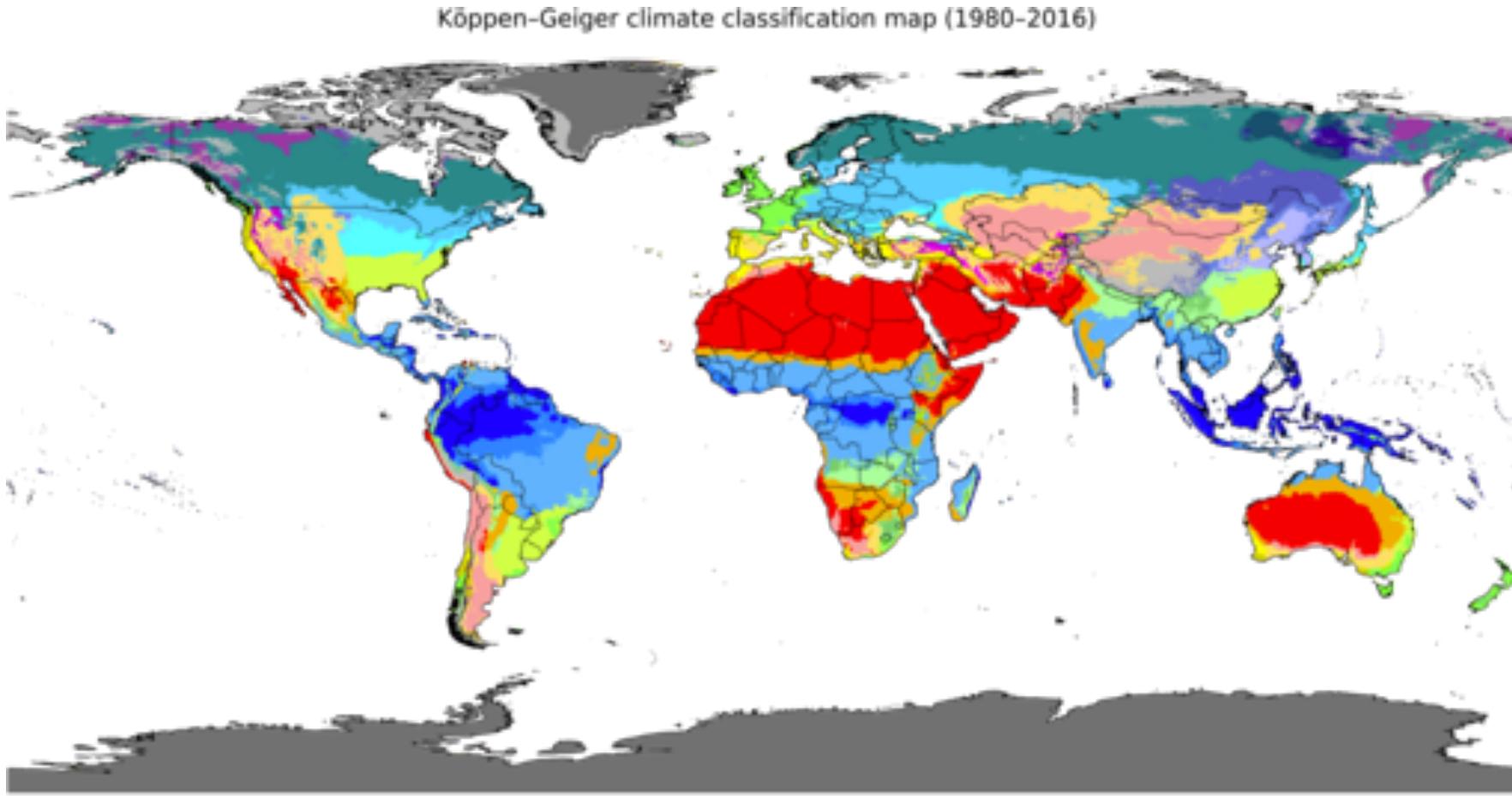


Climate and Soils

September 10, 2019

Climate

Climate = long term average weather

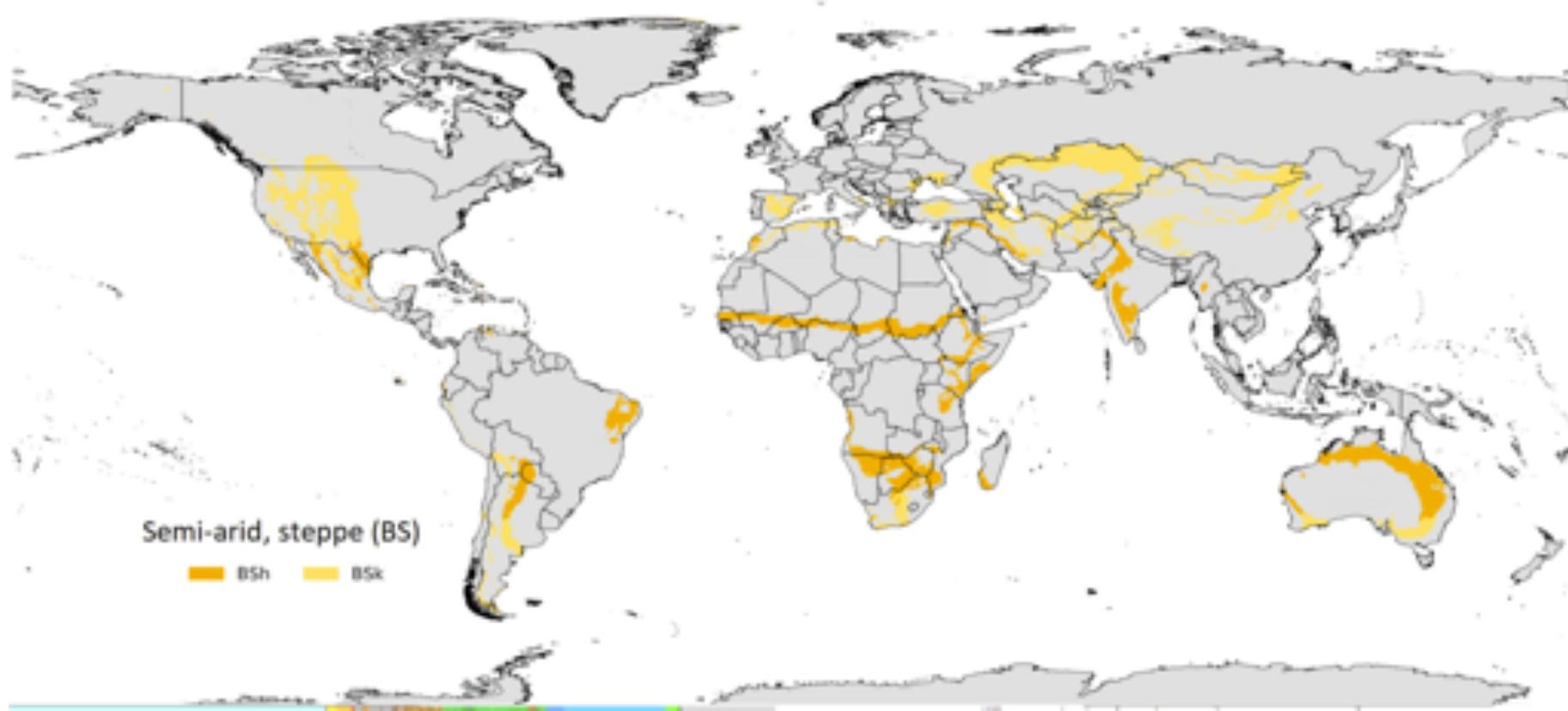


A = tropical
B = arid
C = temperate
D = cold
E = polar

An updated Köppen–Geiger climate map^[1]

Af	Am	Aw/As	BWh	BWk	BSh	BSk	Csa	Csb	Csc	Cwa	Cwb	Cwc				
Cfa	Cfb	Cfc	Dsa	Dsb	Dsc	Dsd	Dwa	Dwb	Dwc	Dwd	Dfa	Dfb	Dfc	Dfd	ET	EF

Climate = long term average weather



BSk = cold,
semi-arid

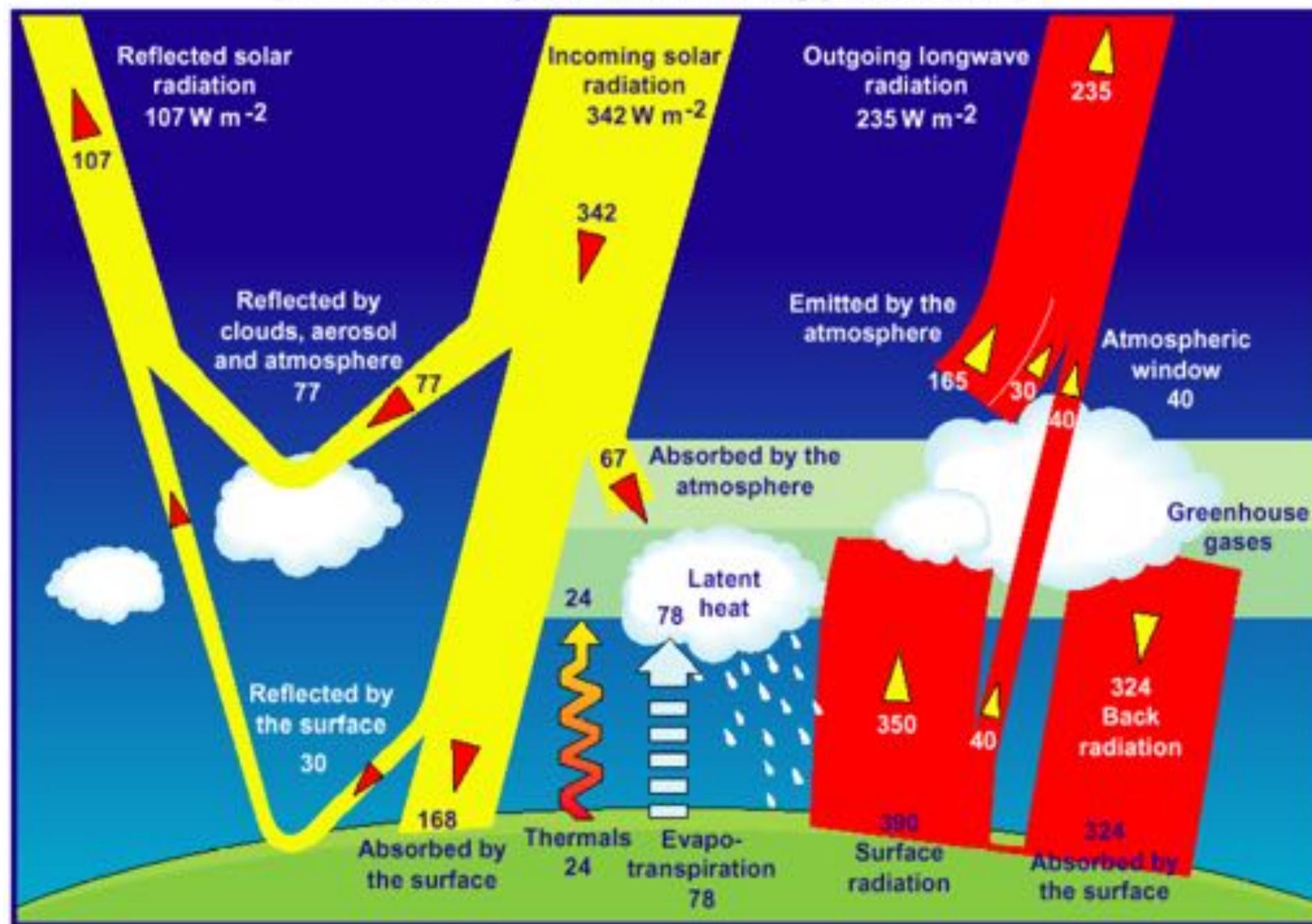
An updated Köppen–Geiger climate map^[1]

Cfa	Cfb	Cfc	Dsa	Dsb	Dsc	Dsd	Dwa	Dwb	Dwc	Dwd	Dfa	Dfb	Dfc	Dfd	ET	EF
Af	Am	Aw/As	BWh	BWk	BSh	BSk	Csa	Csb	Csc	Cwa	Cwb	Cwc				

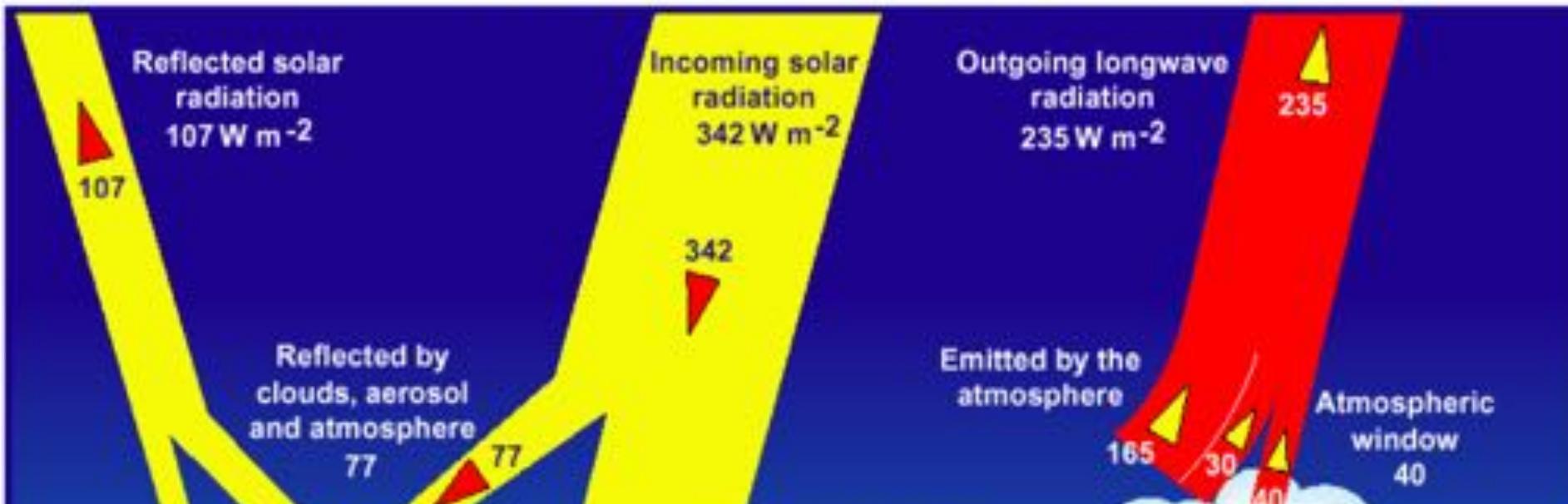
Why do we care about climate?

