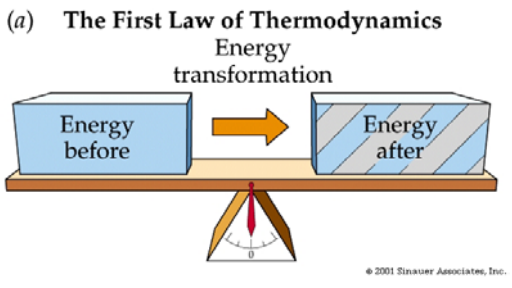
Ecosystems

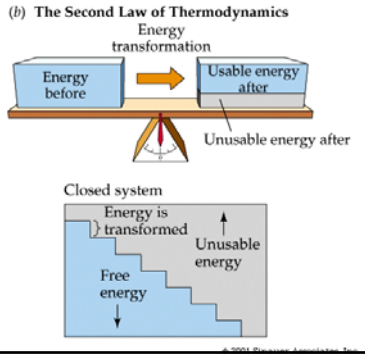
Outline: Ecosystems

- Ecosystem Dynamics
  - Energy flow
  - Chemical cycling
- Primary production
  - Limiting factors
- Trophic levels
- Biogeochemical cycling
- Human activities

Laws of thermodynamics govern energy flow



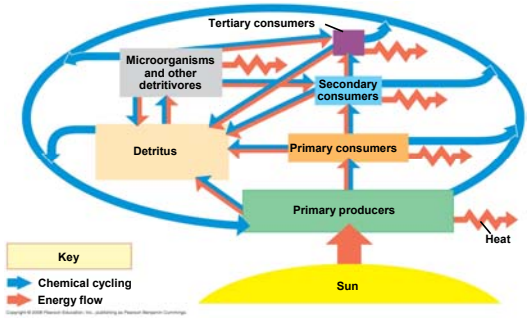
Laws of thermodynamics govern energy flow



Conservation of Mass

- states that matter cannot be created or destroyed

Energy, Mass, and Trophic Levels

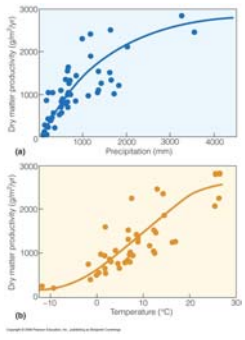


Primary Productivity

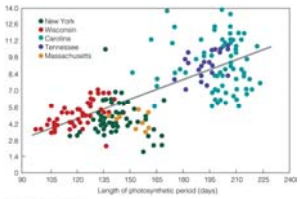
- Rate at which light energy is converted by photosynthesis to organic components

- **Gross primary productivity (GPP)**
- **Net primary productivity (NPP)**
- **Standing crop biomass**

Controls on primary production in terrestrial ecosystems

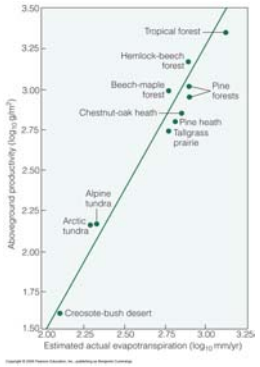


- Temperature
- Precipitation
- Light
- Nutrients



Deciduous forest in N. America

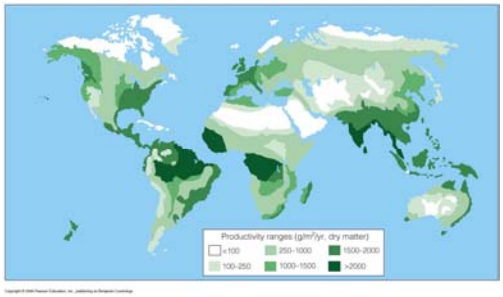
Evapotranspiration



Warm temperature and adequate water supply for transpiration that gives the highest primary productivity.

(Remember that photosynthesis and transpiration are coupled processes)

Global map of primary productivity



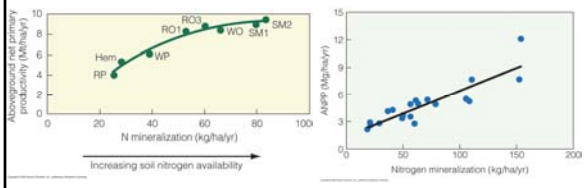
Patterns of productivity reflect global patterns of temperature and precipitation. High NPP in equatorial zone and coastal region.

