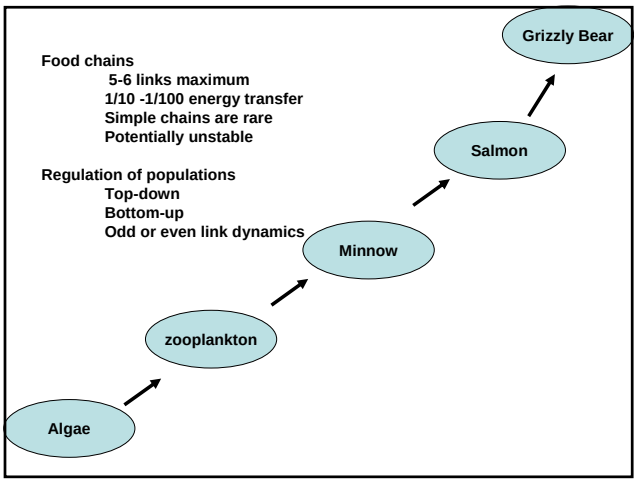
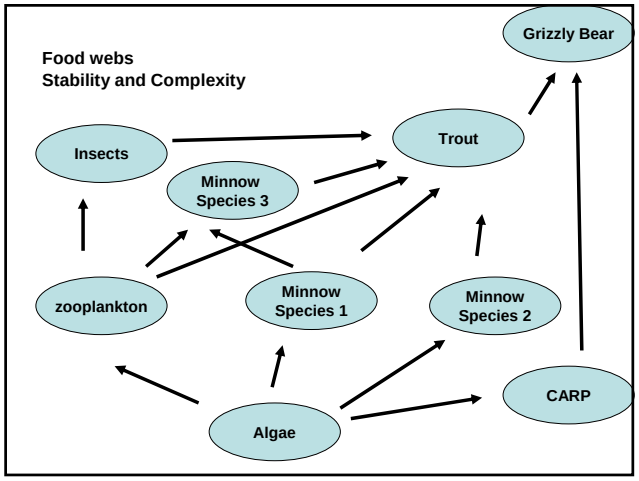
The Final Exam

- Friday, May 11 at 10:30am Be here!
- ½ Non-comprehensive
  - Chapters 15 & 16 and all notes since last exam
  - Notes and review sheets will be posted by 4:00pm Thursday
- ½ Comprehensive
  - Review sheets and chapters covered on previous exams





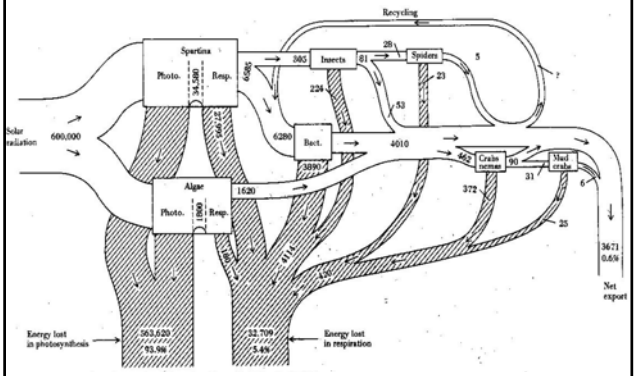
Stability and Complexity

Stable systems can be disturbed and quickly return to their previous equilibrium

Unstable systems do not return to their previous states following disturbance (damage is permenant)

Unstable systems may undergo rapid and permenant change

Energy Flow in a Saltmarsh



CHARACTERISTICS OF ECOSYSTEMS

- **Productivity** -- A measure of the flow of energy through the system.
- **Diversity –** A measure of the abundance and dominance of biotic species and communities in the system
- **Stability** – The ability of the system to maintain its diversity, productivity and function in response to stress and change.
- **Resilience** – The ability to regain the original system function after a stress induced change in system function, diversity or productivity

"Ecosystems Services"

- A term used to describe the benefits that ecosystems provide to humans.
- Anthropocentric view
- **Some examples**
  - Purification of air and water
  - Mitigation of climate extremes
  - Decomposition of toxic wastes
  - CO_2 consumption, O_2 production
  - Maintenance of Soil Fertility
  - Aesthetic concerns

Ecosystems and Energy

- 1st Law of thermodynamics
  - Energy can neither be created or destroyed.
- 2nd Law of thermodynamics
  - Any time energy is converted from one form to another after the conversion less energy is available to do work with than before the conversion.
  - Any time energy is converted from one form to another some of the energy is dissipated as heat and is no longer available to do work.