Earth's Energy Budget

Climate System Energy Balance

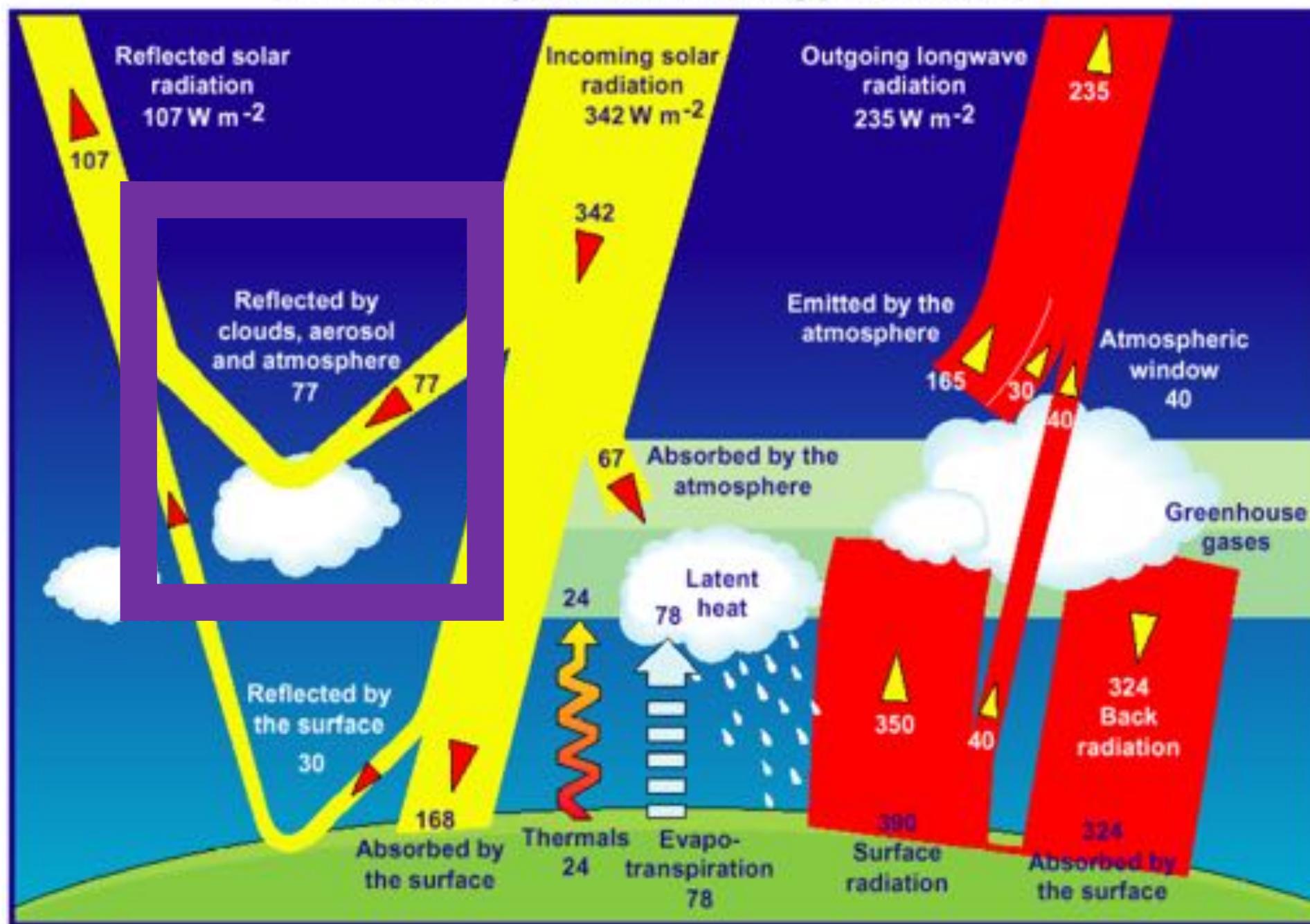


Climate System Energy Balance



The planetary boundary layer:
where the turbulent fluxes happen!

Climate System Energy Balance



Aerosols

- Atmospheric particles
- Reflect incoming radiation back to space
- What's the climate impact?





THE YEAR WITHOUT SUMMER:

1816

AND THE VOLCANO
THAT DARKENED THE W
AND CHANGED HISTO

WILLIAM K. KLINGA
AND NICHOLAS P. KLING

"A book like nothing
you've read before."
—Daniel Walker Howe,
Pulitzer Prize-winning author
of *What Hath God Wrought*



CelebrateBoston.com Boston, Mass.

June 6th, 1816

Mount Tambora erupts (April 5th, 1815)

Madison's Heritage

Richard Petersen 1921

1816 was year without summer

By ROBERT N. GRISE

Our knowledge of Madison County history is limited for that period of time between the Boonesborough stage and the Civil War. Most record accounts of that time were brief, incomplete, or

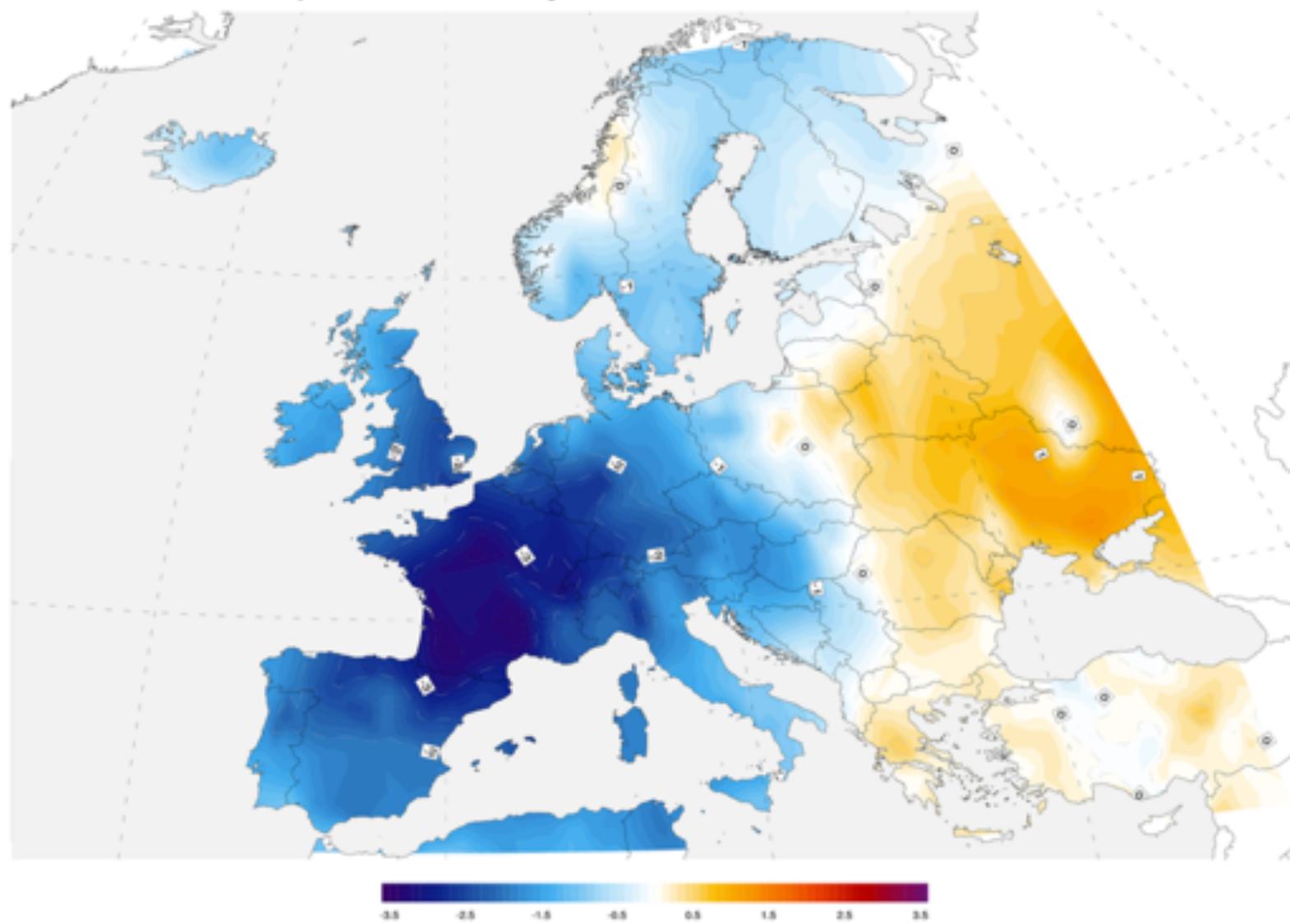
was said to have occurred in 1851.

Frost during every month of the year caused 1816 to be known as "the year without a summer. In 1823 the temperature was said to have gone to minus 23 degrees. It went down to

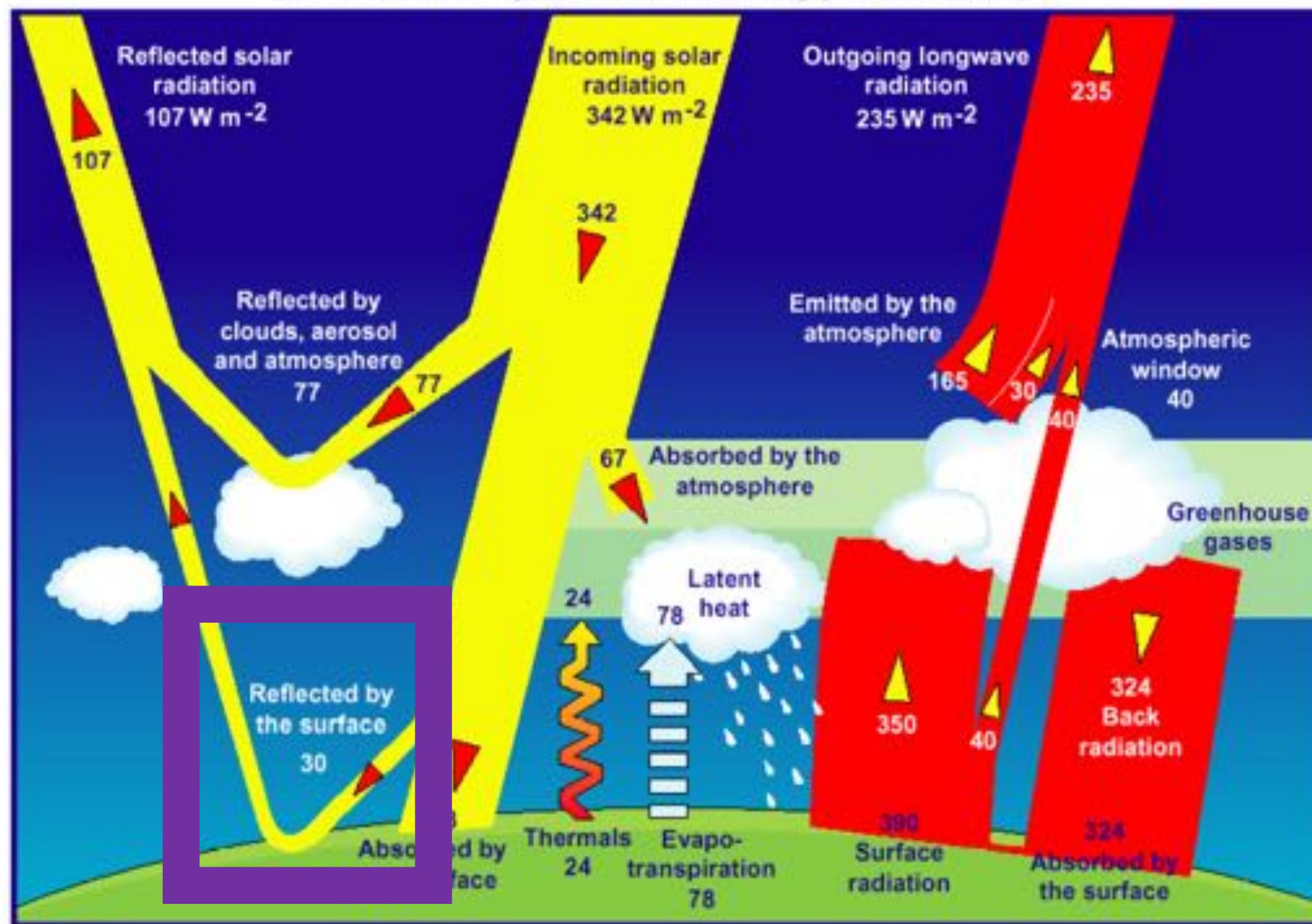
Agricultural Society held a fair at Richmond. There were severe droughts in 1834, '37, and '54, with practically no corn, tobacco, or hemp harvested.

It took the U.S. mail two weeks to arrive from Washington, D.C. in 1814.

1816 Summer Temperature Anomaly



Climate System Energy Balance



Albedo

- Radiation reflected by a surface
- High degree of variability in albedo of Earth's surface



Albedo Examples

- Oceans/lakes
- Sea ice
- Fresh snow
- Tundra
- Conifer forest
- Broadleaf forest
- Desert
- Soil (wet)
- Soil (dry)



Albedo Examples

- Oceans/lakes
- Sea ice
- Fresh snow
- Tundra
- Conifer forest
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- Soil (dry)

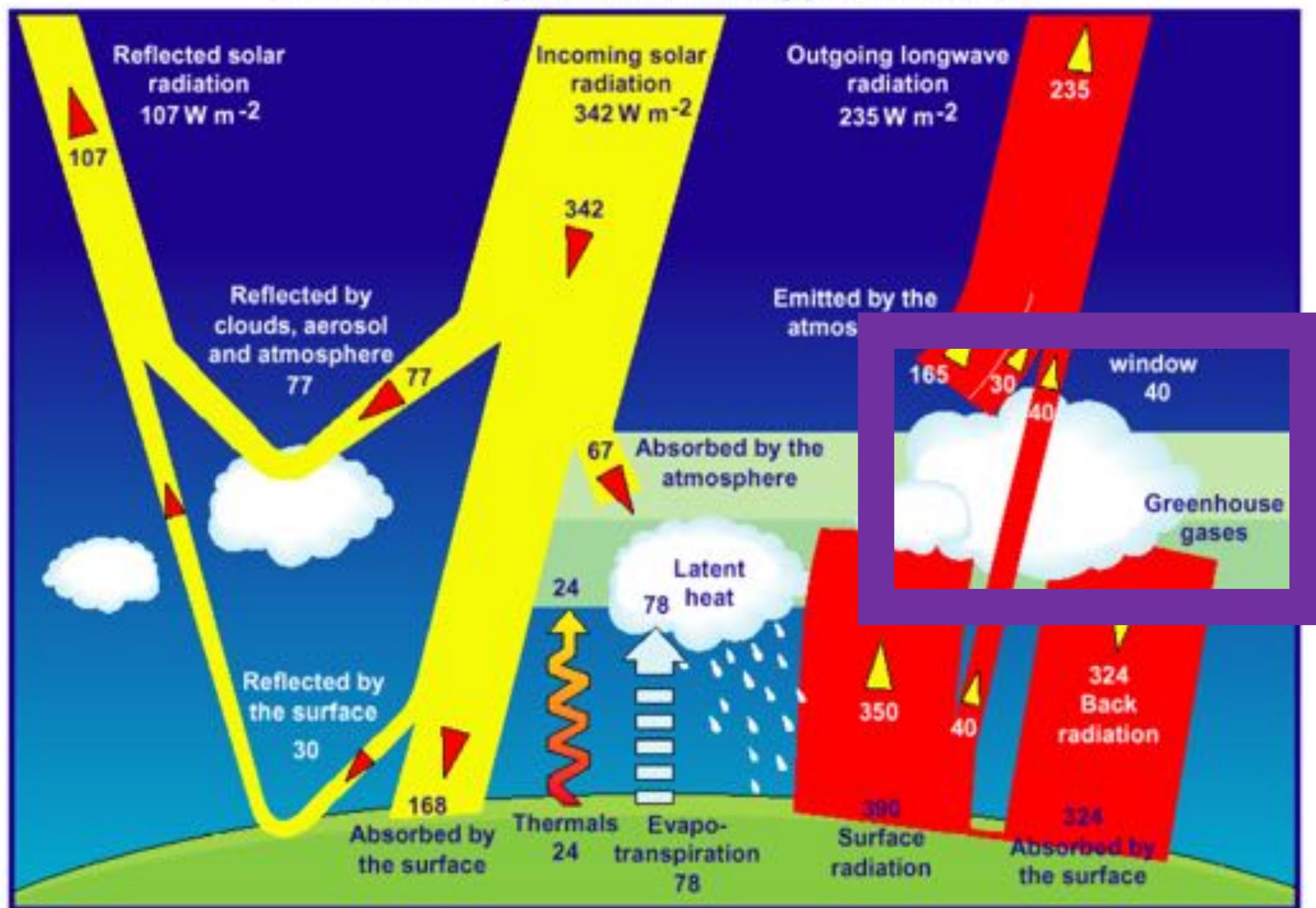


Can you rank these?

	Amount reflected
• Oceans/lakes	0.03-0.10
• Sea ice	0.30-0.45
• Fresh snow	0.75-0.95
• Tundra	0.15-0.20
• Conifer forest	0.09-0.15
• Broadleaf forest	0.15-0.20
• Desert	0.20-0.45
• Soil (wet)	0.05
• Soil (dry)	0.40



Climate System Energy Balance



Greenhouse gases

- Trap outgoing longwave radiation
- Act like a blanket over the Earth's surface
- Keep us warm!



