

# Lecture 12

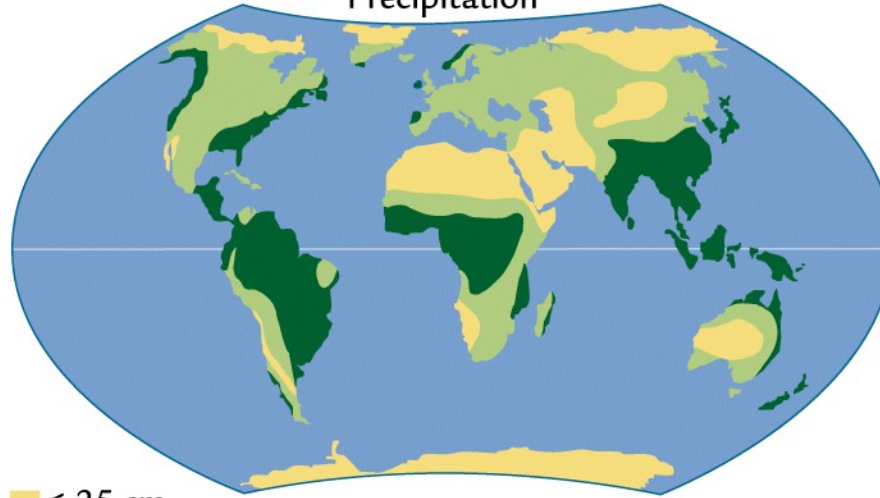
## Earth's Biosphere

[EarthsClimate\\_Web\\_Chapter.pdf](#), p. 30-35; Ch. 3, 46-47, 53-58

- I. Biosphere
  - a. Biosphere Basics
  - b. Carbon Storage and Cycle
  - c. GAIA Hypothesis
- III. Climate → Biosphere
  - a. Distribution of biomes
- IV. Biosphere → Climate
  - a. Natural processes
  - b. Anthropogenic effects

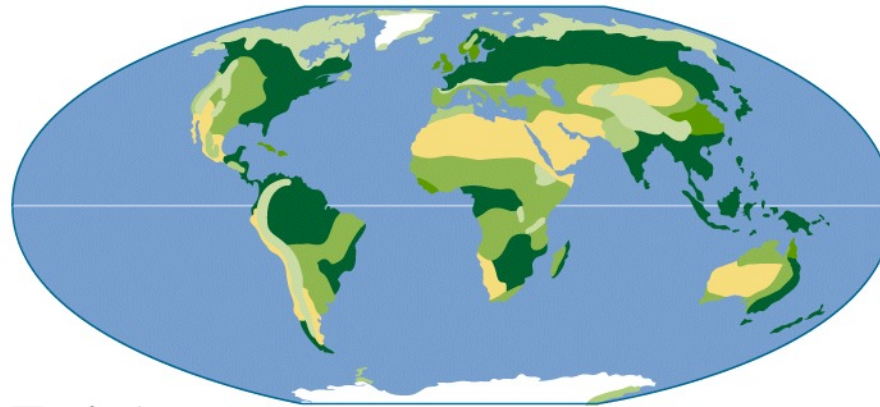
# Precipitation and Vegetation

Precipitation



- < 25 cm
- 25 - 100 cm
- > 100 cm

Vegetation biomes

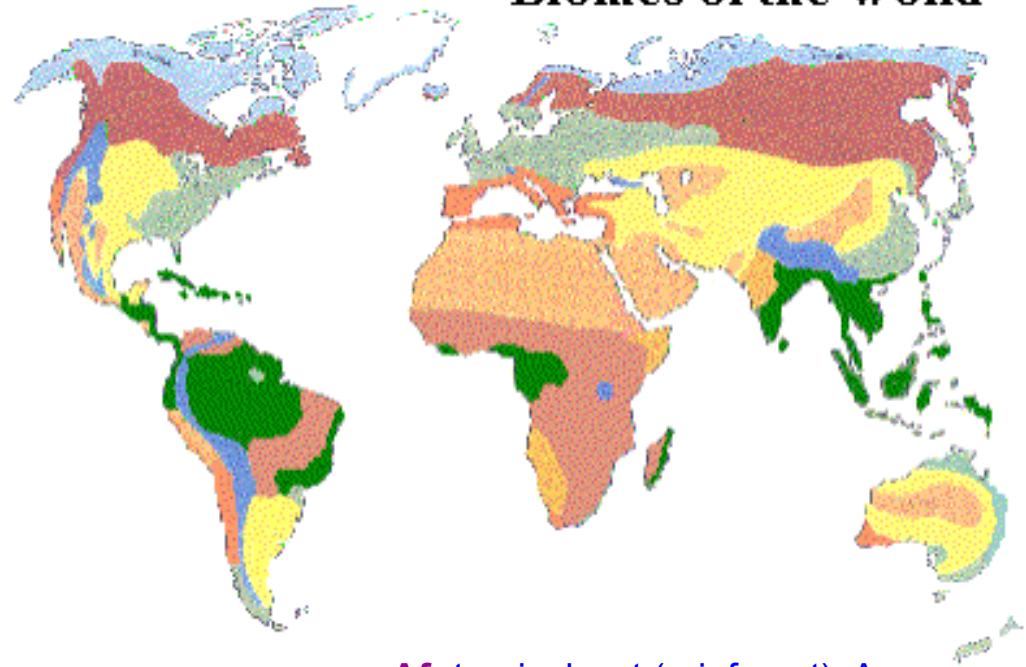


- Polar ice
- Desert
- Alpine and Arctic tundra
- Savanna, woodland, grassland, scrub, tundra
- Forest

