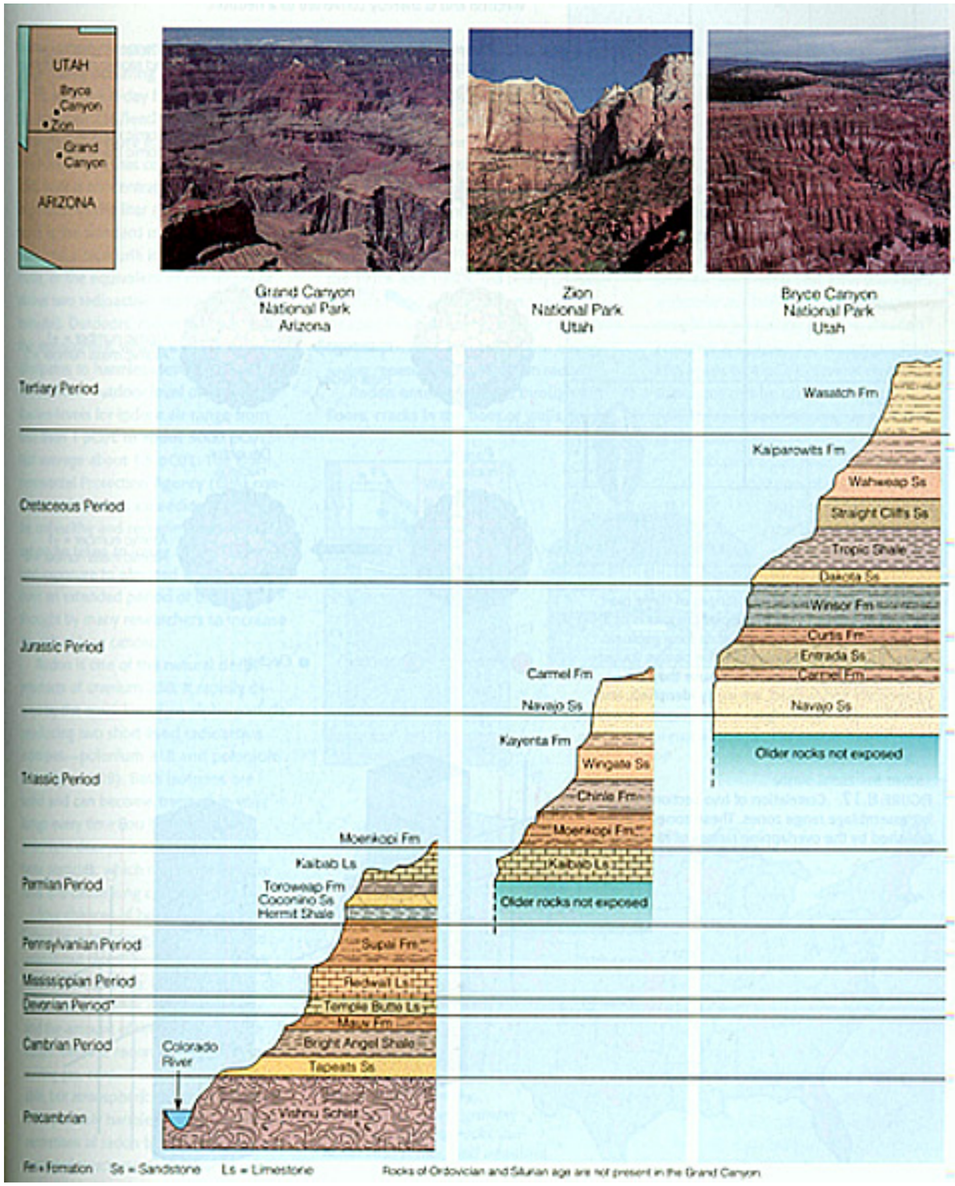
Stratigraphy



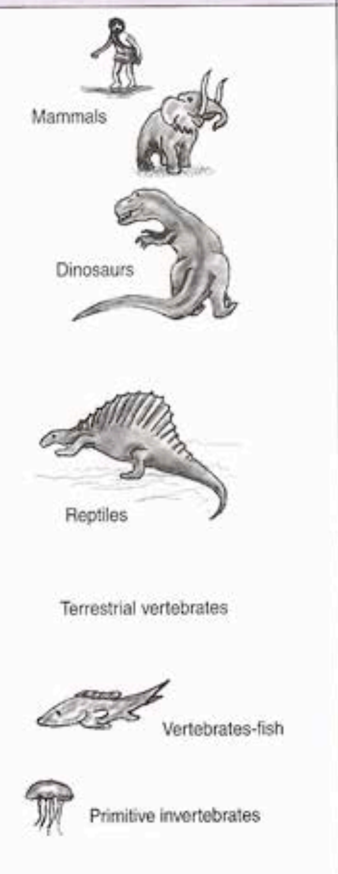
rst.gsfc.nasa.gov/Sect2/Sect2_1b.html

Geologic Time Scale

you are here

RELATIVE GEOLOGIC TIME				ABSOLUTE TIME (Millions of Years)
EON	ERA	PERIOD	EPOCH	
Phanerozoic	Cenozoic (Recent life)	Quaternary	Holocene	
			Pleistocene	2
		Tertiary	Pliocene	5
			Miocene	24
			Oligocene	37
			Eocene	58
			Paleocene	66
	Mesozoic (Middle life)	Cretaceous	Late	
			Early	144
		Jurassic	Late	
			Middle	
			Early	208
		Triassic	Late	
			Middle	
			Early	245
	Paleozoic (Ancient life)	Permian	Late	
			Early	286
		Pennsylvanian	Late	
			Middle	
			Early	
		Carboniferous Mississippian	Late	
			Early	360
		Devonian	Late	
			Middle	
			Early	408
		Silurian	Late	
			Middle	
			Early	438
		Ordovician	Late	
			Middle	
			Early	505
		Cambrian	Late	
			Middle	
			Early	570
	Precambrian			3800+

ANIMALS



PLANTS

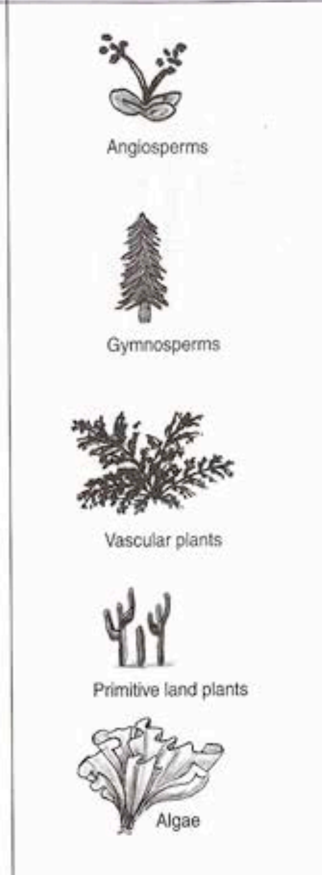


FIGURE 7.1 The geologic time scale with the types of animals and plants typical of the fossil record for different time periods (after Birkeland and Larson, 1989).

Importance of Theory of Continental Drift to Biogeography

"No contribution to biogeography has had more of an impact than the theory of continental drift."

"Plate tectonics, perhaps more than any other phenomenon, has had profound effects on the biogeographic patterns of both terrestrial and marine biotas."

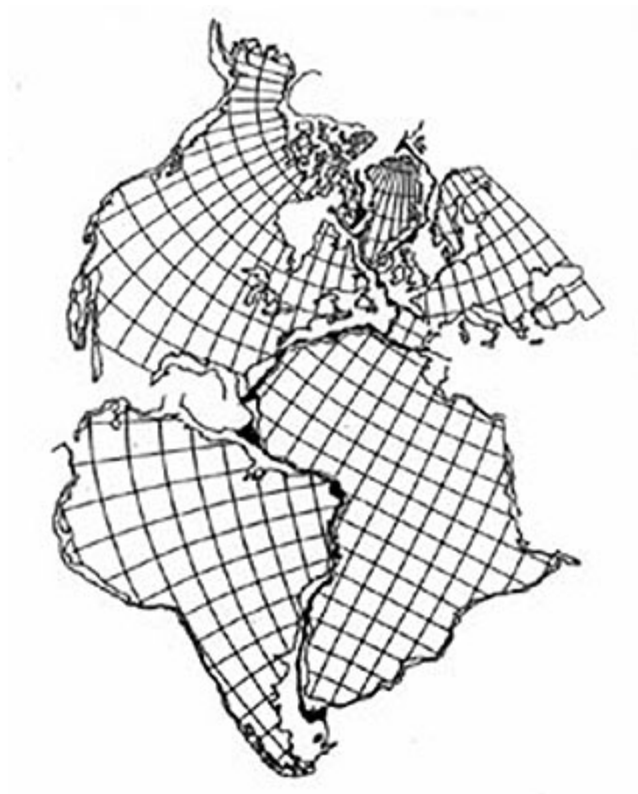
Lomolino et al., 2006, "Biogeography"

"…these changes [geography of continents] explain many aspects of the modern distributions of species."

"Biogeographers recognize that the modern distributions of life reflects both present-day environmental conditions and the past history of the planet."

MacDonald, 2003, "Biogeography"

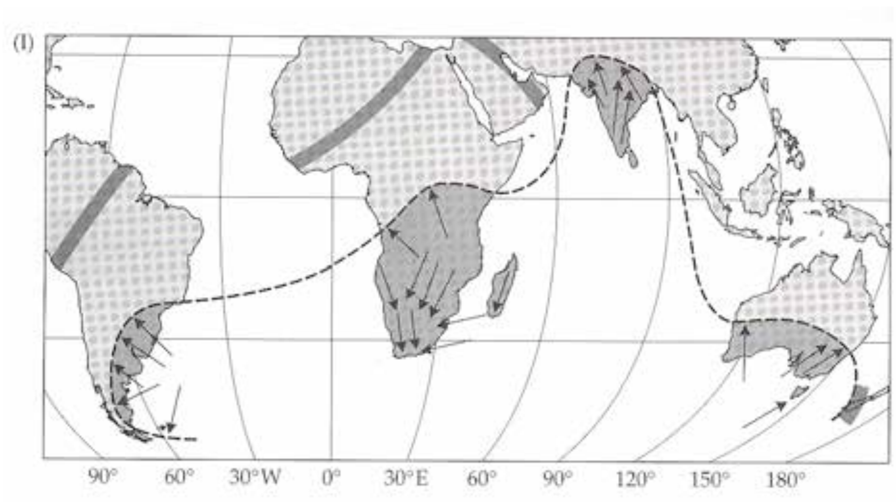
Evidence for shifting continents: Cartographic