@APELAD

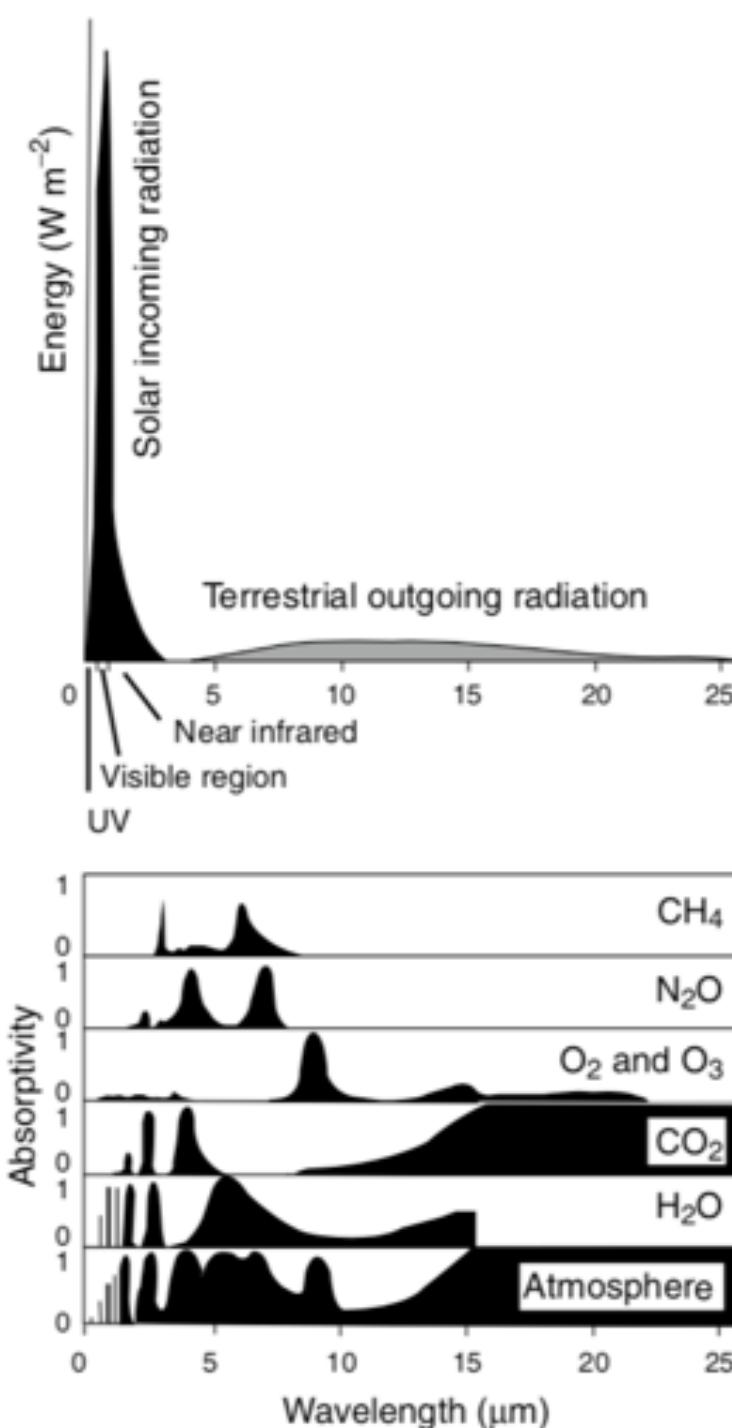
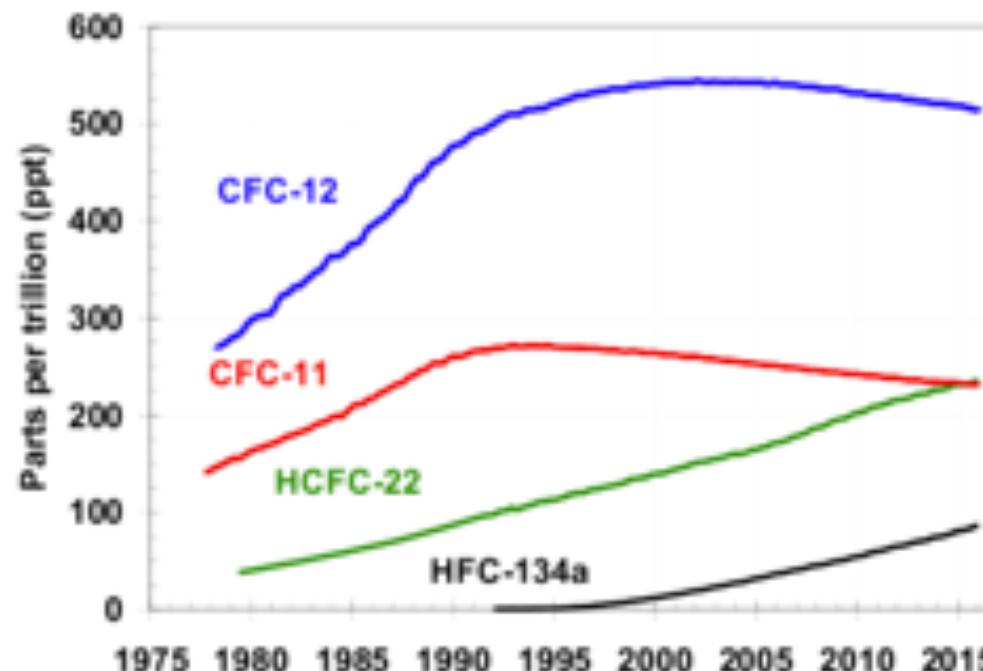
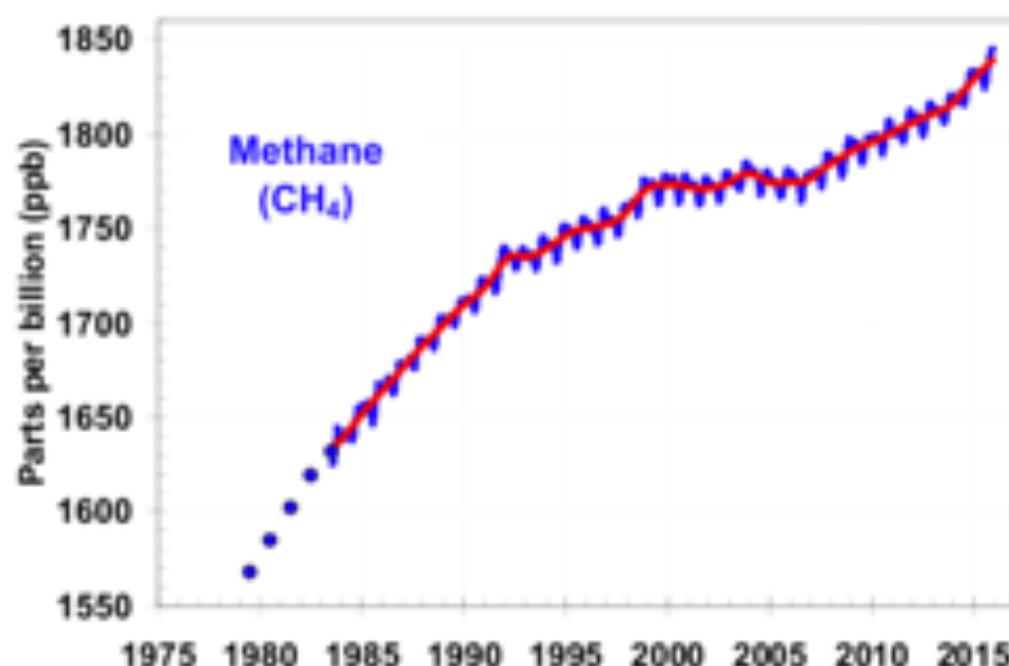
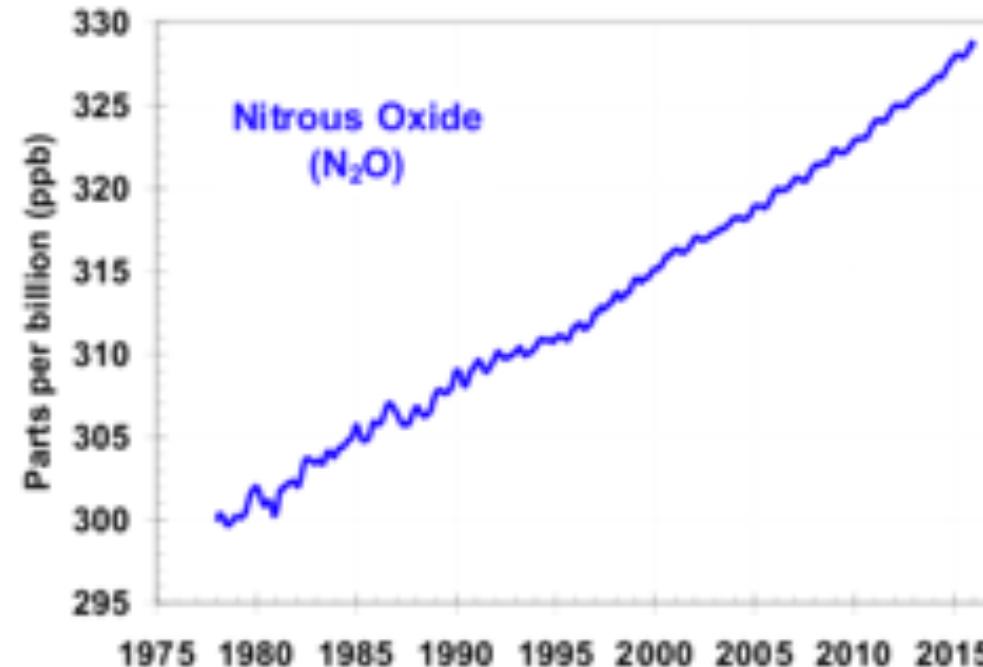
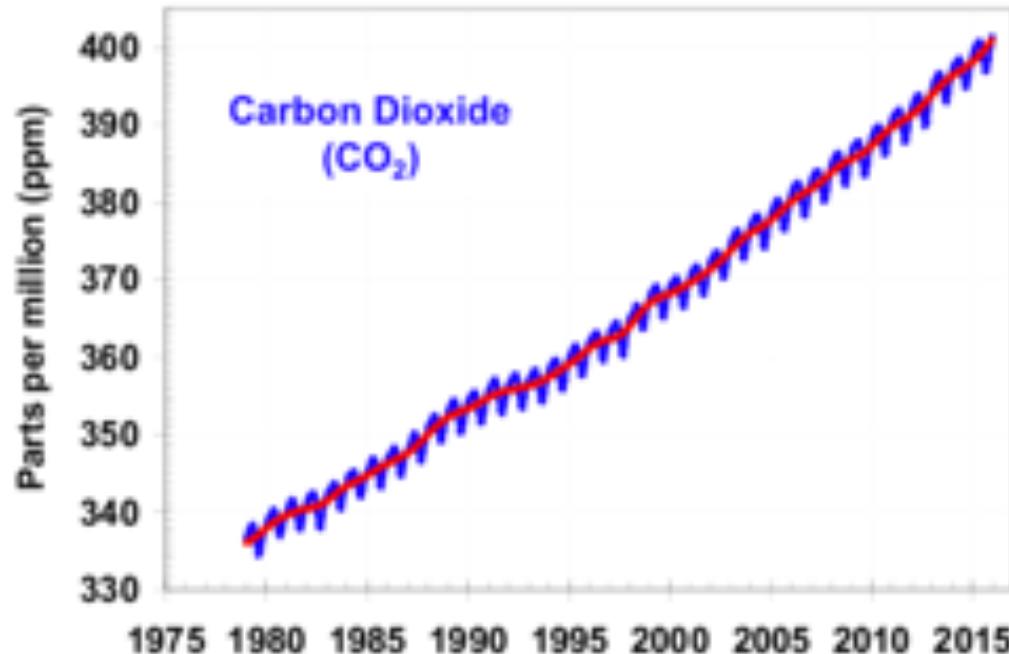


Fig. 2.2 The spectral distribution of solar and terrestrial radiation and the absorption spectra of the major radiatively active gases and of the total atmosphere. These spectra show that the atmosphere absorbs a larger proportion of terrestrial radiation than solar radiation, explaining why the atmosphere is heated from below. Redrawn from Sturman and Tapper (1996) and Barry and Chorley (2003)



Topography

Rain Shadows



Vegetation

Vegetation itself can change climates

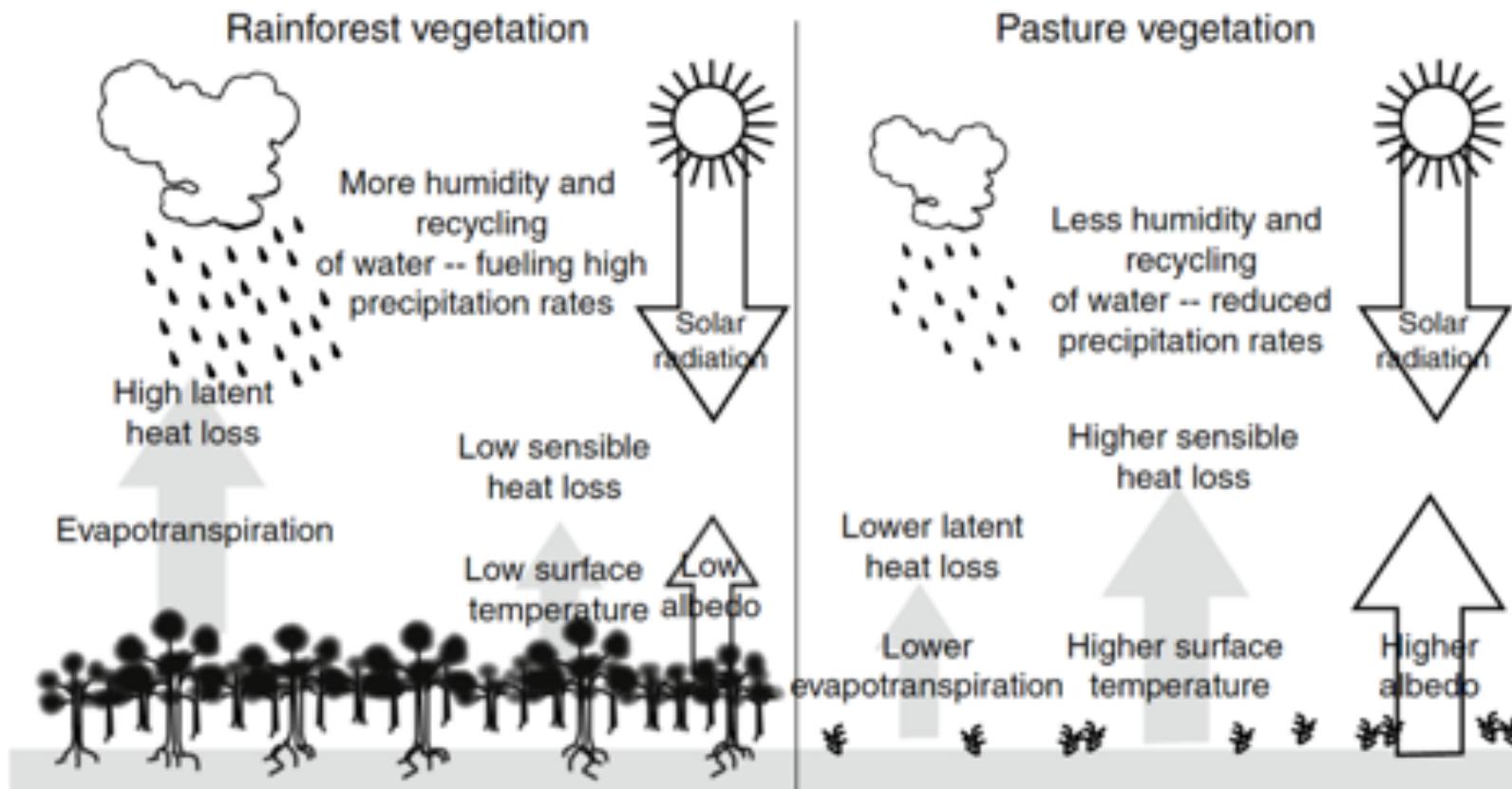


Fig. 2.14 Climatic consequences of tropical deforestation and conversion to pasture. In forested conditions, the low albedo provides ample energy absorption to drive high transpiration rates that cool the surface and supply abundant moisture to the atmosphere to fuel high precipitation rates.