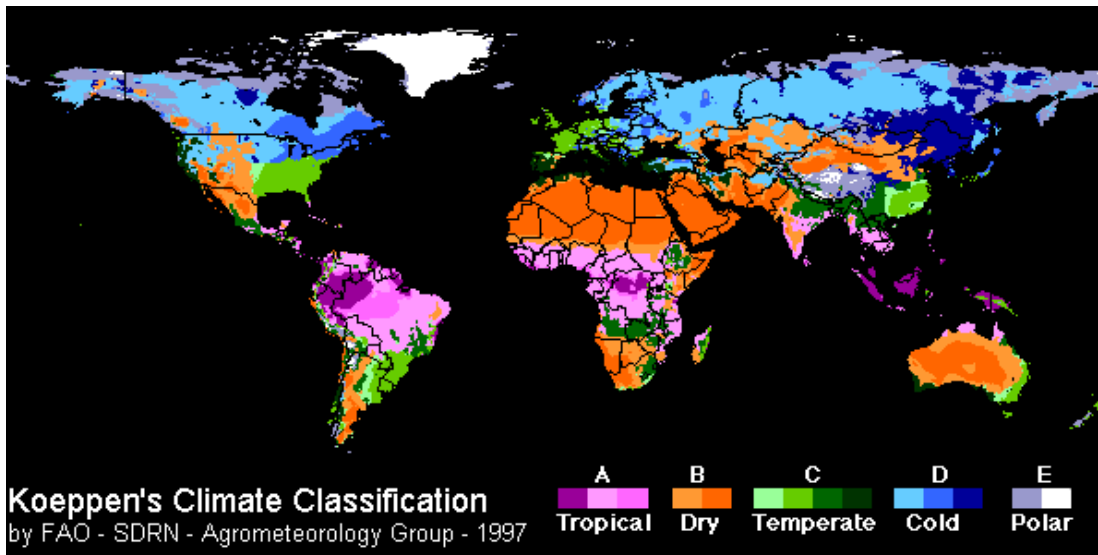
**The law of the minimum:**  
the factor that is least available has the greatest effect on plants.

**The law of the maximum:**  
too much of a certain factor also limits a plant's existence.

## Biomes of the World



## Global Climate Pattern

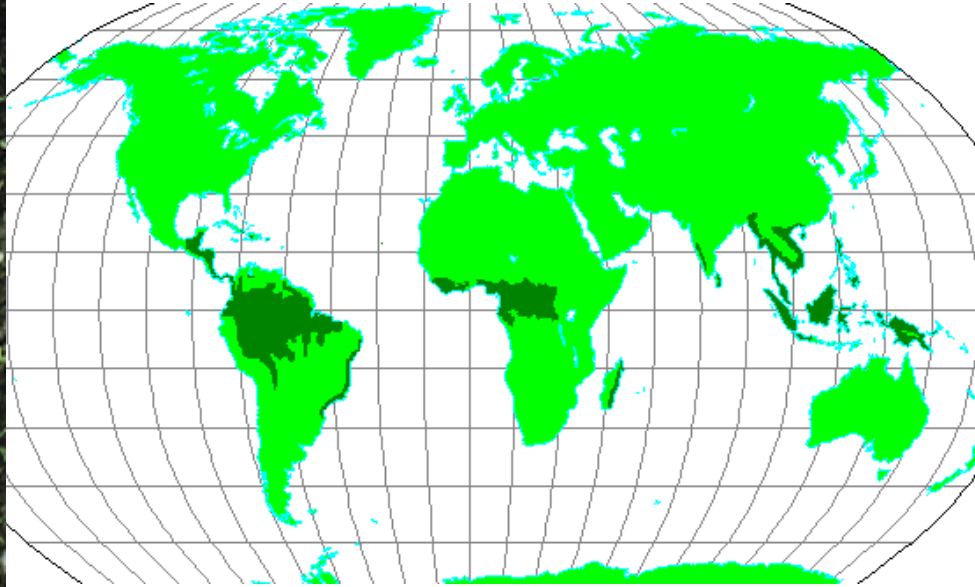


**Af:** tropical wet (rainforest); **Aw:** tropical wet and dry (savanna); **Am:** tropical monsoon  
**Bs:** dry semiarid (steppe); **Bw:** dry arid (desert)  
**Cs:** mediterranean; **Cfa:** humid subtropical; **Cfb:** marine  
**Dw:** dry winters; **Ds:** dry summers; **Df:** wet all seasons  
**ET:** polar tundra; **EF:** polar ice caps

Koeppen's Climate Classification  
by FAO - SDRN - Agrometeorology Group - 1997



## Tropical Rainforest



Earth's most complex biome in terms of both structure and species diversity; abundant precipitation and year round warmth.

**Climate:** Mean monthly temperatures are above  $64^{\circ}\text{F}$ ; precipitation is often in excess of **100 inches a year**.

**Vegetation:** 100 to 120 feet tall canopy.

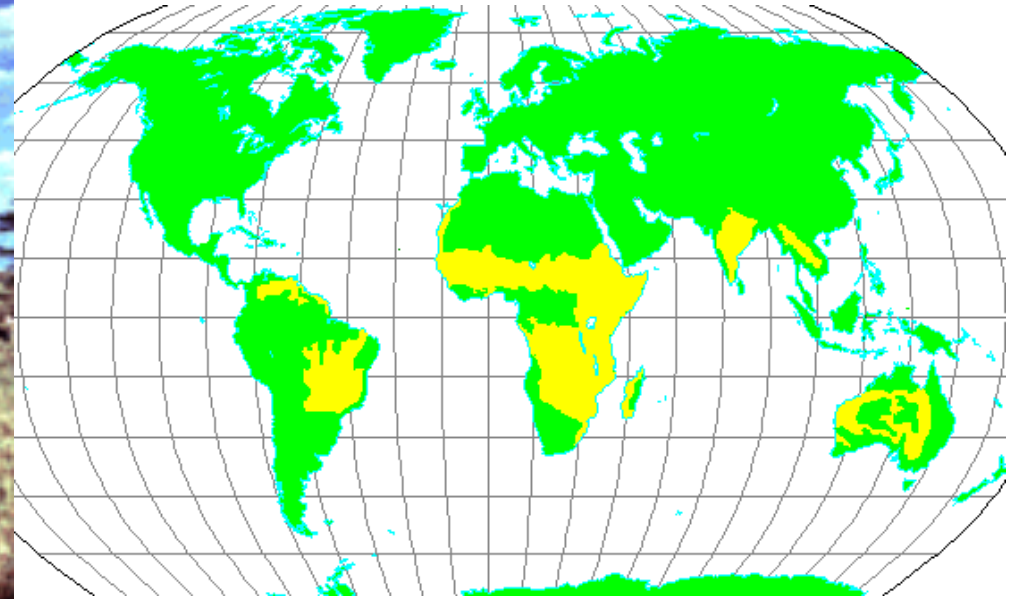
**Soil:** **infertile, deeply weathered** and severely leached. Red color because of high iron and aluminum oxides.

**Fauna:** Animal life is highly diverse

**Distribution of biome:**  **$10^{\circ}\text{N}$  and  $10^{\circ}\text{S}$  latitude**. Neotropical (Amazonia into Central America), African (Zaire Basin with an outlier in West Africa; also eastern Madagascar), Indo-Malaysian (west coast of India, southeast Asia)



# Savanna



The word **savanna** stems from an Amerind term for plains which became Hispanicized after the Spanish Conquest.