Ecosystems and Energy

- Life is a process of converting energy from one form to another.
- The energy to maintain life comes from:
  - Solar energy
  - Left over heat from the formation of earth
  - Energy from the decay of radioisotopes

Ecosystems and Energy

- Photosynthesis the biotic conversion of radiant energy to chemical energy by green plants
- Chemically
  - $CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$
- Provides over 95% of the energy needed to maintain life on earth

Ecosystems and Energy

- Cellular respiration
  - The conversion of energy stored in C-C bonds to a form useful for cells to meet short term energy needs
  - All living cells respire
- Chemically
  - $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ + Useful energy

Ecosystems and Energy

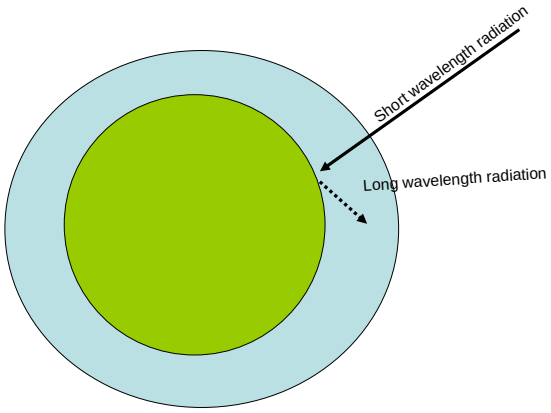
- Primary Productivity
  - The amount of chemical energy made available by plants in a given area in a given amount of time.
  - Units Joules/m^2/year
  - Net vs Gross

Ecosystems and Energy

- Secondary Productivity
  - The amount of chemical energy made and retained in animals that eat plants in a given area in a given amount of time.
  - Units Joules/m^2/year or Kcal/m^2/year
  - Net vs Gross

Greenhouse Effect

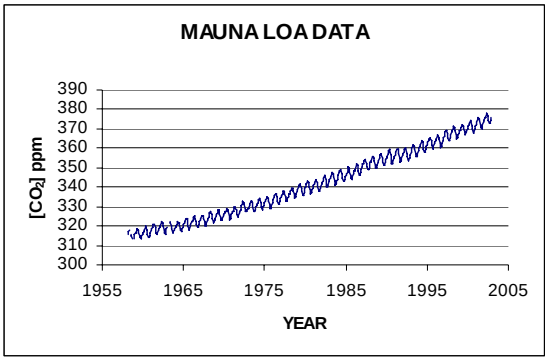
- Radiant energy enter the atmosphere
- As light strikes the molecules some of the light is refracted
- Refracted light has less energy and longer wavelengths than non-refracted light
- Some molecules in the air (heteroatomic gasses CO_2 H_20) absorb longer wavelength light and temporarily retain the energy as heat.
- The result is energy is entering the atmosphere faster than it is radiated, resulting in a net gain of energy.



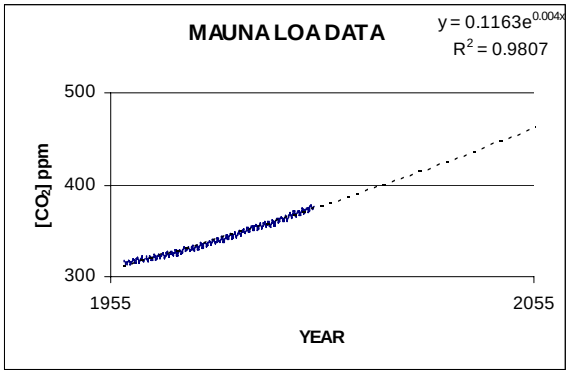
Greenhouse Effect

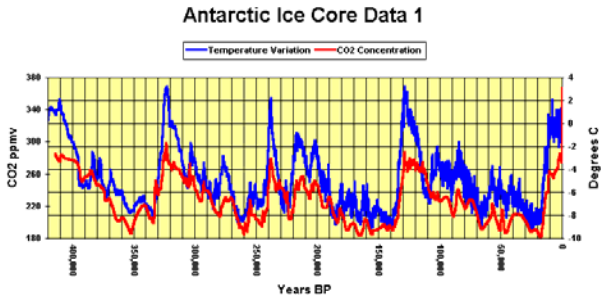
- Statement of Fact
  - CO_2 concentrations are rising in the atmosphere
  - Mauna Lua data
  - Ice core data
- Interactions
  - Increased Photosynthesis?
  - Nutrient Cycling?
  - Carbon Mineralization?

