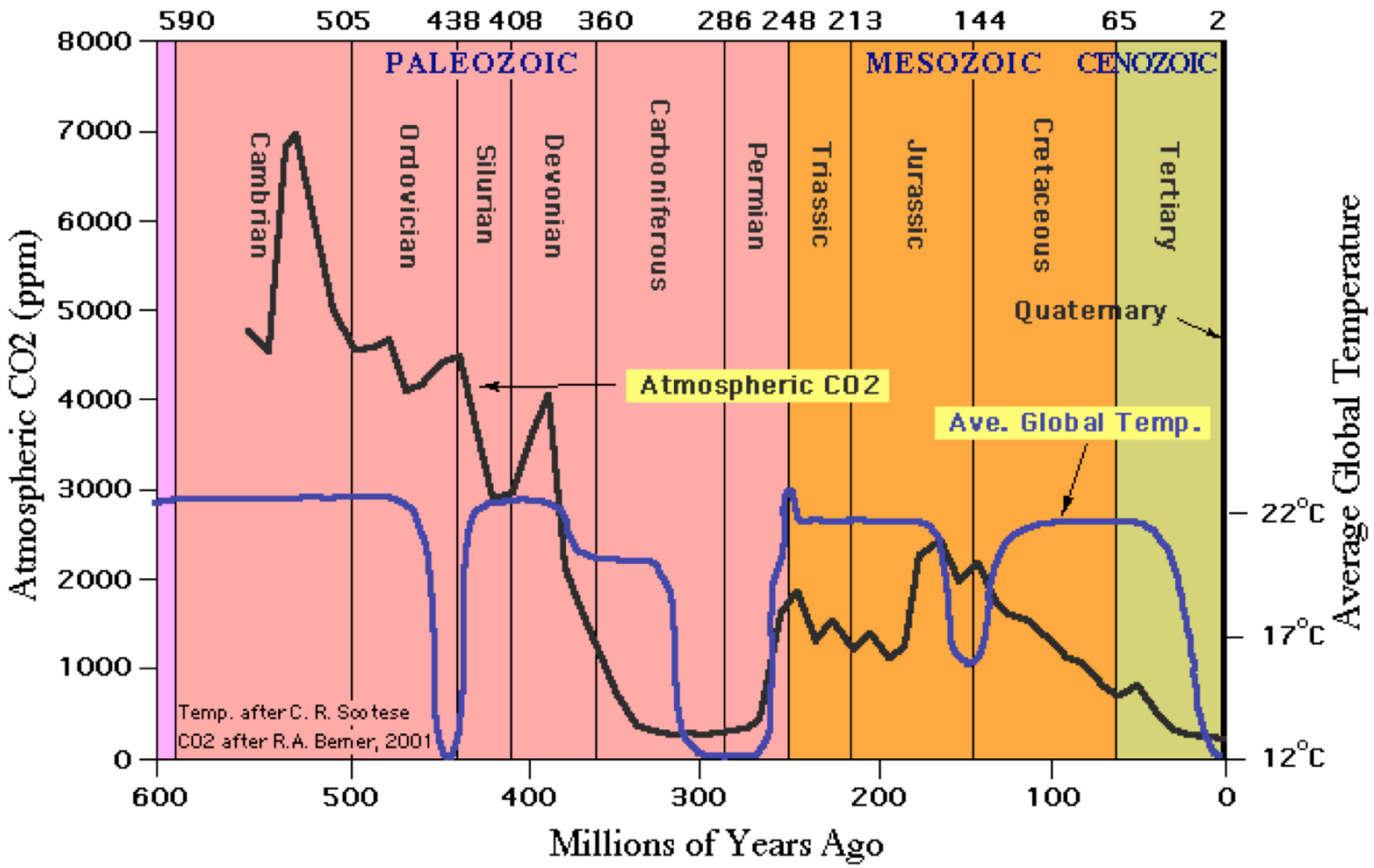
Changes in climate and CO2



http://www.clearlight.com/~mhieb/WVFossils/Carboniferous_climate.html

Effects of Continental Drift on Climate

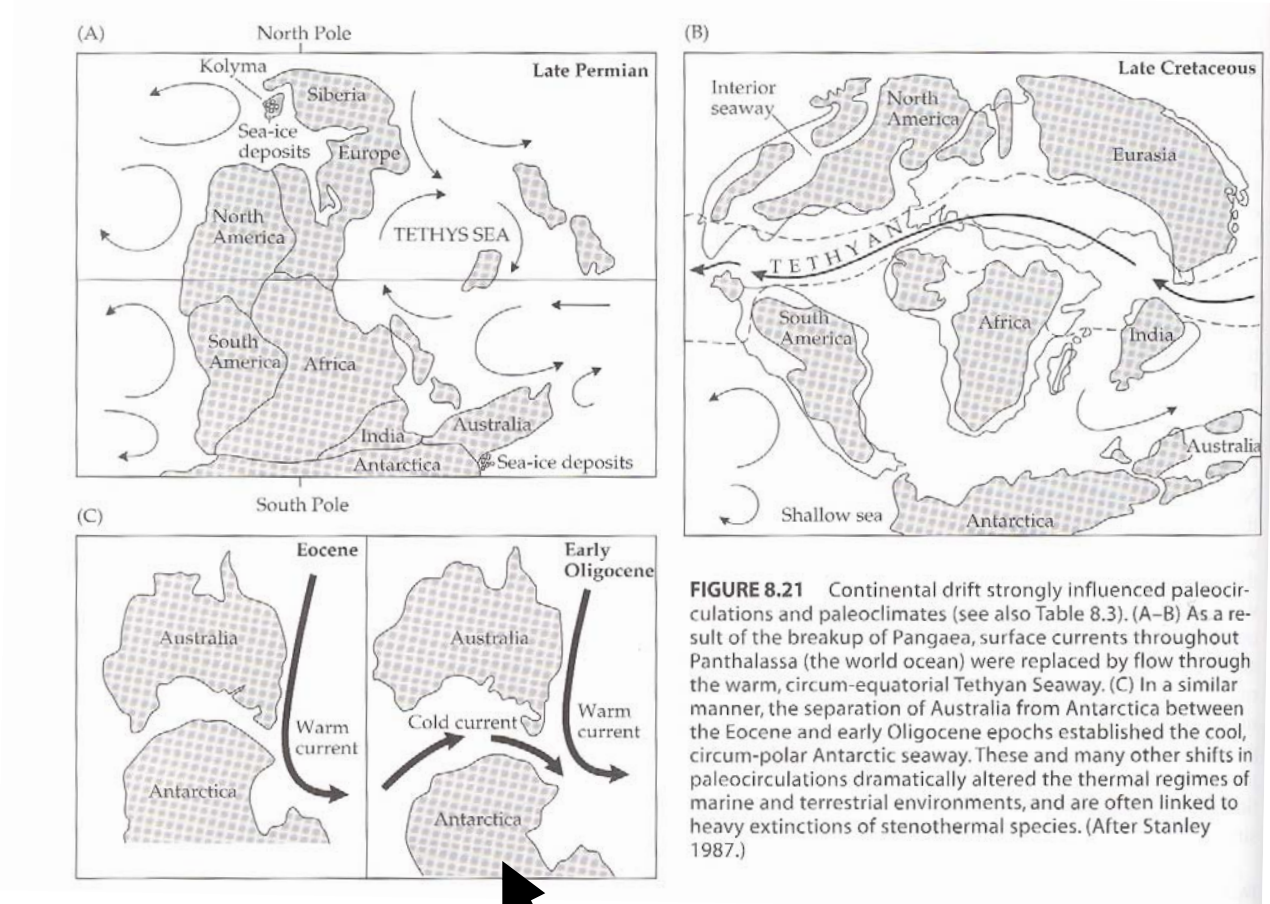


FIGURE 8.21 Continental drift strongly influenced paleocirculations and paleoclimates (see also Table 8.3). (A–B) As a result of the breakup of Pangaea, surface currents throughout Panthalassa (the world ocean) were replaced by flow through the warm, circum-equatorial Tethyan Seaway. (C) In a similar manner, the separation of Australia from Antarctica between the Eocene and early Oligocene epochs established the cool, circum-polar Antarctic seaway. These and many other shifts in paleocirculations dramatically altered the thermal regimes of marine and terrestrial environments, and are often linked to heavy extinctions of stenothermal species. (After Stanley 1987.)