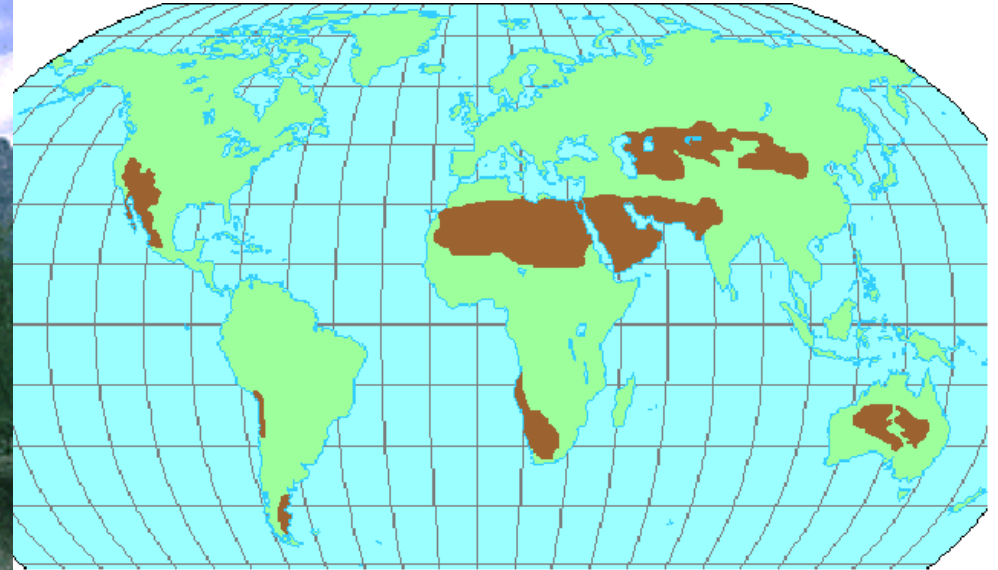
**The vegetation.** Grasslands to **grasslands with scattered trees**

**Climate.** Mean monthly temperatures are at or above **64° F** and annual precipitation averages between **30 and 50 inches**.

**Soils.** low fertility.

**Fauna.** plains zebra, rhinos, giraffes, elephants, warthogs

## Deserts



**Four** distinct conditions: 1) under zones of high atmospheric pressure associated with the subtropics and centered near  $30^{\circ}$  latitude; 2) west coasts of continents between  $20^{\circ}$  and  $30^{\circ}$  latitude; 3) rainshadows of high mountain ranges; 4) interiors of continents.

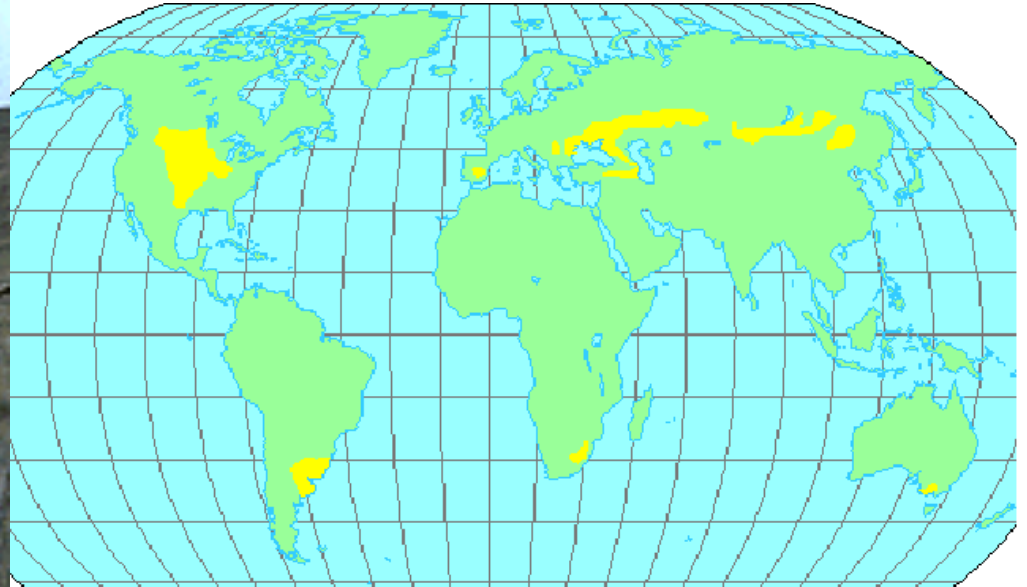
**Climate.** Arid climates less than **10 inches** of precipitation a year.

**Vegetation.** Shrubs are the dominant growth form of deserts.

**Soils.** Calcification is the dominant soil-forming process.

**Fauna.** Like the plants, the animals of the desert have evolved an array of strategies for dealing with aridity.

## Temperate Grasslands



**Climate:** Semiarid, continental climates of the middle latitudes, precipitation [10-20 inches/year](#).

**Vegetation.** Perennial grasses and perennial forbs.

**Soils.** Calcification is the dominant soil-forming process in semiarid regions.

**Fauna.** very low in diversity.

North America: **prairies**

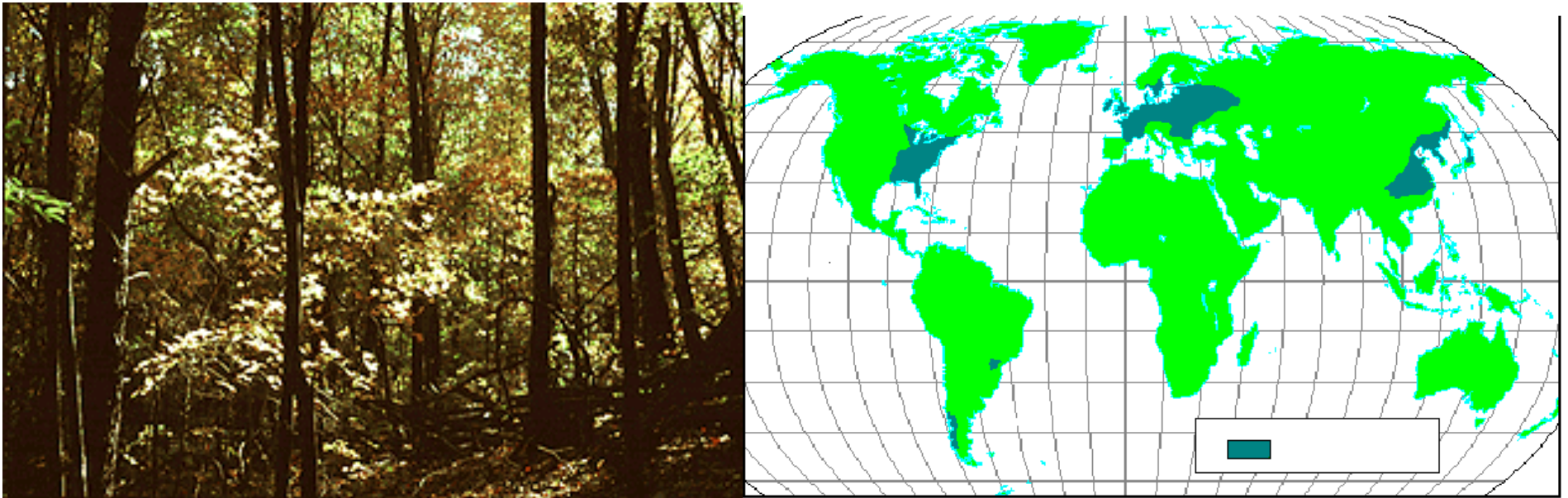
Eurasia: the **steppes** from Ukraine eastward through Russia and Mongolia.