rst.gsfc.nasa.gov/Sect2/Sect2_1b.html

Evidence for shifting continents: Geologic mapping

Glacier location and movement in the past



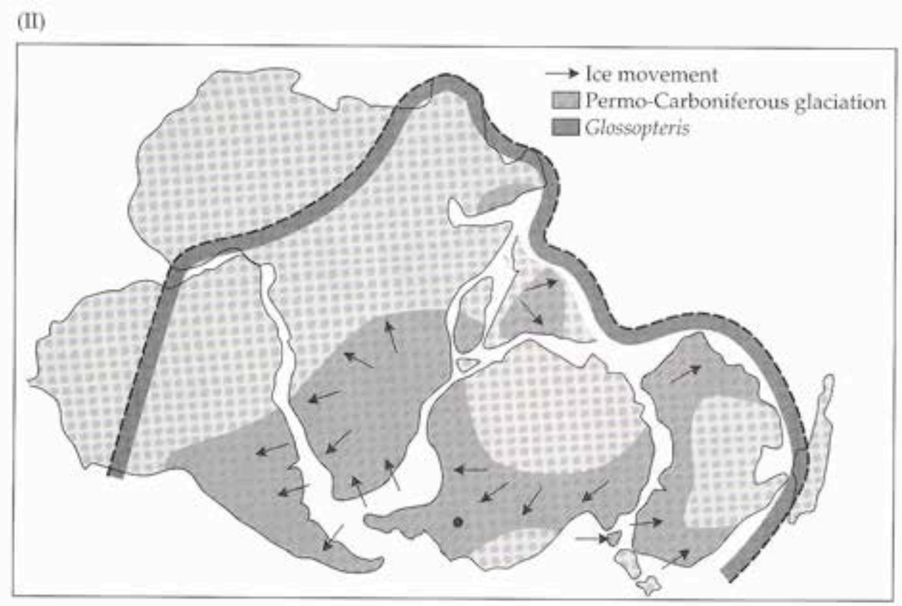


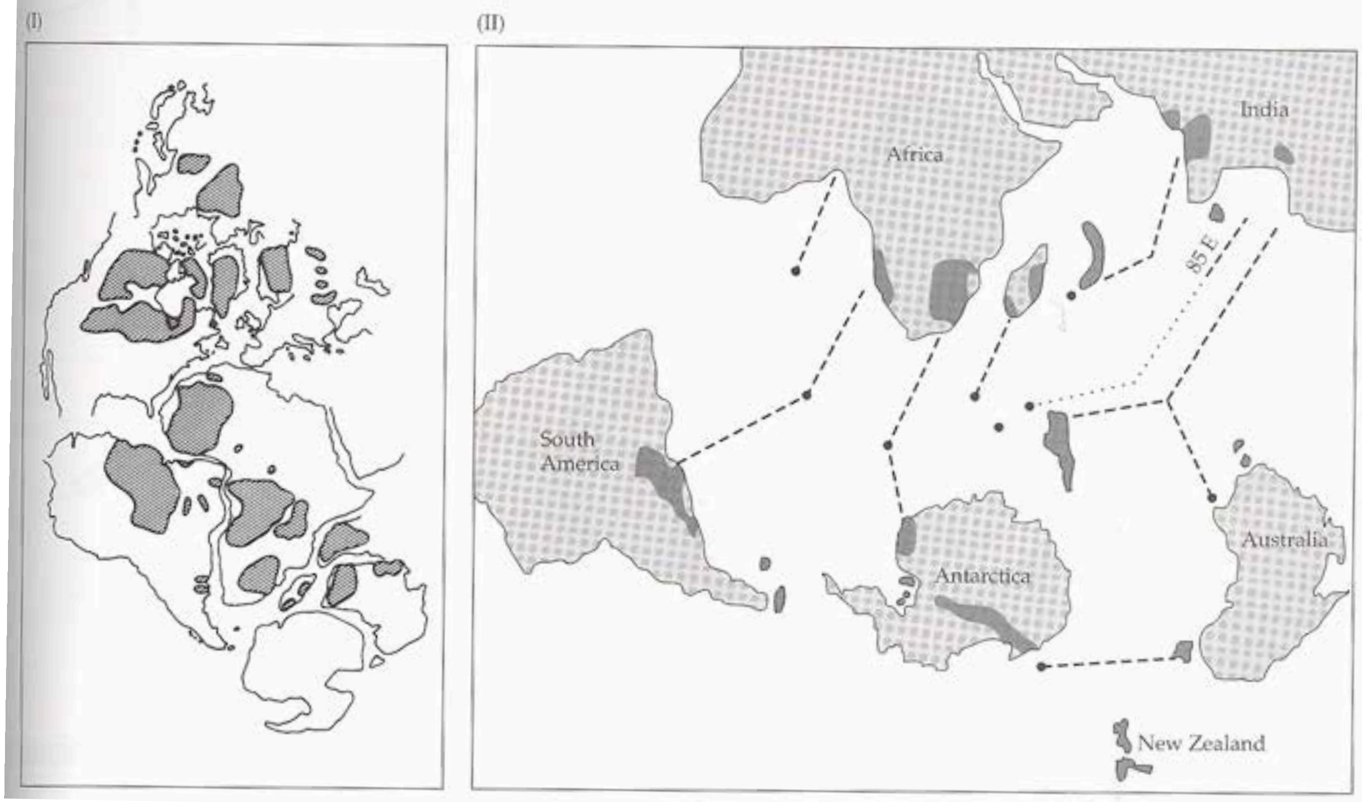
Figure B Two lines of paleontological evidence for continental drift found on the southern continents. Glaciers carved lines in the underlying rock material, marking their location and direction of movement (arrows). The *Glossopteris* flora (or "southern beeches") included several groups of plants that grew along the margins of the glaciers. (I) The origin and directions of glacial movement (shaded area with arrows) and the distributions of *Glossopteris* fossils (darker shading) are difficult to explain based on the current positions of the southern continents because they imply that glaciers moved from oceans onto land. (II) These patterns, however, are consistent with reconstructions of Gondwanaland as it was during the Permian period. (I after Stanley 1987; II after Windley 1977.)

Lomolino et al., 2006

Evidence for shifting continents: Geologic mapping

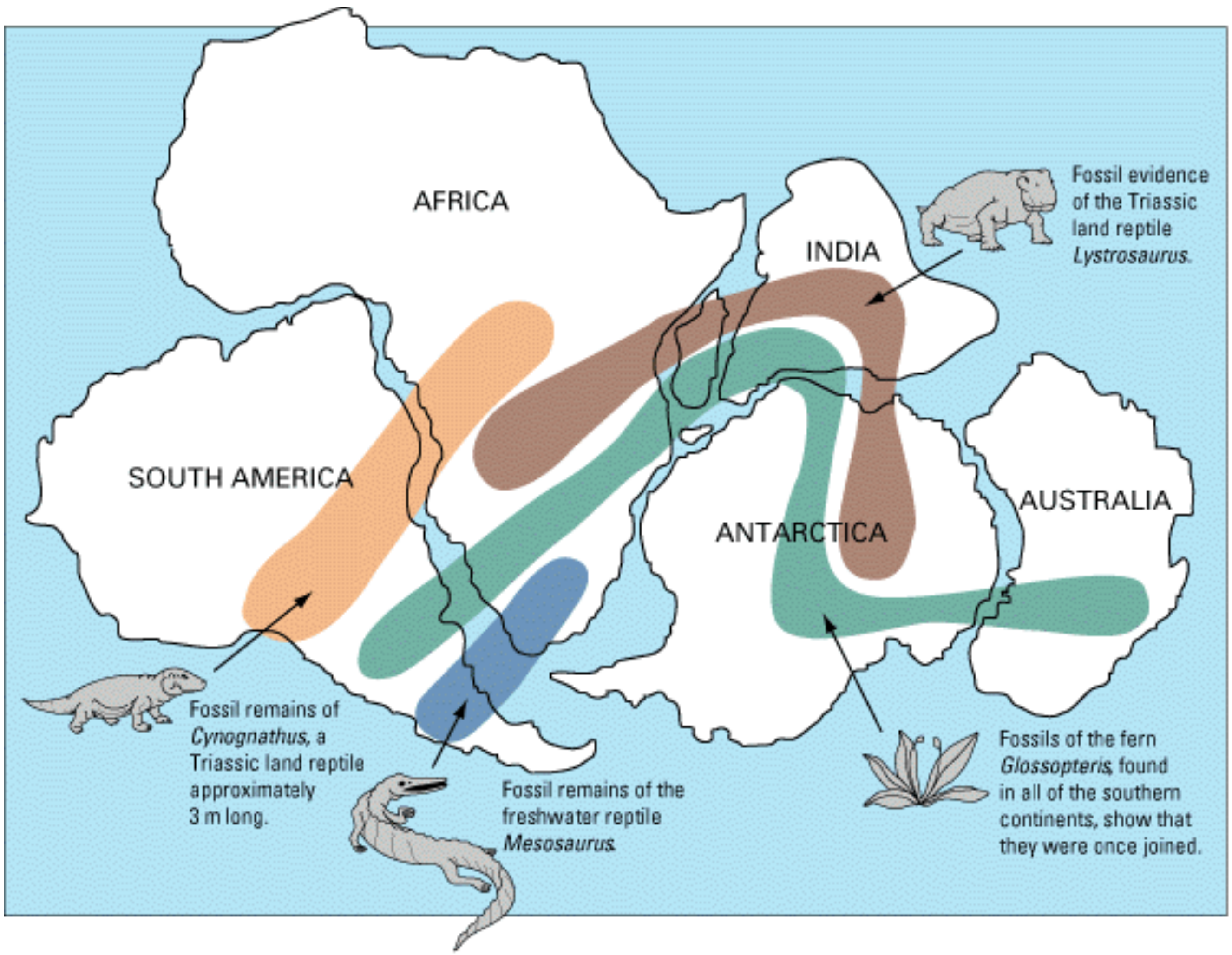
Locations of rock formations

Figure A (I) Distributions of Precambrian shields (hatched areas), illustrating how they match up if the continents are reassembled as they were before the breakup of Pangaea. (After P. M. Hurley and J. R. Rand.) (II) Although substantially isolated today, flood basalts also serve as evidence of the previous connections of the southern continents in the former Gondwanaland. (After Storey 1995.)



Lomolino et al., 2006

Evidence for shifting continents: Distributions of fossils



en.wikipedia.org/wiki/Image:Snider-Pellegrini_Wegener_fossil_map.gif

Evidence of Continental Drift: Distributions of living species

Beetles

Fishes

Plants

Clawed frogs

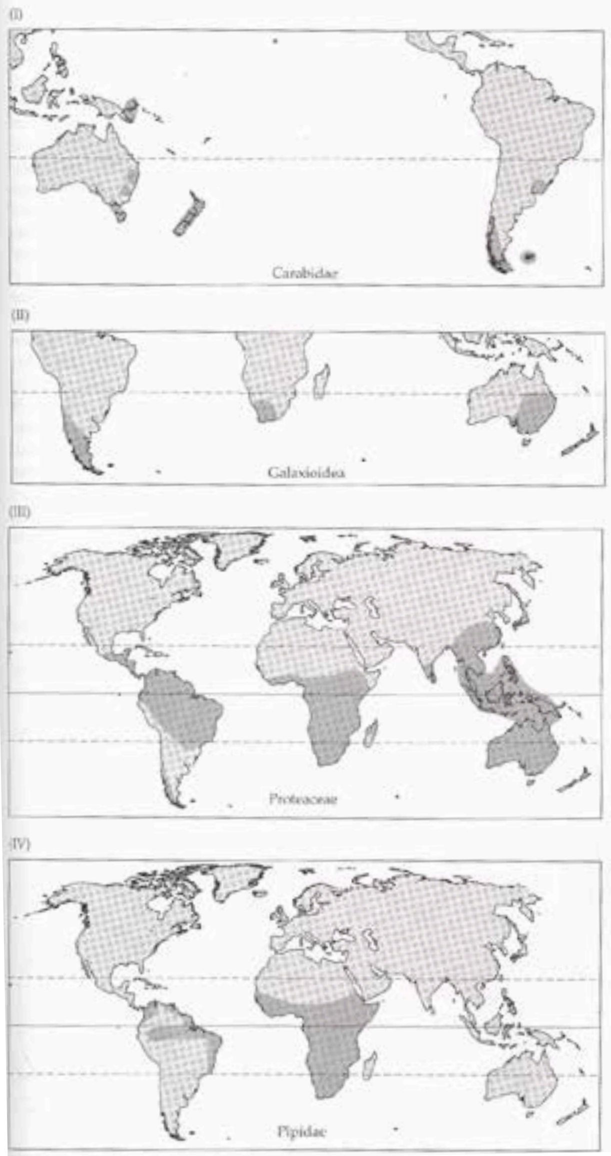
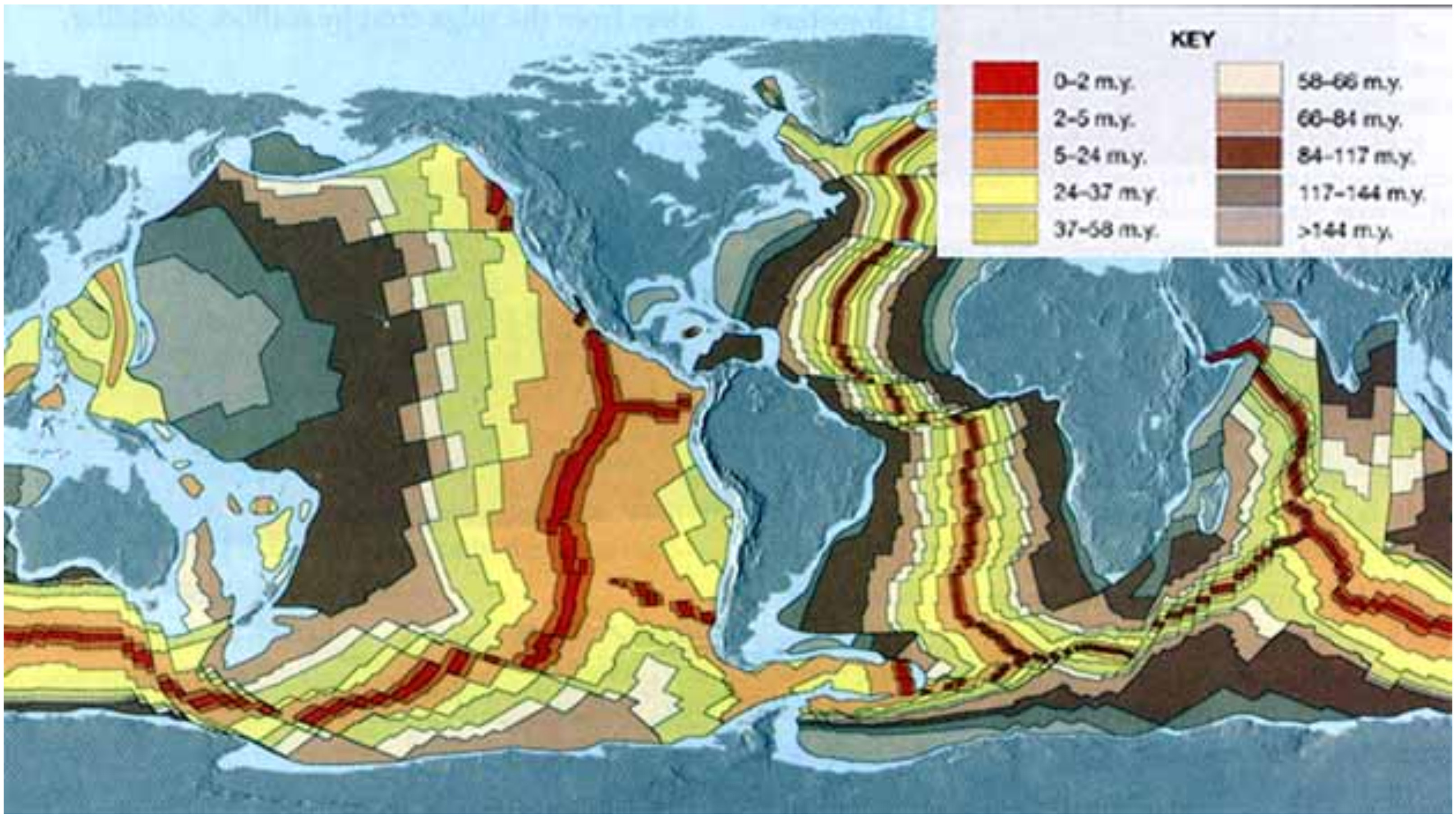