Cooling of Antarctica

Lomolino et al., 2006

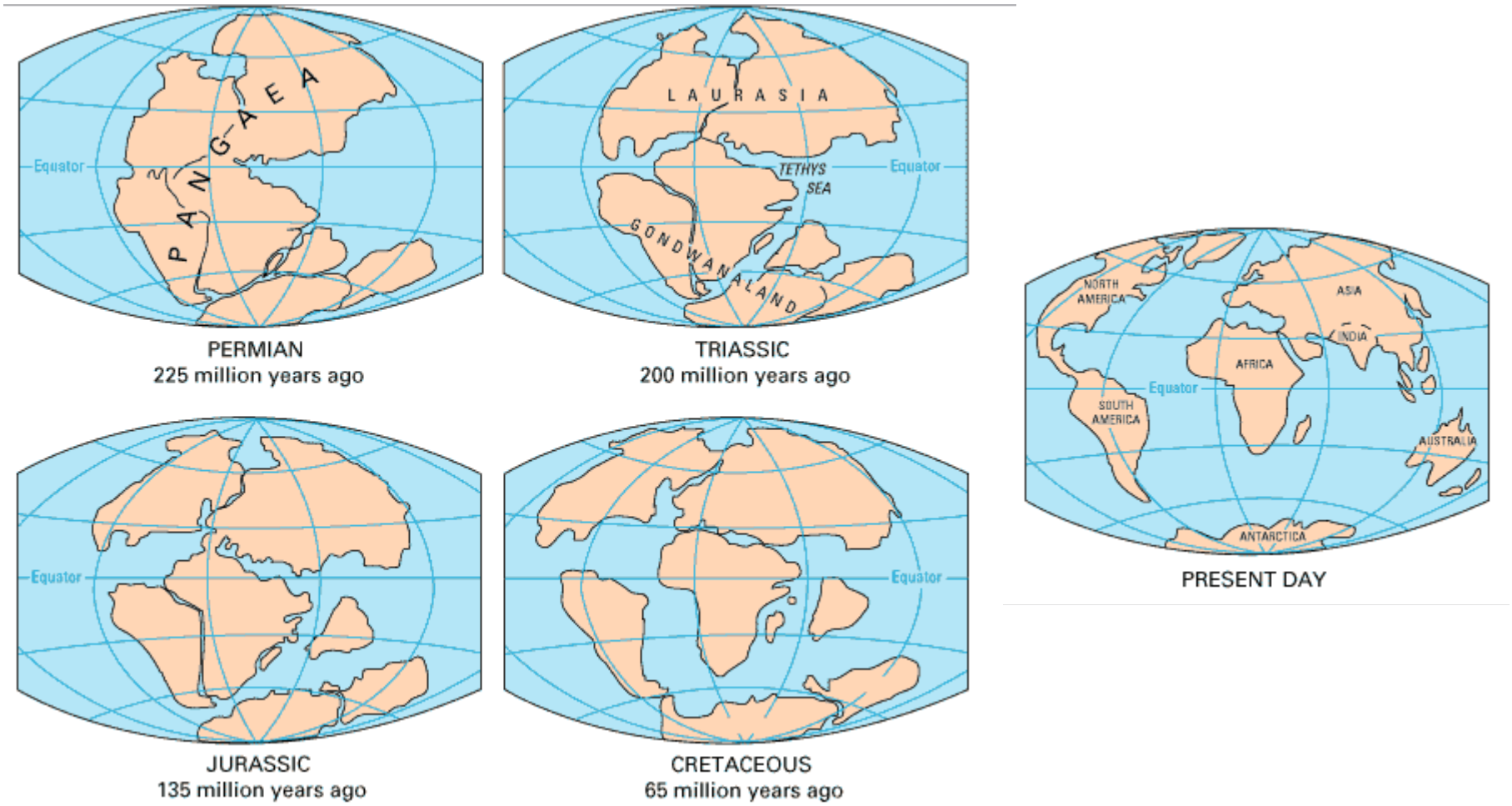
(At least) Two possible mechanisms for major global climate change

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

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

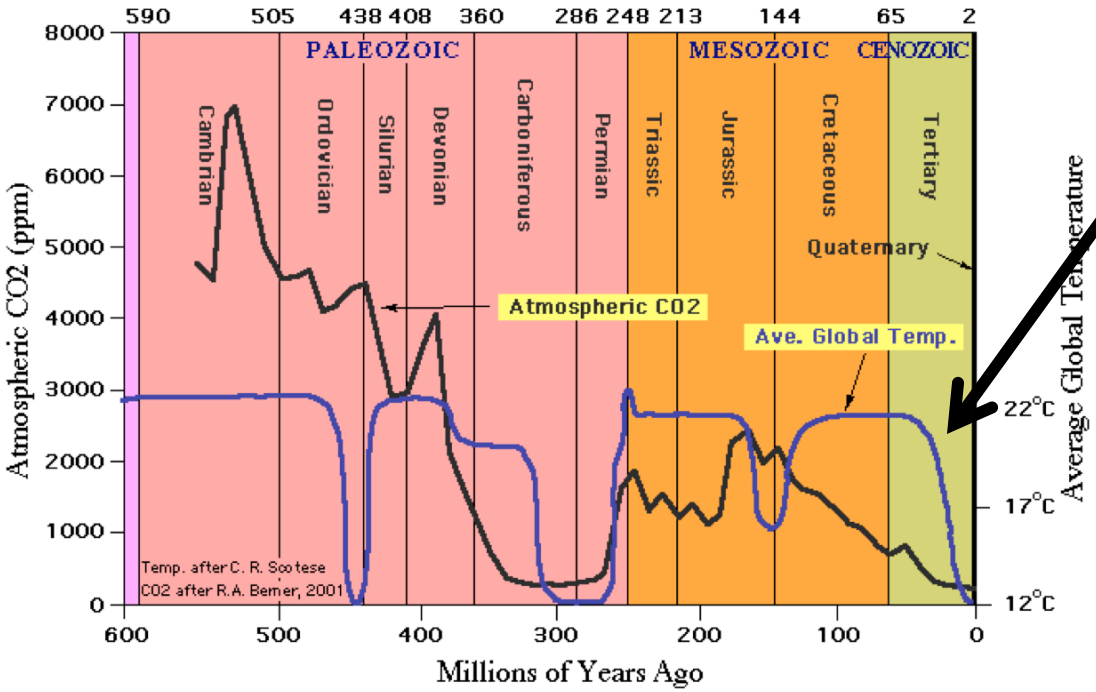
http://www.scotese.com/paleocli.htm

Movement of Plates Through Time



http://pubs.usgs.gov/gip/dynamic/graphics/Fig2-5globes.gif

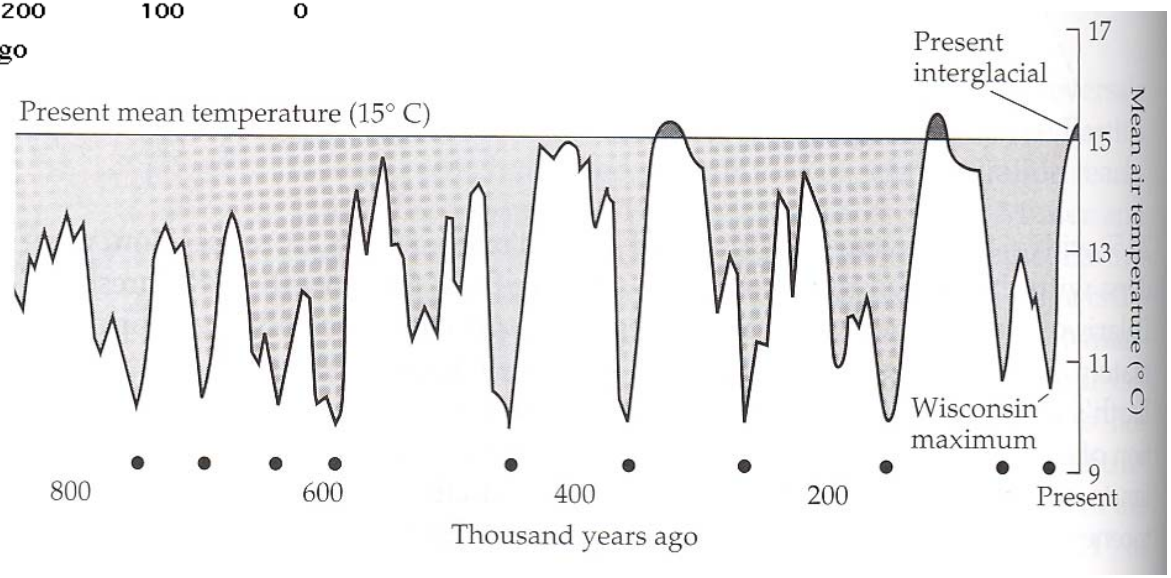
Transition to Quaternary: Shocks to biota