South America: the **pampas** of Argentina and Uruguay

Africa: the **veld** in the Republic of South Africa.



# Temperate Broadleaf Deciduous Forest



## Temperate Broadleaf Deciduous Forest

**Vegetation:** oak, maple, beech, chestnut, hickory, elm, basswood or linden, walnut, and sweet gum. Different species of these genera occur on each continent.

**Climate:** warmer continental and humid subtropical climates. 20-60 inches of annual total precipitation.

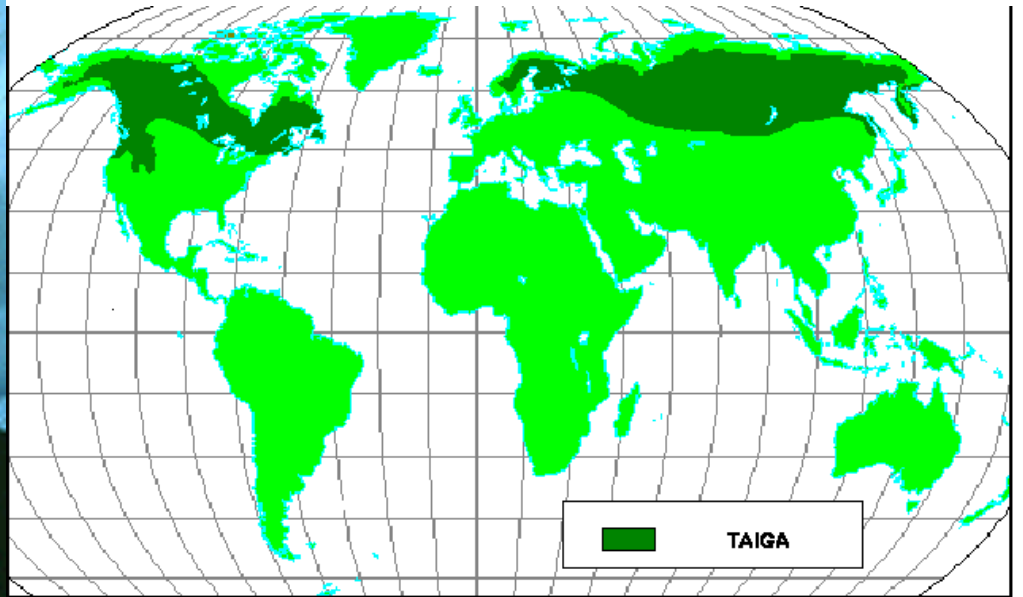
**Soil:** Brown forest soils (good farming soil)

**Fauna:** mast-eaters (nut and acorn feeders) or omnivores (skunk, and black bear).

**Distribution:** western and central Europe; eastern Asia, including Korea and Japan; and eastern North America.



## Taiga or Boreal Forest



**Taiga or boreal forest** exists as a nearly continuous belt of coniferous trees across North America and Eurasia.

**Climate:** **subarctic and cold** continental climate. Precipitation: **15-20 inches/yr.**

**Vegetation:** Needleleaf & coniferous. Species: evergreen **spruce**, **fir**, and **pine**, and the deciduous **larch** or **tamarack**. Also, alder, birch, and aspen.

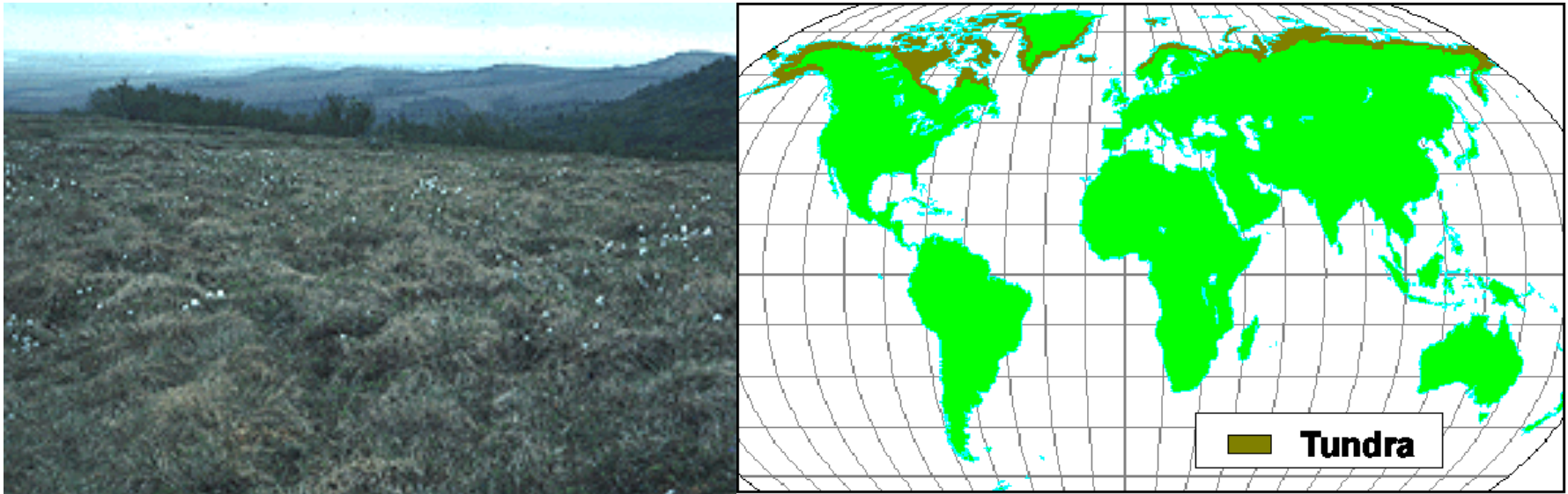
200-yr cycle between nitrogen-depleting spruce-fir forests and nitrogen-accumulating aspen forests.