Figure C The disjunct distributions of some living taxa suggest that their ancestral forms radiated across Gondwanaland in the Permian period. (I) Southern temperate beetles of the trib Migadopini of the family Carabidae. (II) Fishes of the superfamily Galaxioidea. These fishes are restricted to nontropical waters in the Southern Hemisphere. (III) Plants of the family Proteaceae. This group is found on all of the southern conti nents, but barely reaches the Northern Hemisphere. (IV) Clawed aquatic frogs of the family Pipidae. This family is comprise of two subfamilies, the Pipinae in tropical South America and the Xenopinae in trop cal Africa, suggesting a common ancestor that was once distributed in western Gondwanaland. (I after Darlington 1965; II after Berra 1981; III after Johnson and Briggs 1975; IV after Savage 1973.)

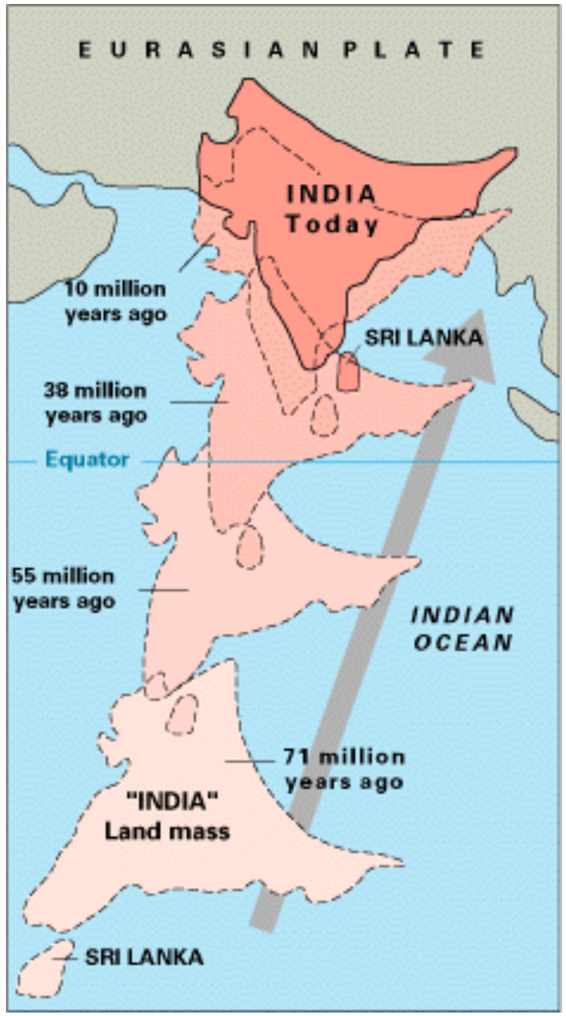
Lomolino et al., 2006

Mapping age of ocean floor



www.calstatela.edu/faculty/acolvil/plates/seafloor_ages.jpg

Examples of Continental Drift



pubs.usgs.gov/gip/dynamic/himalaya.html

Examples of Continental Drift

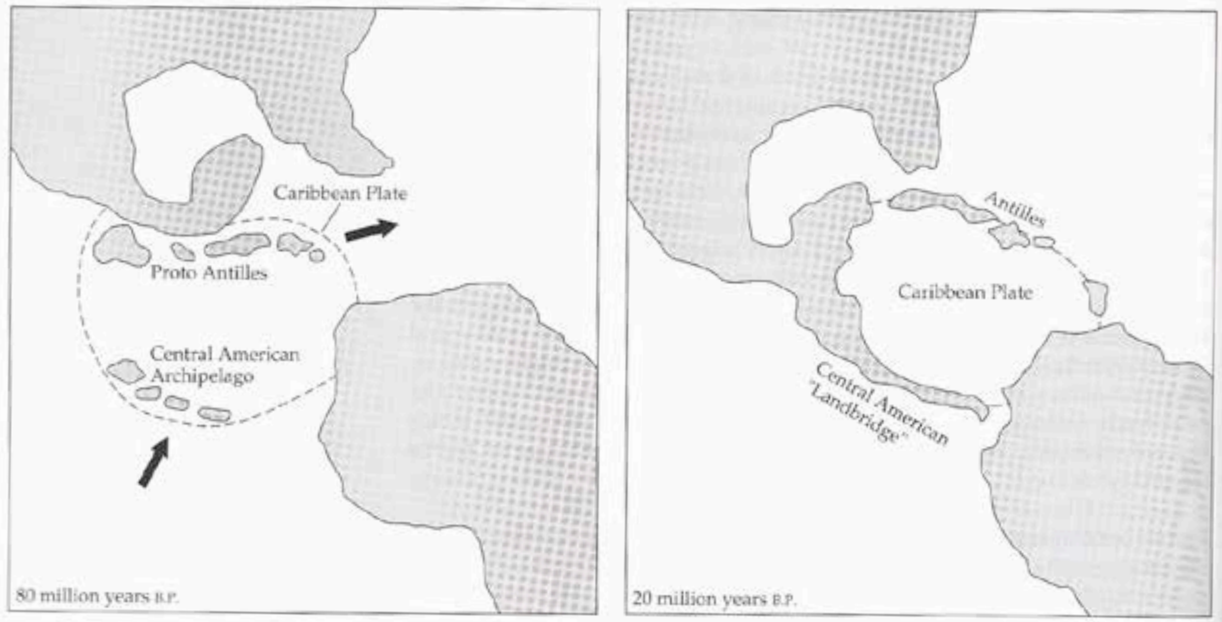
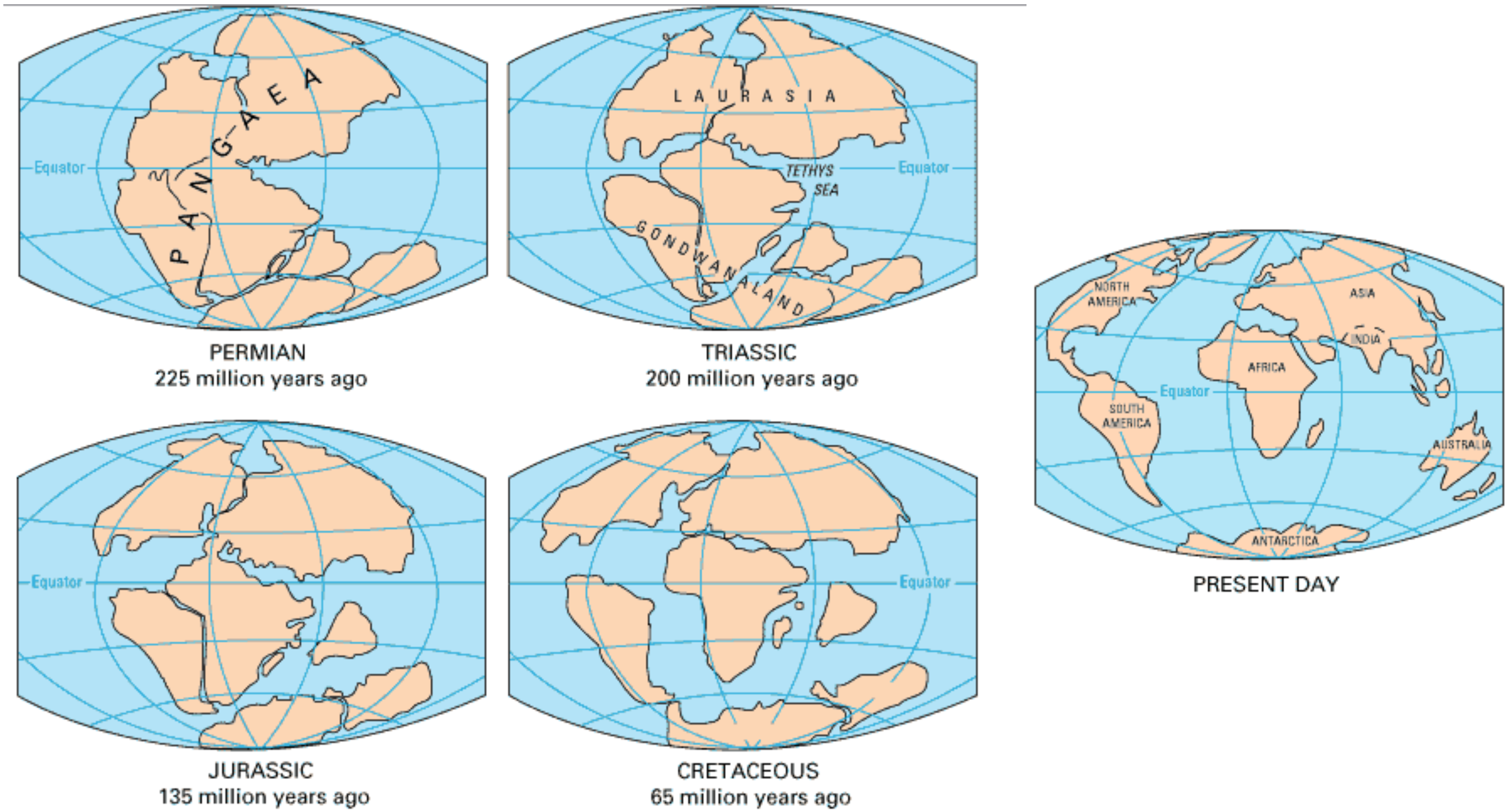


FIGURE 8.18 One possible reconstruction of tectonic events in the Caribbean. Central America first formed as an archipelago in the Pacific Ocean during the early Cretaceous (120 to 140 million years B.P.), then continued to drift eastward along with the Caribbean Plate and the Proto-Antilles. The Central American Archipelago eventually drifted to its position between the two continents by the mid-Miocene (20 million years B.P.), but did not form a complete landbridge until the late Pliocene (around 3.5 million years B.P.). (After Briggs 1994.)

Other mechanisms behind land bridge formation?