Primary Productivity

Table 29.1 Net Primary Production and Plant Biomass of World Ecosystems

Ecosystems (in Order of Productivity)	Area (10^6 km^2)	Mean Net Primary Production per Unit Area (g/m^2/yr)	World Net Primary Production (10^9 Mt/yr)	Mean Biomass per Unit Area (kg/m^2)
Continental				
Tropical rain forest	17.0	2000.0	34.00	44.00
Tropical seasonal forest	7.5	1500.0	11.30	36.00
Temperate evergreen forest	5.0	1300.0	6.40	36.00
Temperate deciduous forest	7.0	1200.0	8.40	30.00
Boreal forest	12.0	800.0	9.50	20.00
Savanna	15.0	700.0	10.40	4.00
Cultivated land	14.0	644.0	9.10	1.10
Woodland and shrubland	8.0	600.0	4.90	6.80
Temperate grassland	9.0	500.0	4.40	1.60
Tundra and alpine meadow	8.0	144.0	1.10	0.67
Desert shrub	18.0	71.0	1.30	0.67
Rock, ice, sand	24.0	2.2	0.09	0.02
Swamp and marsh	2.0	2500.0	4.90	15.00
Lake and stream	2.5	500.0	1.20	0.02
Total continental	149.0	720.0	107.09	12.30

Primary production varies with nutrient availability



Different forest ecosystems

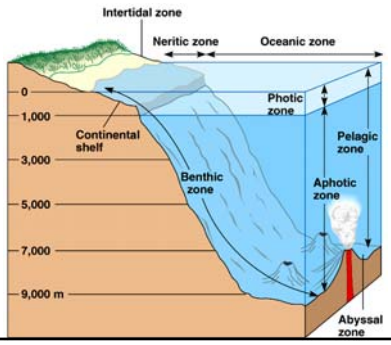
RO, red oak; RP, red pine; SM, sugar maple, Hem, hemlock; WP, white pine

20 oak savanna in Minnesota

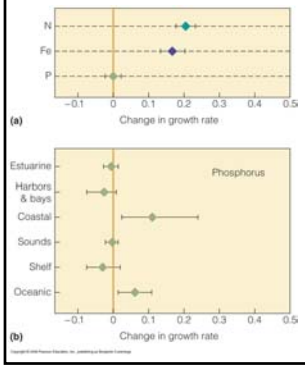
Factors limiting primary productivity in aquatic ecosystems

- Light
- Nutrients

Primary Productivity
in aquatic ecosystems



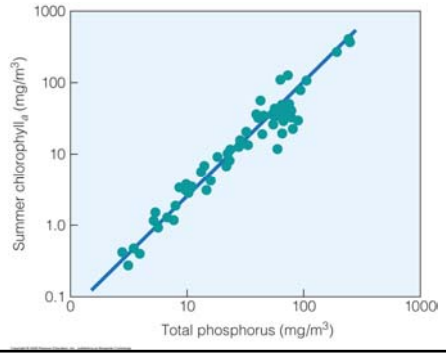
Controls on primary production in aquatic ecosystems



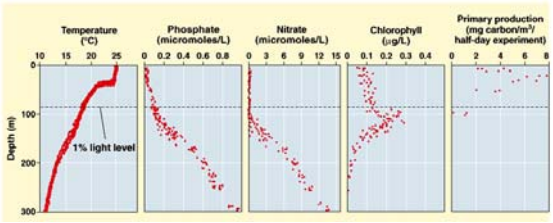
John downing, Iowa State
Conducted 303 experiments
Nitrogen addition stimulated phytoplankton growth the greatest, follow closely by Fe, addition of P showed no effect

Effect of P addition varied among different ecosystems. In polluted areas, show negative effect

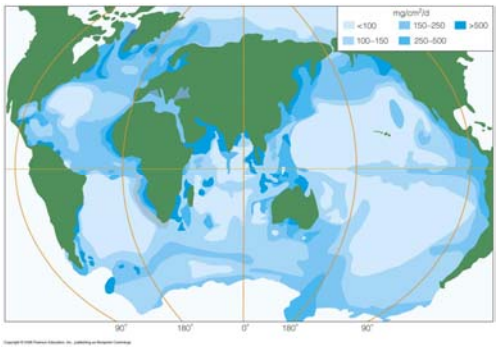
Controls on primary production in aquatic ecosystems