**Soil:** acidic because of leaching of calcium and decaying conifer needles and wood

**Fauna:** Fur-bearing predators

**Distribution patterns within the boreal forest:** restricted to the northern hemisphere, circumpolar in distribution.

# Tundra



The word **tundra** derives from the Finnish word for barren or treeless land. The tundra is the simplest biome in terms of species composition and food chains.

**Vegetation:** lichens, mosses, sedges, perennial forbs, and dwarfed shrubs

**Climate:** long, cold, dark winters (6 to 10 months with mean monthly temperatures below **32° F or 0° C.**) low precipitation (less than **5 inches/year**)

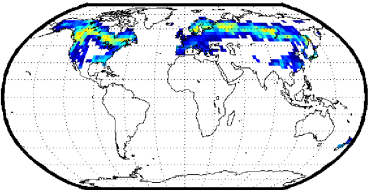
**Soil:** No true soil is developed in this biome

**Fauna:** bird (ptarmigan) and mammal (muskox, arctic hare, arctic fox, musk ox)

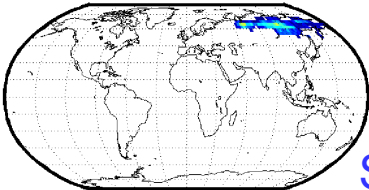
**Distribution:** restricted to the high latitudes of the northern hemisphere in a belt around the Arctic Ocean.

# Satellite-Derived Plant Geography

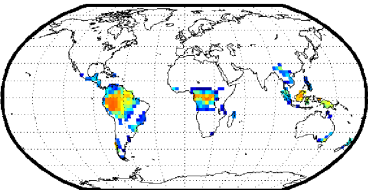
(A) NEEDLELEAF EVERGREEN TREES



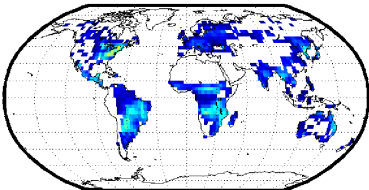
(B) NEEDLELEAF DECIDUOUS TREES



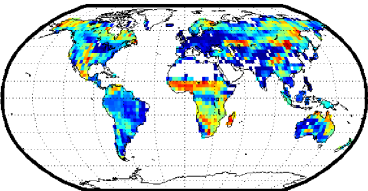
(C) BROADLEAF EVERGREEN TREES



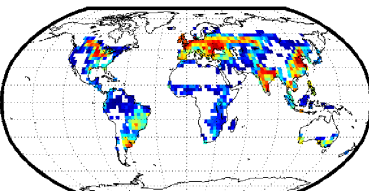
(D) BROADLEAF DECIDUOUS TREES



(E) GRASSES



(F) CROPS



(percent)



Previous maps are constructed based on atlas, surface surveys.

Emphasize climate Factors (Precip, Temp)

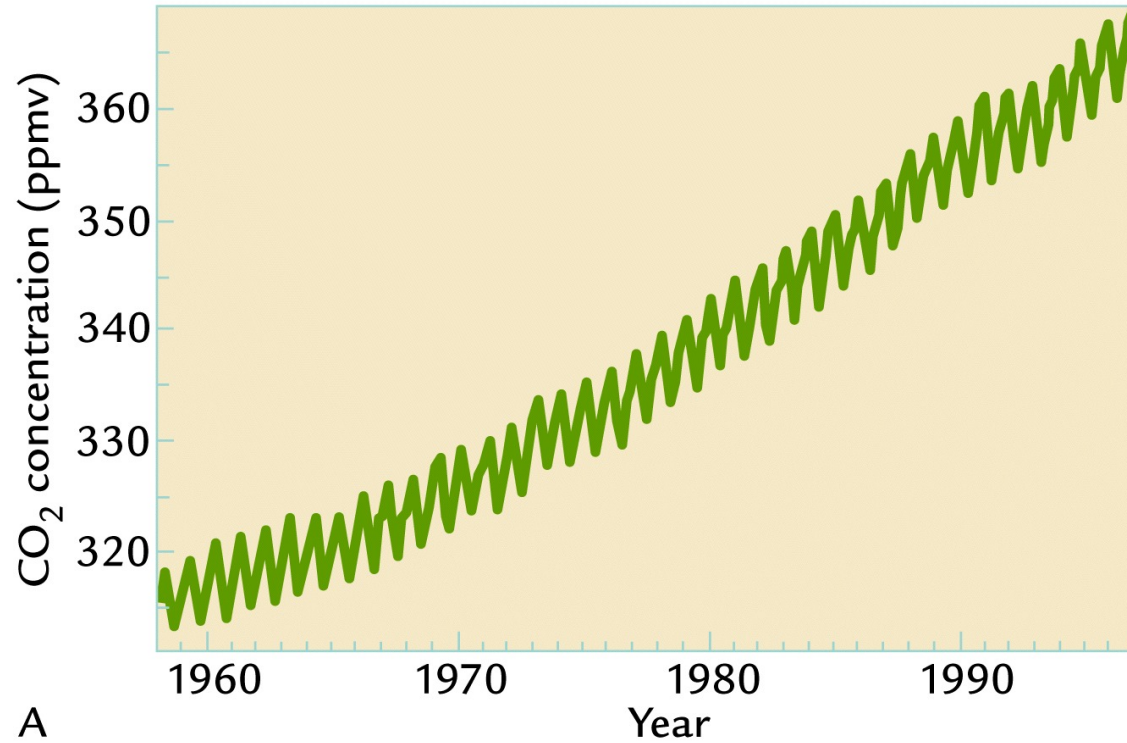
Neglect human factors

Satellite remote sensing provides global, systematic, continuous measurements

Monitor land use and land cover changes

Quantitative.