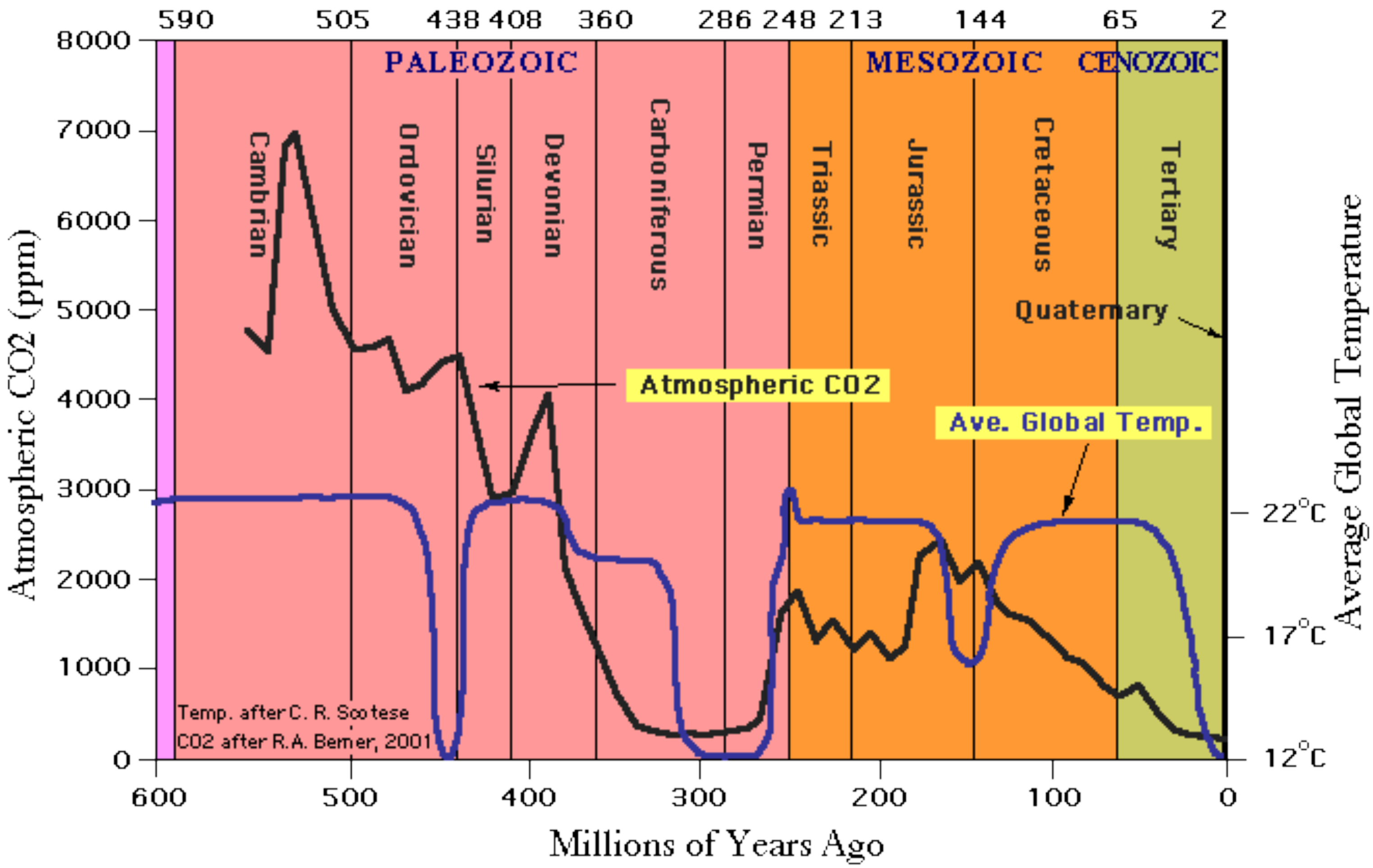
Lomolino et al., 2006

Movement of Plates Through Time



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

Changes in climate and CO2



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

Effects of Continental Drift on Climate

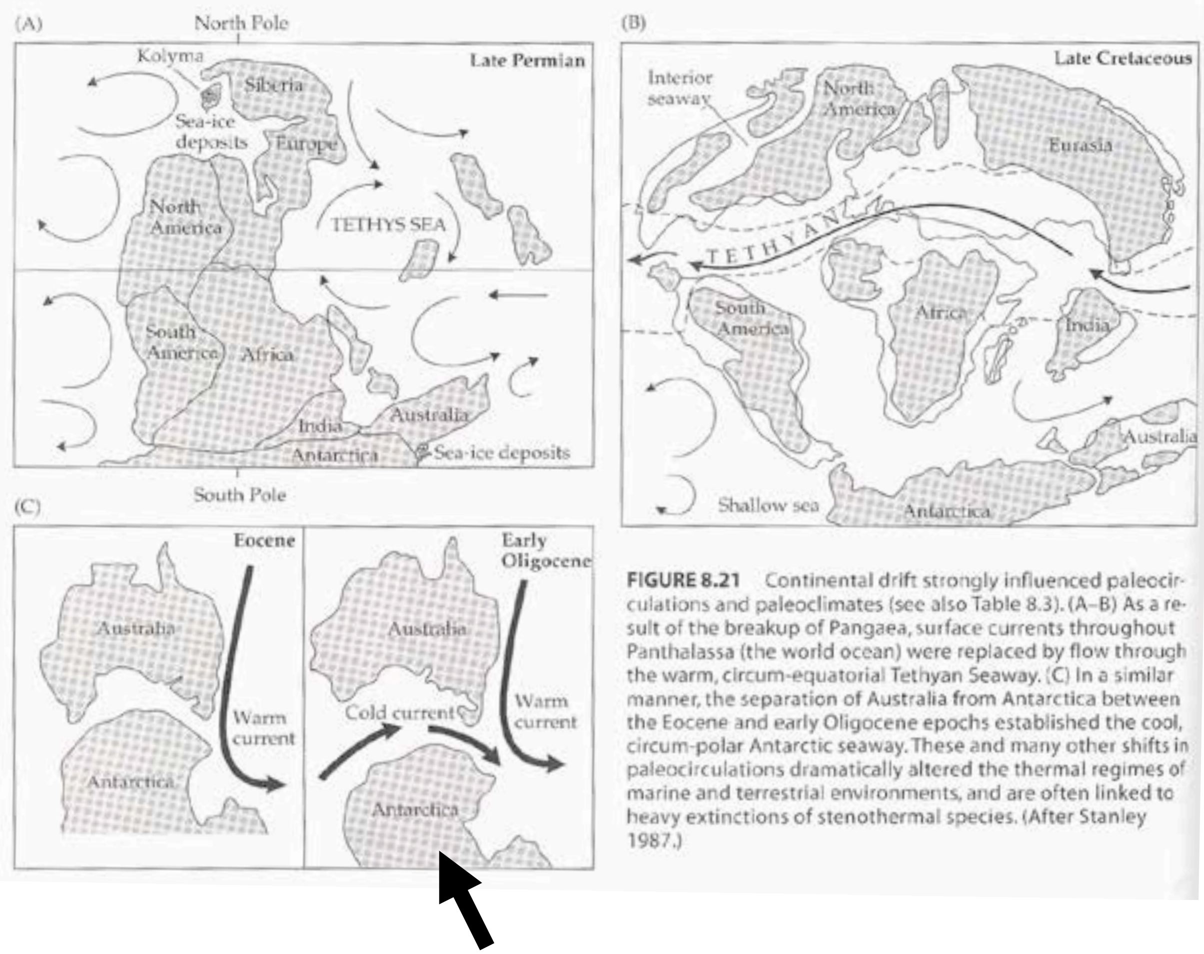


FIGURE 8.21 Continental drift strongly influenced paleocirculations and paleoclimates (see also Table 8.3). (A–B) As a result of the breakup of Pangaea, surface currents throughout Panthalassa (the world ocean) were replaced by flow through the warm, circum-equatorial Tethyan Seaway. (C) In a similar 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.)

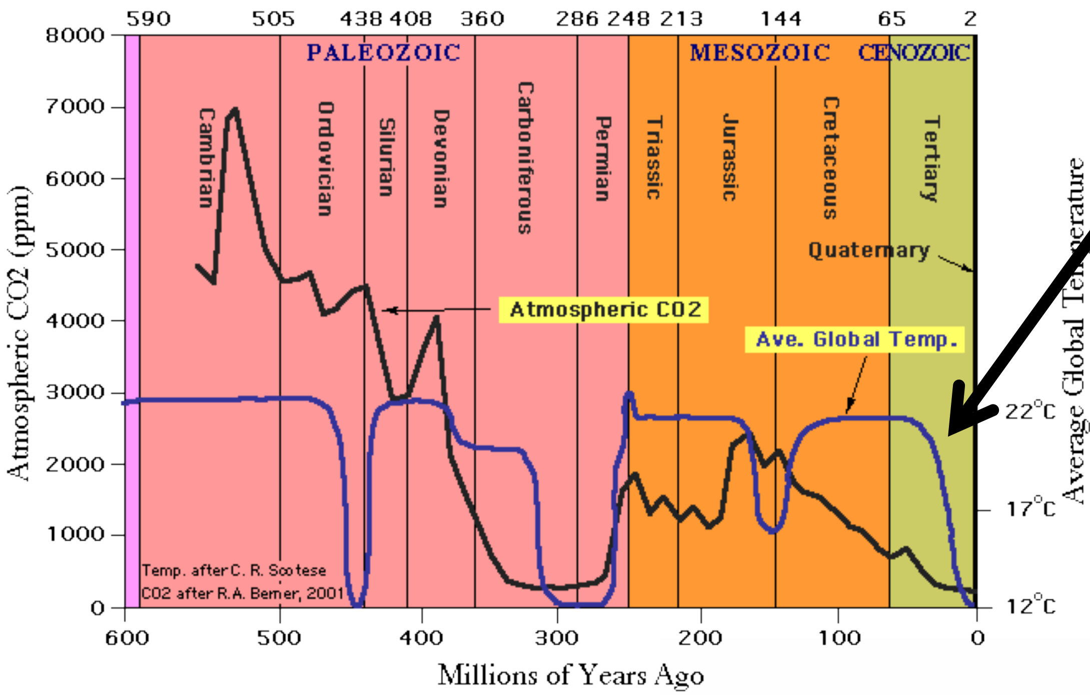
Cooling of Antarctica

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

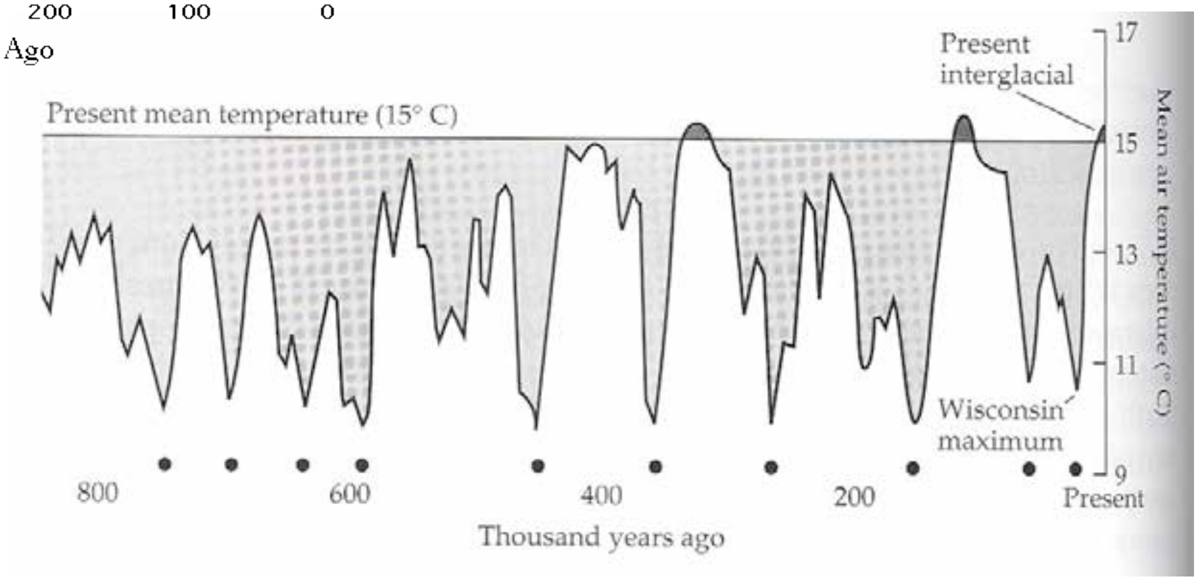
Transition to Quaternary: Shocks to biota