Upwelling is Needed



Global map of primary productivity

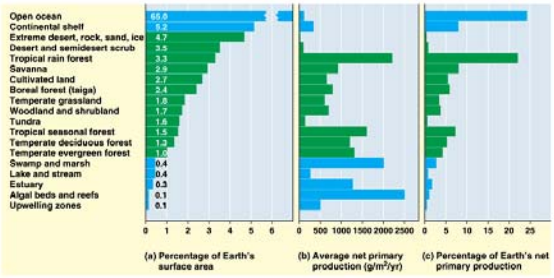


Production in Freshwater Ecosystems

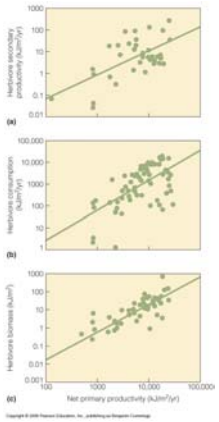
- Solar radiation
- Temperature
- Nutrients
- Eutrification

Estimating primary productivity in aquatic ecosystems

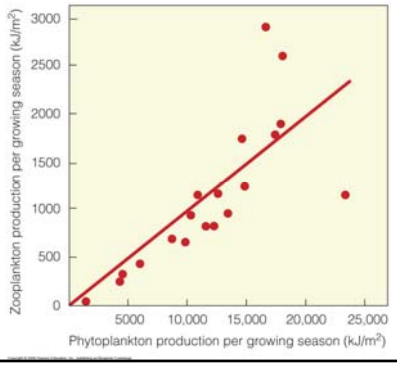
Different ecosystems differ greatly in their production as well as in their contribution to the total production of the Earth.



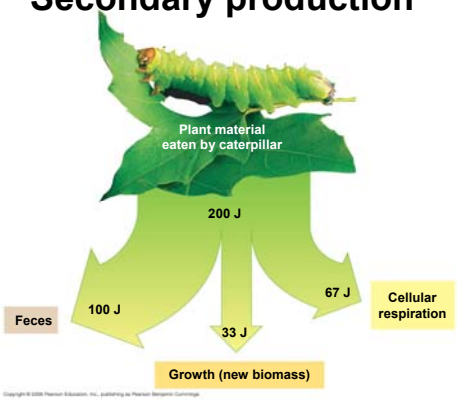
Primary productivity limits secondary productivity



Primary productivity limits secondary productivity



Secondary production



Assimilation Efficiency

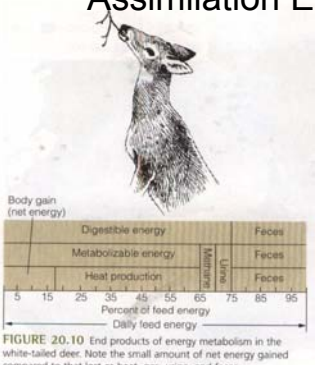


FIGURE 20.10 End products of energy metabolism in the white-tailed deer. Note the small amount of net energy gained compared to that lost as heat, gas, urine, and feces.

I = ingested
A = assimilated through gut wall
W = expelled as waste product
Of A,
R = respired
P = production

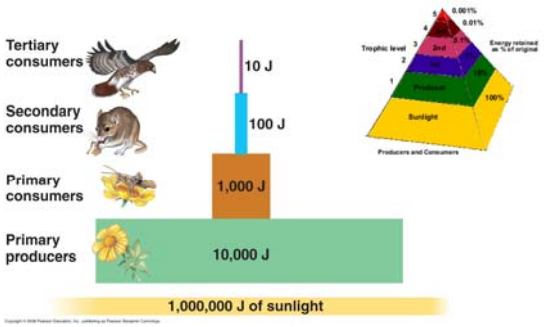
Table 20.2 Production Efficiency ($P/A \times 100$) of Various Animal Groups

Group	P/A (%)
Mice	4.10
Voles	2.63
Other mammals	2.92
Birds	1.26
Fish	9.74
Social insects	8.31
Orthoptera	41.67
Hemiptera	41.90
All other insects	41.23
Mollusca	21.59
Crustacea	24.96
All other non-insect invertebrates	27.68
Non-insect invertebrates	
Herbivores	18.81
Carnivores	25.05

Source: Data from Humphreys 1979.