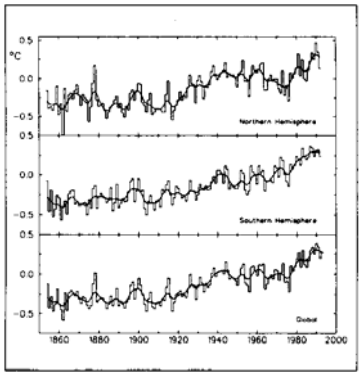
Muana Loa Data



Future Predictions







Hemispheric and mean global temperature trends, 1854 to the present

Greenhouse Effect

- Understanding ecosystem function is crucial to understanding long term effects of CO_2 rise
- Extrapolation of trends
- Pools and fluxes and rate of change

Greenhouse Effect

- Light enters atmosphere
- Light reflects and refracts as it bounces of molecules
- Refraction results in longer wavelength light
- CO_2 and other gasses absorb longer wavelength light and warm up
- Consequently – light energy is entering the atmosphere faster than it is leaving the atmosphere.
- Likely to cause global warming

Ozone

- O_3 absorbs UV light
- O_3 may be declining
- O_3 reacts with certain pollutants and is destroyed
- UV causes mutations and cancer

Nitrogen Cycling

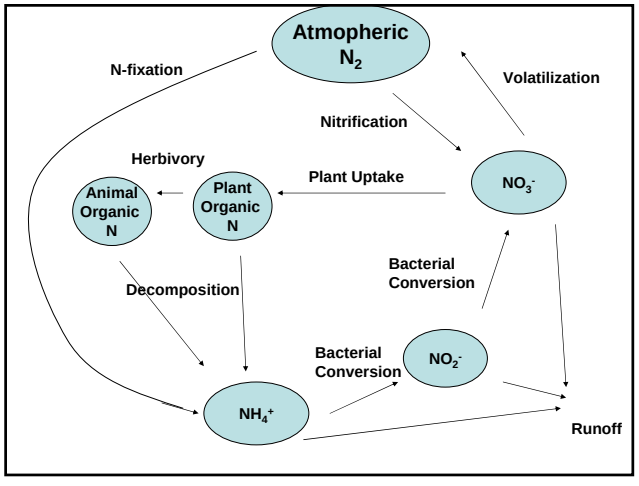
- Atmospheric Nitrogen N_2
  - (N-triple bond-N)
  - Very Stable
  - Very Abundant
  - Biologically not very useful
- Biological necessity
  - Amino acids – Proteins – enzymes
  - 2-5% of the dry weight of most organism is N

Energy Vs Matter

- Energy flows through ecosystems
- Energy is “dissipated” with each change in form, resulting in a continuous loss of “useful” energy
- Matter is cycled through ecosystems
- Matter is conserved

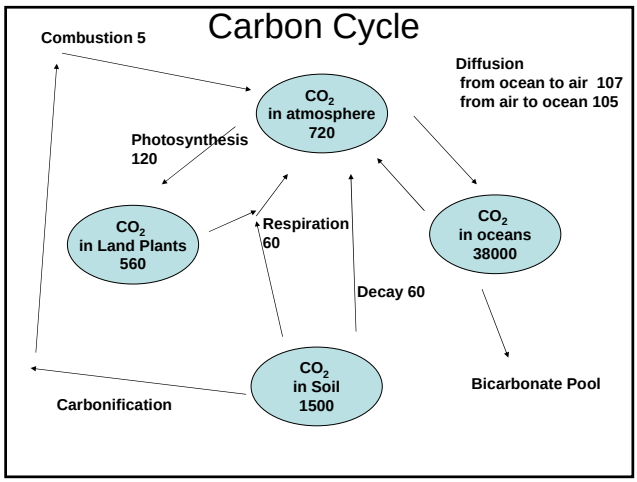
Nitrogen Fixation

- Lightning
  - $N_2 \rightarrow NH_4NO_3$ 13% of N deposition
- Rhizobium – legume symbionts
  - $N_2 \rightarrow NO^-_3$ 54% of N deposition
- Haber-Bosch Process
  - Industrial
  - Energetically expensive
  - 38% of N deposition



Nutrient Cycling Terms

- Pools -- A component of the ecosystem where the nutrient is “stored”
- Fluxes – A the flow of nutrients from one pool to the next
- Flux rate – the rate at which the nutrient flows from one pool to the next. (Kilotons/year)
- Turnover rate – how long it takes before all the nutrient in a pool is totally replaced


Carbon Cycle
Combustion 5
Diffusion
from ocean to air 107
from air to ocean 105
CO2
in atmosphere
720
Photosynthesis
120
CO2
in Land Plants
560
Respiration
60
CO2
in oceans
38000
Decay 60
CO2
in Soil
1500
Bicarbonate Pool
Carbonification