slow cooling

http://www.clearlight.com/~mhieb/WVFossils/Carboniferous_climate.html

rapid oscillations



Lomolino et al., 2006

Biological tools for assessing past climate
Palynology

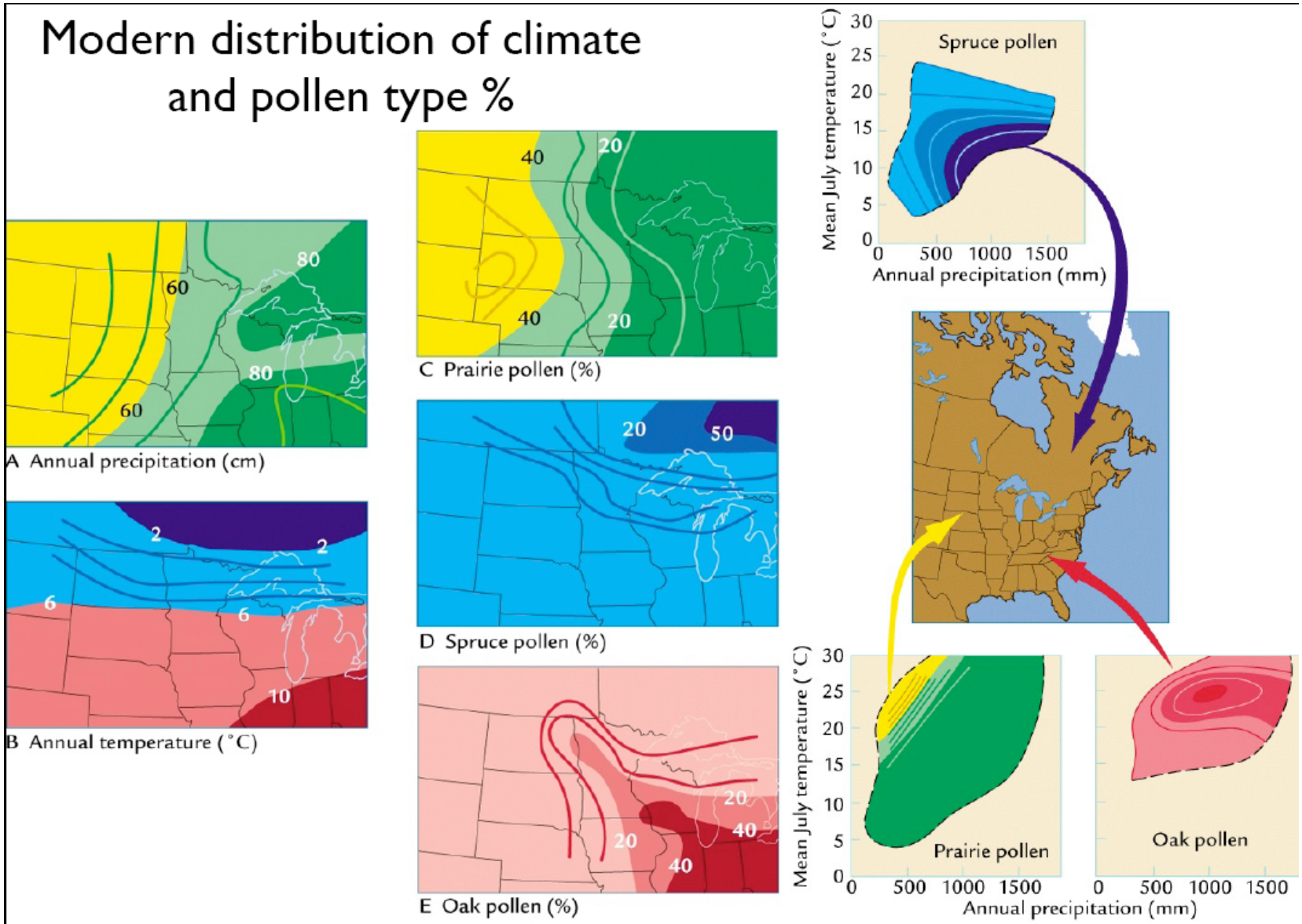


Image Credit: *Earth's Climate* by W. Ruddiman
Slide courtesy C. Still

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

en.wikipedia.org/wiki/Tree_rings

Biological tools for assessing past climate

Coral bands

hundreds of years

oceanworld.tamu.edu/students/coral/coral5.htm

Position of ice sheets, exposed land during LGM

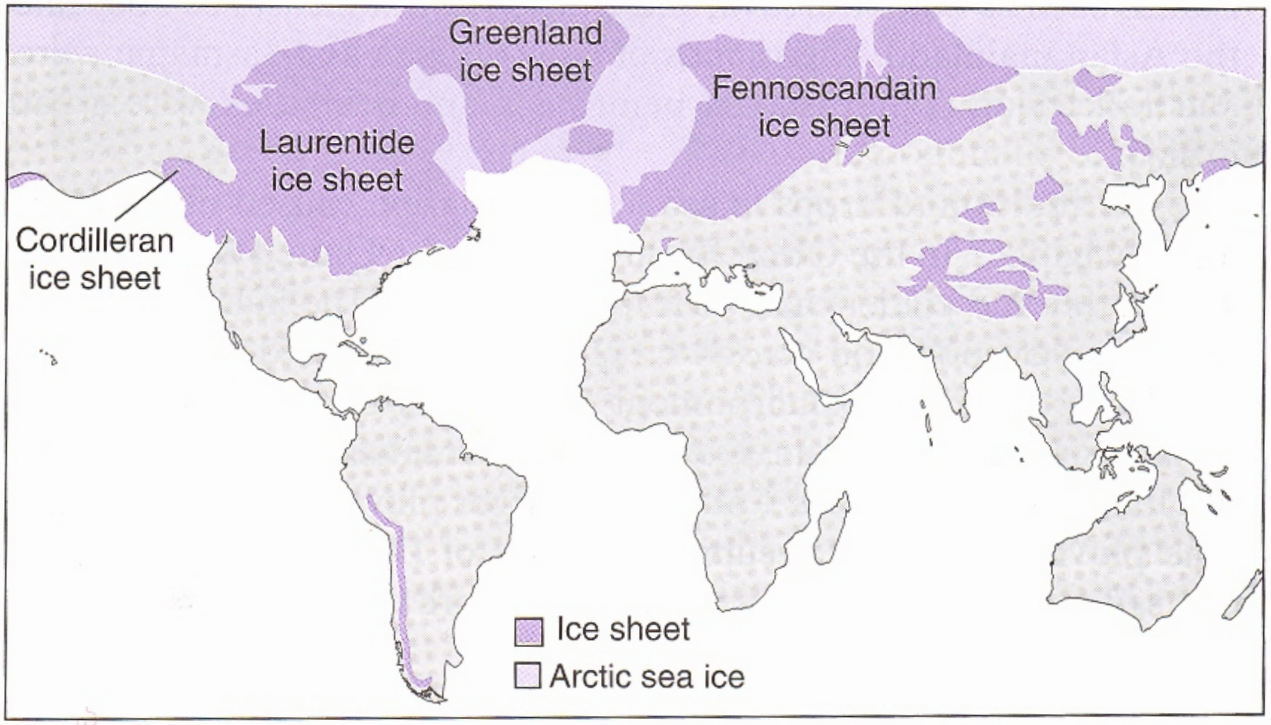


FIGURE 7.7 The location of major ice sheets and major areas of continental shelf exposed due to lower sea levels (eustatic sea-level changes) during the last glacial maximum (after Roberts, 1989).