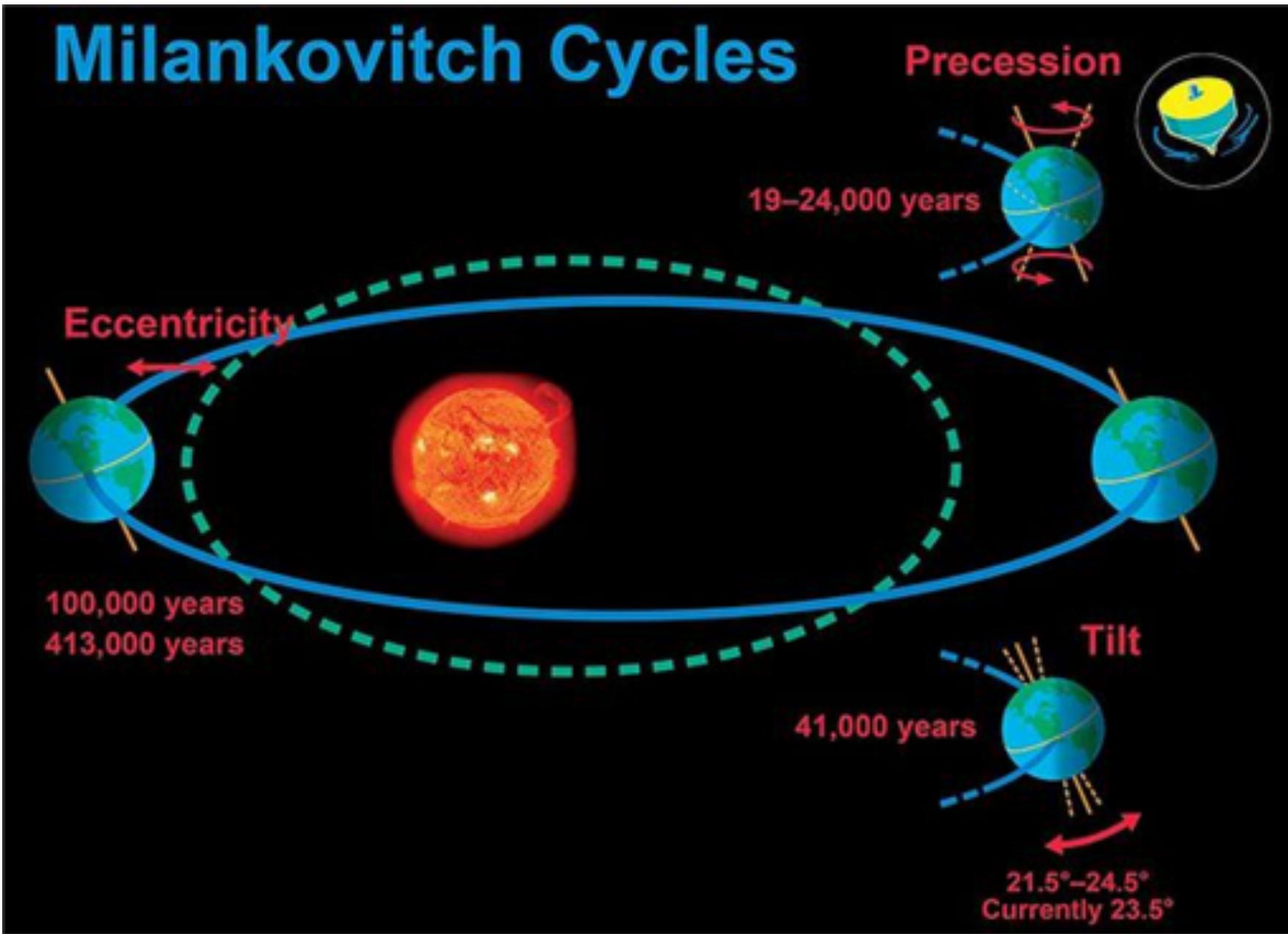
In pasture conditions that develop after deforestation, low vegetation cover and shallow roots restrict transpiration and therefore the moisture available to support precipitation. This, together with high sensible heat flux leads to a warm, dry climate. Based on Foley et al. (2003b)

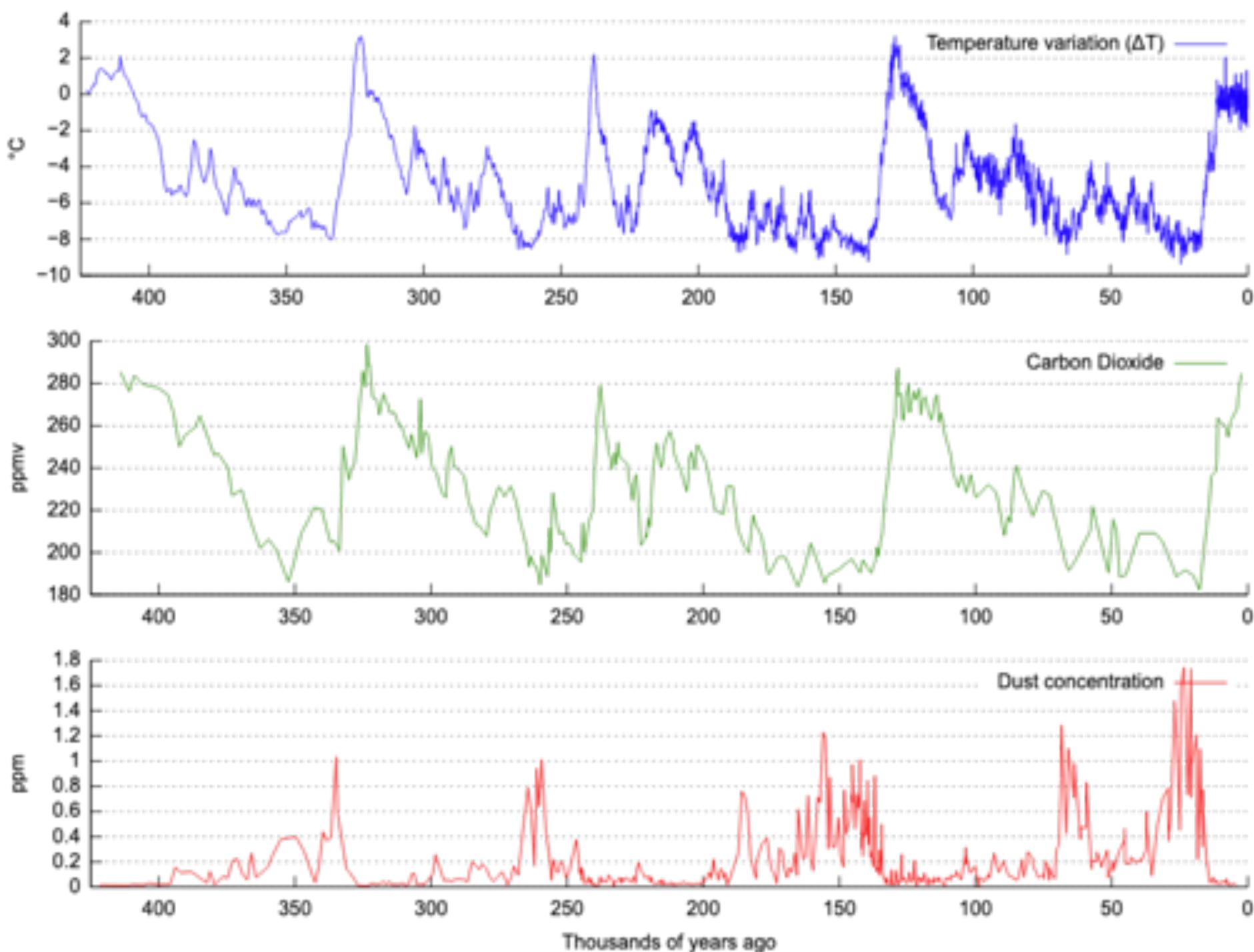
Long-term climate

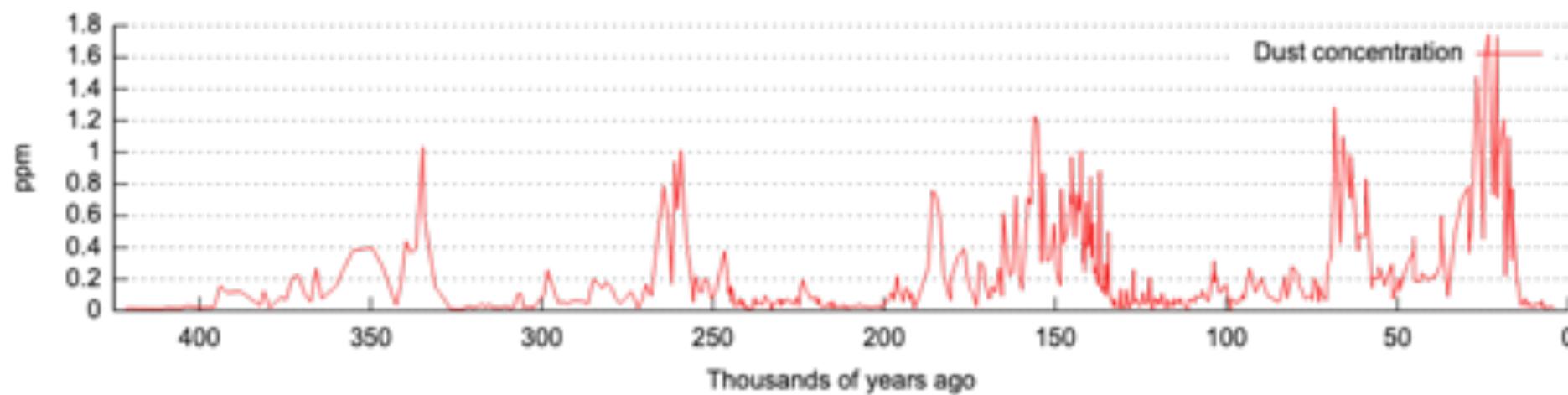
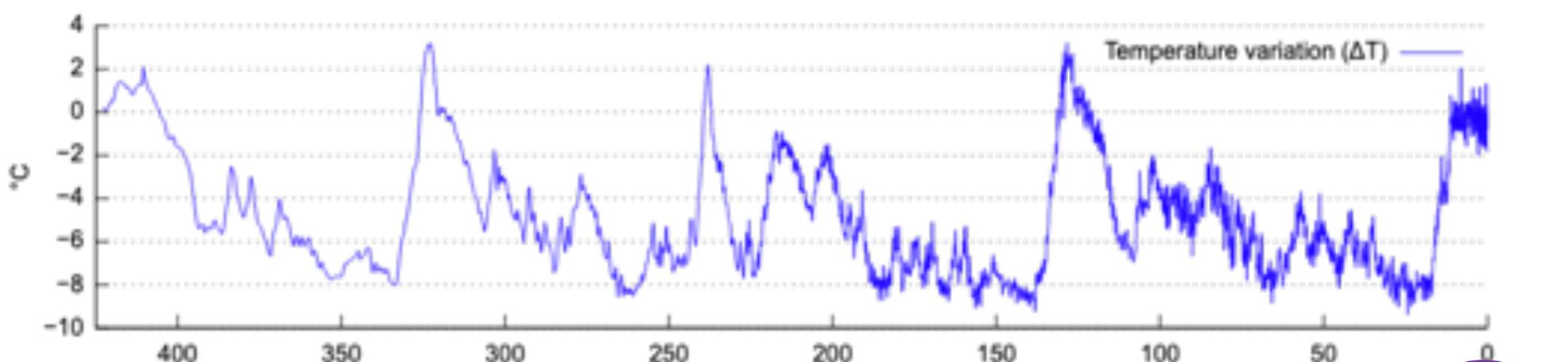
Without humans would climate
change over time?

Without life on Earth would
climate change over time?

Milankovitch Cycles





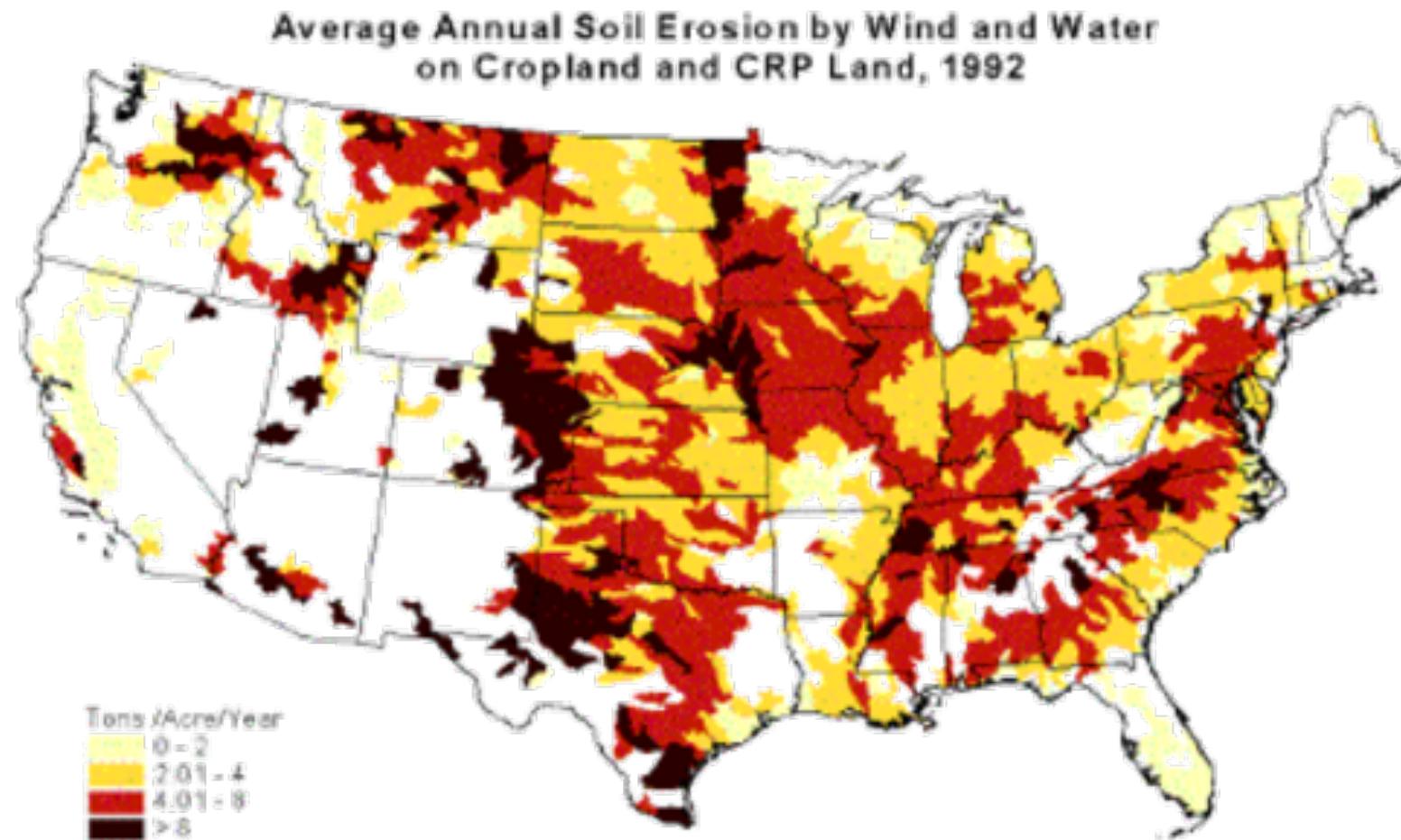


Soils

Soil Erosion and Formation



Soil Erosion



Erosion

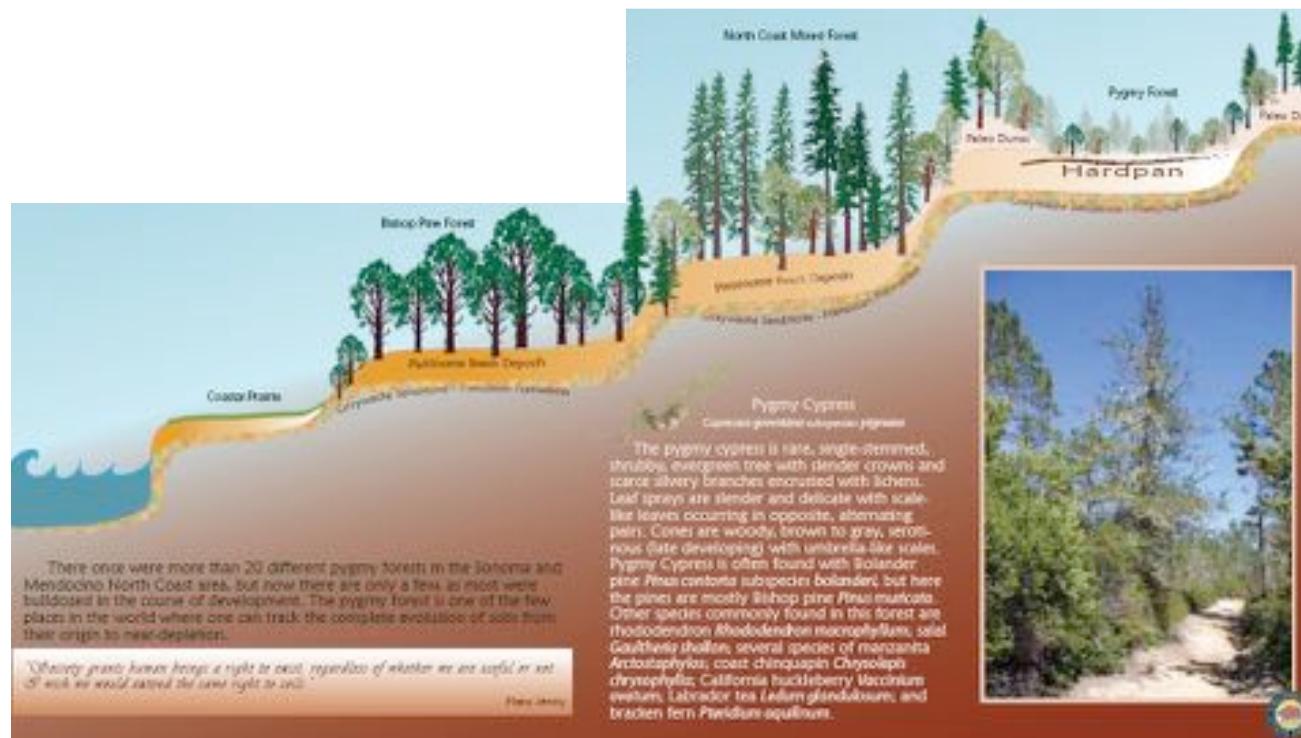
- Transfers carbon, nutrients and sediment from terrestrial to aquatic ecosystems
- Often occurs faster than soils can be rebuilt
 - Leads to loss of fertility of agricultural soils

