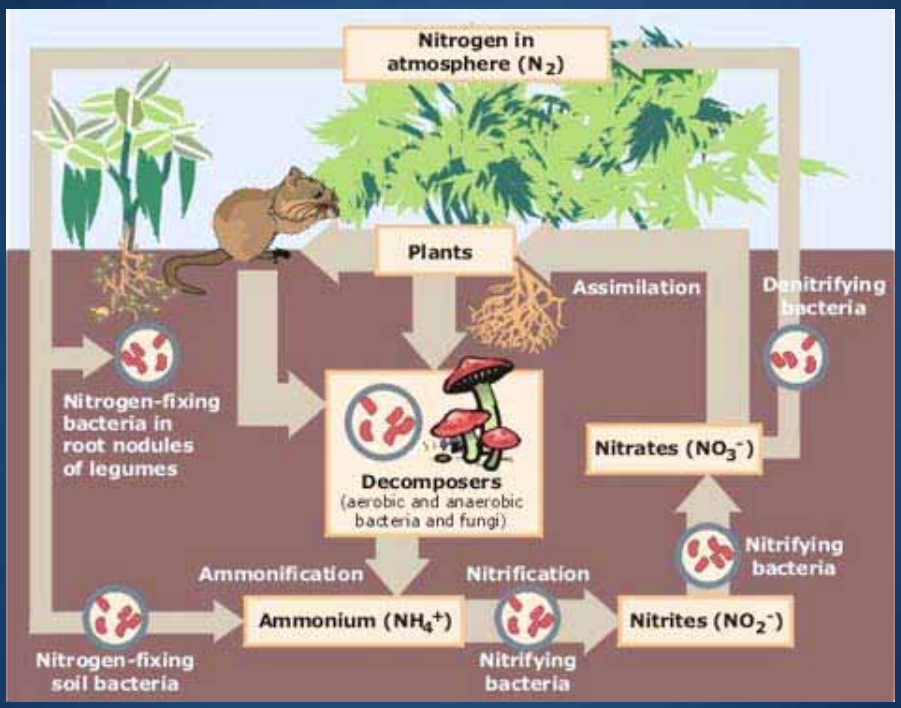
- 2 types of fixation
- High-energy fixation
  - Lightning
  - Combines nitrogen with O and H of water (requires very high energy)
  - Results in ammonia and nitrates
  - Responsible for less than 0.4 kg N/ha per year (2/3 ammonia and 1/3 nitric acid (HNO_3)
- Biological fixation
  - Produces 10 kg N/ha per year (~ 90%)
- How does this happen?
  - Symbiotic bacteria/plant relationship
  - Free-living aerobic bacteria
  - Cyanobacteria (blue-green algae)

Nitrogen Fixation

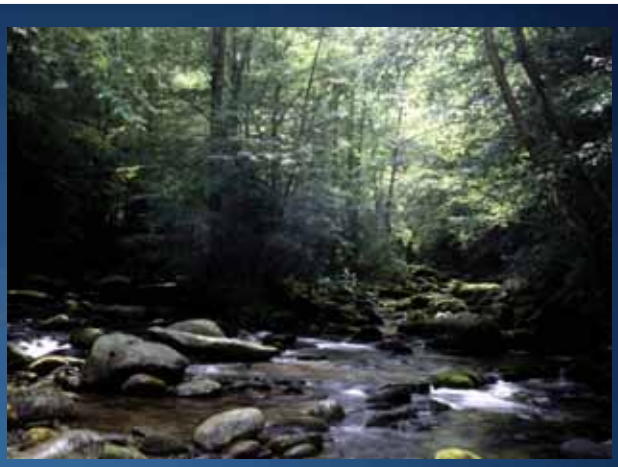


- N_2 is split into 2 free N's
- Combined with H to form 2 molecules of ammonia (NH_3)
- Requires considerable energy
  - 1g of N fixed requires 10g glucose (and where does glucose come from?)
- Some examples:
  - *Rhizobium* bacteria
  - Associated with legumes (preeminent nitrogen fixers)
  - Certain Lichens
    - What is a Lichen?