Global mean temperature was 4-5 deg C lower than today

Regional Effects during Glacial Periods

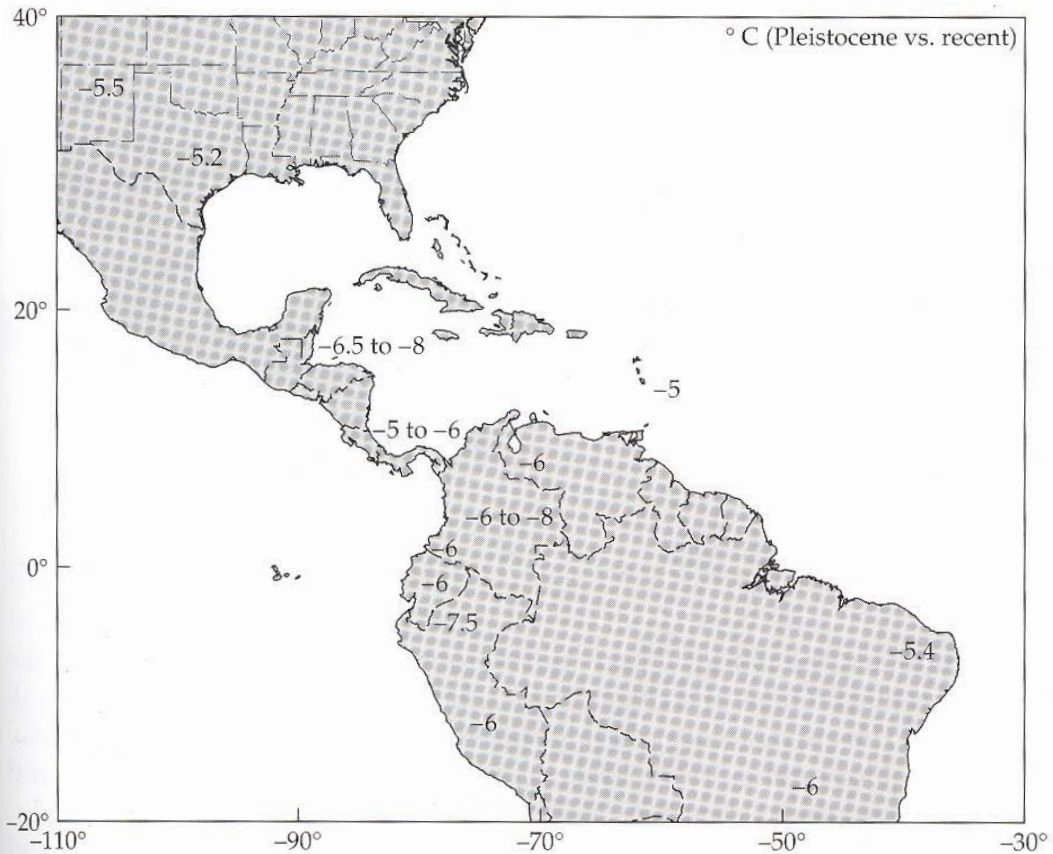
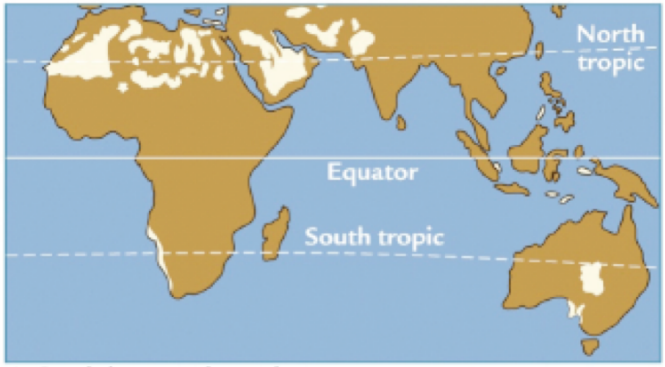


FIGURE 9.7 Glacial cycles of the Pleistocene influenced regional climates far from the edges of the glaciers. Temperatures over much of North and South America, for example, ranged from 4° to 8° C cooler during the Wisconsin. (After Stute et al. 1995.)

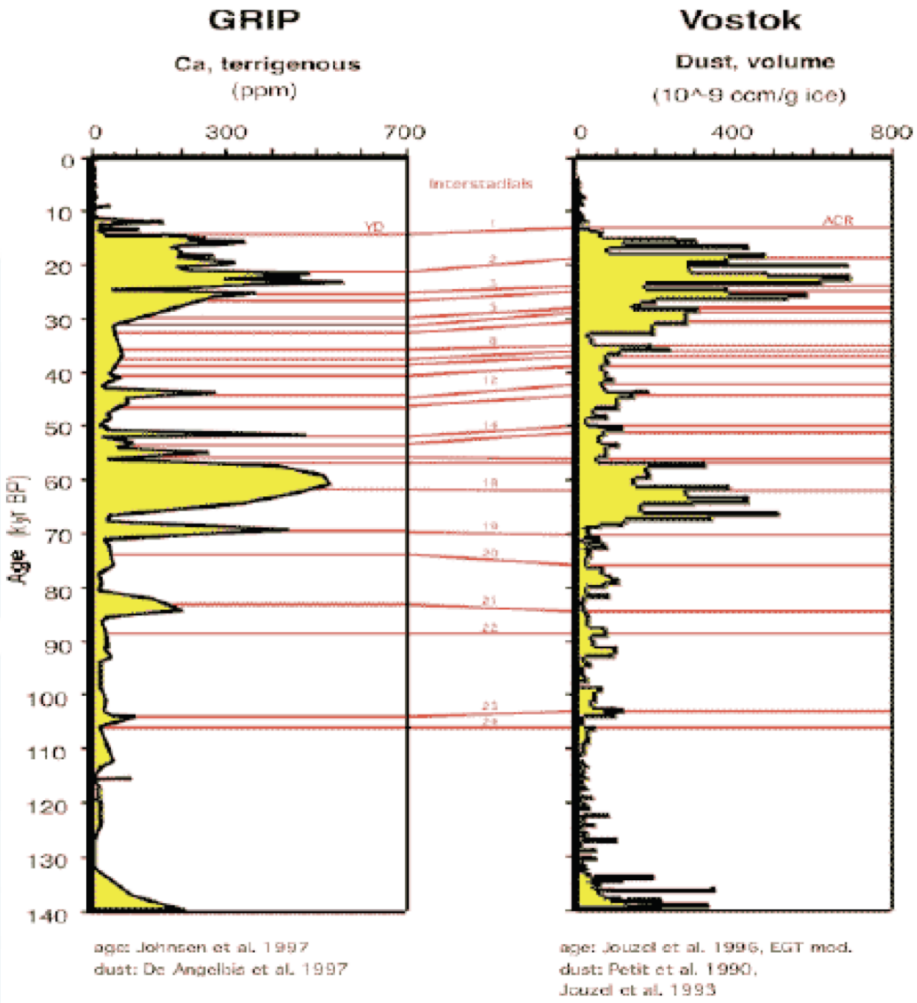
Lomolino et al., 2006

Overall, the world was drier as well



A Sand dunes active today

B Sand dunes active at glacial maximum

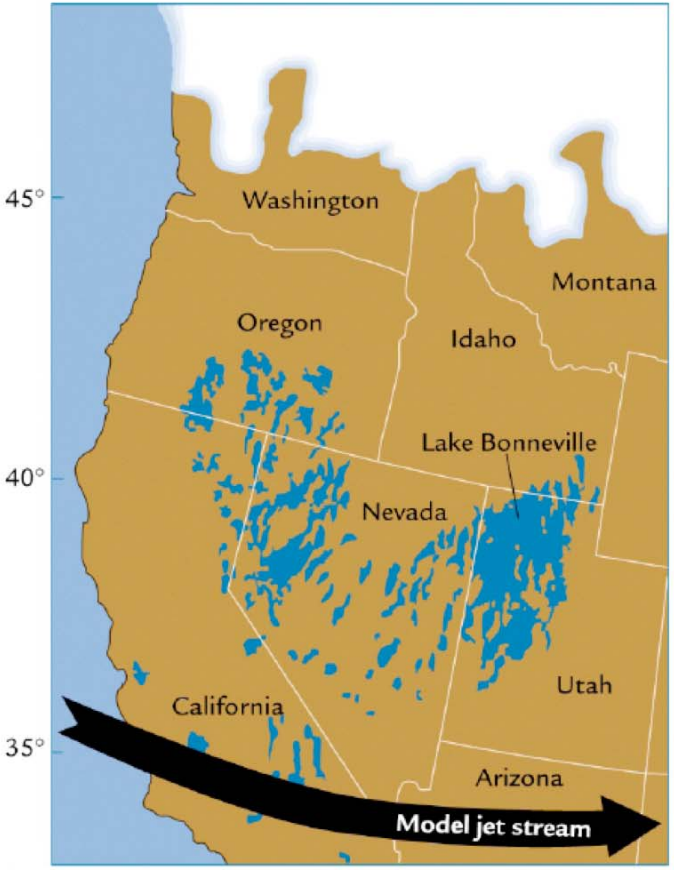


http://www2.uni-jena.de/chemie/geowiss/angeol/vorlesungen/eis/Eis_abb_web/GRIP_Vostok_dust.gif

