Changes in climate and CO2

http://www.clearlight.com/~mhieb/WVFossils/Carboniferous_climate.html
Effects of Continental Drift on Climate

(At least) Two possible mechanisms for major global climate change

1. amount of land mass at poles to support ice caps

3. ocean circulation
   - transfer heat from equator to pole
   - effects on aridity

Cooling of Antarctica

Lomolino et al., 2006
http://www.scotese.com/paleocli.htm
Movement of Plates Through Time

PERMIAN
225 million years ago

TRIASSIC
200 million years ago

JURASSIC
135 million years ago

CRETACEOUS
65 million years ago

http://pubs.usgs.gov/gip/dynamic/graphics/Fig2-5globes.gif
Transition to Quaternary: Shocks to biota

slow cooling

rapid oscillations

http://www.clearlight.com/~mhieb/WVFossils/Carboniferous_climate.html
Biological tools for assessing past climate

*Palynology*

Modern distribution of climate and pollen type %

- **A** Annual precipitation (cm)
- **B** Annual temperature (°C)
- **C** Prairie pollen (%)
- **D** Spruce pollen (%)
- **E** Oak pollen (%)

Image Credit: *Earth’s Climate* by W. Ruddiman

Slide courtesy C. Still

Biogeography
Biological tools for assessing past climate

*Packrat middens*

up to 40,000 years ago

Why?
- crystallized urine slows the decay of the material
- dry climate of the American Southwest
- middens protected under rock overhangs or in cave

geology.about.com/library/bl/images/blpackratmidden.htm
Biological tools for assessing past climate

*Tree rings*

up to ~10,000 years ago
Biological tools for assessing past climate

*Coral bands*

hundreds of years

oceannot.wold.tamu.edu/students/coral/coral5.htm
Global mean temperature was 4-5 deg C lower than today
Regional Effects during Glacial Periods

FIGURE 9.7 Glacial cycles of the Pleistocene influenced regional climates far from the edges of the glaciers. Temperatures over much of North and South America, for example, ranged from 4° to 8°C cooler during the Wisconsin. (After Stute et al. 1995.)

Lomolino et al., 2006
Overall, the world was drier as well.
Utah during the LGM - definitely not drier!

Image Credit: Earth’s Climate by W. Ruddiman

Slide courtesy C. Still
Eustatic sea level change

FIGURE 9.9 Glaciation during the Pleistocene resulted in the lowering of sea levels by 100 m to as much as 160 m below their current levels. As a result, many terrestrial regions and associated biotas now isolated by oceanic barriers were connected during glacial maxima. (A) Beringia connected North America and Asia. (B) Many islands of Indonesia were connected to mainland Asia and Australia, respectively. Wallace’s line, marking a division between the biotas of Southeast Asia and Australia, coincides with the division between these glacial landmasses. (A after Petitou 1991; B after Heaney 1991, 2004.)

Lomolino et al., 2006
Eustatic sea level change

Lomolino et al., 2006

**FIGURE 9.10** (A) Changes in global sea level during the past 140,000 years based on oxygen-isotope data (black line) from analysis of benthic foraminifers found in deep sea cores of the Caribbean, and raised coral reefs (gray line) in New Guinea. In addition to these global (or eustatic) changes in sea levels, regional sea levels may vary substantially as Earth’s crust rises and sinks in the asthenosphere. Such isostatic fluctuations in sea level can occur even when global levels remain unchanged. (B) Changes in global sea level throughout the Pleistocene (i.e., the past 1.8 million years). This figure illustrates the rapid transitions between full glacial and interglacial periods. (A after Hopkins et al. 1982; B after Dyer 1986.)
Differences in vegetation types

Last Glacial Maximum (18,000 $^{14}$C years ago)

Present Potential Vegetation

www.esd.ornl.gov/projects/qen/nerc.html
Vegetation cover changes from LGM to present in Europe

B. Glacial vegetation

Image Credit: Earth's Climate by W. Ruddiman

Slide courtesy C. Still
Equatorial Mountain Changes

Lomolino et al., 2006

FIGURE 9.15 Elevational shifts in vegetation zones in the eastern Cordillera of the Andes in Colombia in response to climatic change following the most recent glacial maximum. Note that while all zones tended to shift in concert, the upper zones became narrower as they shifted upward in response to global warming. (After Henley 1979a.)
Differential species responses: rates, direction
North America refugia

FIGURE 9.27  (A) Even during the Wisconsin glacial maximum, ice-free refugia may have occurred between the Laurentide and Cordilleran ice sheets and in a region called the driftless area. (B, C) Ice-free areas in mountainous regions along the Pacific coast may also have served as refugia—and possibly as migration corridors—for plants and animals, during full glacial conditions. (A after Rogers et al. 1991; B and C after Pielou 1991.)

Lomolino et al., 2006
Different refugia, different dispersal patterns of species that coexist today

Figure 18.19 | The postglacial migration of four tree genera: (a) spruce, (b) white pine, (c) oak, and (d) maple. The dark lines represent the leading edges of the northward-expanding populations. The white lines indicate the boundaries of the present-day ranges. The numbers are thousands of years before present (kyr). (Adapted from Dansh 1998.)

Smith and Smith, 2006