Erosion

- Transfers carbon, nutrients and sediment from terrestrial to aquatic ecosystems
- Often occurs faster than soils can be rebuilt
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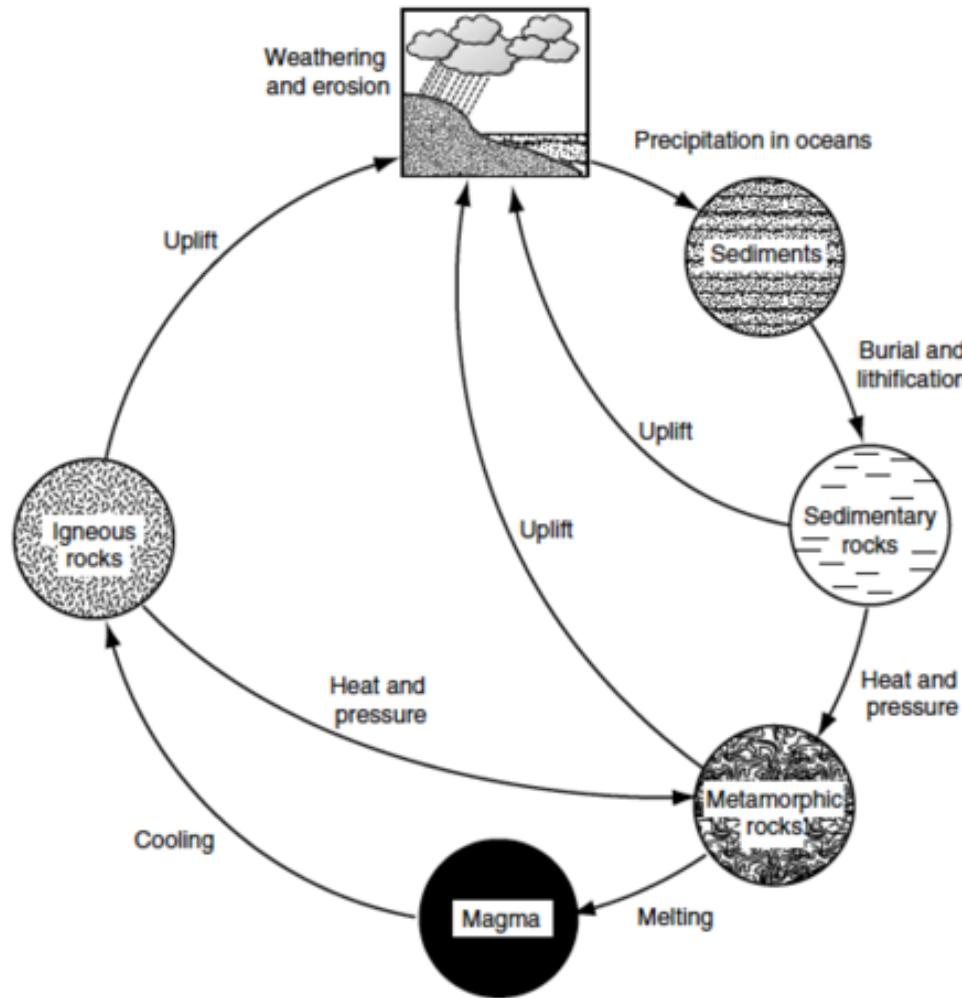
Formation: State factors

- Parent material
- Climate
- Organisms
- Topography/Relief
- Time



Parent Material

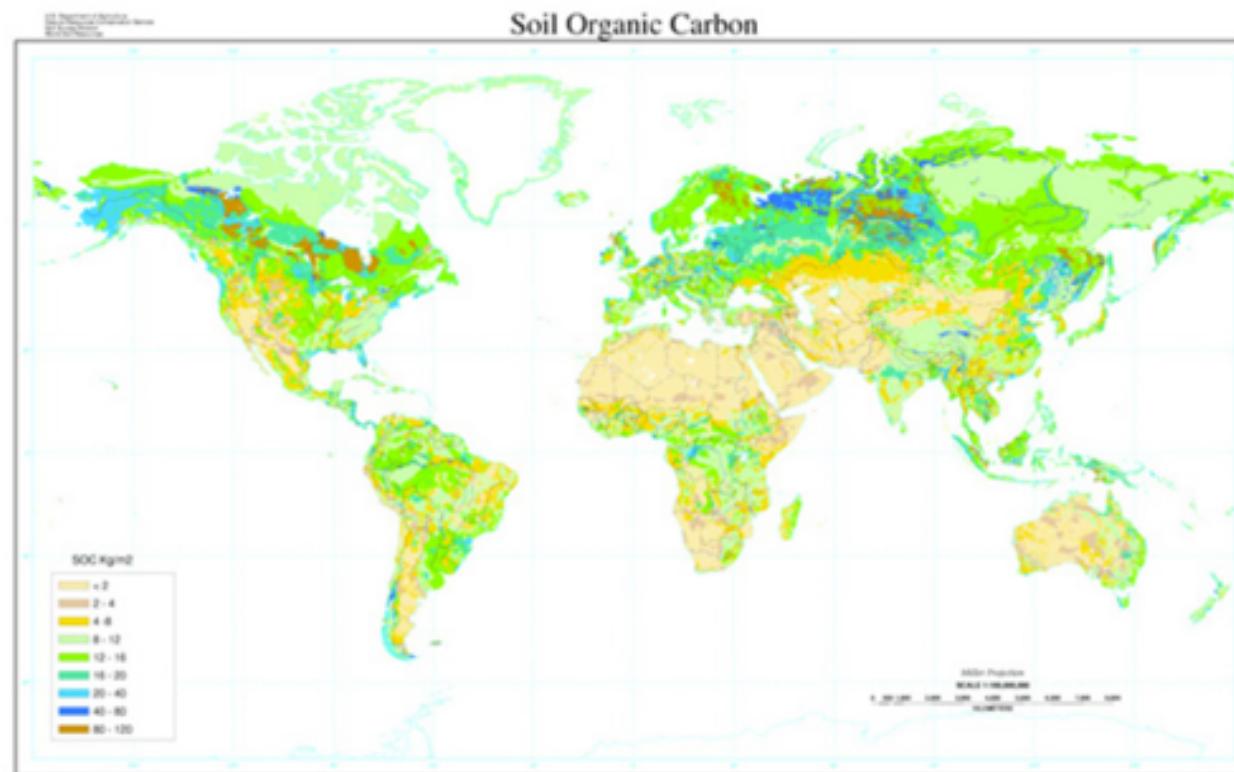
- Physical and chemical properties of rocks
 - Uplift and weathering occur at different rates



100-
200my

Climate

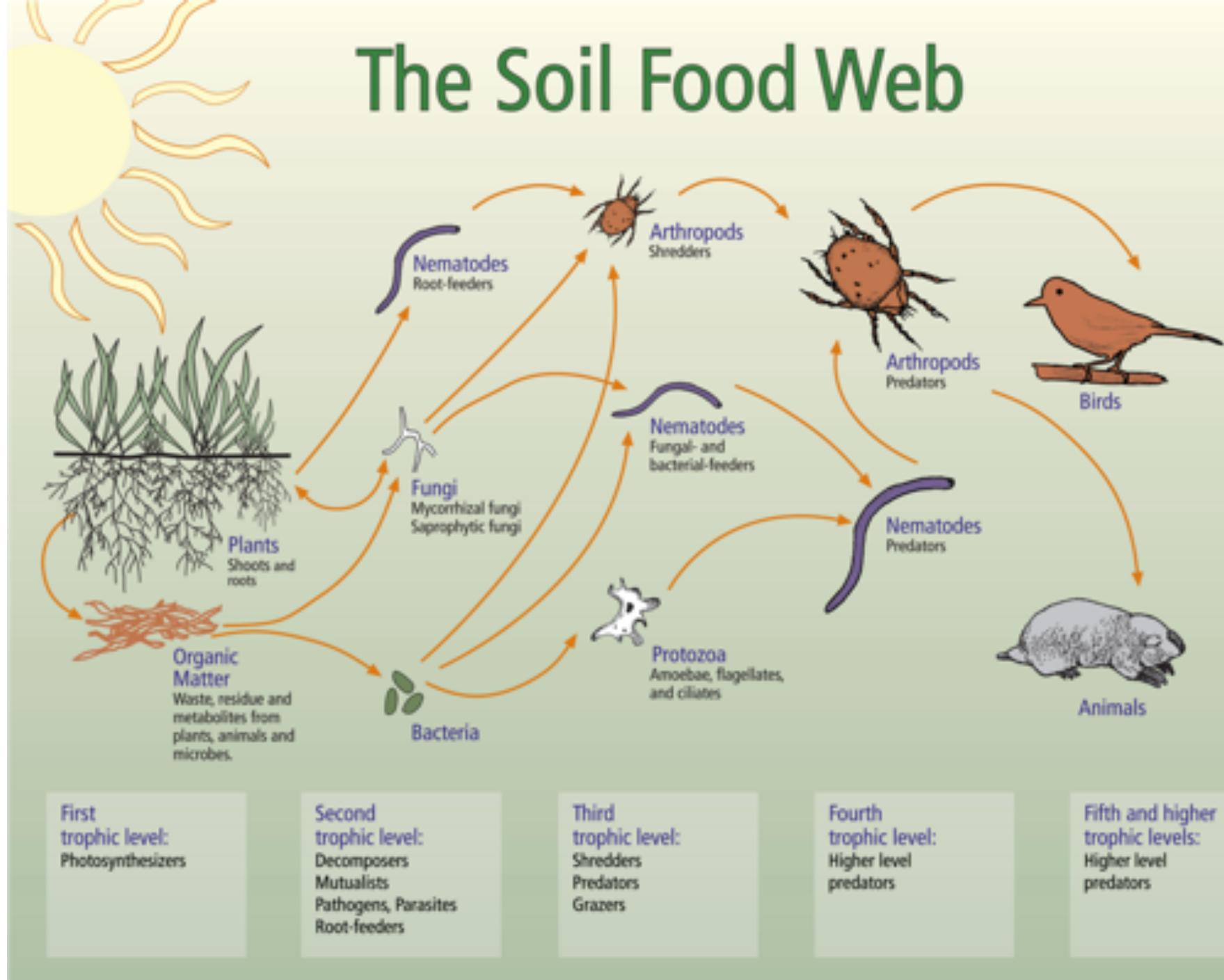
- Temperature, moisture, CO₂, O₂
- Determine weathering and soil formation



Organisms

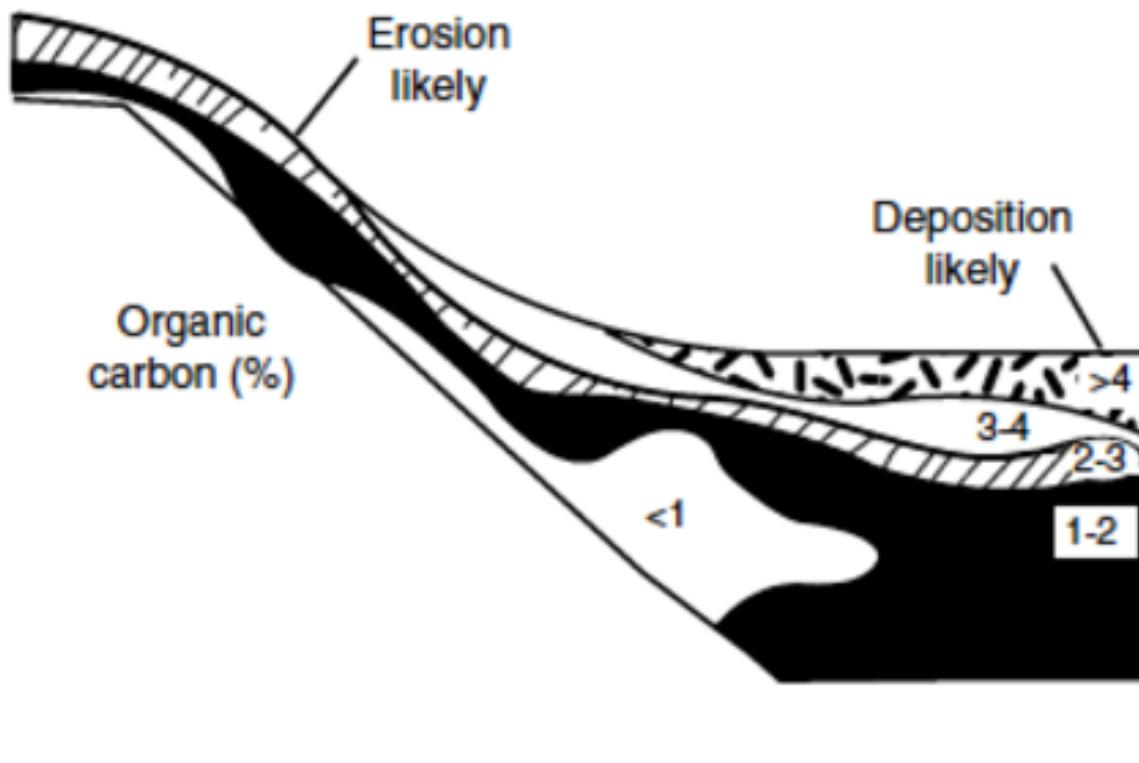
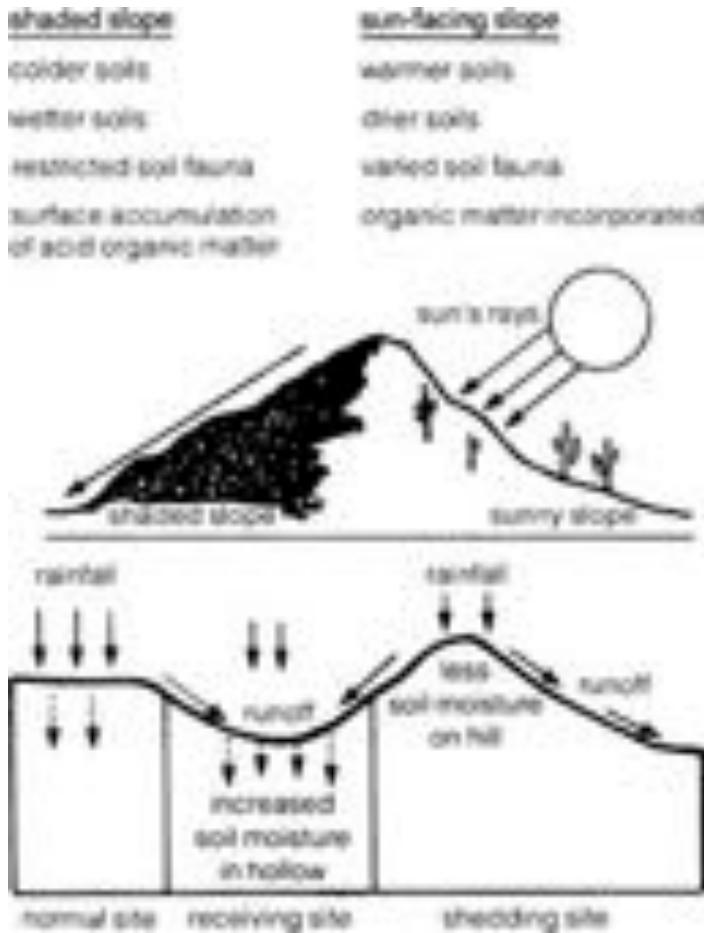
- Influence soil chemical and physical properties
 - Input litter quantity/quality
 - Uptake of mineral nutrients and input of organic nutrients