slow cooling

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

rapid oscillations



Lomolino et al., 2006

Biological tools for assessing past climate
Palynology

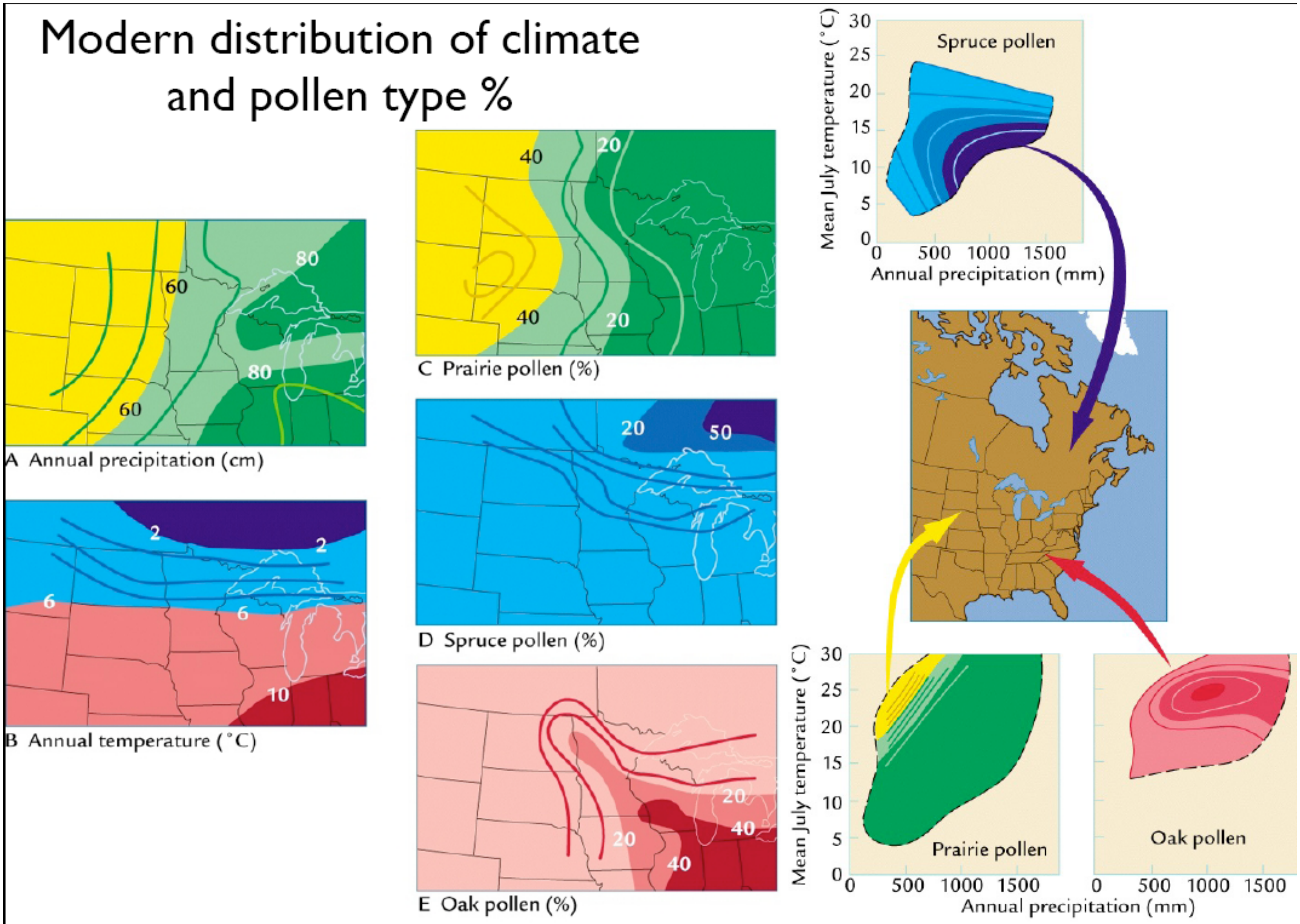


Image Credit: *Earth's Climate* by W. Ruddiman

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

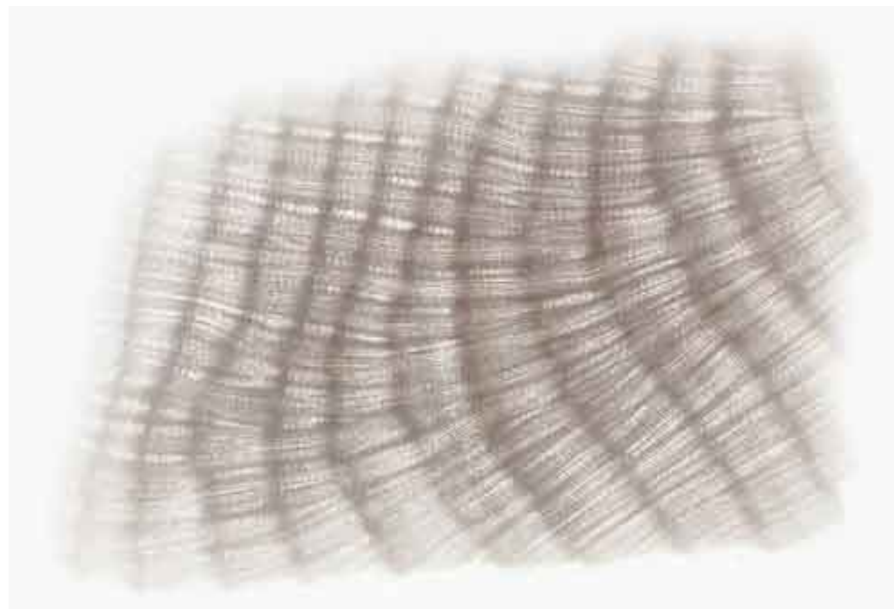
Biological tools for assessing past climate

Tree rings and coral bands

up to ~10,000 years ago

en.wikipedia.org/wiki/Tree_rings

hundreds of years



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

Position of ice sheets, exposed land during LGM

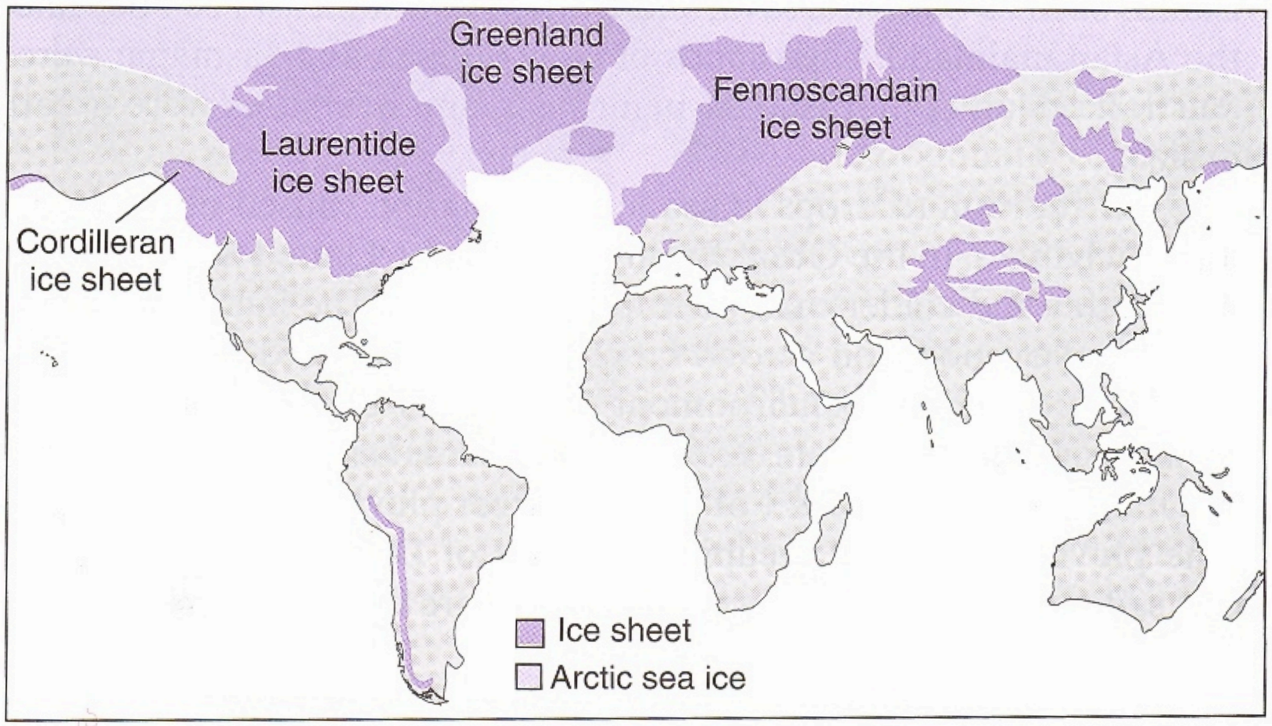


FIGURE 7.7 The location of major ice sheets and major areas of continental shelf exposed due to lower sea levels (eustatic sea-level changes) during the last glacial maximum (after Roberts, 1989).

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

Regional temperature effects during glacial periods

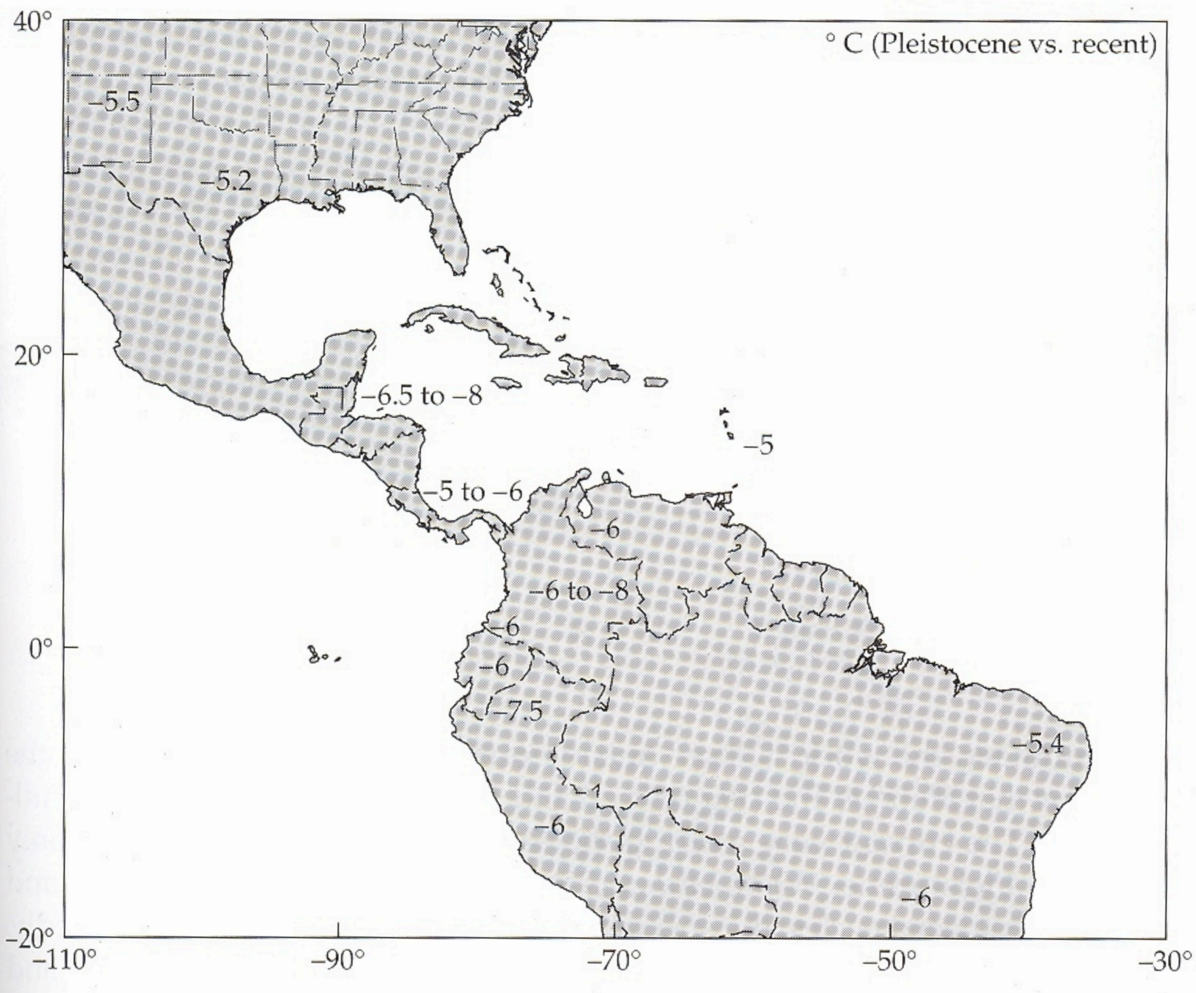
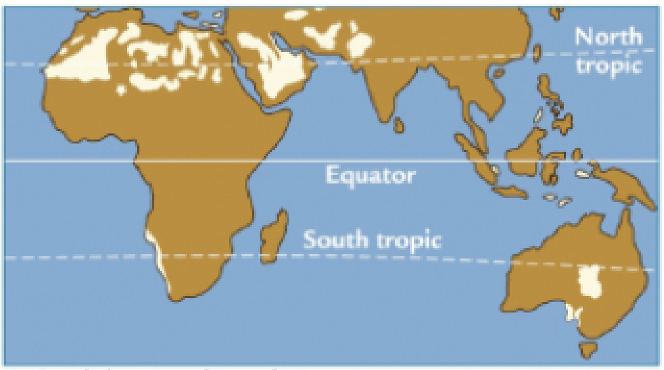