Efficiency of secondary production

Energy Cycle -Trophic Levels



Energy loss between trophic levels

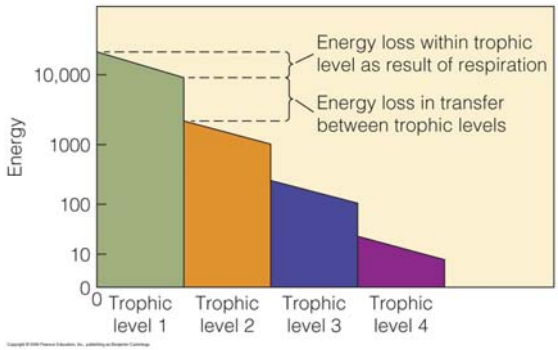
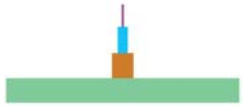


Fig. 55-11

Pyramids of biomass



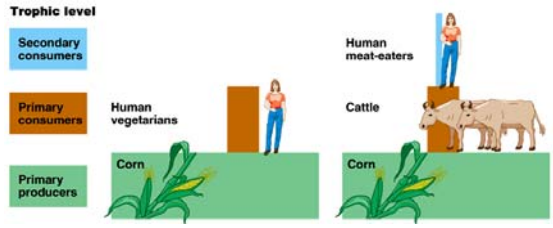
Trophic level	Dry mass (g/m^2)
Tertiary consumers	1.5
Secondary consumers	11
Primary consumers	37
Primary producers	809

(a) Most ecosystems (data from a Florida bog)

Trophic level	Dry mass (g/m^2)
Primary consumers (zooplankton)	21
Primary producers (phytoplankton)	4

(b) Some aquatic ecosystems (data from the English Channel)

Implications for Humans

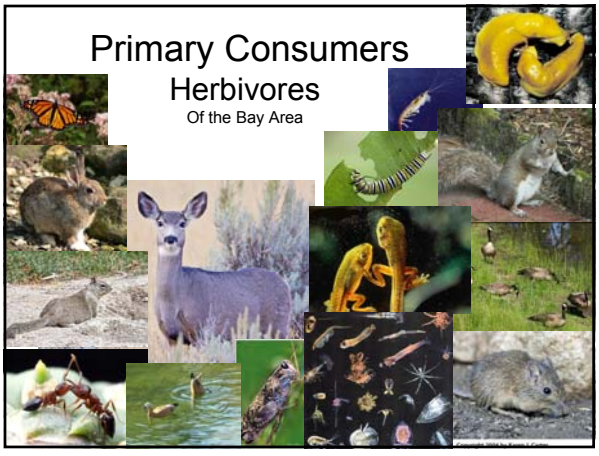


Green World Hypothesis

Primary Consumers

Herbivores

Of the Bay Area



Second Level Consumers

Carnivores

of the Bay Area

Tertiary Level Consumers

"Top Predators"

Of the Bay Area

Scavengers: Omnivores

Consumers of animal carrion and detritus

Decomposers

Exist at every trophic level

Detrital Food Webs

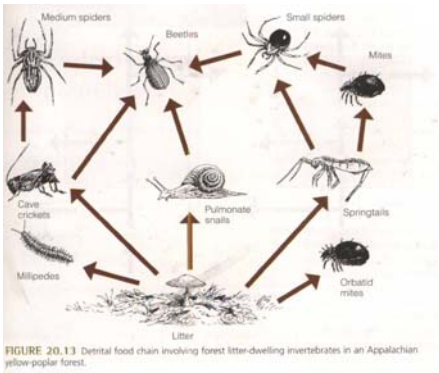


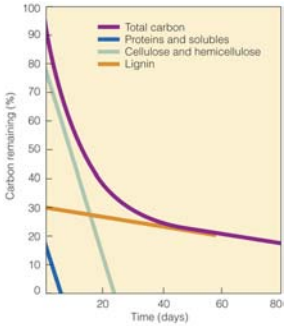
FIGURE 20.13 Detrital food chain involving forest litter-dwelling invertebrates in an Appalachian yellow-poplar forest.