The Soil Food Web



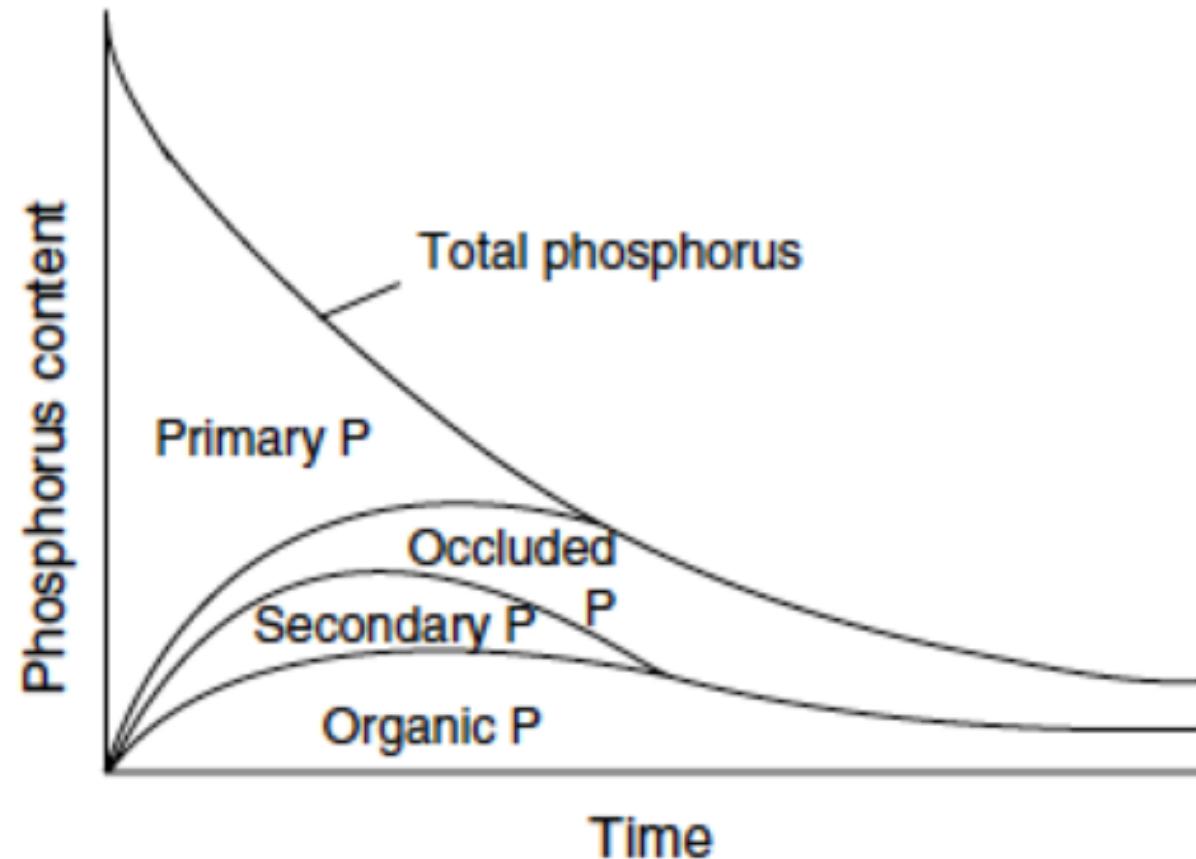
Topography

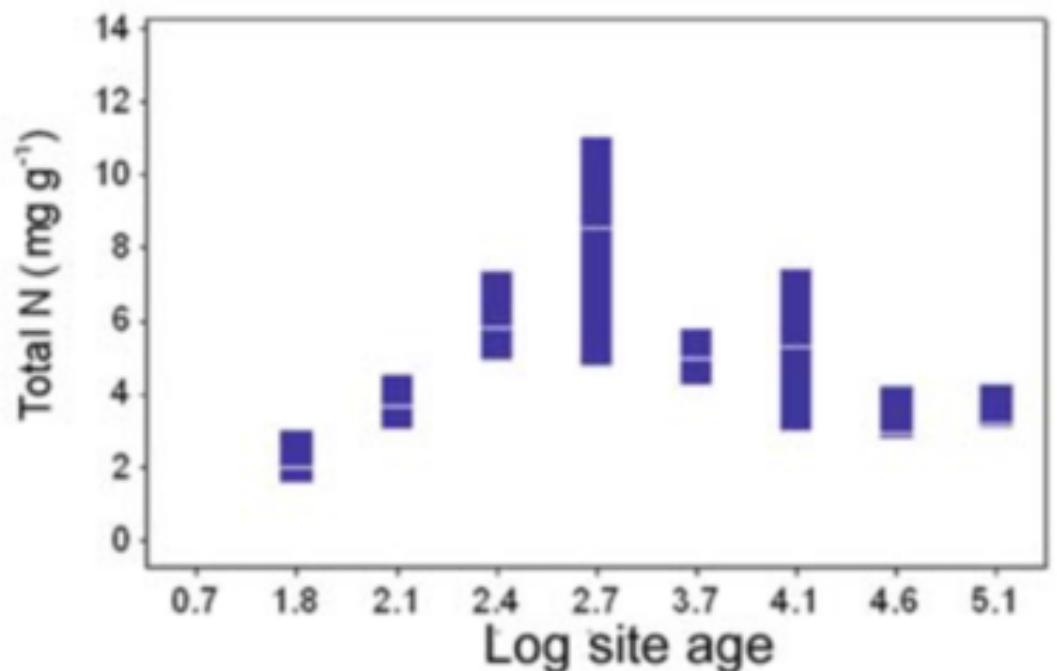
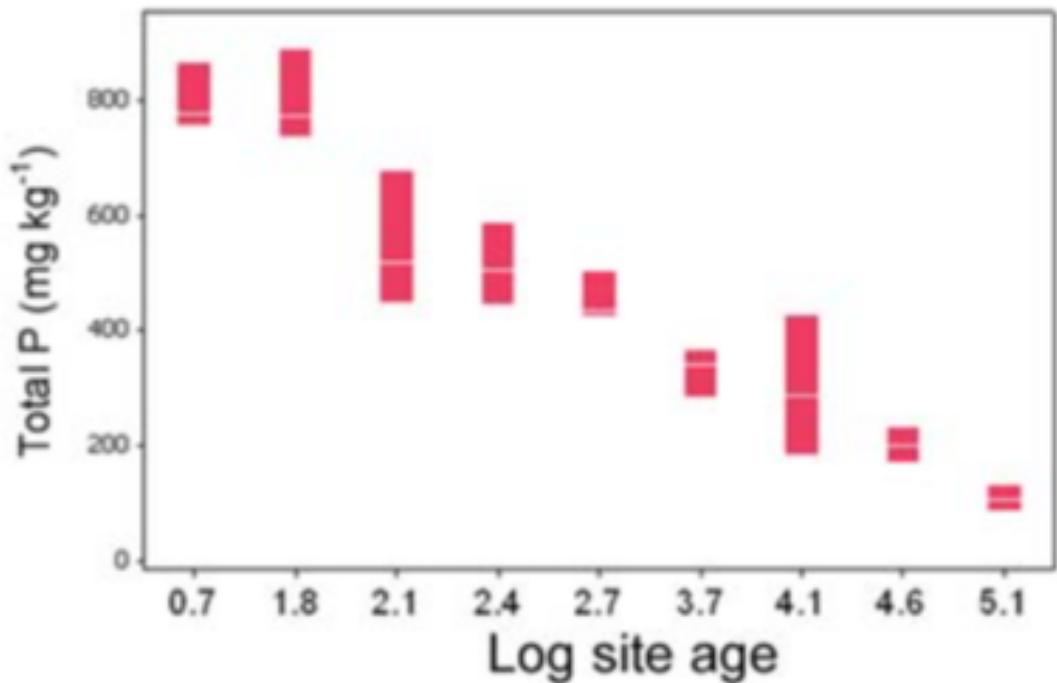
- Influences climate, moisture availability, and particle transport



Time

- Rocks weather slowly - minerals become occluded





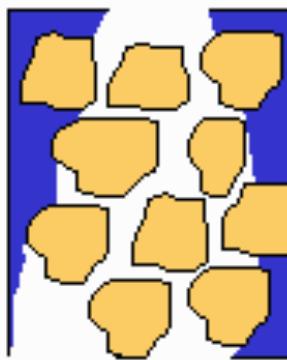
What could explain these trends?

Soil properties

Soil Texture

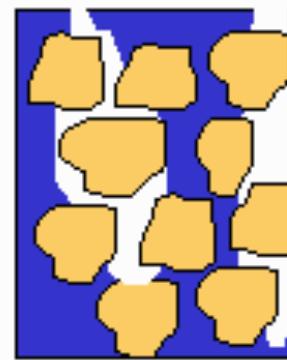
Soil texture: Sand

Size [mm]: 0.05 - 2



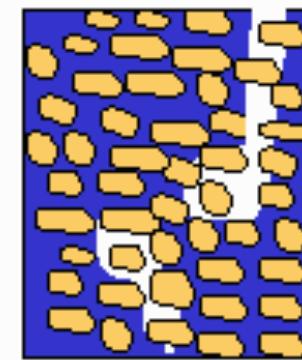
Silt

0.002 - 0.05



Clay

< 0.002



Macropores +++

Medium-sized p. ++

Micropores (+)

++

++

++

(+)

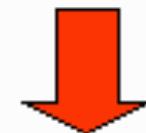
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Percolation:

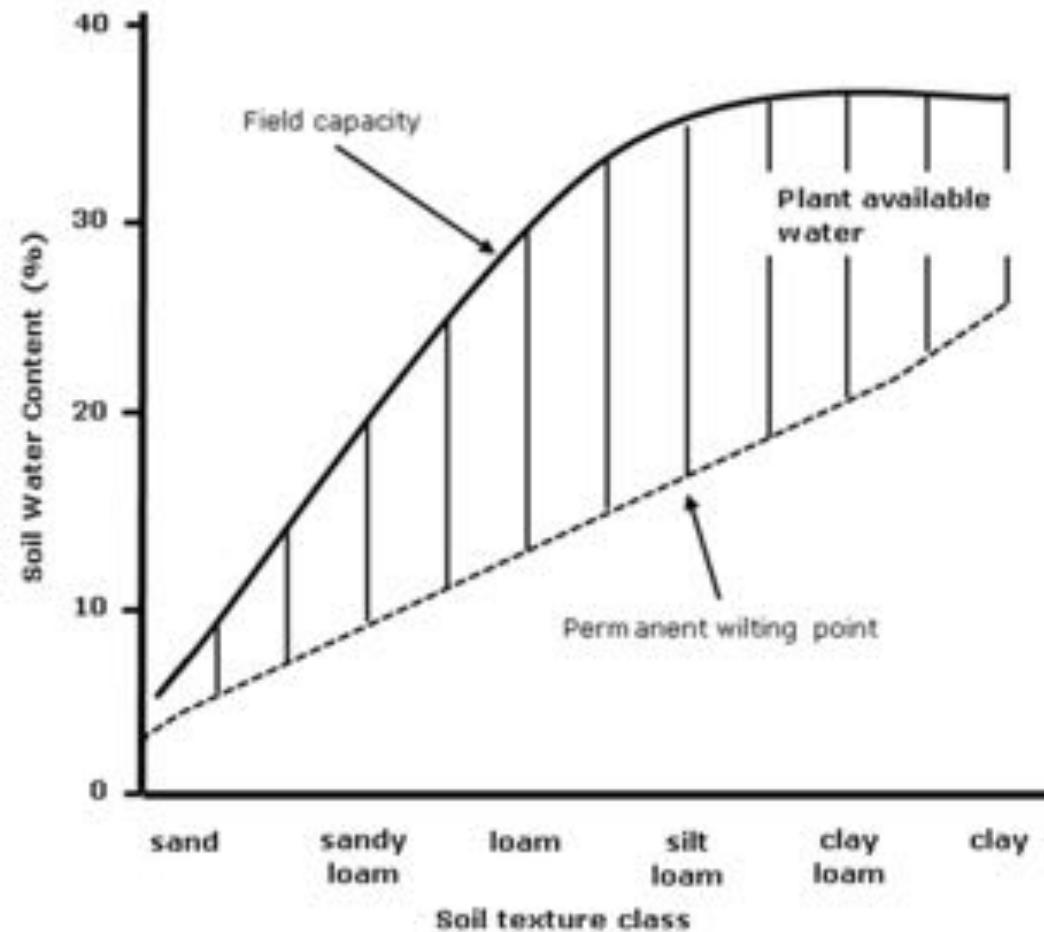


Leaching:

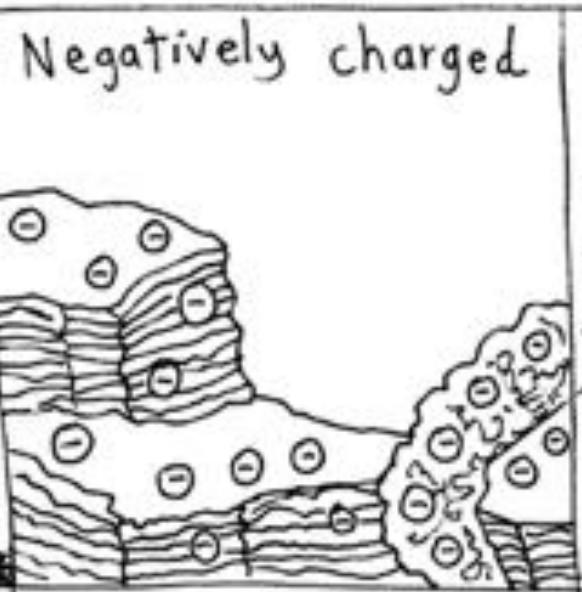
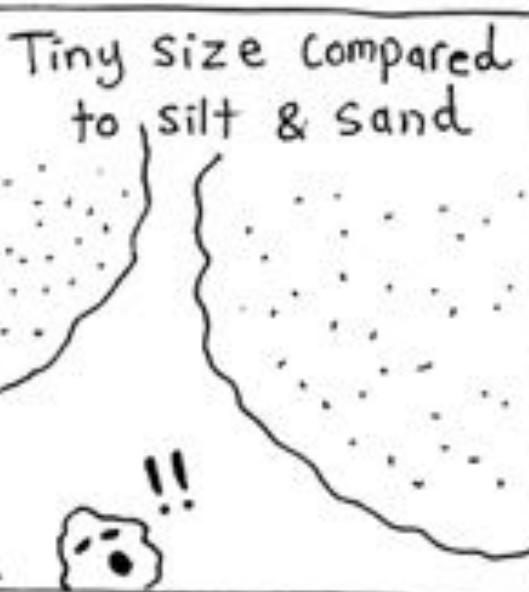
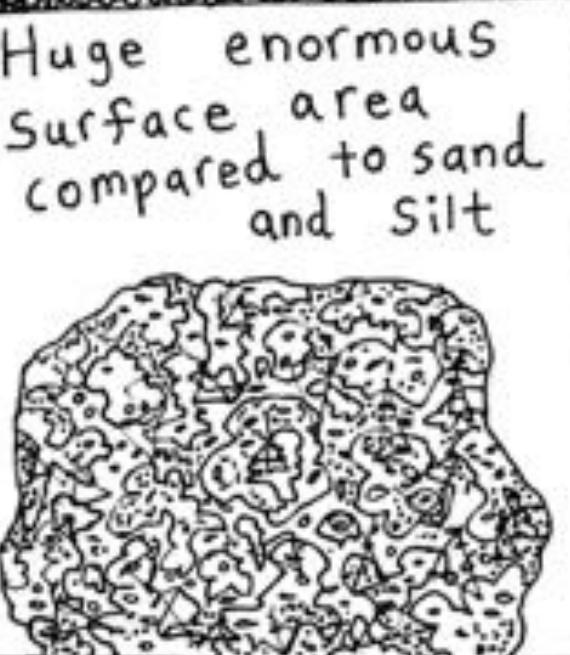
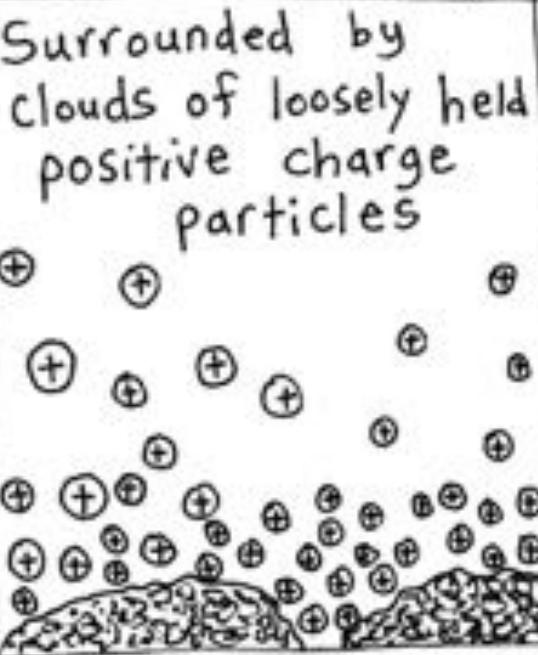