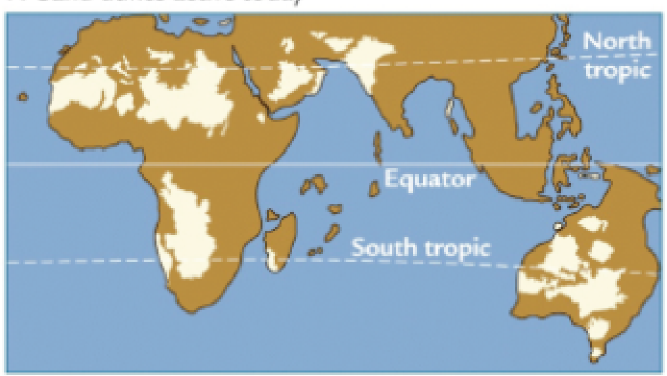
FIGURE 9.7 Glacial cycles of the Pleistocene influenced regional climates far from the edges of the glaciers. Temperatures over much of North and South America, for example, ranged from 4° to 8° C cooler during the Wisconsin. (After Stute et al. 1995.)

Lomolino et al., 2006

Overall, the world was drier as well



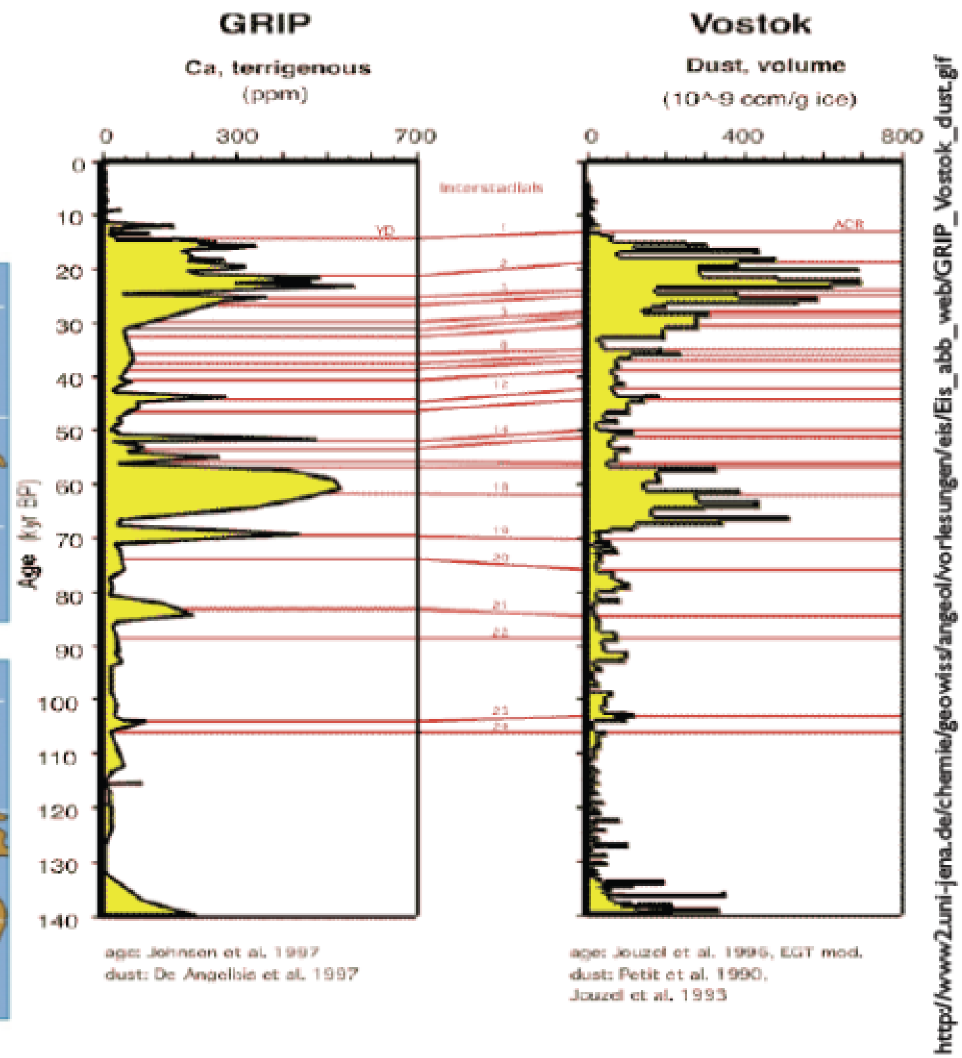
A Sand dunes active today



B Sand dunes active at glacial maximum

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

Dust measured in ice cores



Slide courtesy C. Still

Utah during the LGM - definitely not drier!

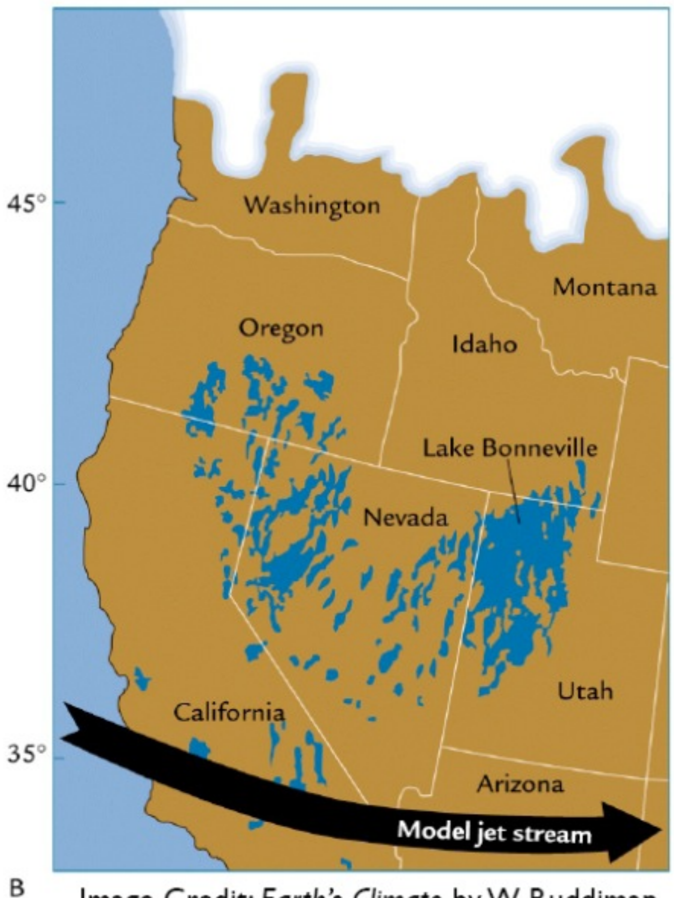
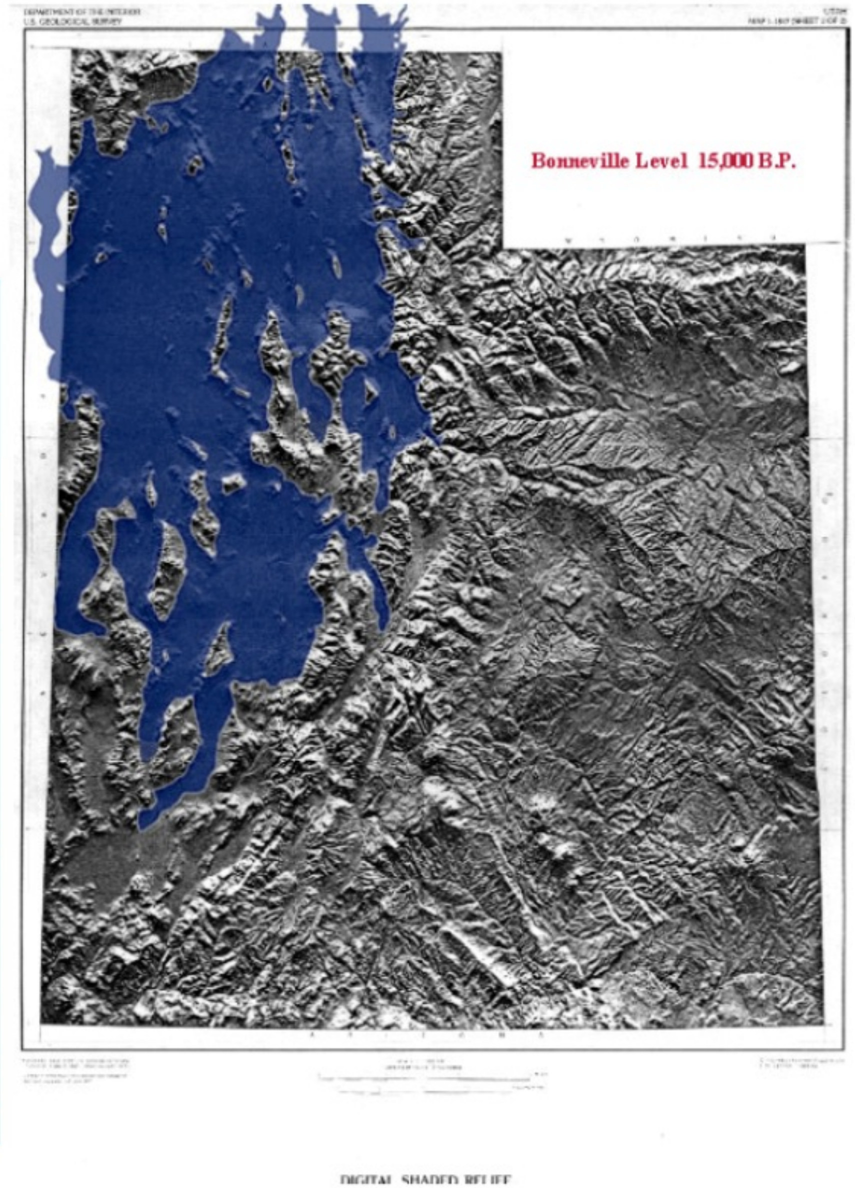