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

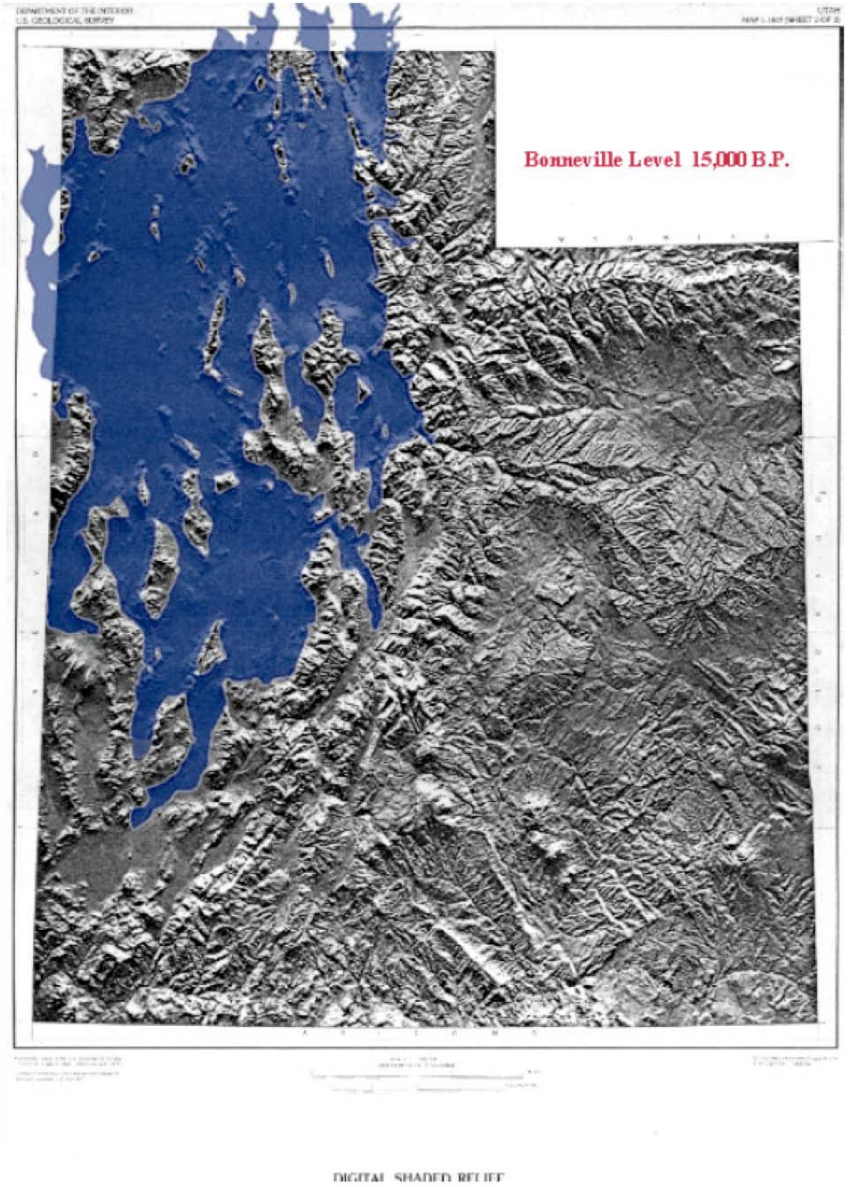
Slide courtesy C. Still

Utah during the LGM - definitely not drier!



B

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



http://raven.umnh.utah.edu/units/great.salt.lake/new6.gif

Slide courtesy C. Still

Eustatic sea level change

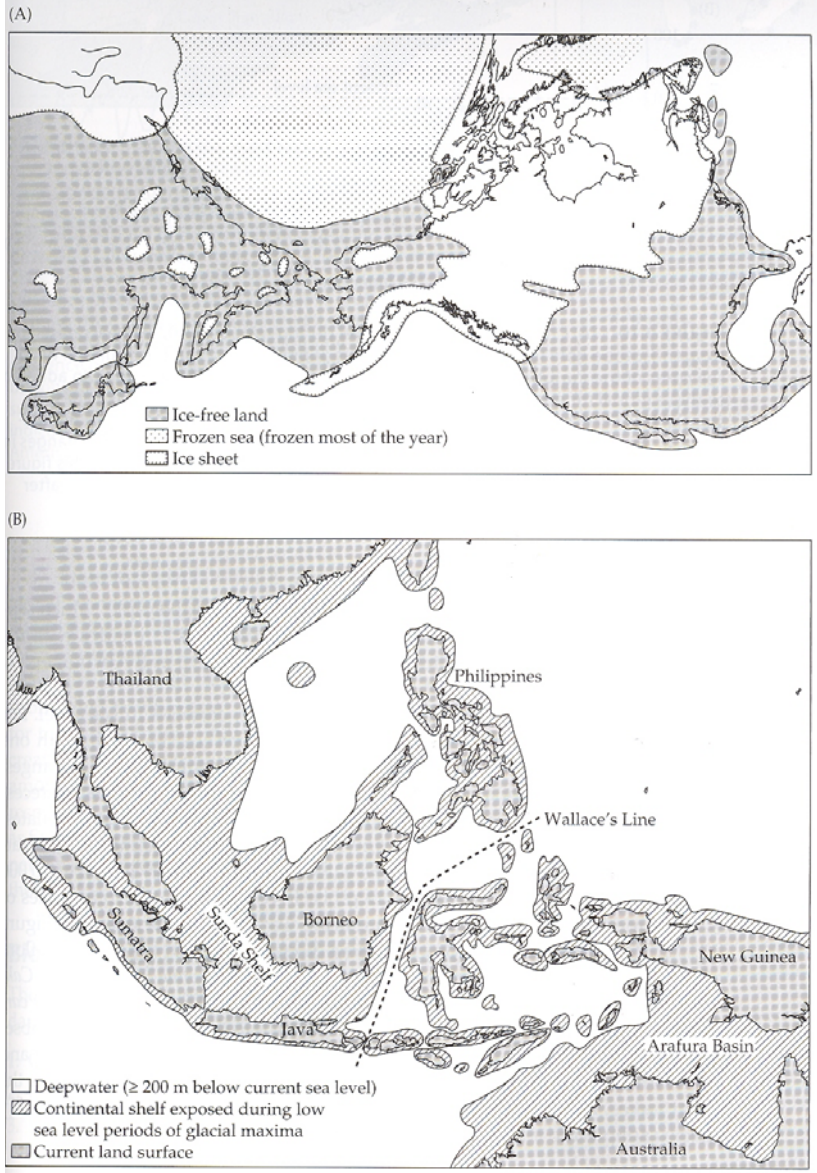


FIGURE 9.9 Glaciation during the Pleistocene resulted in the lowering of sea levels by 100 m to as much as 160 m below their current levels. As a result, many terrestrial regions and associated biotas now isolated by oceanic barriers were connected during glacial maxima. (A) Beringia connected North 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 Pielou 1991; B after Heawey 1991, 2004.)