# Recent Increases in Carbon Dioxide

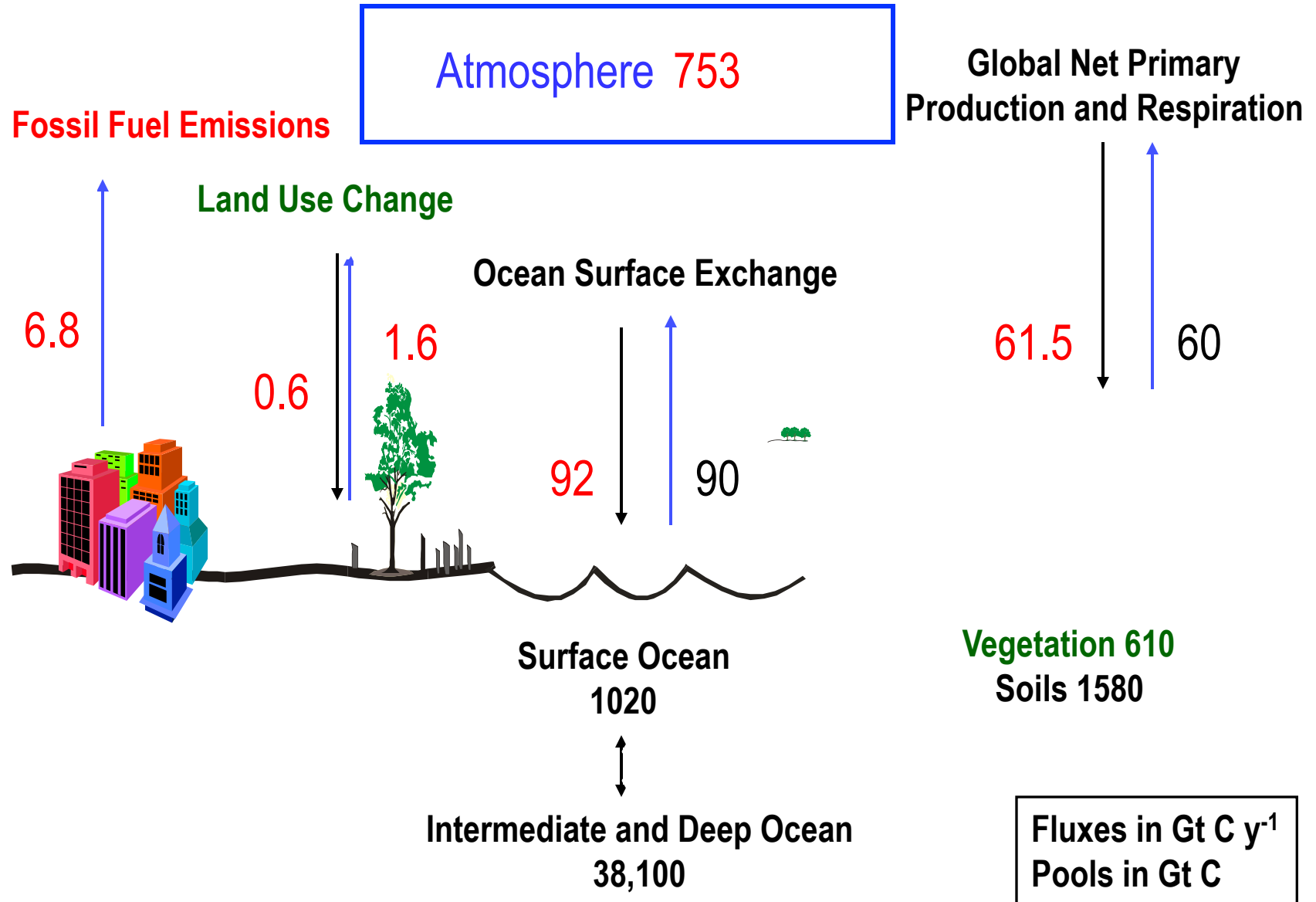


A

Two superimposed effects:  
Seasonal cycle  
Graduate overall increase



# Global Carbon Budget

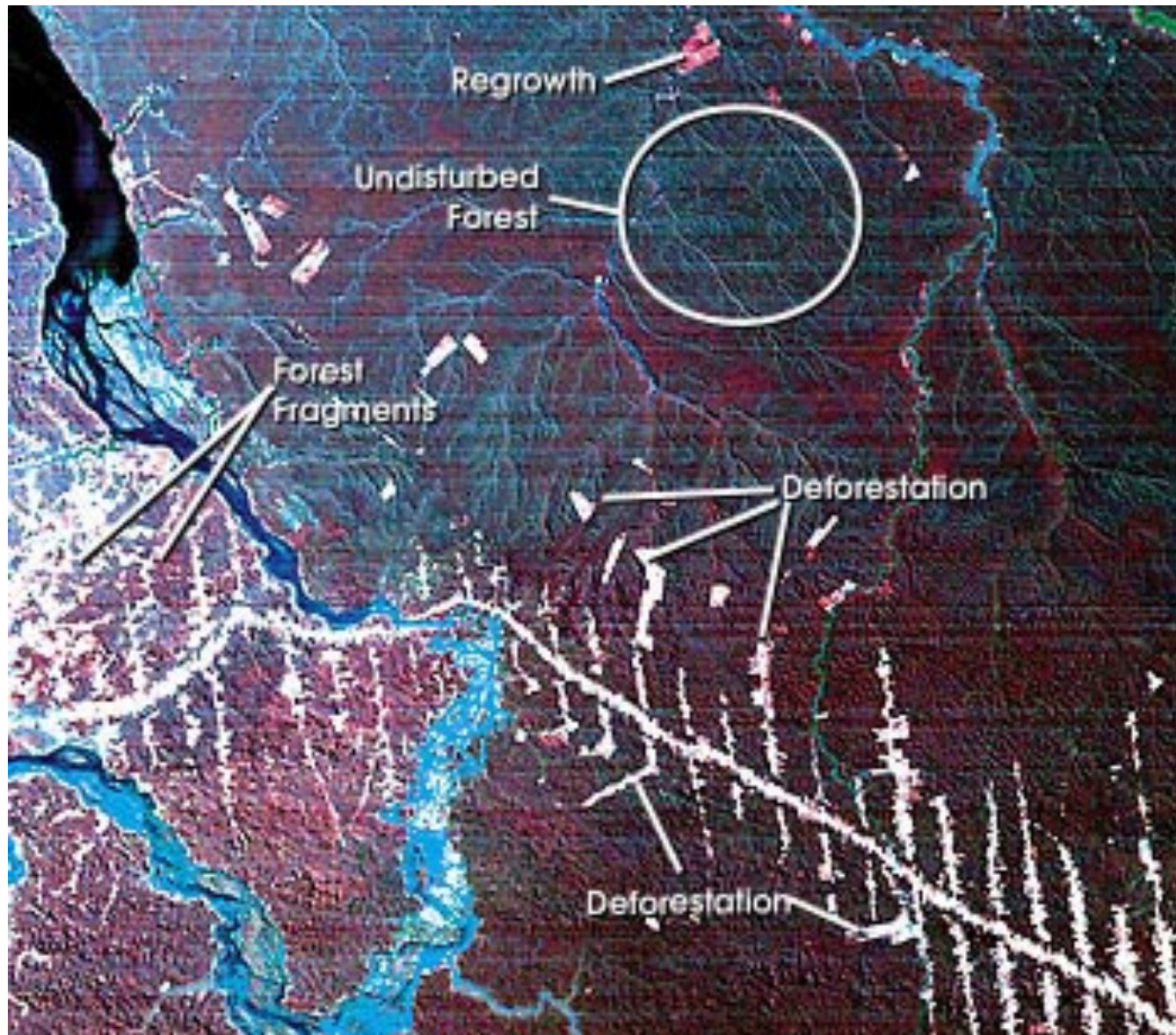


# Recent Range Shifts due to Warming

<u>Species Affected</u>	<u>Location</u>	<u>Observed Changes</u>
Arctic shrubs	Alaska	Expansion into shrub-free areas
Alpine plants	Alps	Elevational shift of 1-4 m per decade
39 butterfly spp.	NA, Europe	Northward shift up to 200 km in 27 yrs.
Lowland birds	Costa Rica	Advancing to higher elevations
12 bird species	Britain	19 km northward average range extension
Red & Arctic Fox	Canada	Red fox replacing Arctic fox