Physical: Soil texture

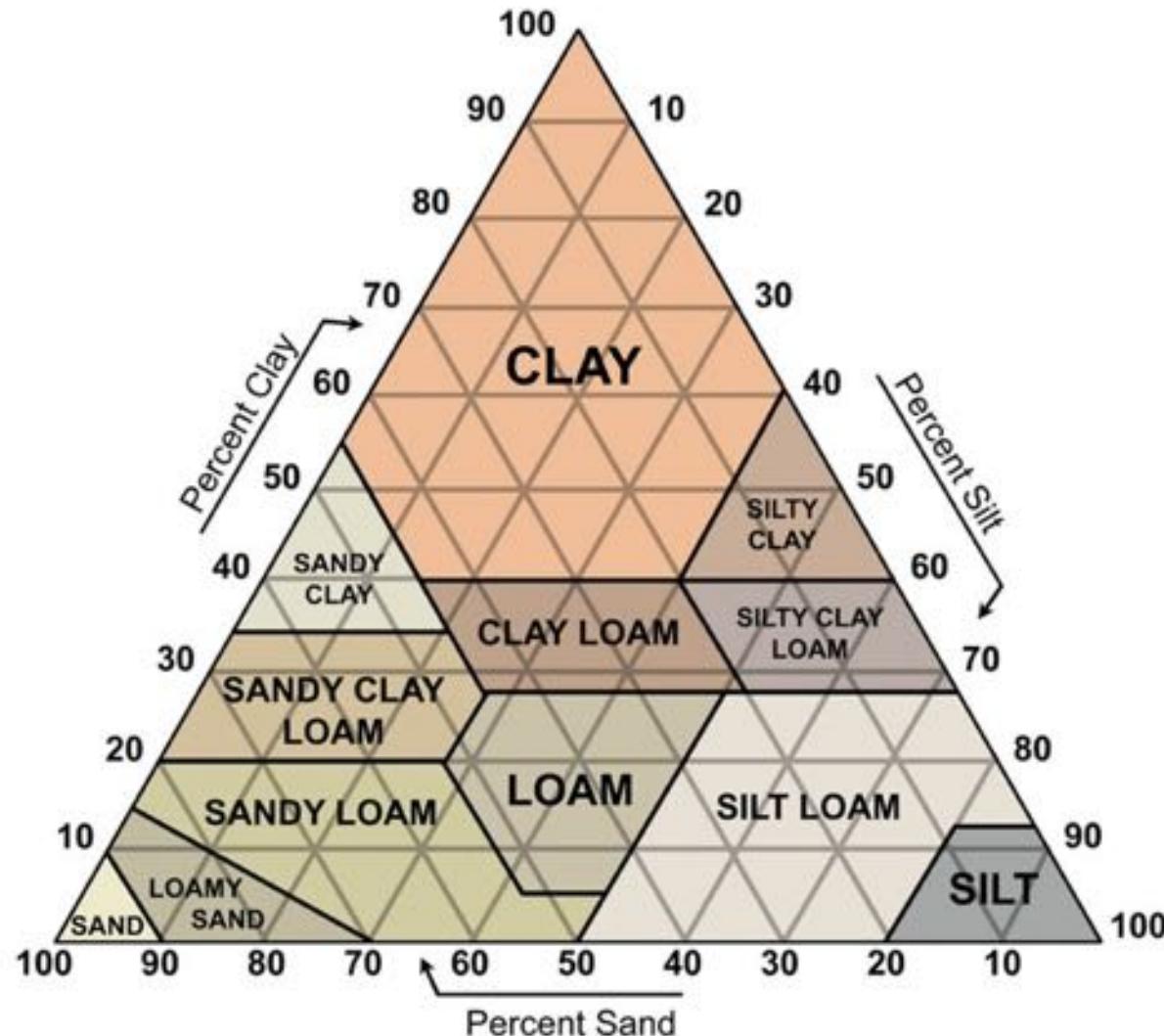
- Sand: 0.05 - 2.0 mm
- Silt: 0.002 - 0.05 mm
- Clay: < 0.002 mm



Colloids of clay and humus : properties

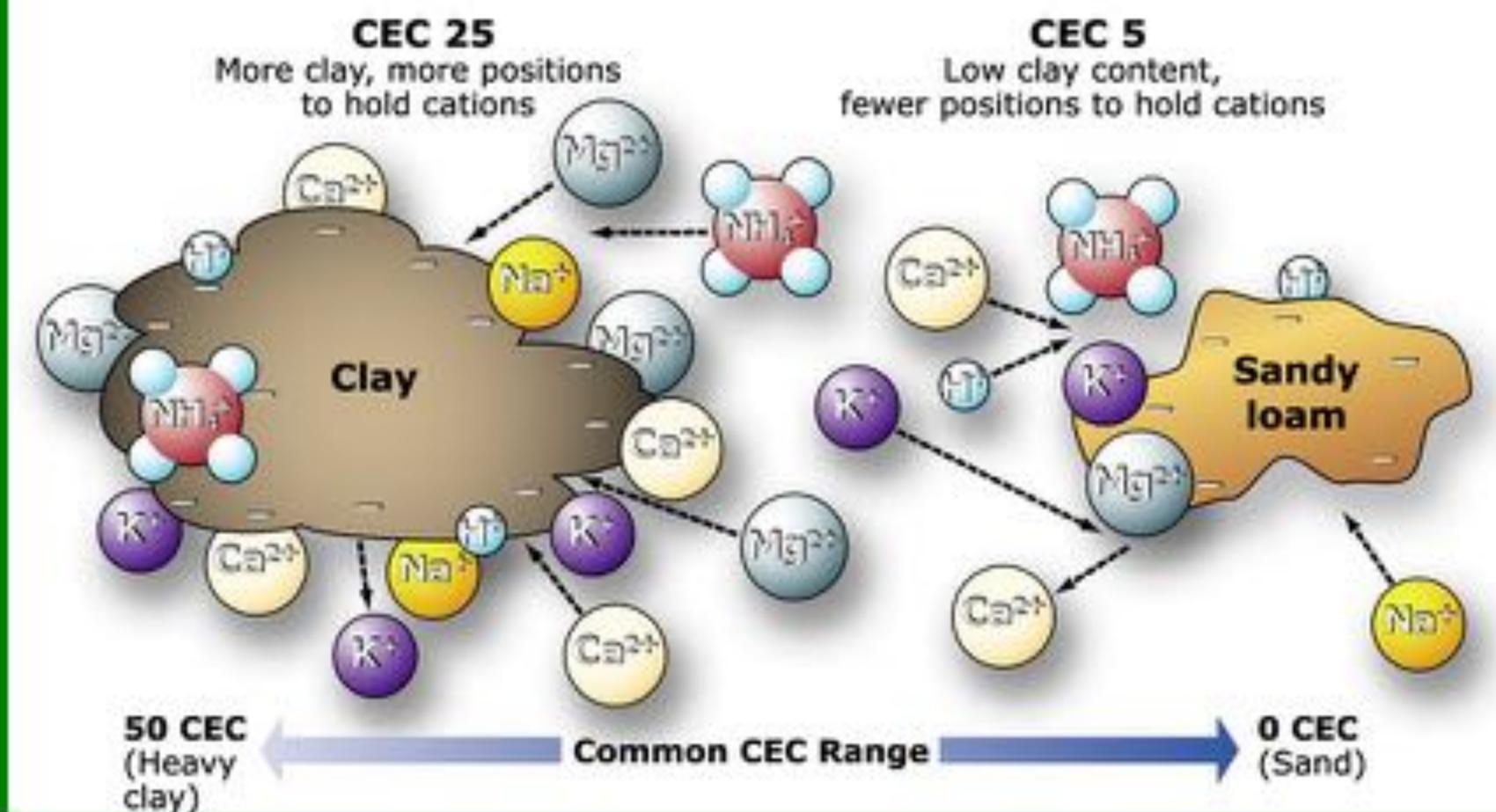
Stay suspended in water for a long time while sand settles quickly	Negatively charged 	Tiny size compared to silt & sand 
Huge enormous surface area compared to sand and Silt 	Surrounded by clouds of loosely held positive charge particles 	Sites of dynamic activity in the soil 