Lomolino et al., 2006

Eustatic sea level change

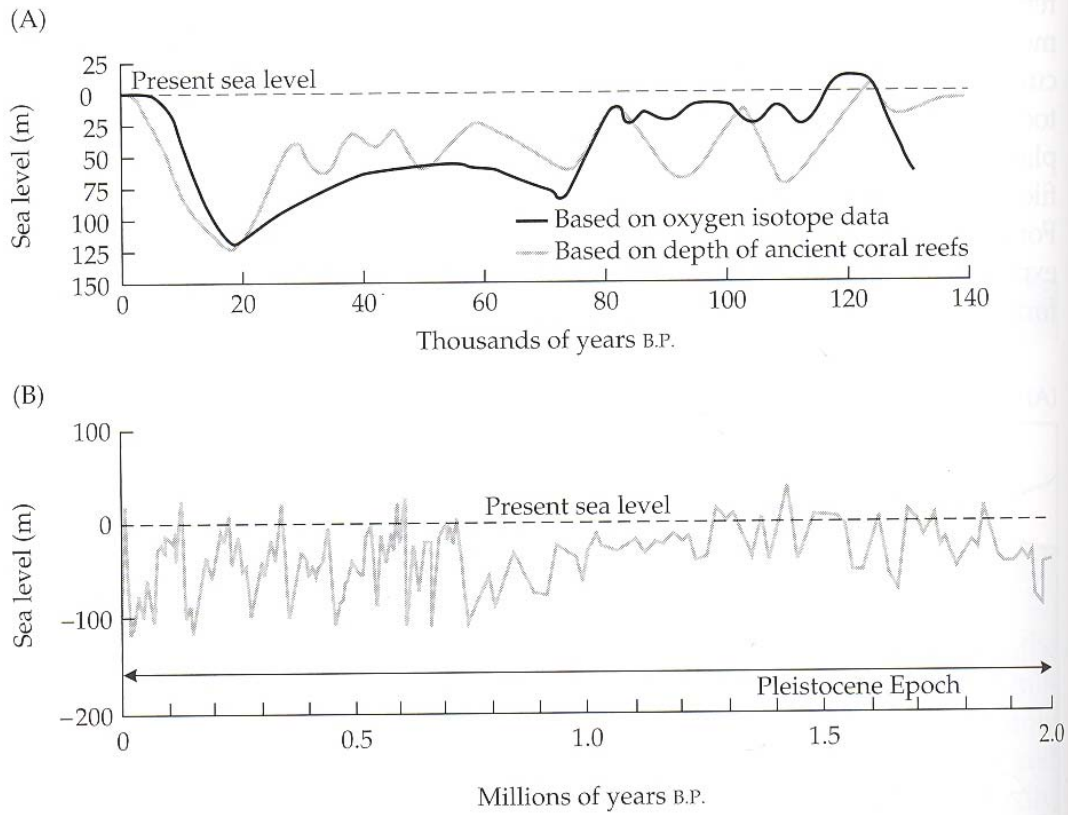
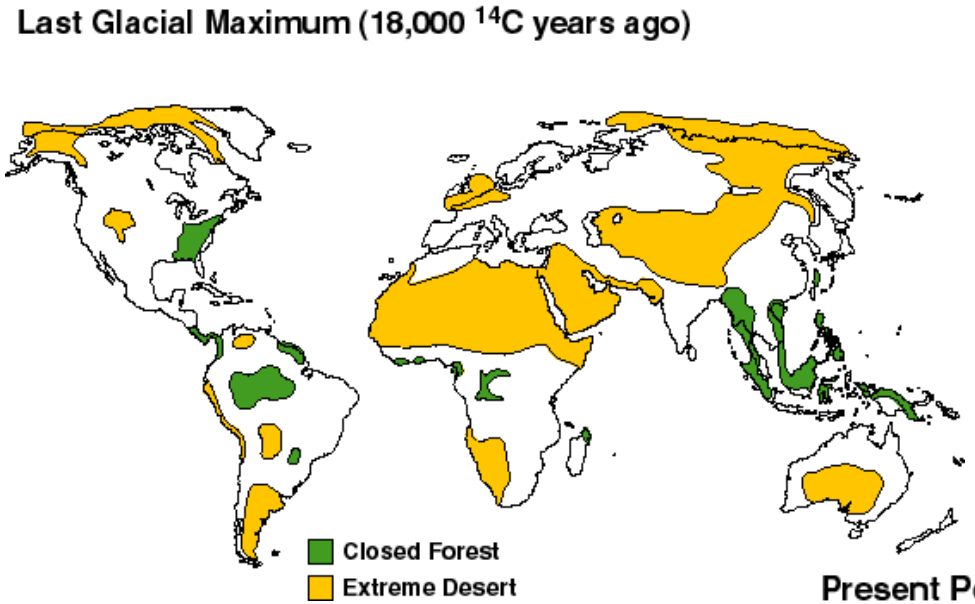
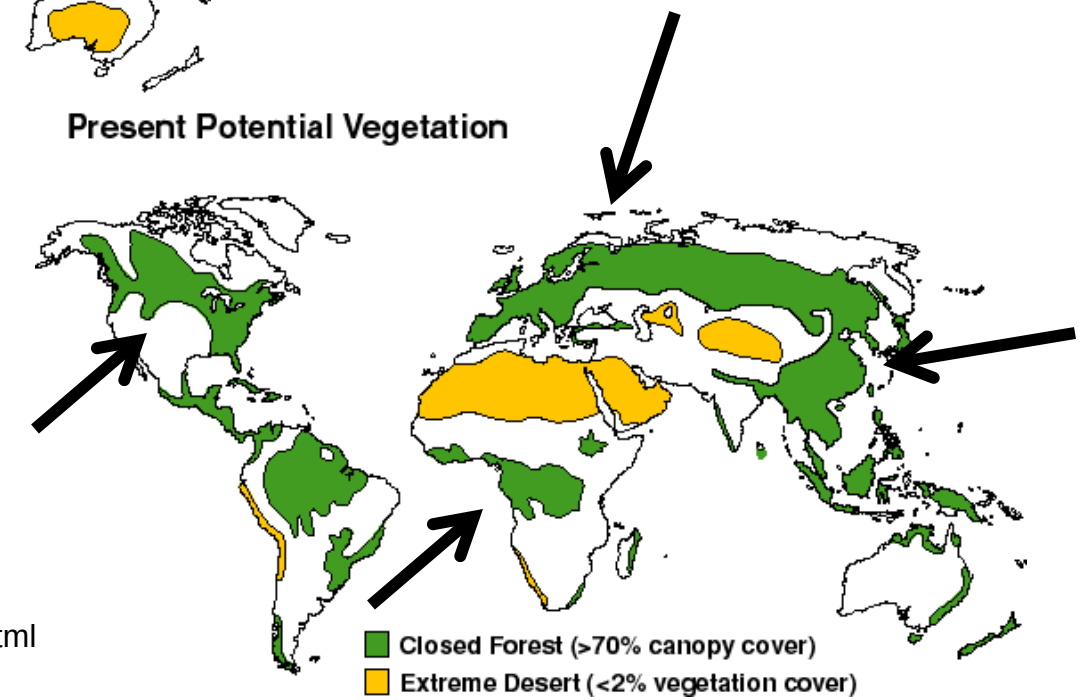


FIGURE 9.10 (A) Changes in global sea level during the past 140,000 years based on oxygen-isotope data (black line) from analysis of benthic foraminifers found in deep sea cores of the Caribbean, and raised coral reefs (gray line) in New Guinea. In addition to these global (or eustatic) changes in sea 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.)