Image Credit: *Earth's Climate* by W. Ruddiman



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

Slide courtesy C. Still

Eustatic sea level change

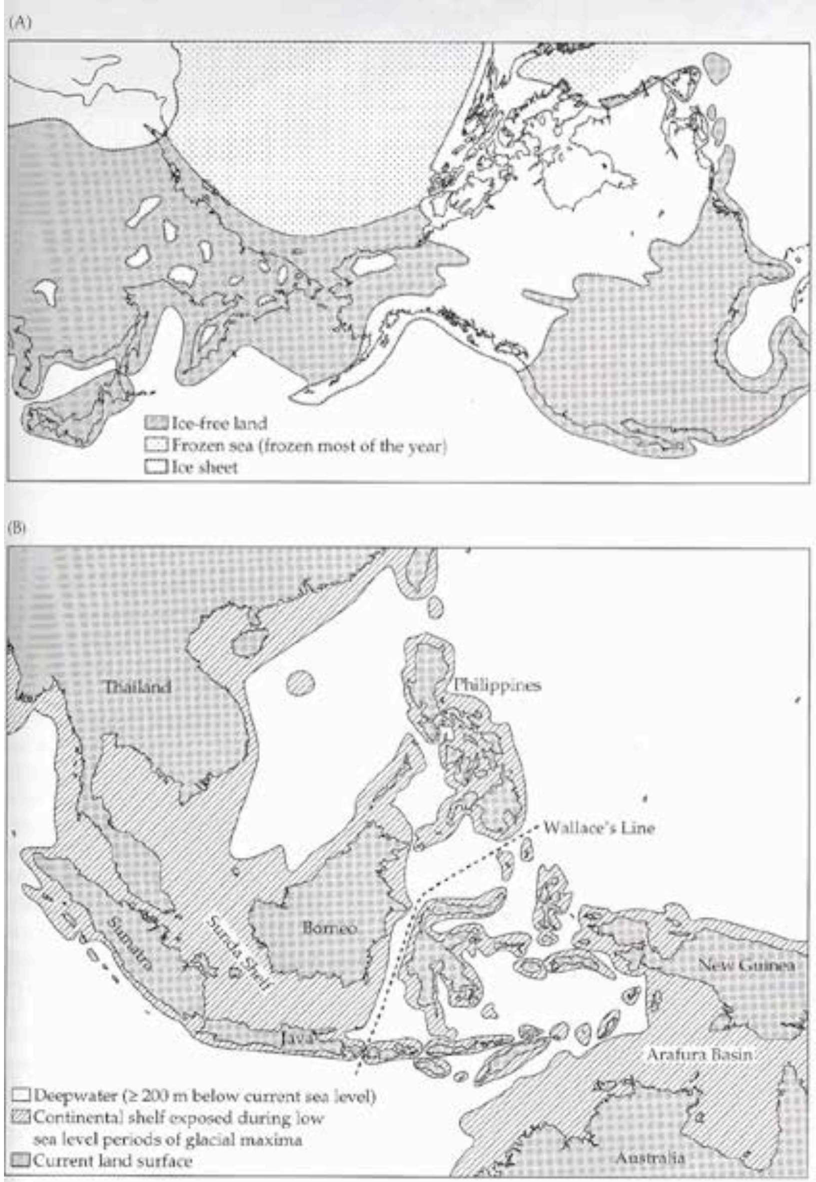


FIGURE 9.9 Glaciation during the Pleistocene resulted in the lowering of sea levels by 100 m to as much as 160 m below their current levels. As a result, many terrestrial regions and associated biotas now isolated by oceanic barriers were connected during glacial maxima. (A) Beringia connected North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

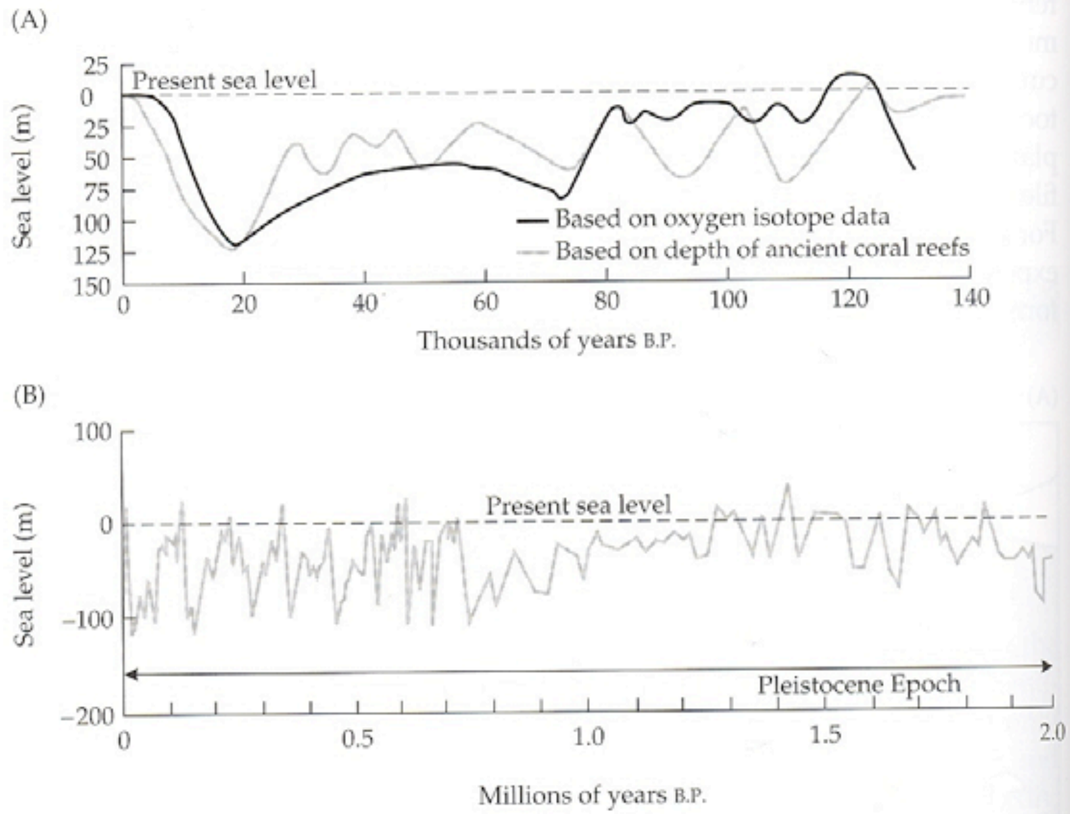
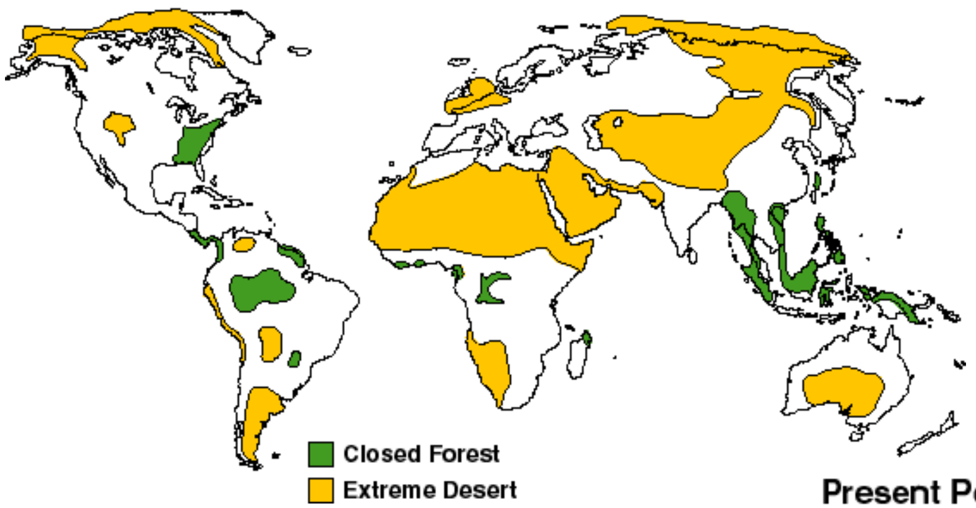


FIGURE 9.10 (A) Changes in global sea level during the past 140,000 years based on oxygen-isotope data (black line) from analysis of benthic foraminifers found in deep sea cores of the Caribbean, and raised coral reefs (gray line) in New Guinea. In addition to these global (or eustatic) changes in sea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

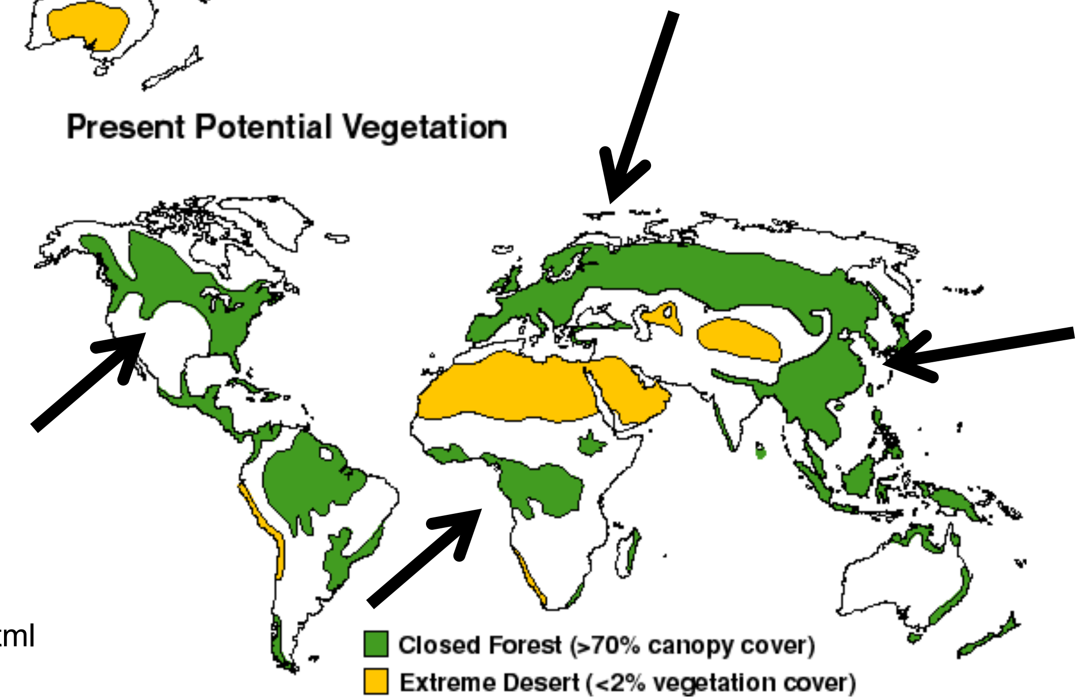
"LGM"