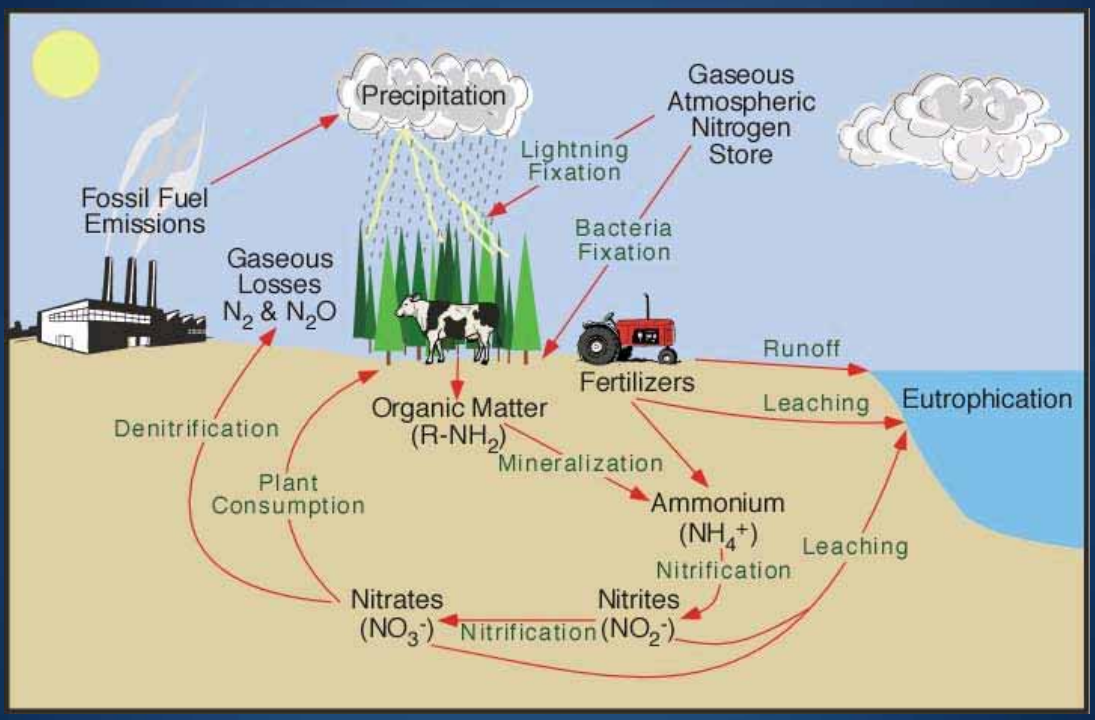




Nitrogen Cycle

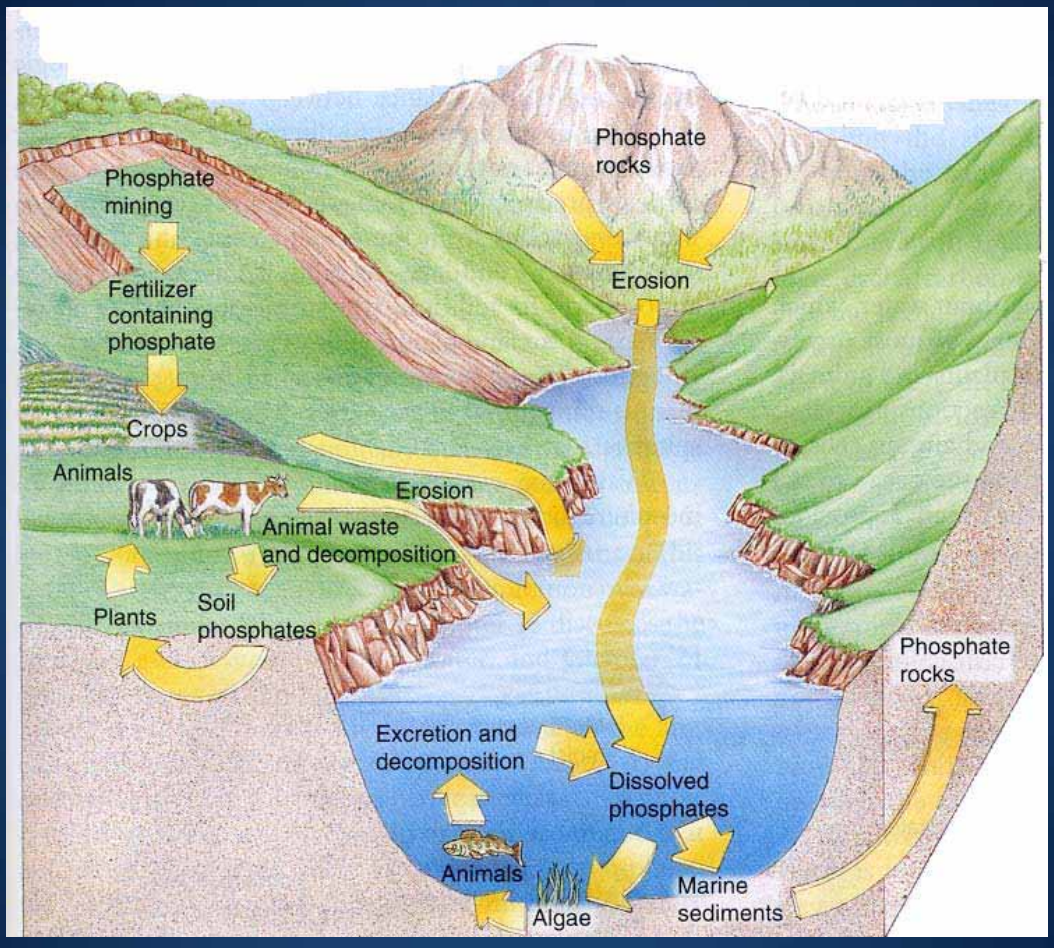


- Ammonification
- Nitrification
- Denitrification
  - Common in anaerobic conditions
- Nitrates are the most common form of nitrogen exported from terrestrial ecosystems in stream water
  - In undisturbed systems this is small
- The global Nitrogen cycle
  - Same idea, global scale
  - Human impacts



Phosphorus Cycle

- No atmospheric pool
- Short supply under natural conditions
- When phosphorus is added to aquatic systems, what happens?
- Major reservoir for P is
  - Rock
  - Minerals
- 3 states in aquatic ecosystems
  - Particulate organic phosphorus
  - Dissolved organic phosphates