Lomolino et al., 2006

Differences in vegetation types





www.esd.ornl.gov/projects/qen/nerc.html

Vegetation cover changes from LGM to present in Europe

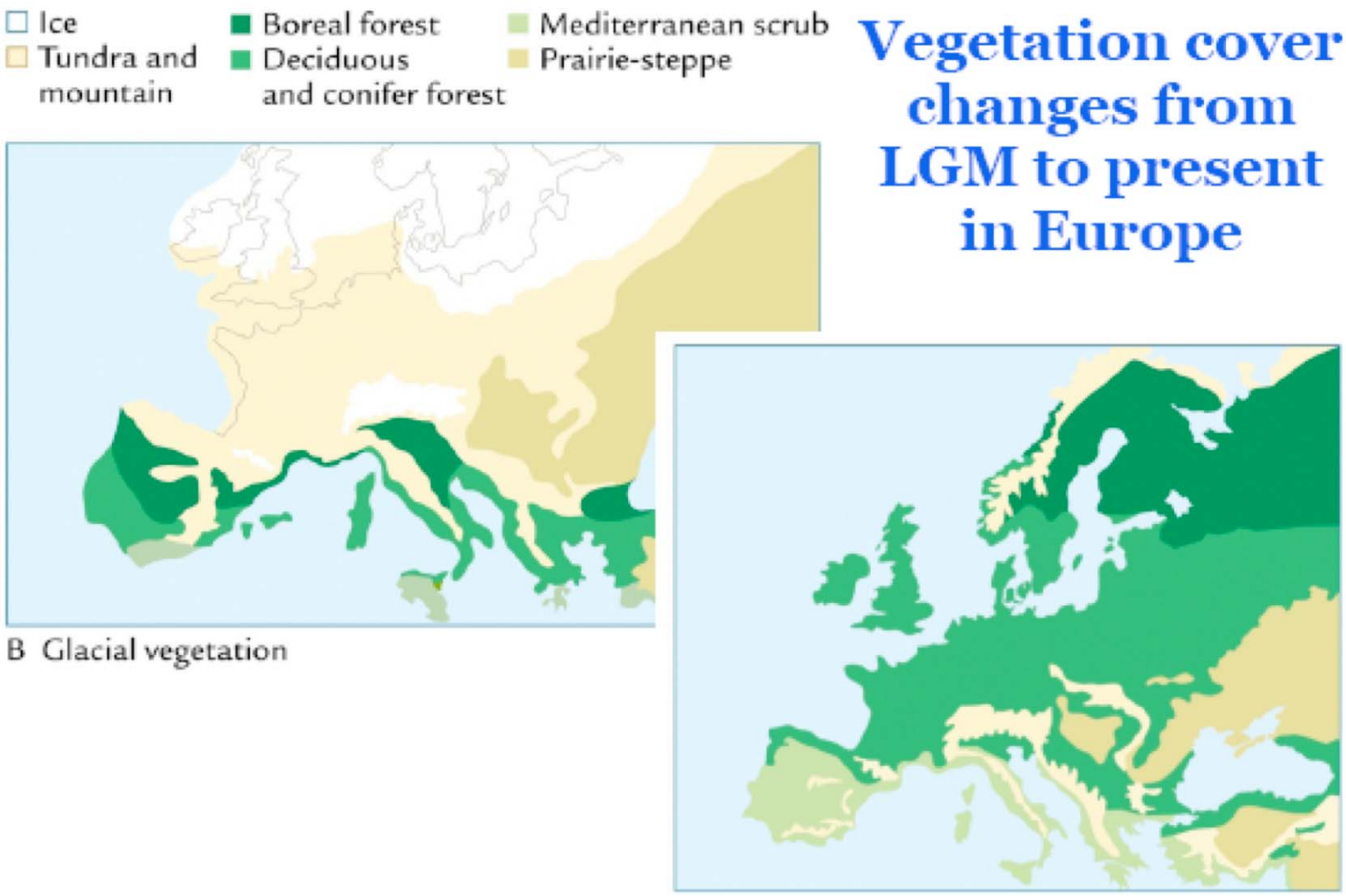


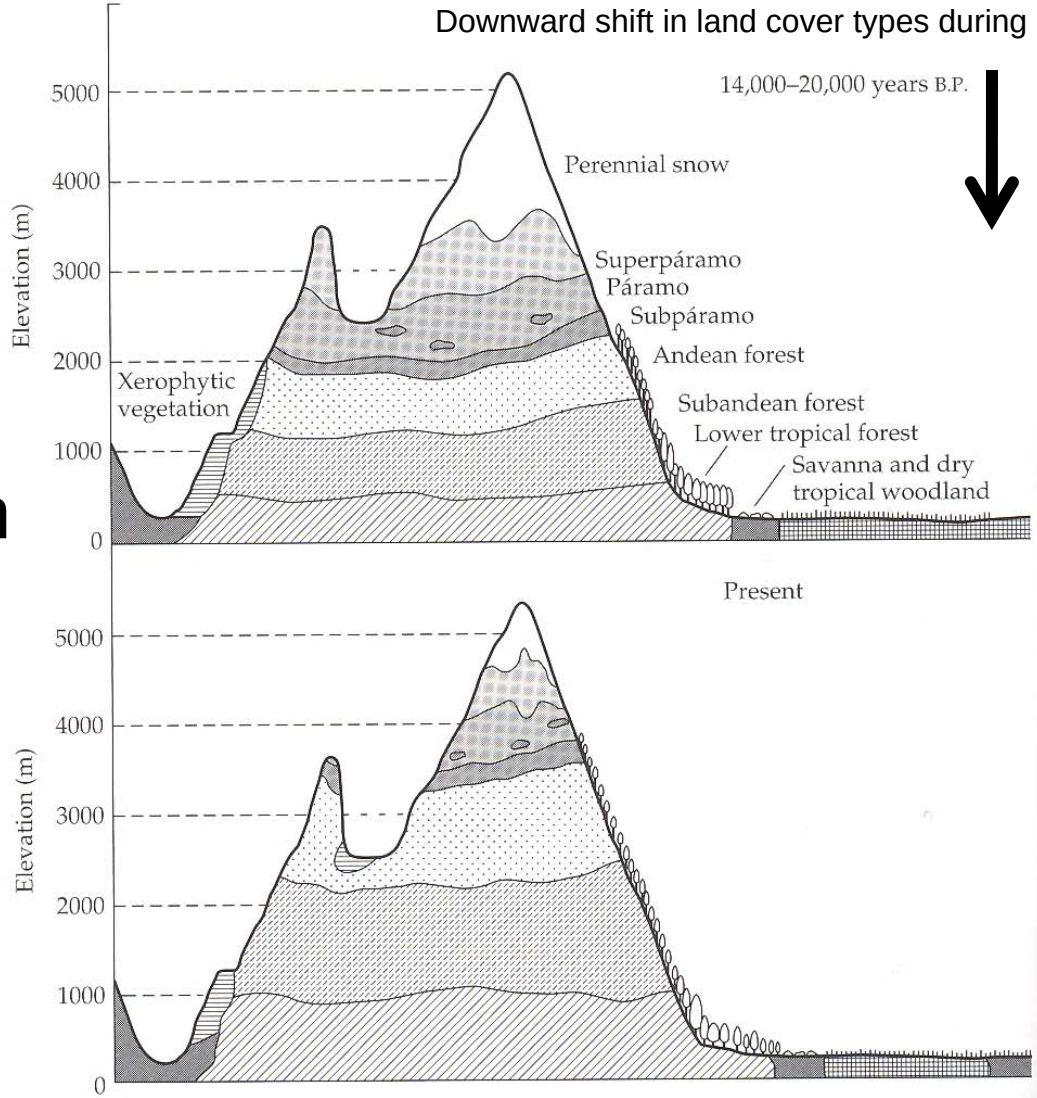
Image Credit: *Earth's Climate* by W. Ruddiman

Slide courtesy C. Still

Equatorial Mountain Changes

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 Flenley 1979a.)

Downward shift in land cover types during LGM



Lomolino et al., 2006

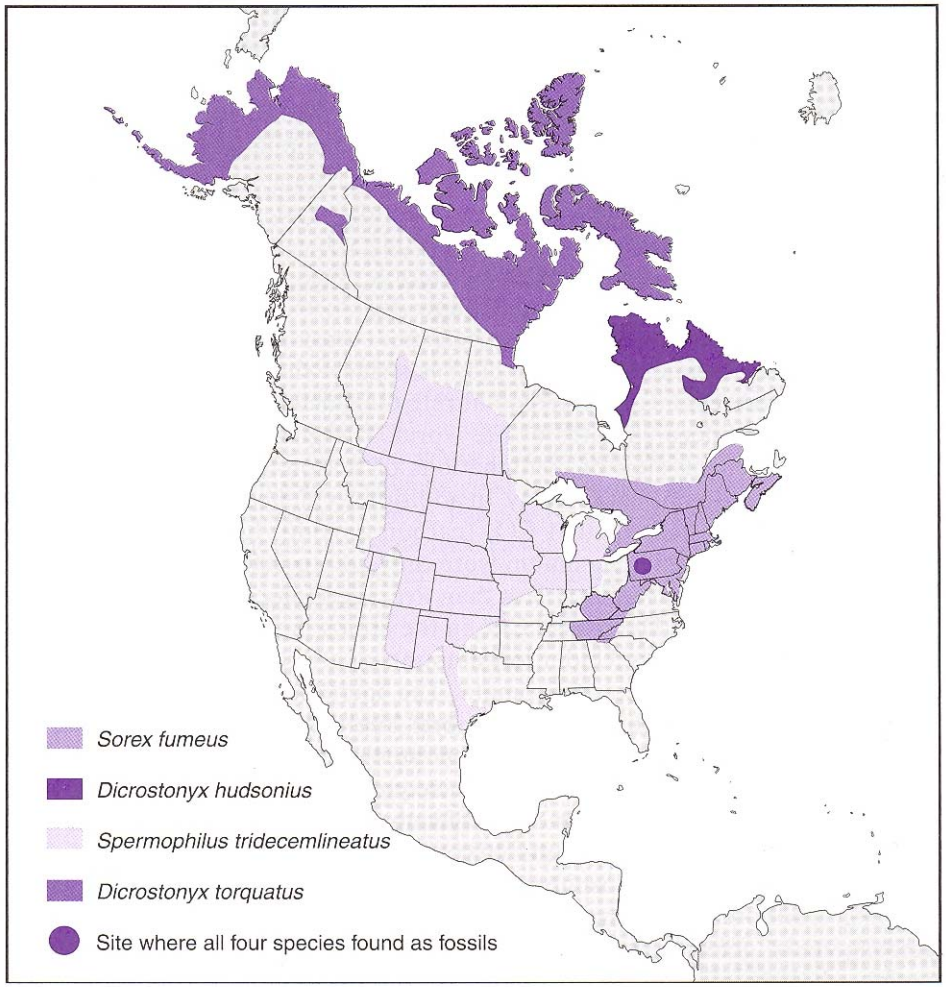


FIGURE 7.8 The modern distributions of eastern shrew *(Sorex fumens)*, eastern collared lemming *(Dicrostonyx hudsonius)*, prairie ground squirrel *(Spermophilus tridecemlineatus)*, and western collared lemming *(Dicrostonyx torquatus)*, and a site in Pennsylvania where fossil evidence indicates that all four species coexisted during the last glacial maximum, although they clearly do not live together today (after Graham, 1986; Graham et al., 1996; Brown and Lomolino, 1998).