Treeline	Europe, NZ	Advancing to higher altitude
Plants & invertebrates	Antarctica	Distribution changes
Zooplankton, fish & invertebrates	California, N. Atlantic	Increasing abundance of warm water spp.

Walther et al., Ecological responses to recent climate change, Nature 416:389 (2002)

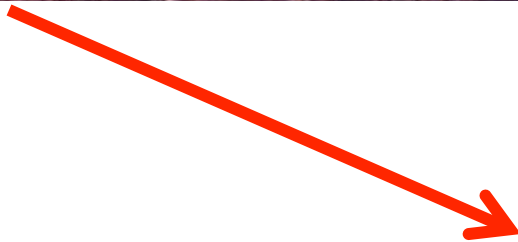
# Deforestation





## Deforestation affects

Carbon balance  
Hydrologic cycle  
Radiative energy balance  
Biodiversity



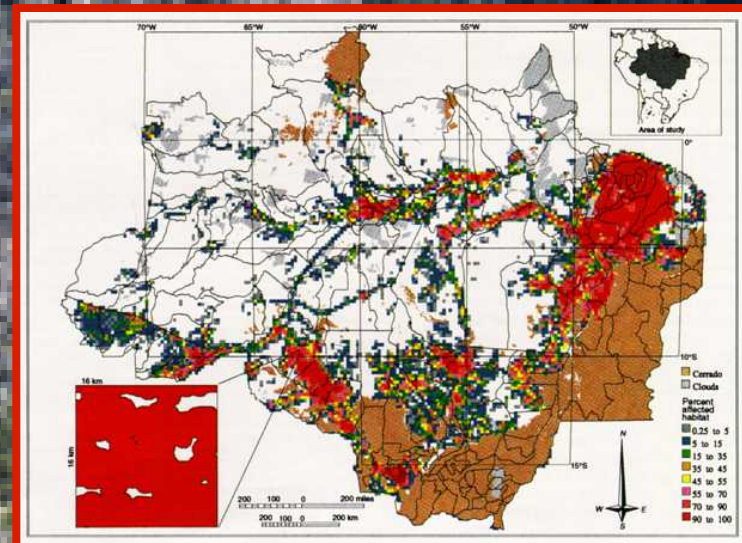
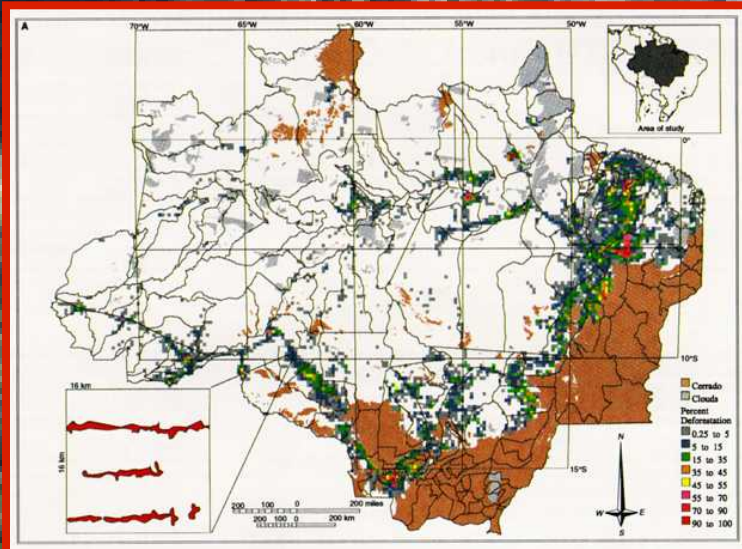


**Deforestation increases atmospheric CO<sub>2</sub> concentrations, because trees remove CO<sub>2</sub> from the atmosphere.**