  - Inorganic phosphates
- Concentration in water is low but there is a lot of water!
  - Turnover of organic phosphorus is very high
- The phosphorus cycle is active on a geological time-scale

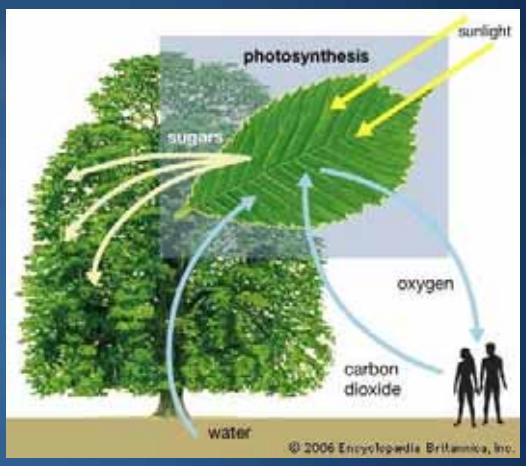


Sulfur Cycle

- Both sedimentary and gaseous phases
- Poorly understood globally

Oxygen Cycle

- Supports Life (found mostly in the atmosphere)
- 2 significant sources
  - Breakup of water vapor (via sunlight)
  - Photosynthesis



- Other reservoirs
  - Water
  - Carbon Dioxide
  - Also biologically exchangeable as nitrates and sulfates (transformed to ammonia and hydrogen sulfide)
- Oxygen is very reactive!
  - Cycling is complex
  - Constitutient of carbon dioxide