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



Differences in vegetation types

Present Potential Vegetation



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

Vegetation cover changes from LGM to present in Europe

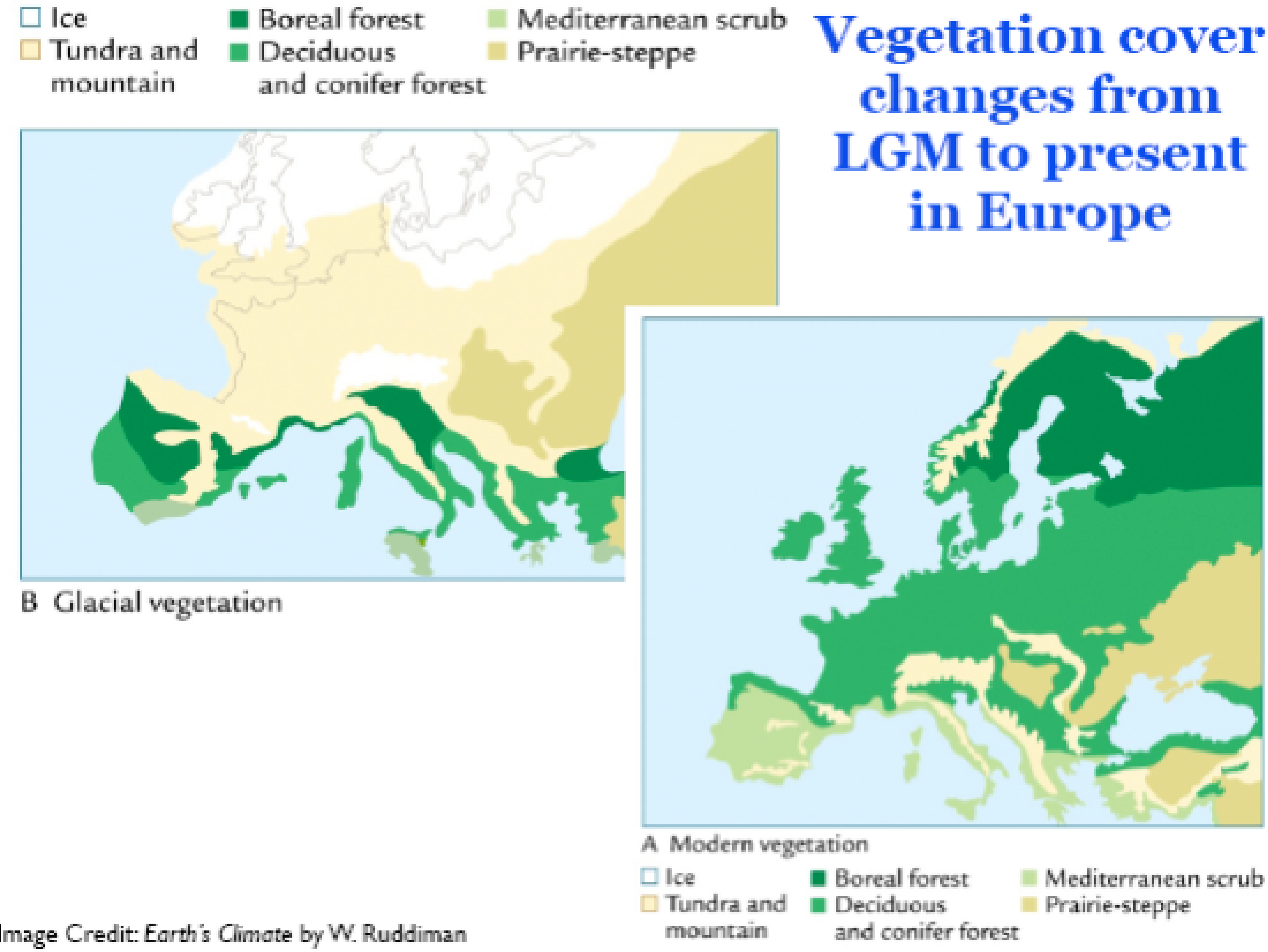
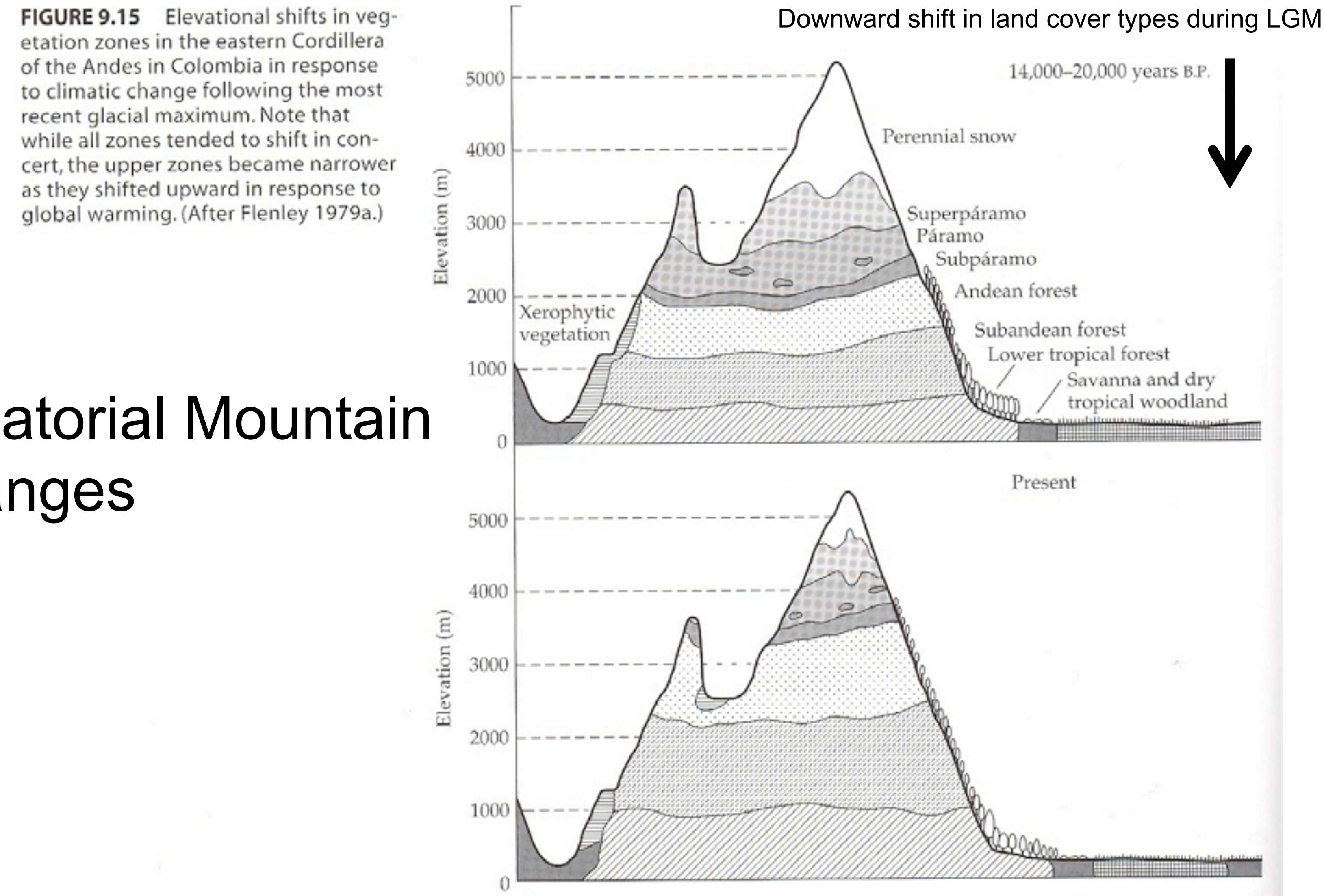


Image Credit: *Earth's Climate* by W. Ruddiman

Slide courtesy C. Still

Equatorial Mountain Changes



Lomolino et al., 2006

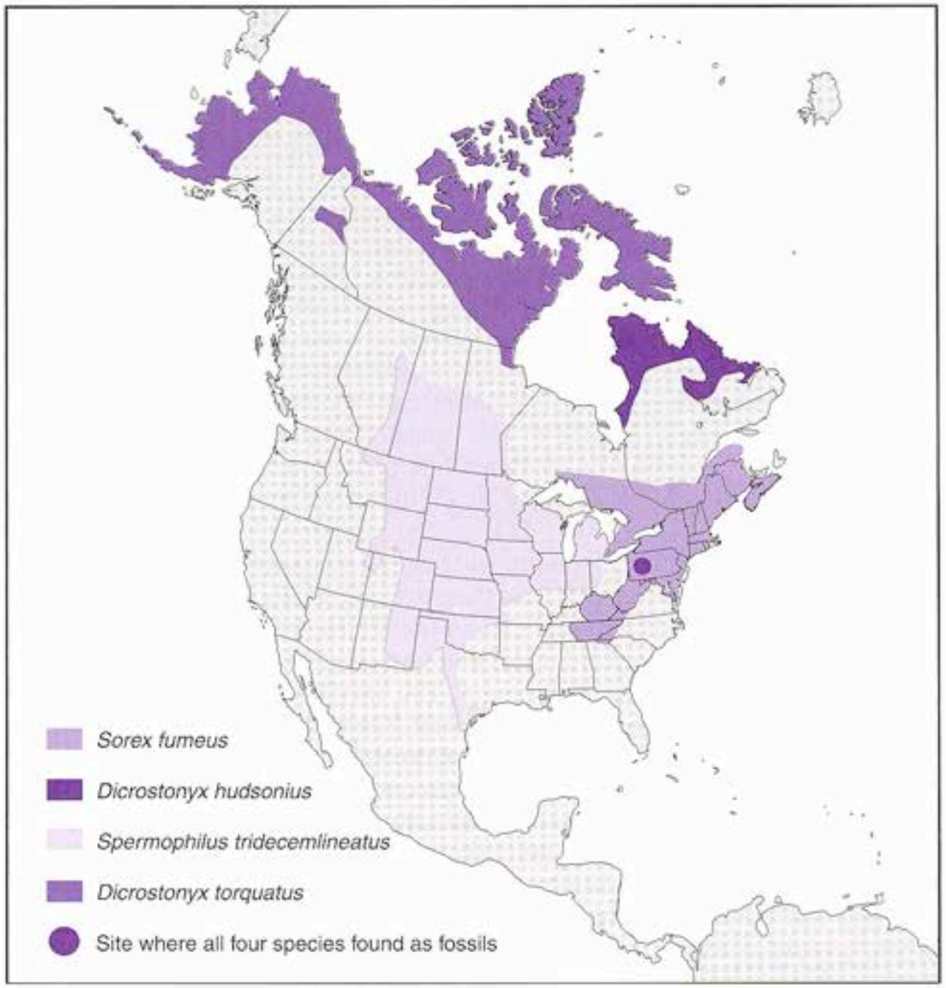


FIGURE 7.8 The modern distributions of eastern shrew *(Sorex fumens)*, eastern collared lemming *(Dicrostonyx hudsonius)*, prairie ground squirrel *(Spermophilus tridecemlineatus)*, and western collared lemming *(Dicrostonyx torquatus)*, and a site in Pennsylvania where fossil evidence indicates that 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

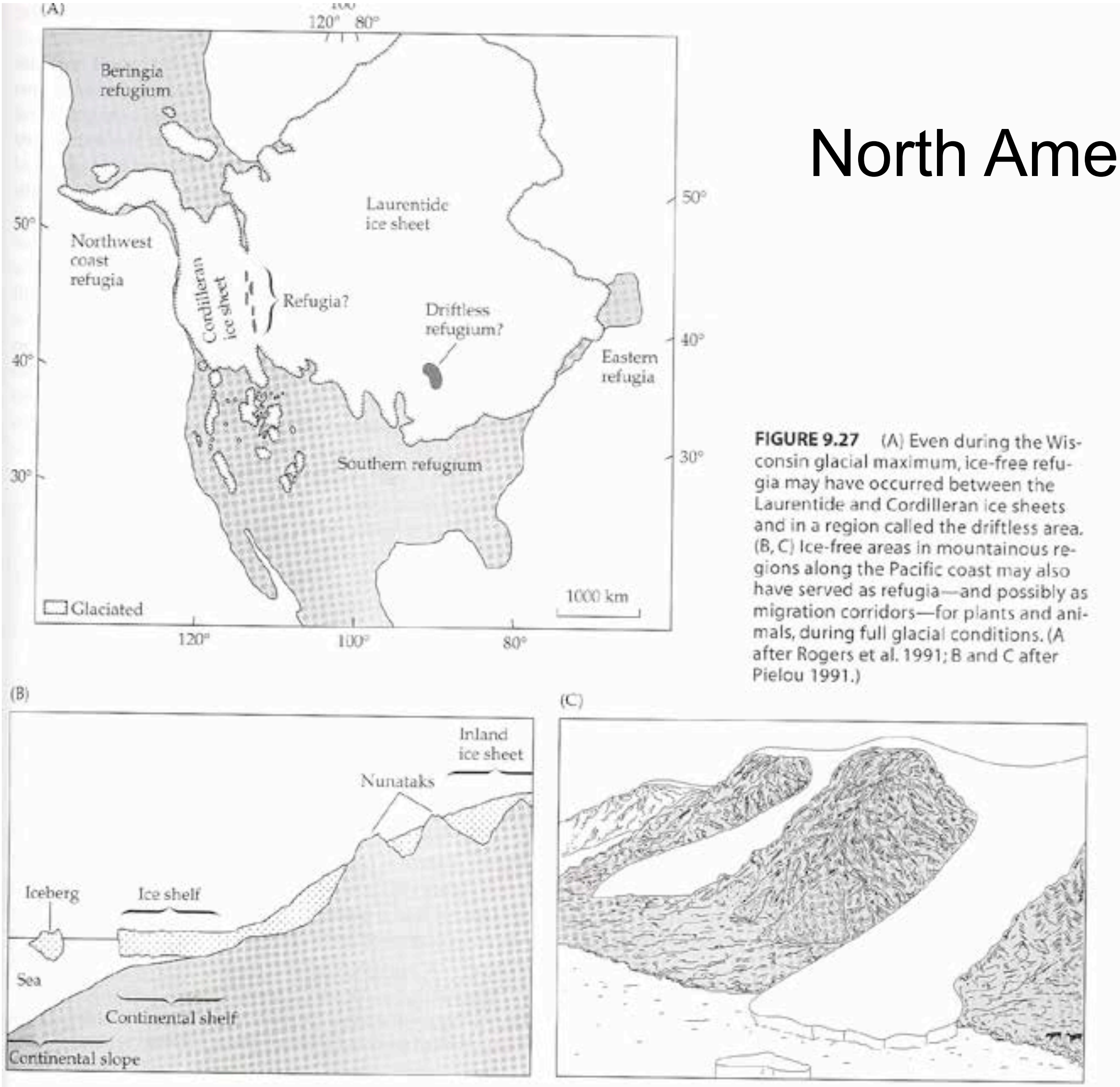


FIGURE 9.27 (A) Even during the Wisconsin glacial maximum, ice-free refugia may have occurred between the Laurentide and Cordilleran ice sheets and in a region called the driftless area. (B, C) Ice-free areas in mountainous regions along the Pacific coast may also have served as refugia—and possibly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