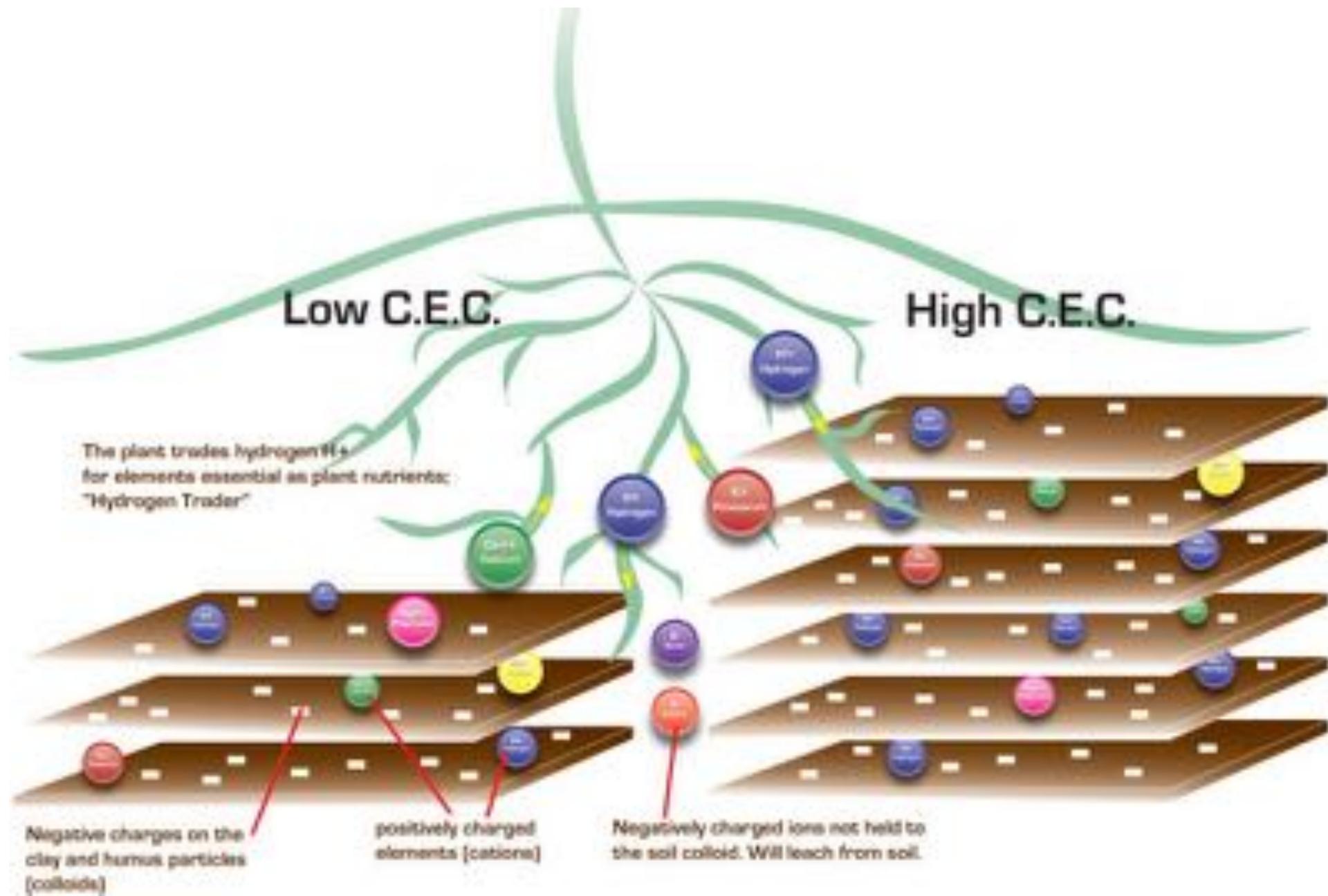
Physical: Soil texture



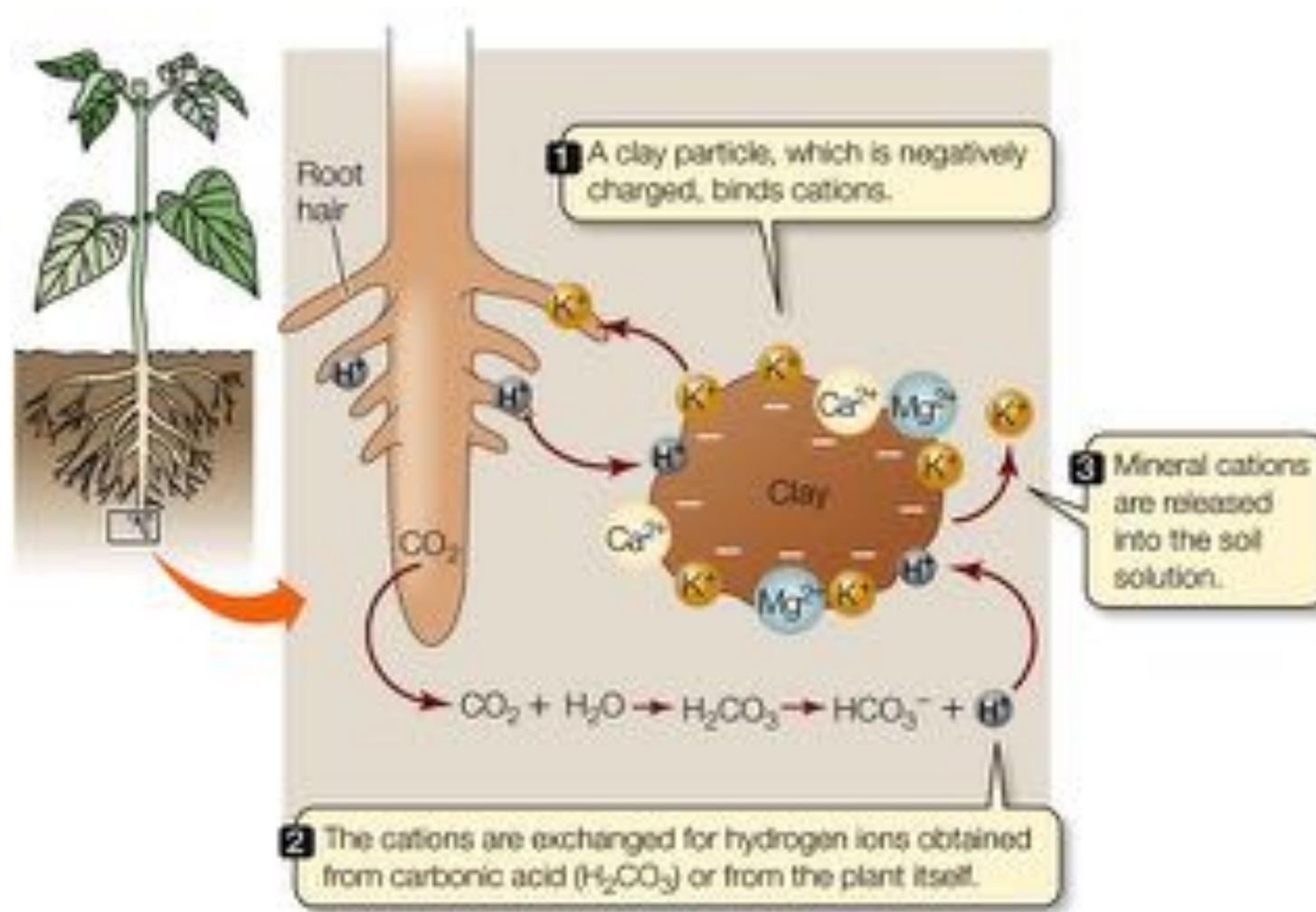
Cation Exchange Capacity

A schematic look at cation exchange



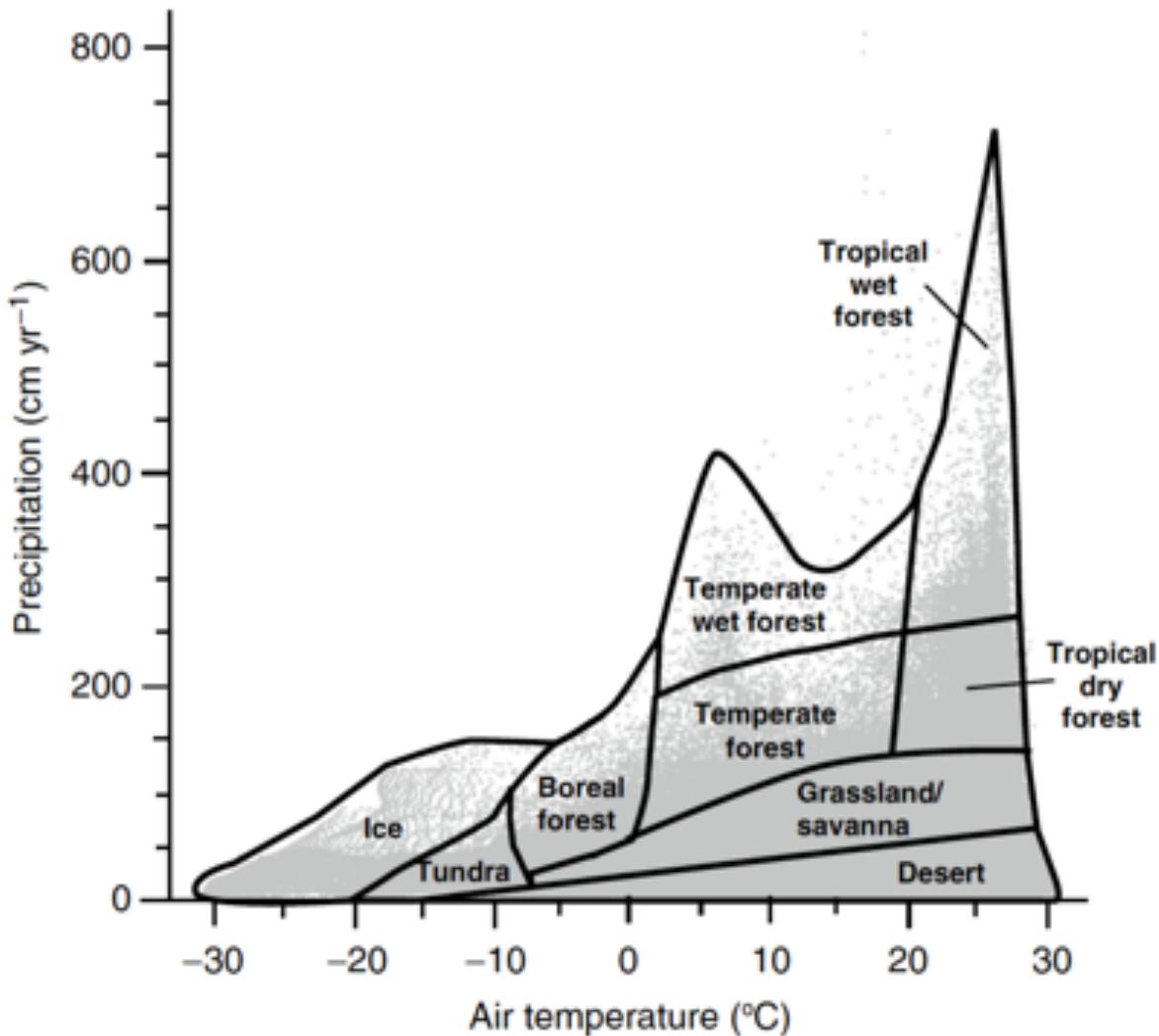


Chemical: Cation Exchange Capacity

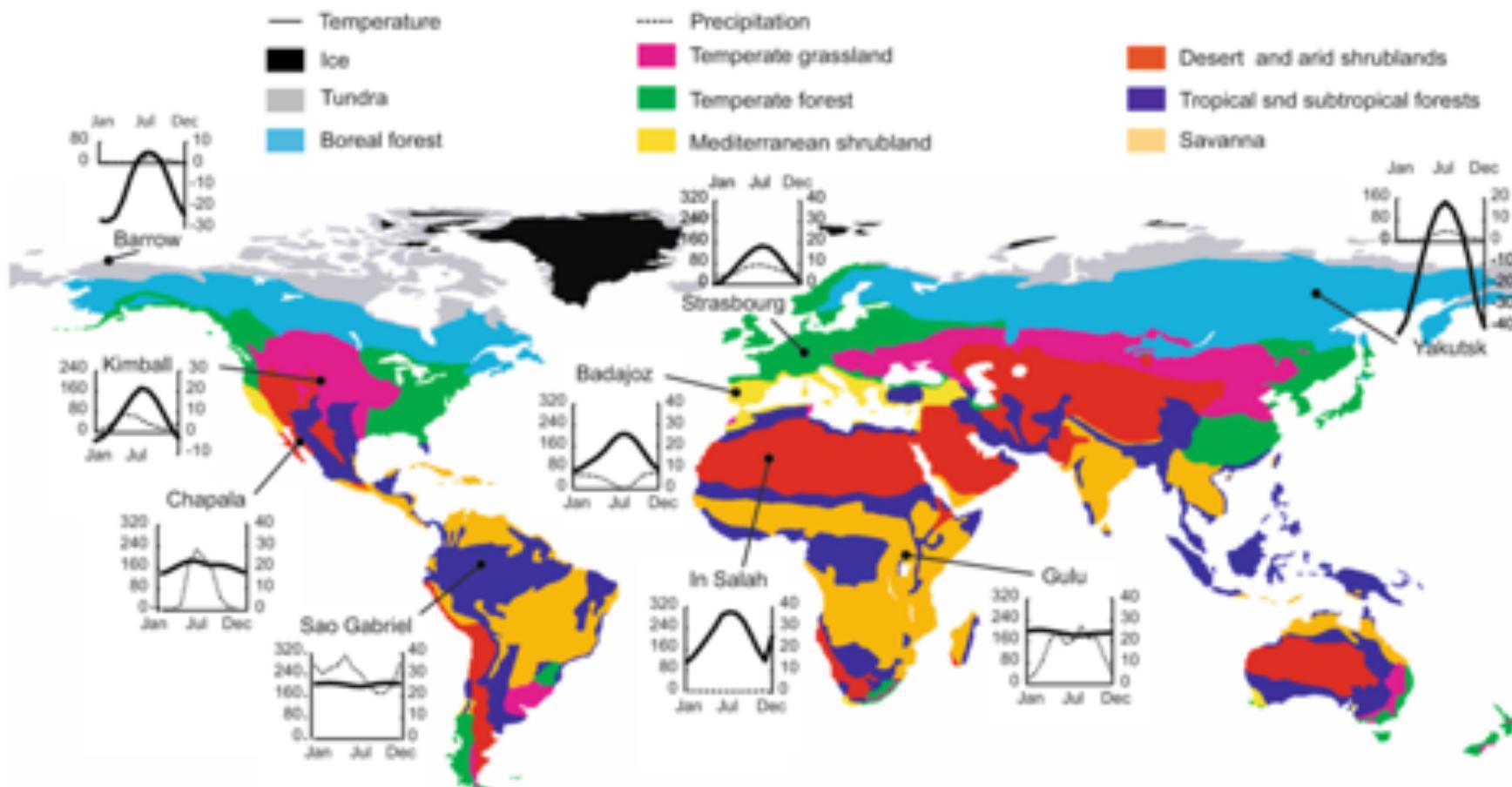


Biomes

Climate determines biome distributions



Biome distributions on Earth



Characteristics of Biomes



Tropical Rainforest

- Species diverse
- Nutrient poor
- Consistent climate

Desert

- Bare soil
- Calcium carbonate soils (basic)
- Inconsistent climate



Temperate Grasslands

- Clay soils
- Deep soil carbon layer
- Fire prone

Mediterranean shrublands

- One of the most endangered habitats
- Many endemic species
- Only in coastal areas



Temperate forests

- Relatively species rich
- Can have deciduous and non-deciduous trees

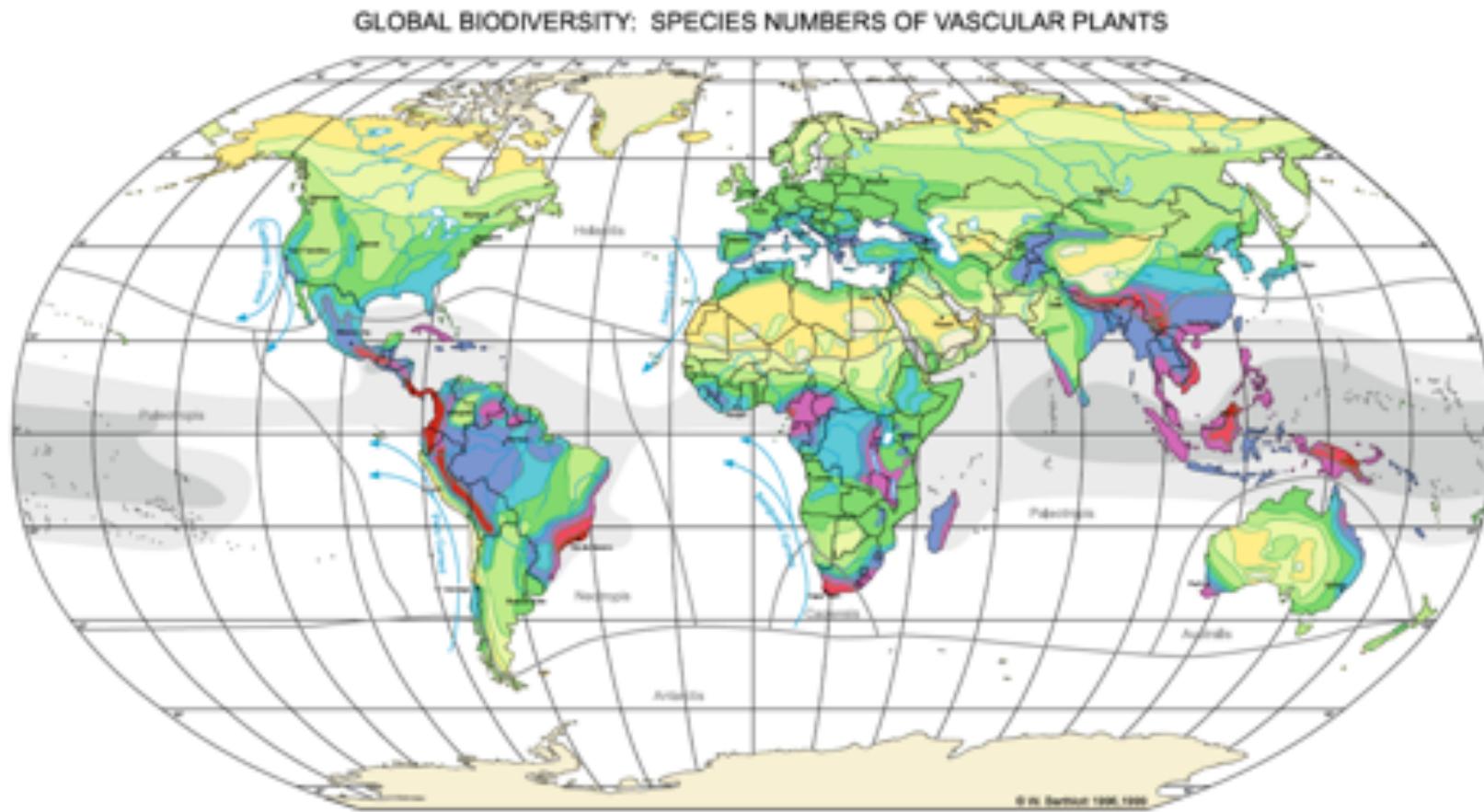


Taiga (Boreal forests)

- Species poor
- NPP in growing season can be as large as tropical forests
- Experiencing warming at faster rates

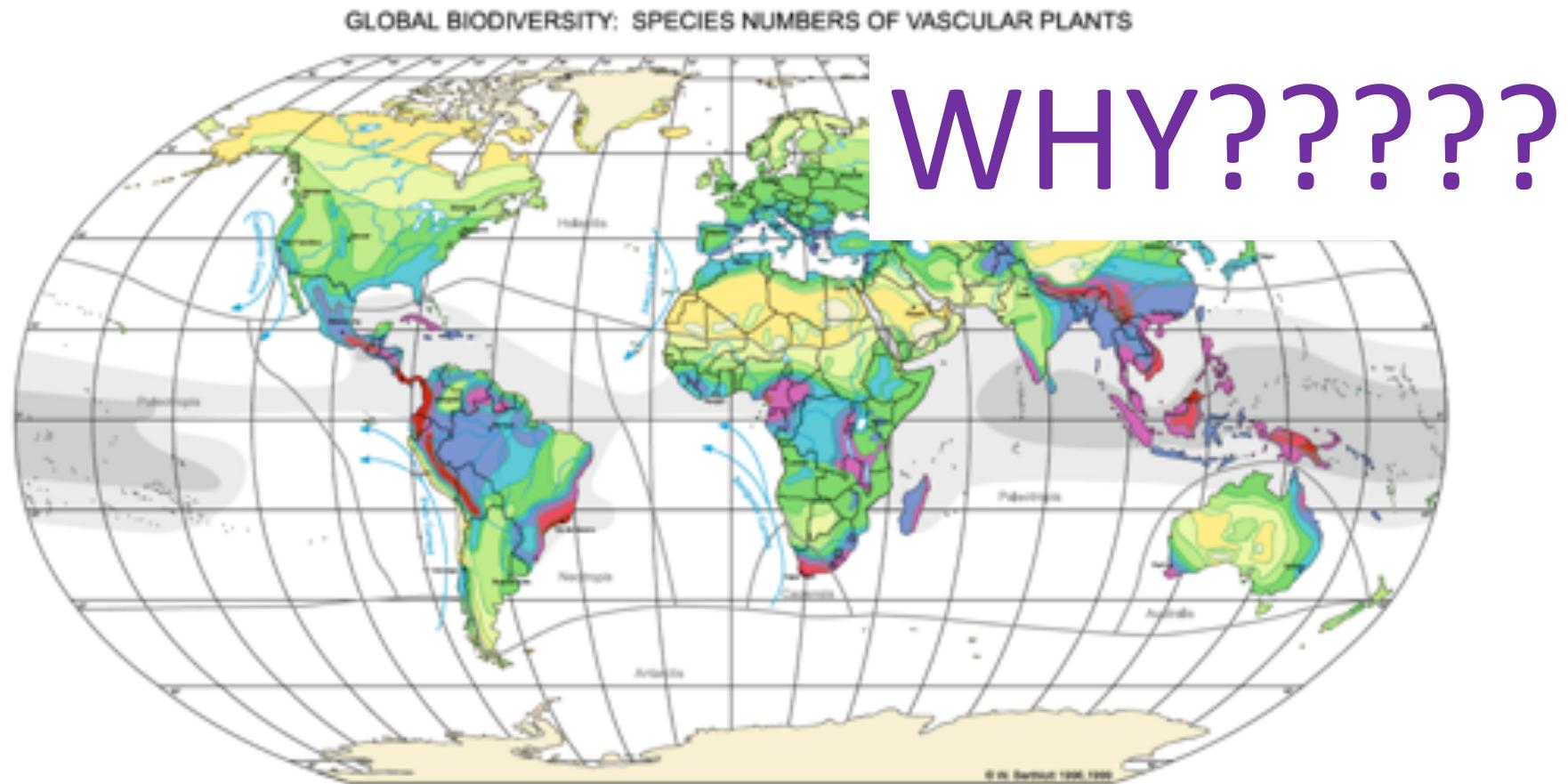
What is our biome?

Latitudinal diversity gradient



Applies to plants and animals, but not necessarily
microbes

Latitudinal diversity gradient



Applies to plants and animals, but not necessarily
microbes