Differential species responses:

rates, direction

North America refugia

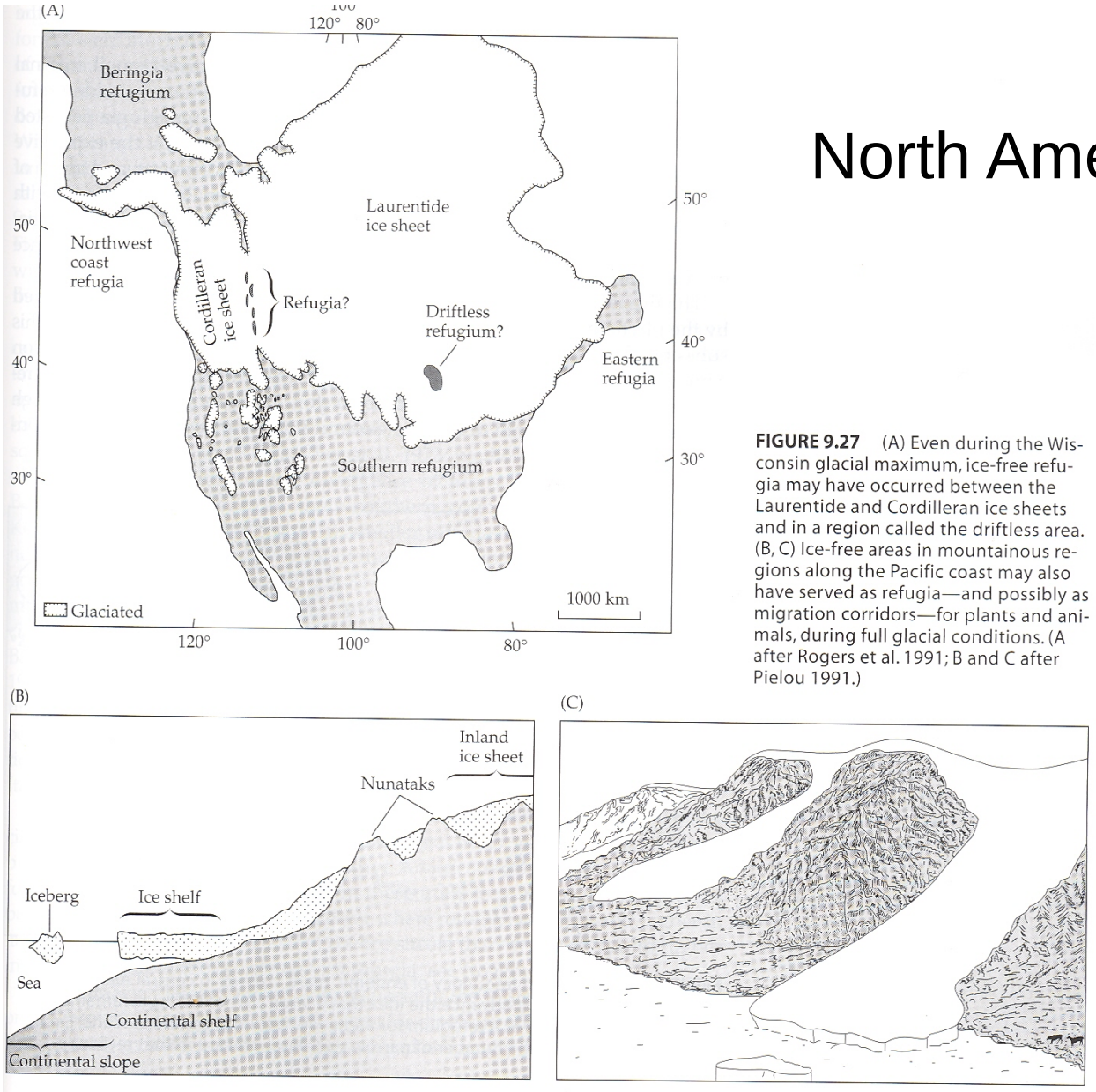


FIGURE 9.27 (A) Even during the Wisconsin glacial maximum, ice-free refugia may have occurred between the Laurentide and Cordilleran ice sheets and in a region called the driftless area. (B, C) Ice-free areas in mountainous regions along the Pacific coast may also have served as refugia—and possibly 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

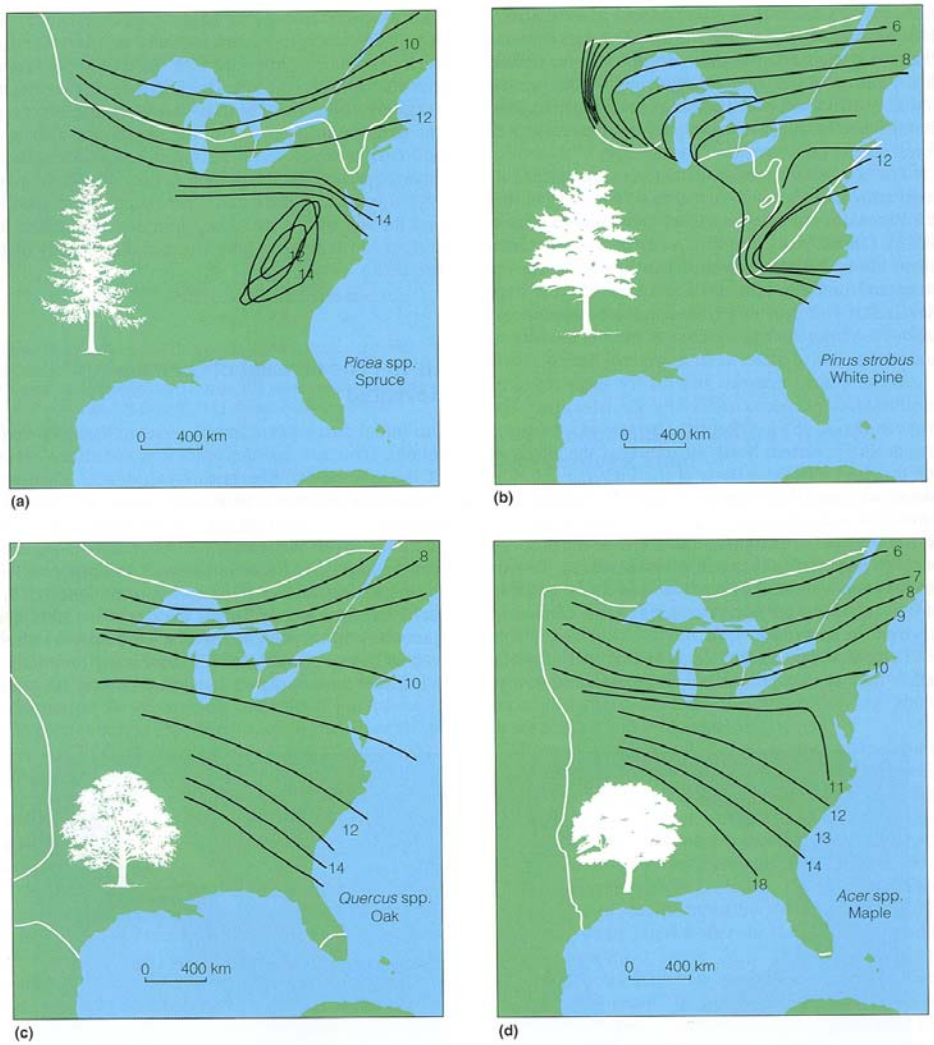


Figure 18.19 | The postglacial migration of four tree genera: **(a)** spruce, **(b)** white pine, **(c)** oak, and **(d)** maple. The dark lines represent the leading edges of the northward-expanding populations. The white lines indicate the boundaries of the present-day ranges. The numbers are thousands of years before present (BP). (Adapted from Davis 1981.)

Smith and Smith, 2006