**1978**

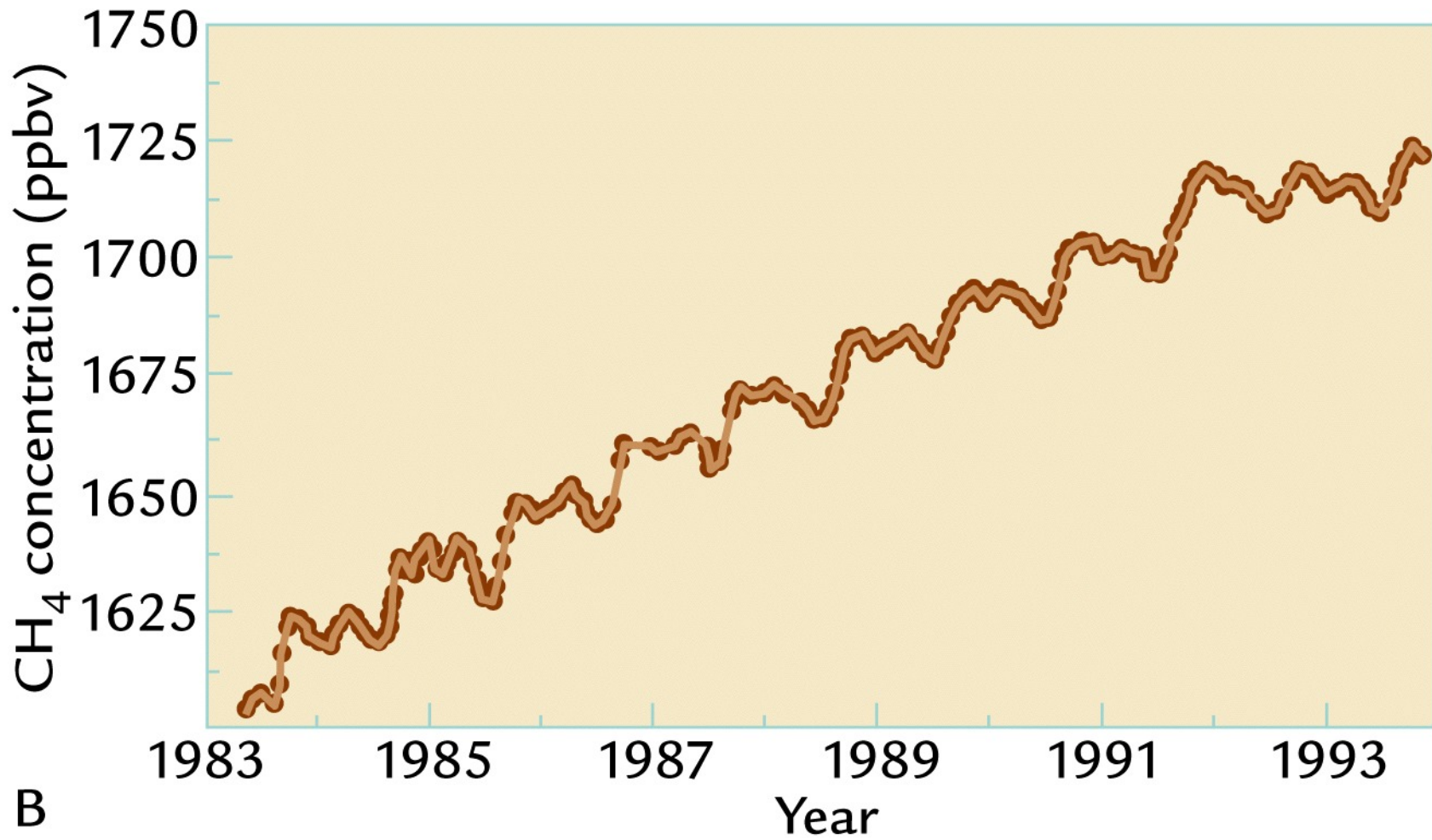
**Deforestation in Brazil**

**1988**



Source: OSTP

## Recent Increases in Methane



CH<sub>4</sub> from wetlands, rice paddies, termites, stomachs and bowels of cows

# Biosphere: Climatic Cause and Effect

**Climate** ← **Biosphere**

**Radiative effects at surface**

**Clouds and precipitation**

**Radiatively-active gases**

Effects of Biosphere on Climate (partial list)

Affects albedo

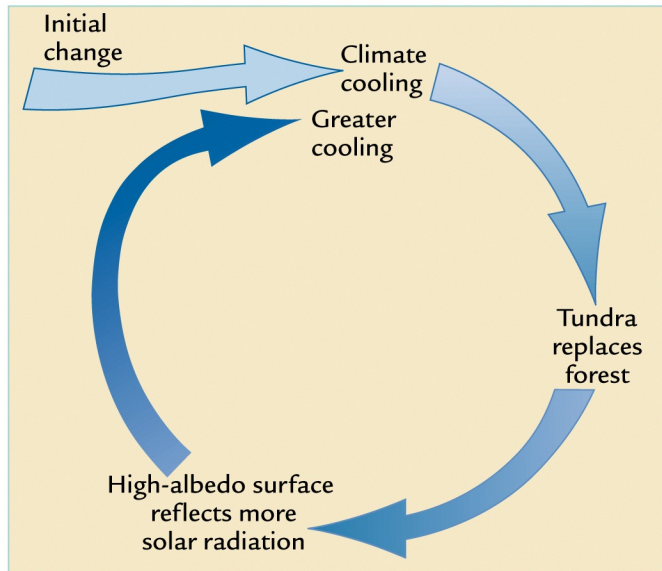
Affects global CO<sub>2</sub> budget

Marine phytoplankton emissions affect aerosols/clouds

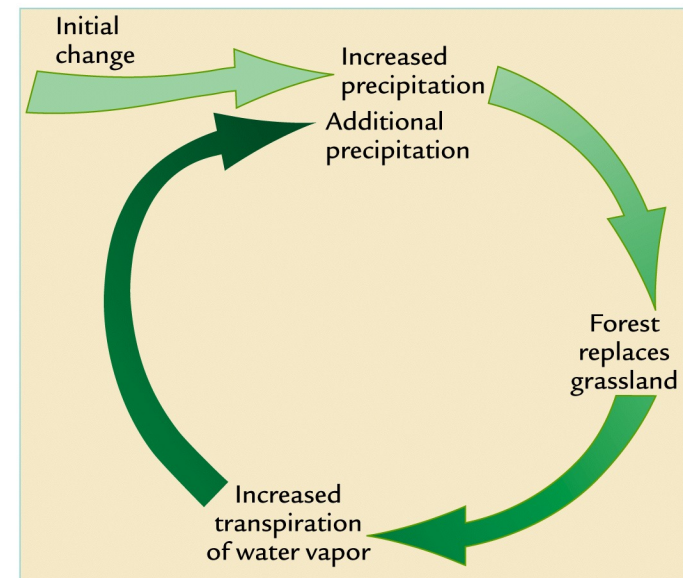
Volatile organic compounds emissions affect O<sub>3</sub> formation

Affects evapotranspiration and rainfall

# Vegetation-Climate Feedbacks



A Vegetation-albedo feedback



B Vegetation-precipitation feedback



# Summary:

- Terrestrial biomes distribution is primarily dominated by climate condition, although other factors such as topography, soil and human impacts.
- There are 7 major terrestrial biomes on earth in current climate: tropical rainforests, savanna, deserts, temperate broadleaf deciduous forests, temperate grassland, boreal forests or taiga, tundra.
- Climate change and human impact have already exerted significant impacts on all these biomes. The terrestrial and marine biosphere so far have absorbed  $\sim \frac{1}{2}$  of the CO<sub>2</sub> emitted by human.