Decomposition and Nutrient cycling

Outline:

- Process of decomposition
  - Controls on decomposition
  - Decomposition in lakes and rivers
- Nutrient cycling: generalities
- Nutrient cycles
  - Carbon
  - Nitrogen
  - Phosphorus

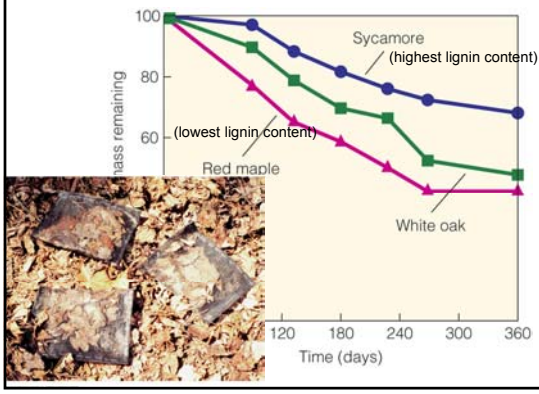
Factors Influencing Decomposition Rates



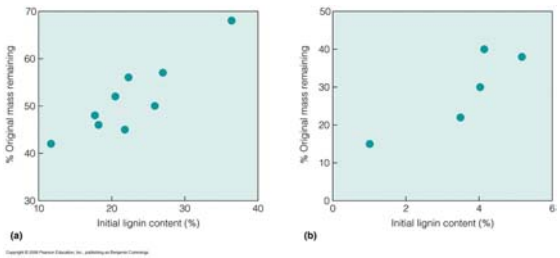
Decomposition of Straw

- **Quality of litter**
  - **% various components**
- **Physical environment**
  - **pH**
  - **Temperature**
  - **Humidity**
  - **Oxygen availability**

Measuring Decomposition Rates



Lignin Content

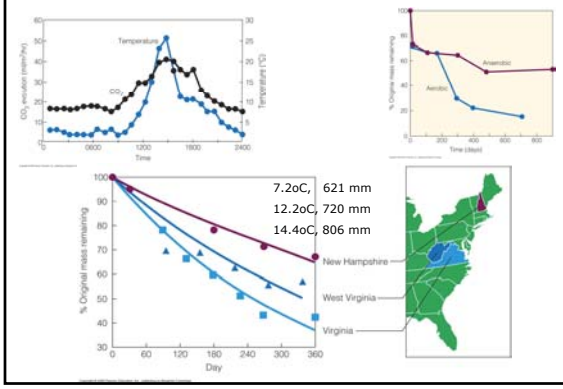


Terrestrial environment

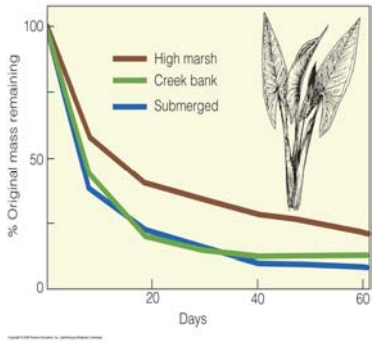
Aquatic environment

Lignin contents influence litter decomposition

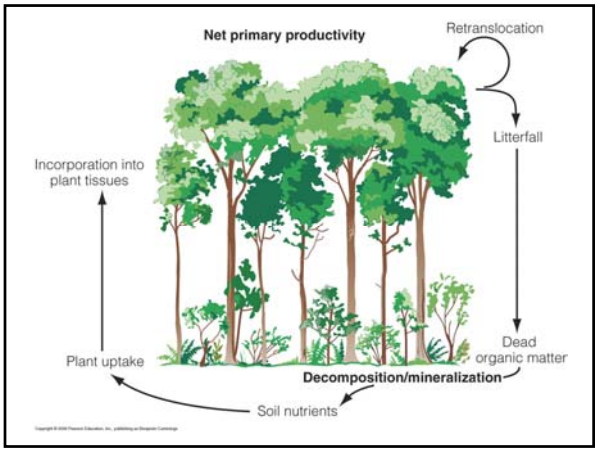
Temp, Oxygen, Climate

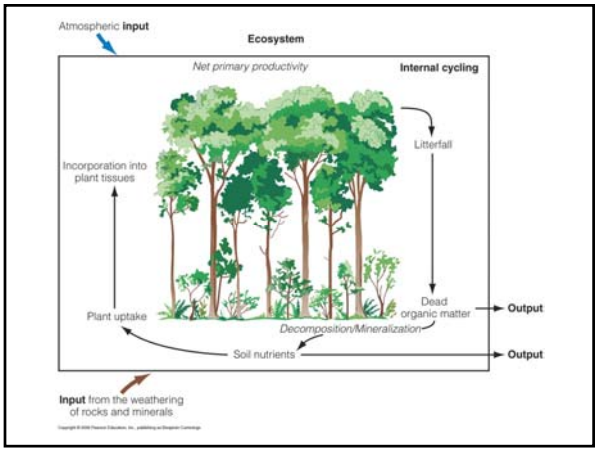


Decomposition in Aquatic Environment

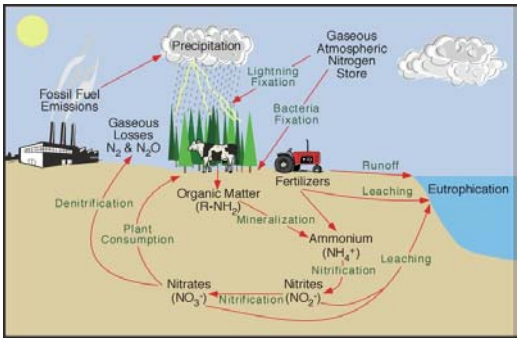


Nutrients in organic matter are mineralized during decomposition

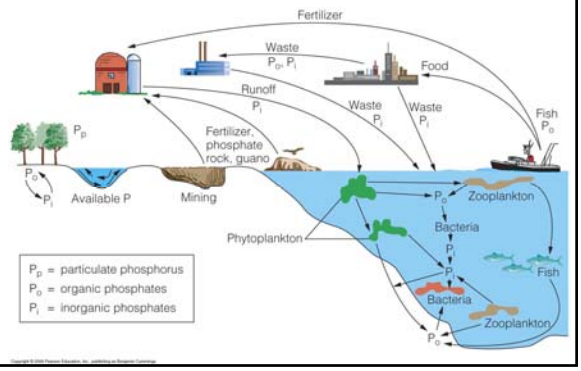




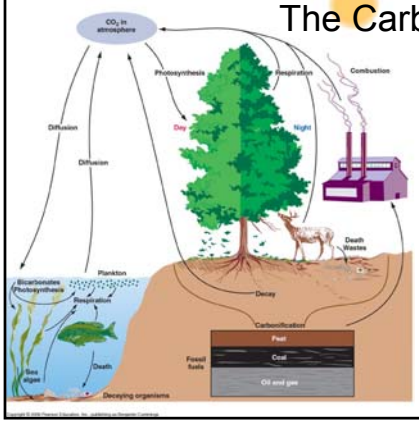
Nitrogen Cycle



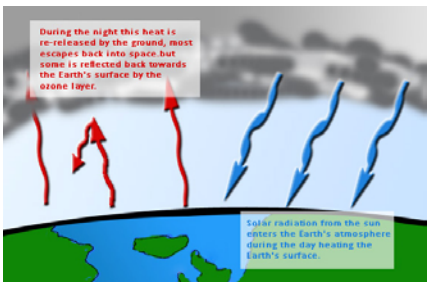
The phosphorus cycle



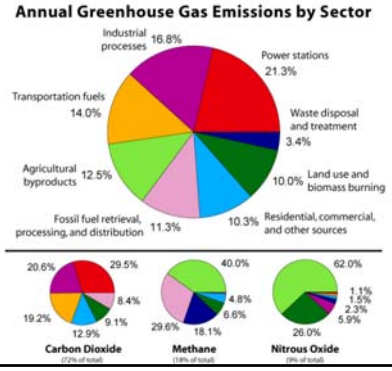
The Carbon Cycle



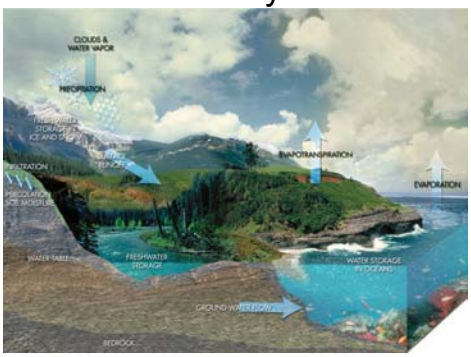
Global Warming



Green-House Gas Sources



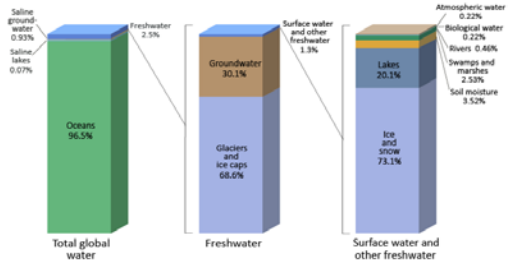
Water Cycle



http://ga.water.usgs.gov/edu/watercycle.html

Where's the Water?

Distribution of Earth's Water



Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources.