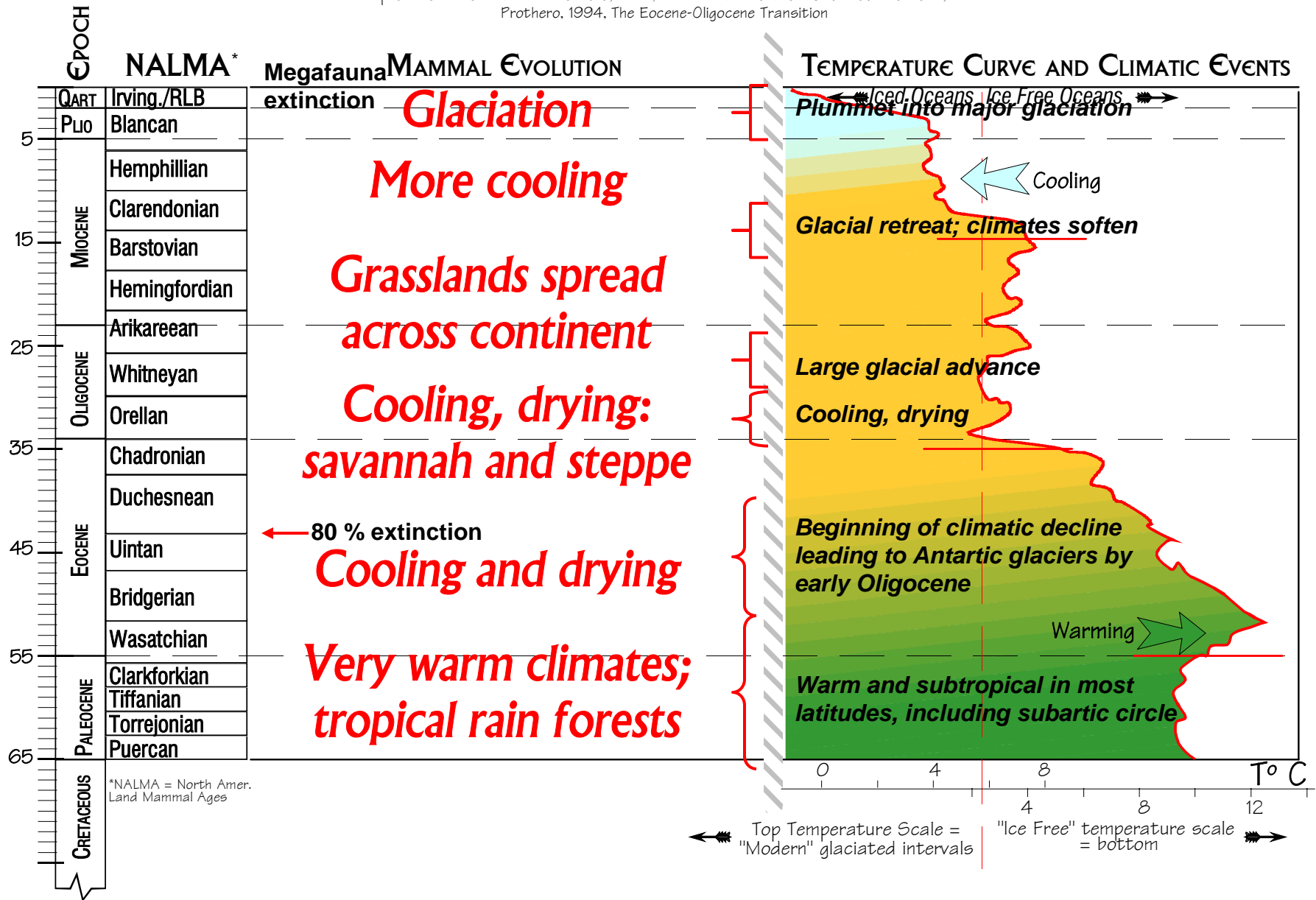


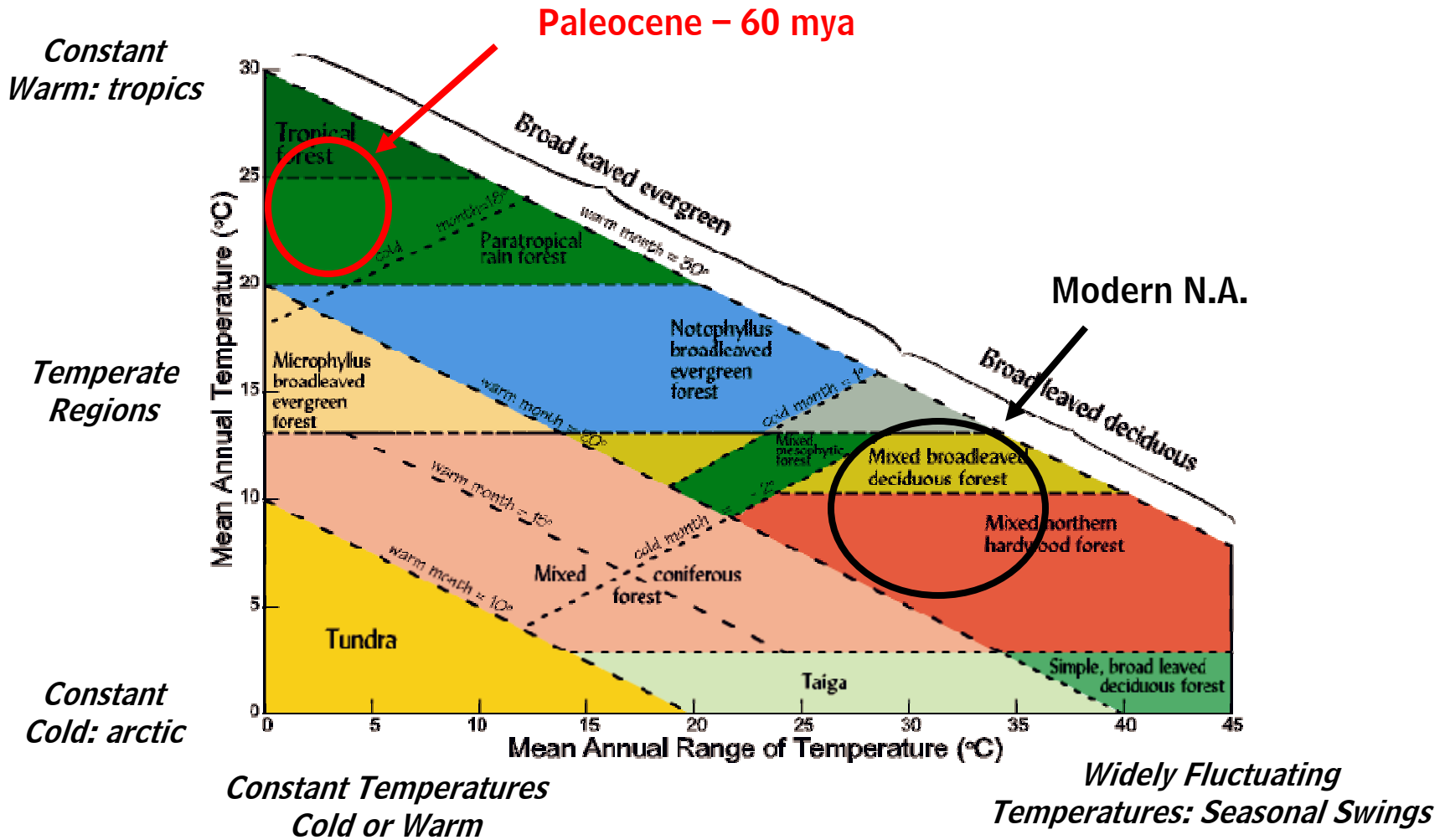
**65 *Million Years*
of Climate
*Change***

CENOZOIC FAUNAL AND CLIMATIC EVOLUTION

Adapted from two charts in Prothero, 1994, Mammalian Evolution: Short Course No. 7, and Prothero, 1994, The Eocene-Oligocene Transition



VEGETATION TYPES AND CLIMATES

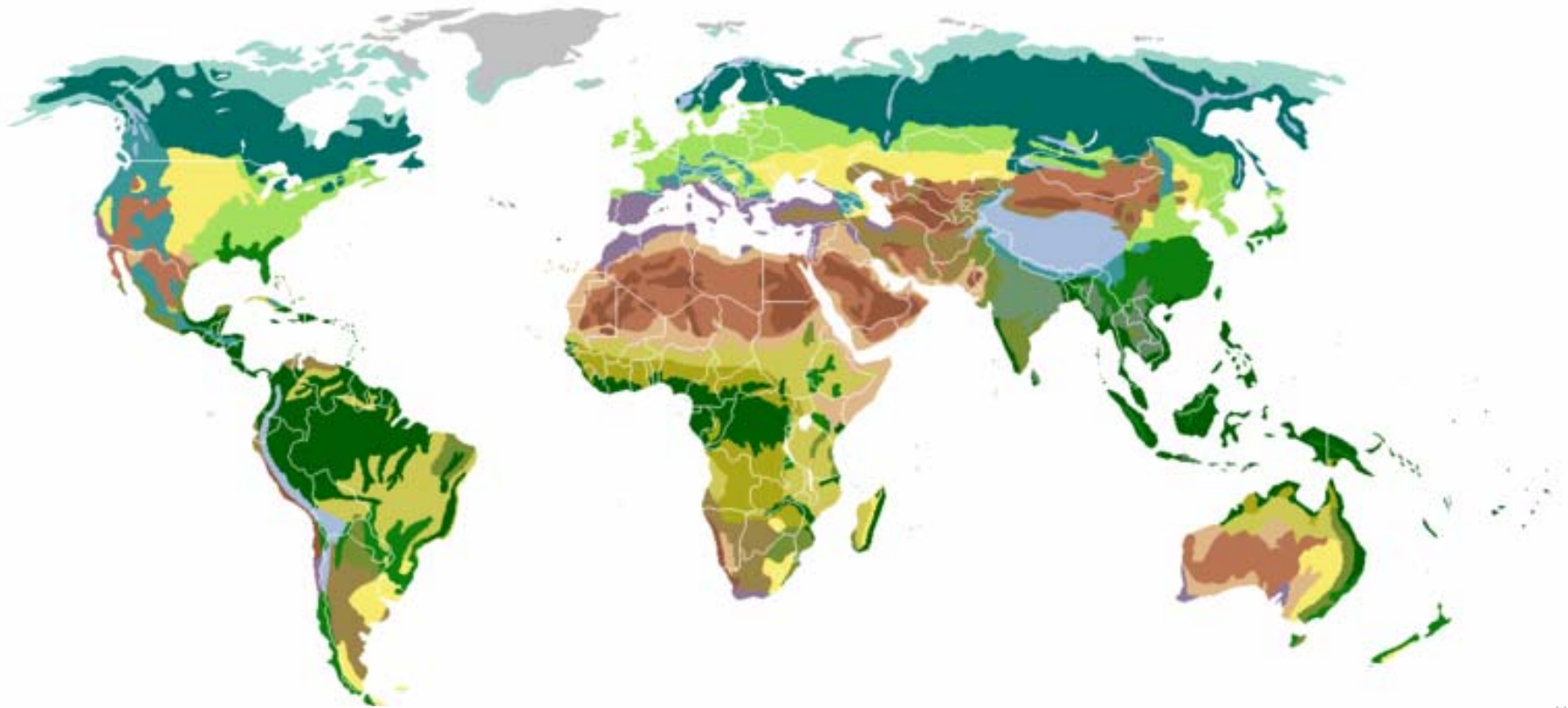


Plot of mean annual temperature versus mean annual range of temperature for different climatic and vegetative types. Note that mean annual temperature and warm month means (long dashed lines; upper left to lower right) are of major significance in determining what vegetation prevails. Only two cold month means (short dashed lines; lower left to upper right) are of major significance. The 1° mean separates dominantly broad-leaved evergreen from broad-leaved deciduous forests. When cold month means are between 1° and -2° notophyllous broad-leaved evergreens occur as an understory (Mixed mesophytic forest).

BIOME

A climatically and geographically defined area of ecologically similar communities of plants, animals, and soil organisms, often referred to as ecosystems. Biomes are defined based on factors such as plant structures (such as trees, shrubs, and grasses), leaf types (such as broadleaf and needleleaf), plant spacing (forest, woodland, savanna), and climate. Unlike ecozones, biomes are not defined by genetic, taxonomic, or historical similarities. Biomes are often identified with particular patterns of ecological succession and climax vegetation.

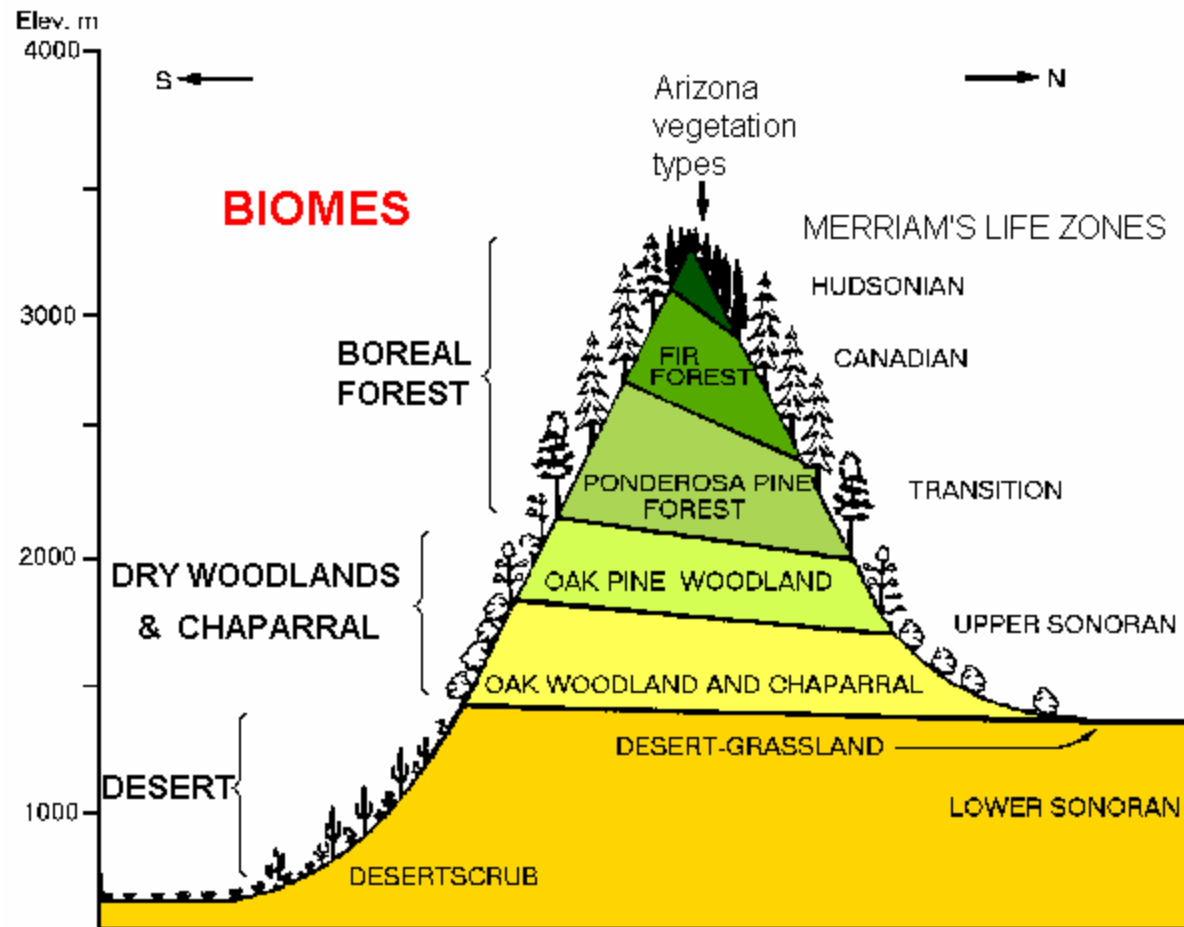
BIOME



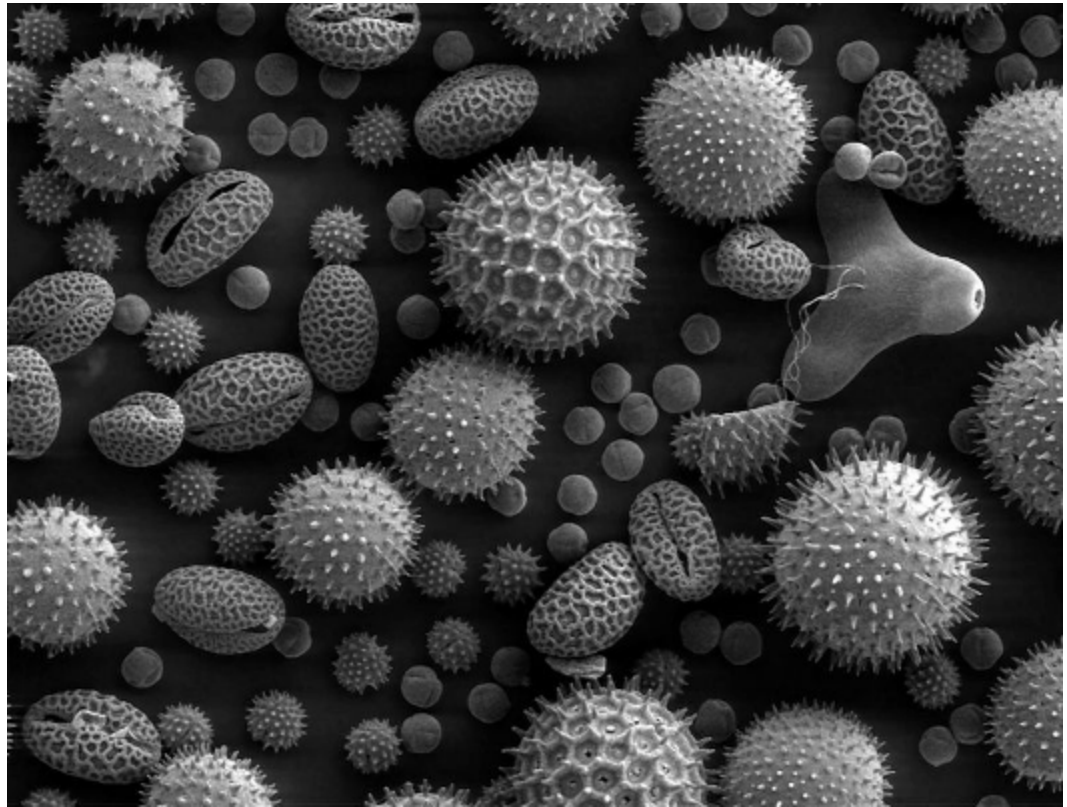
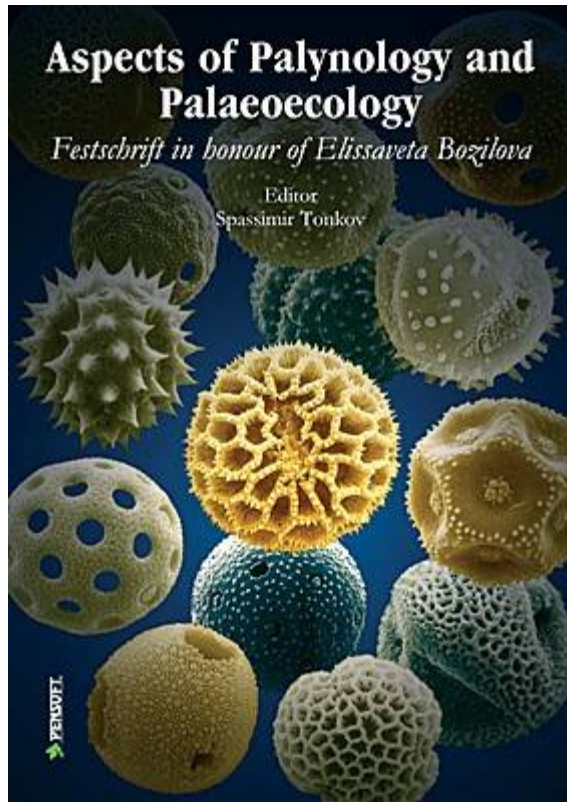
Terrestrial biomes classified by vegetation

Ice desert	Mediterranean	Grass savanna
Tundra	Monsoon forest	Tree savanna
Taiga	Desert	Subtropical dry forest
Temperate broadleaf	Xeric shrubland	Tropical rainforest
Temperate steppe	Dry steppe	Alpine tundra
Subtropical rainforest	Semidesert	Montane forests

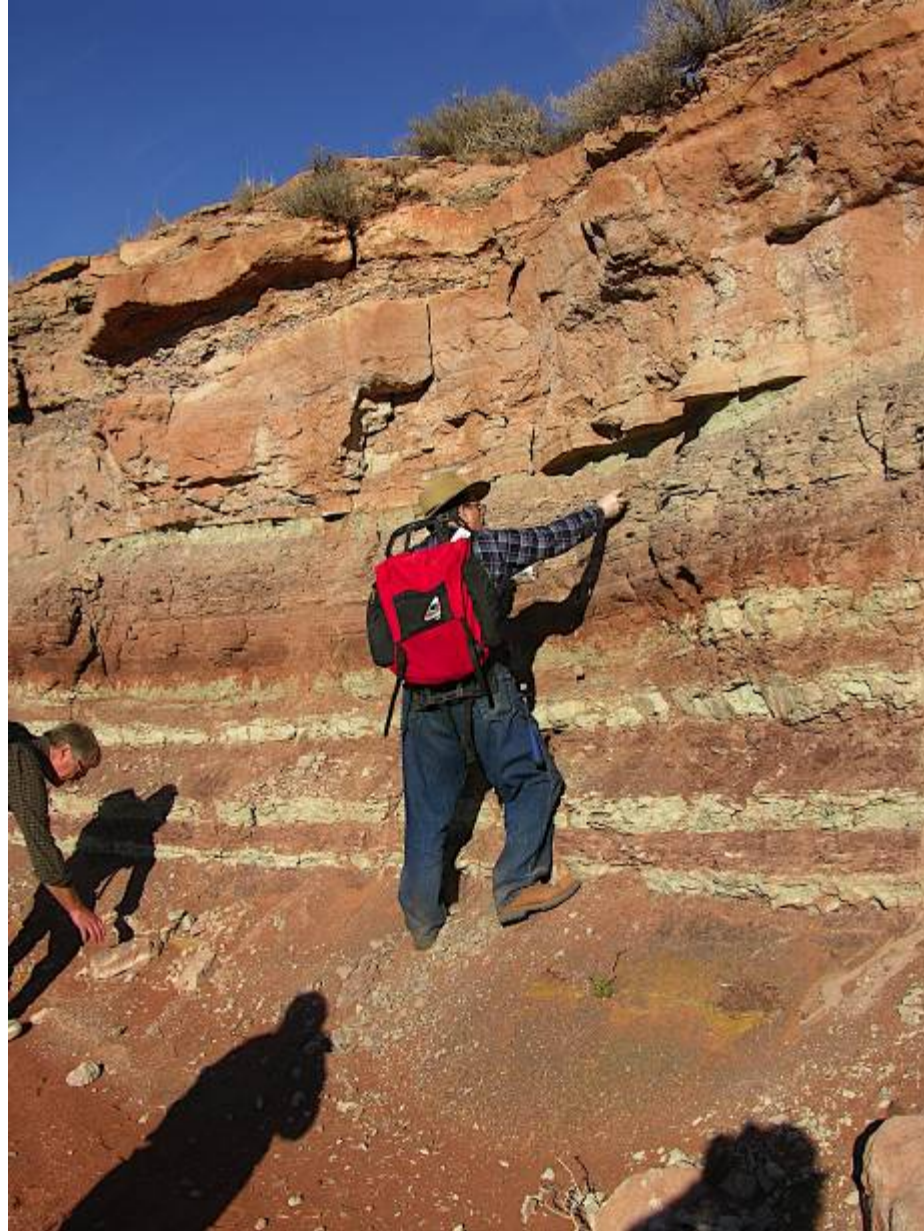




Palynology



Palynology



Palynology

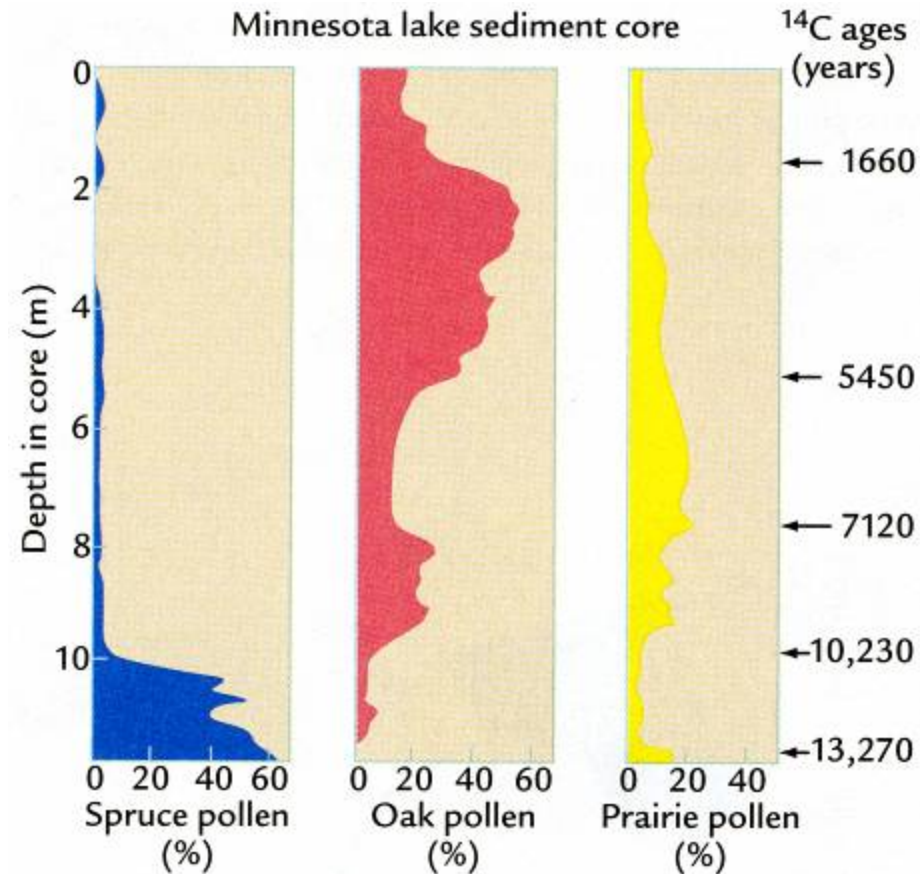
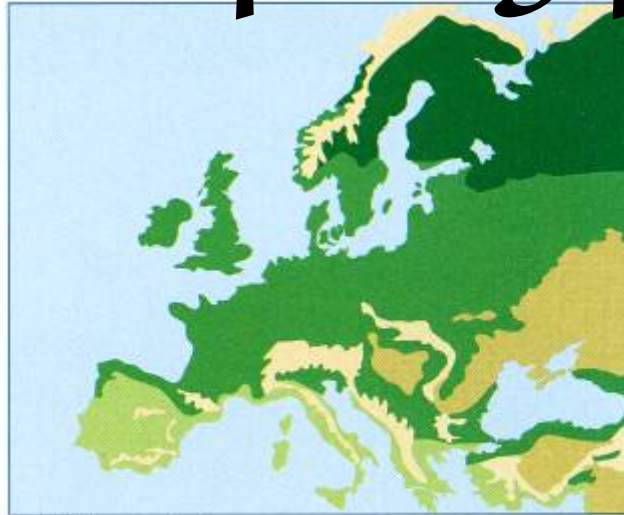
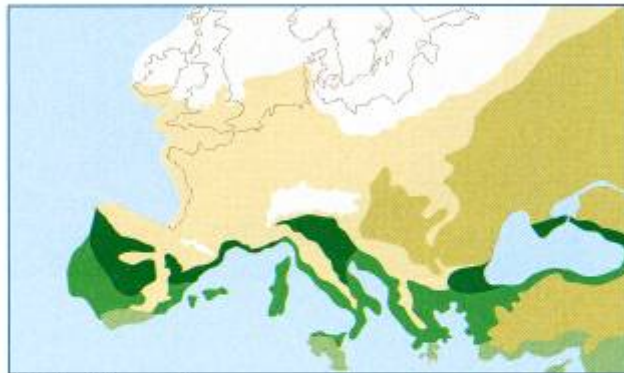
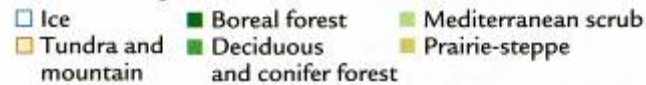


FIGURE 12-9 Pollen in a lake core A ¹⁴C-dated sediment core from a Minnesota lake shows a transition in climate near 10,000 years ago from colder conditions (abundant spruce) to a warmer climate (abundant oak). High percentages of prairie grasses near 6000 years ago indicate a drier climate. (Adapted from H. E. Wright et al., "Two Pollen Diagrams from Southeastern Minnesota: Problems in the Late- and Postglacial Vegetation History," *Geological Society of America Bulletin* 74 [1963]: 1371-96.)

Palynology



A Modern vegetation

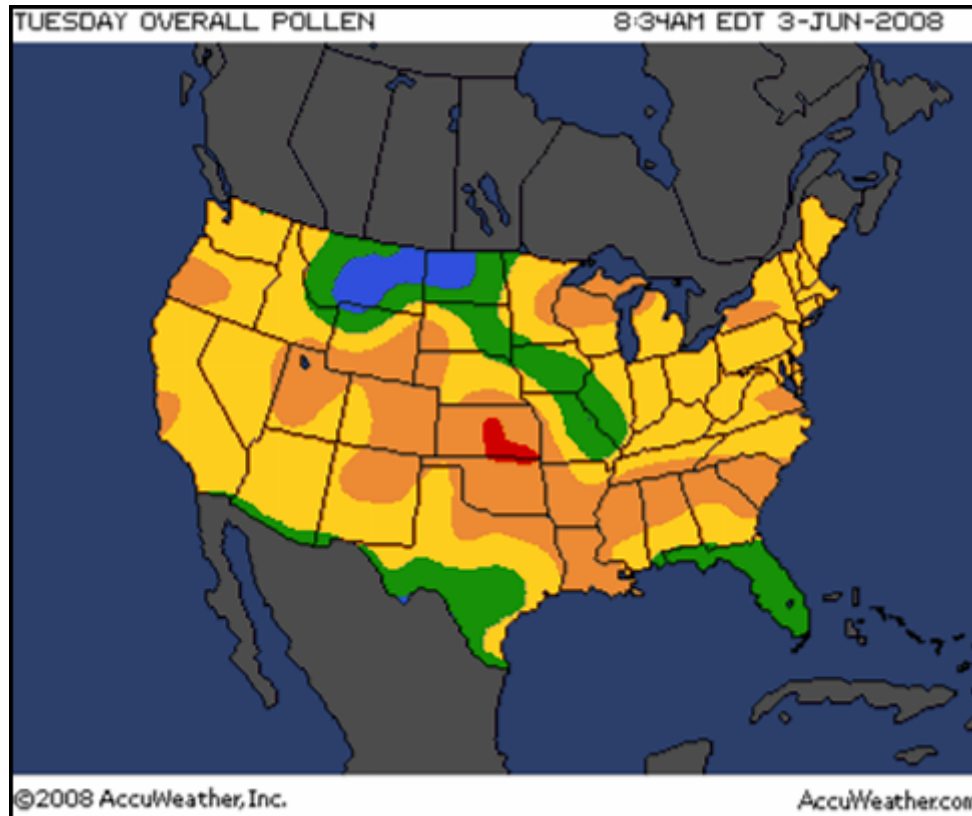


B Glacial vegetation

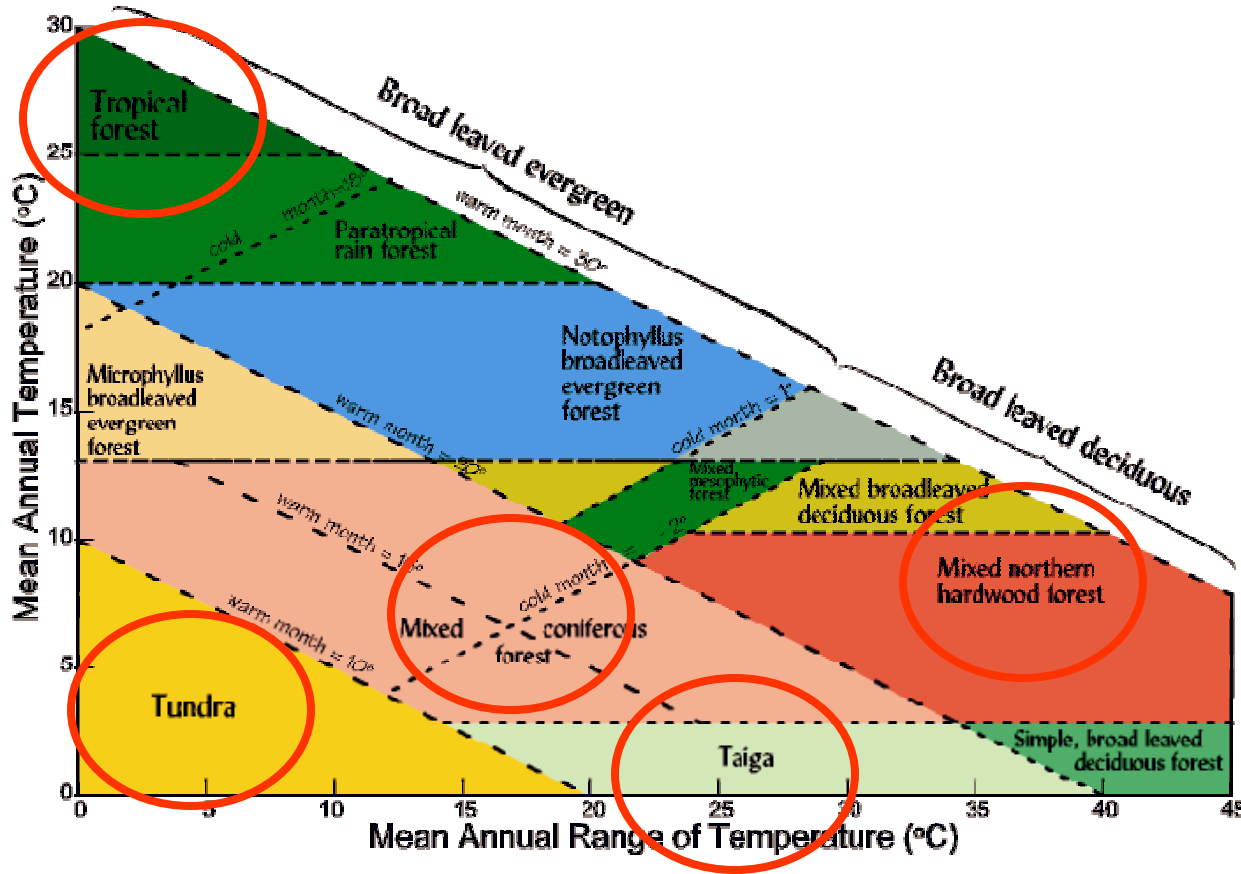
FIGURE 12-15 Glacial north-central Europe was treeless

(A) Vegetation in modern Europe is dominated by forest, with conifers in the north and deciduous trees to the south. (B) At the glacial maximum, Arctic tundra covered a large area south of the ice sheet, with grassy steppe farther south and east and patchy forests near the Mediterranean coasts. (Adapted from R. F. Flint, *Glacial and Quaternary Geology* [New York: Wiley, 1971].)

Palynology



VEGETATION TYPES AND CLIMATES



- Tropical Rain Forest
- Hardwood deciduous forest
- Mixed coniferous/deciduous
- Mediterranean scrub, or Chaparral
- Savannah
- Steppe
- Taiga - Boreal
- Tundra

Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.
Tropical Rain Forests



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Tropical Rain Forest

Transitional complex microphyll-notophyll vine-fern forest (cool subtropical rainforest) on basalt



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

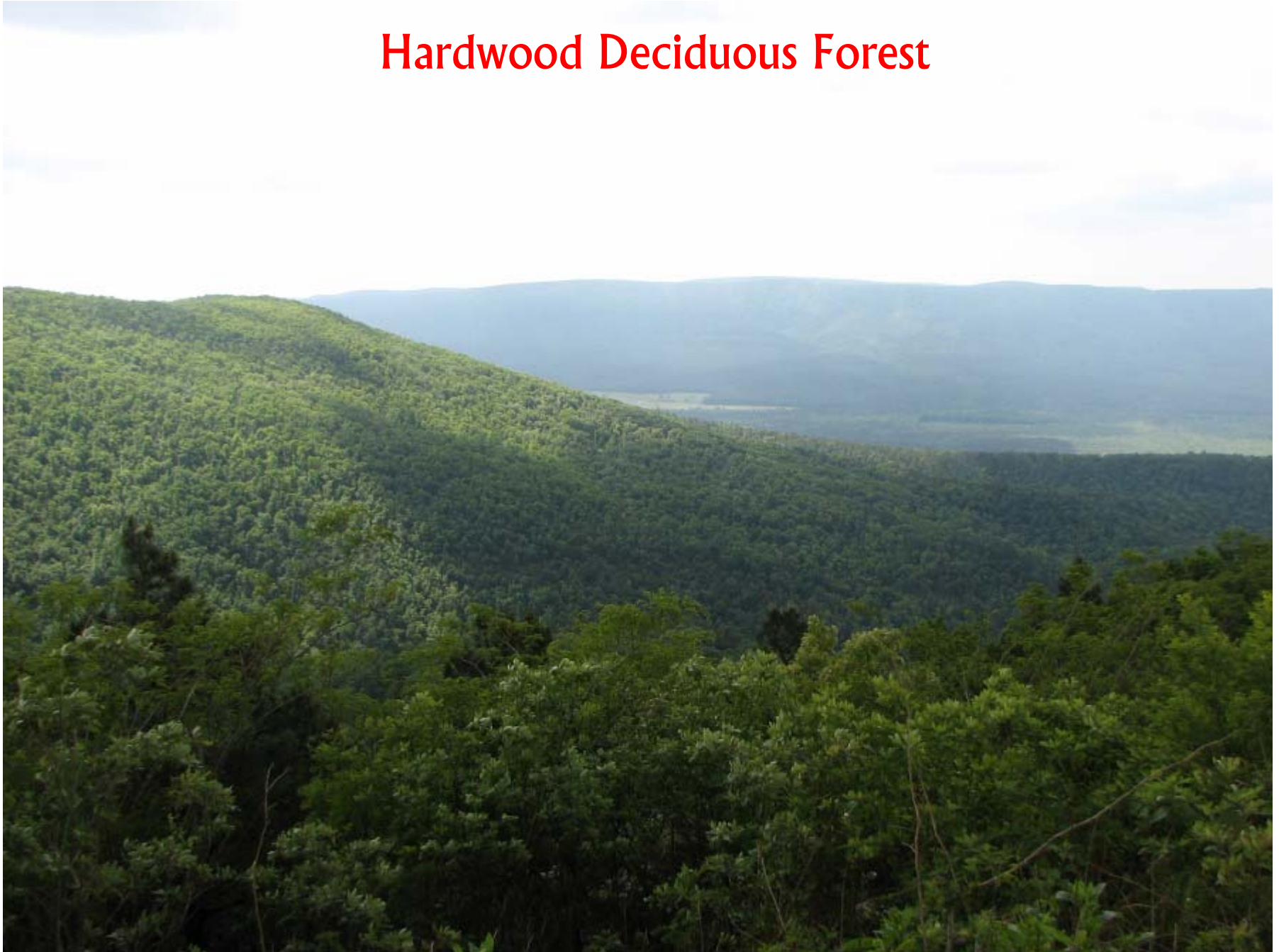
Hardwood Deciduous Forest



Mix deciduous forest on Aravalli hills

Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Hardwood Deciduous Forest



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Hardwood Deciduous Forest



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Mixed Coniferous-Deciduous Forest



Photo: Åke Nilsson

Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Mixed Coniferous-Deciduous Forest



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Mediterranean Scrub/Chaparral



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Mediterranean Scrub/Chaparral



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Mediterranean Scrub/Chaparral



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Mediterranean Scrub/Chaparral



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Savannah
Grassland with scattered trees



<http://www.cfsan.fda.gov/~dms/fscupd32.html>

Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Savannah
Grassland with scattered trees



Savannah Grassland with scattered trees



Limpopo Province South Africa



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Steppe Treeless Grassland

Short grass steppe, Wyoming



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Steppe Treeless Grassland

**Short grass prairie with buffalo in
South Dakota**



Floral Transition from Tropical Rain Forests, to Savannahs and Gallery Forests.

Steppe Treeless Grassland

One of the most abundant antelopes on the Eurasian steppe is the Saiga (*Saiga tatarica*).



The Taiga or Boreal Forest



Taiga or Boreal Forest

Characterized by a climate of long, severe winters and a constant cover of snow, and short, cool summers. The vegetation is dominated by conifers such as spruce, fir, and hemlock. Characteristic animals are elk, moose, mule deer, black bears, and grizzly bears.



Taiga or Boreal Forest



http://www.mountain.ru/photo/2001/osennie_kraski/alb.shtml

Tundra

A treeless area between the icecap and the tree line of Arctic regions, having a permanently frozen subsoil and supporting low-growing vegetation such as lichens, mosses, and stunted shrubs



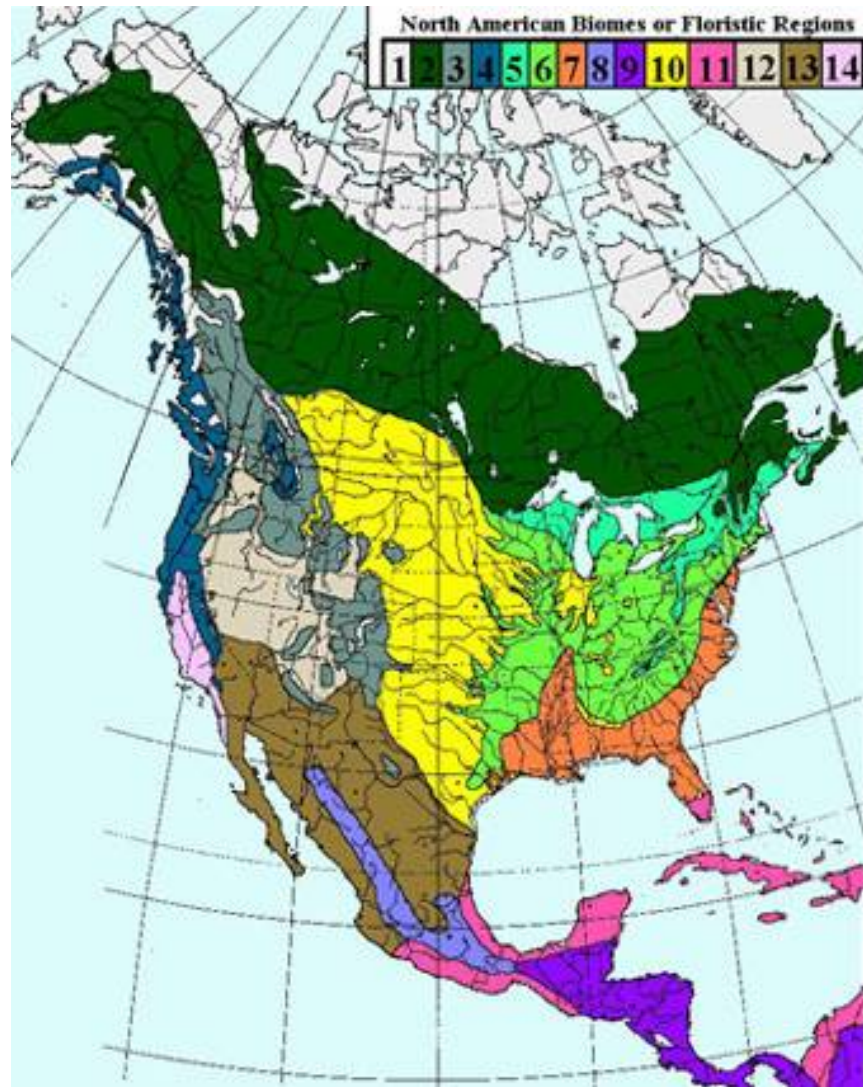
In the Kobuk Valley National Park, Northwest Alaska



Tundra of Alaska



North American Biomes or Floristic Regions													
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Tundra	Taiga	Mountain Forest		Temperate Deciduous Forest		Mountain Forest	Tropical Rain Forest		Grasslands and Savannas		Deserts and Semideserts		Mediterranean scrub



Middle-Late Eocene Tropical Rain Forest

35 – 43 mya – before the extinction

North America looked something like this; dense tropical jungles, thick with vegetation. Aquatic animals like crocodilians and turtles are still common (but declining), as well as tree climbing primates. Most animals are relatively small and the ancestors to hoofed animals (artiodactyls and perissodactyls) are present.



Temperate Forest

Oligocene

25 – 35 mya

The detritus eroding from the Rocky Mountains along with a drying spell helped create a savannah-like environment in which ungulates (hooved animals with long legs) could come into their own. For the first time there is plenty of grass. Artiodactyls predominate but odd-toed perisodactyls make great strides.

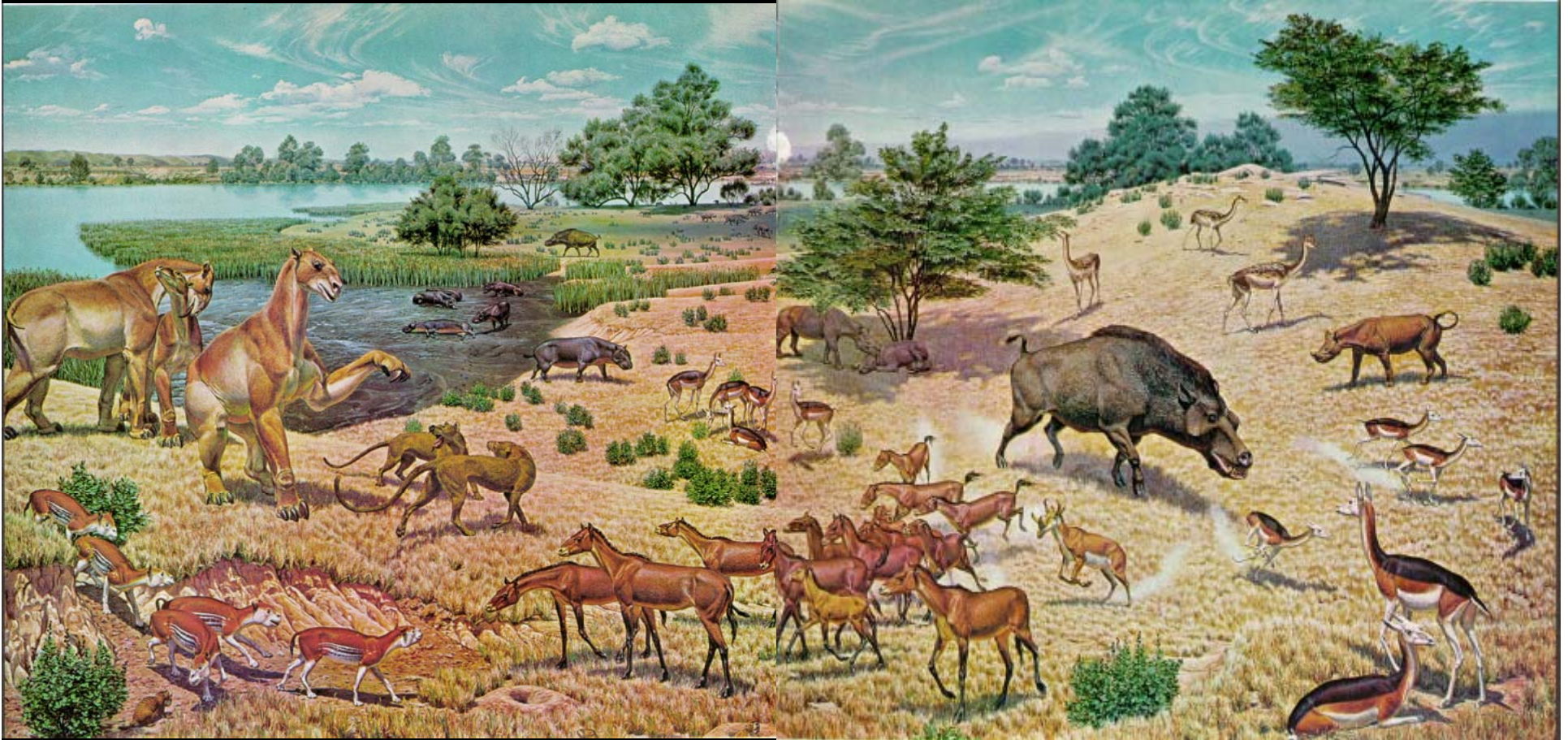


Savannah with Gallery Forests

Early Miocene

25 – 20 mya

Grasses evolved and spread during this time leading to the rise of grassland animals with longer legs and faster running. Browsing dentition shifted to grazing dentition with higher crowns and resistance to the abrasion in the silica rich grasses. Giant animals such as Moropus and the giant (entelodon) pig. Camels, antelopes, and horses are abundant.



Steppe with Gallery Forests

Early Pliocene

12 – 9 mya

The American grasslands support a variety of plains animals, including horses of many kinds, but also rhinos (dying out), camels, pronghorn antelopes, giant pigs, peccarys and shovel tusked mastodons.



Steppe with Gallery Forests

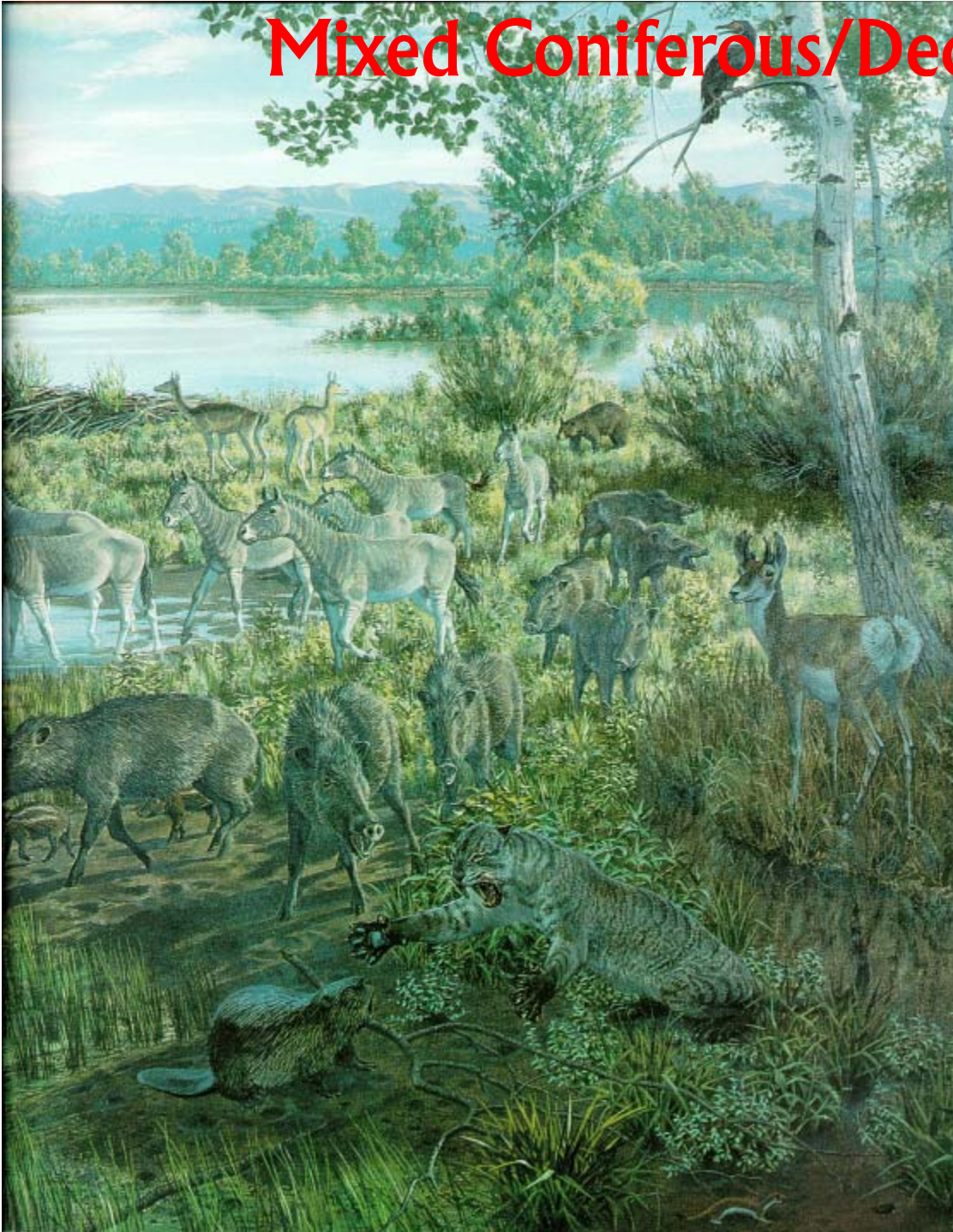
Early Pliocene

12 – 9 mya

The American grasslands support a variety of plains animals, including horses of many kinds, but also rhinos (dying out), camels, pronghorn antelopes, giant pigs, peccarys and shovel tusked mastodons.



Mixed Coniferous/Deciduous Forest

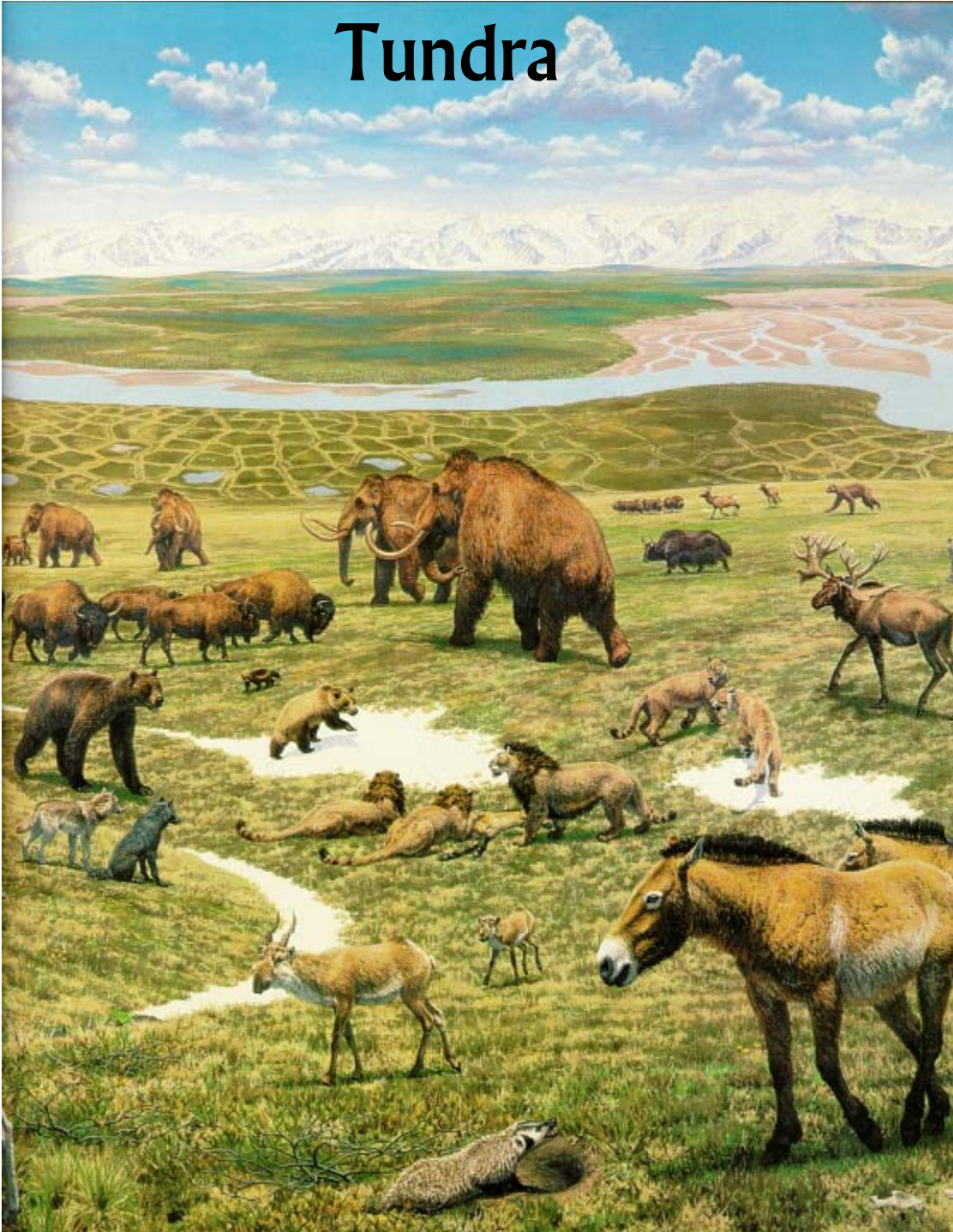


Late Pliocene

3.4 mya

Climate is cooling and more woodland environments are present, especially in the mountain regions (this scene is from southern Idaho). Animals are now adapting to more woodland environments. Most of the animals here are present in the Early Pliocene as well.

Tundra

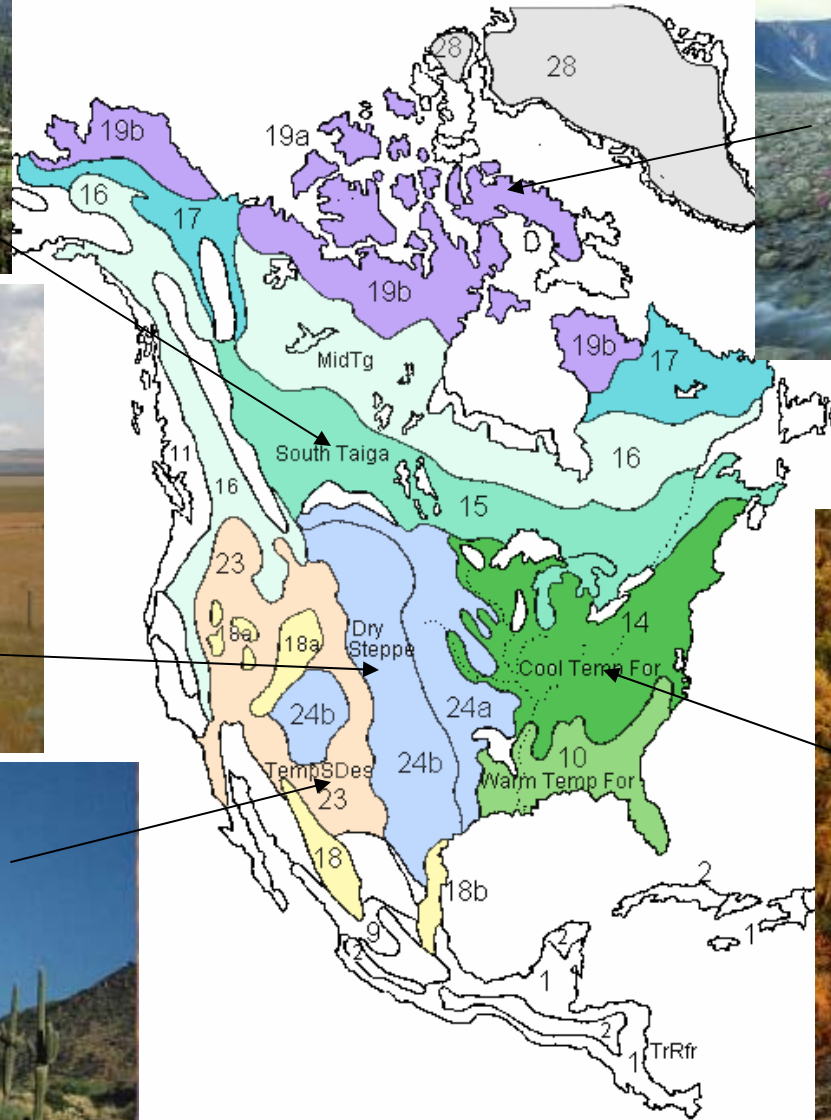


Late Pleistocene

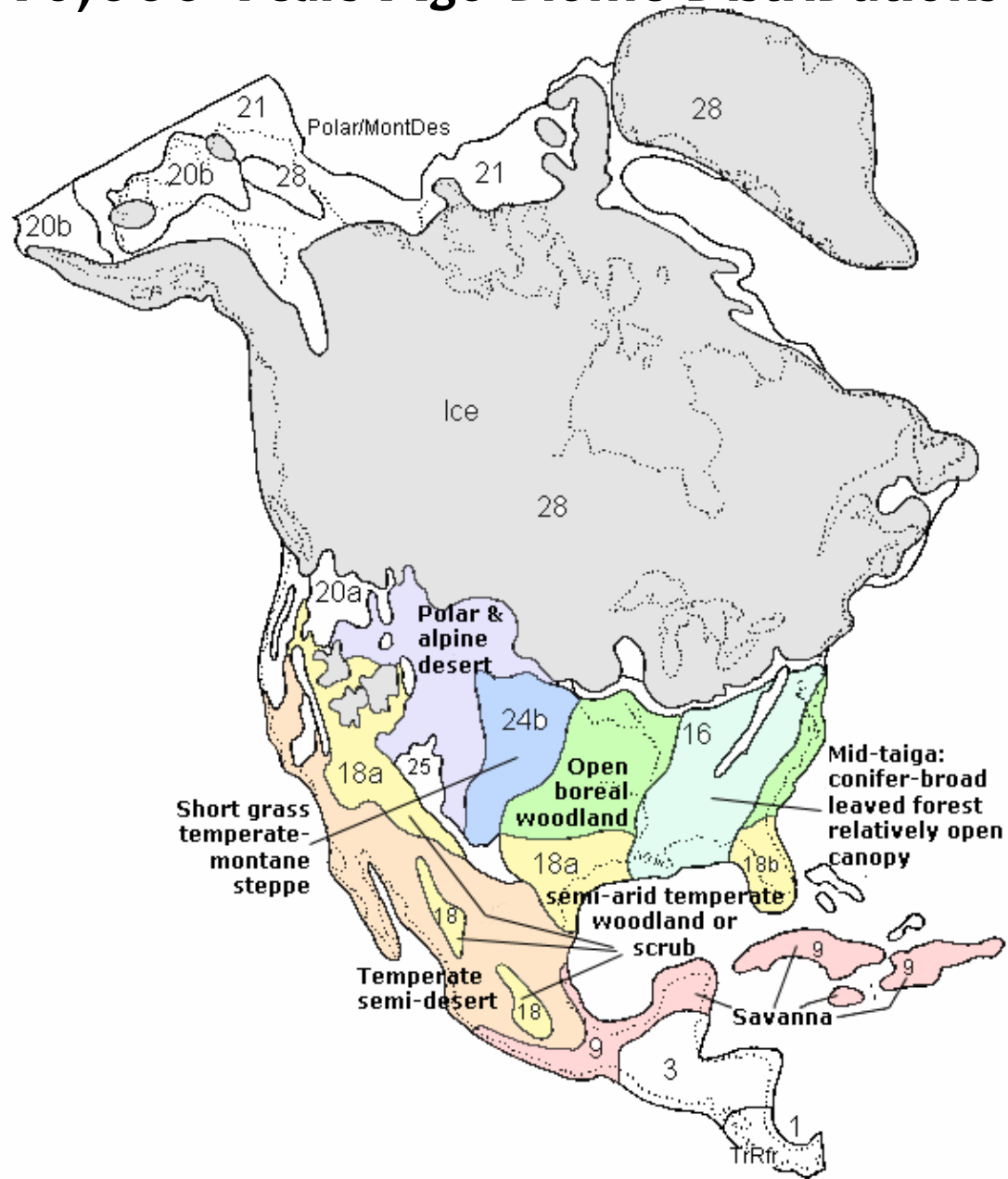
12,000 years ago

This scene is from central Alaska and shows much evidence of the glaciation that is now retreating northward. The patterned ground from frost wedging in permafrost is present, as well as glaciers in the mountains in the back. This represents the Pleistocene megafauna with giant ground sloths, large horned bison, woolly mammoth, mastodons, yak, horses, giant cats, musk ox and elk. Humans are entering North America at this time. Within one or two thousand years most of this fauna will be extinct and America will be greatly impoverished.

Modern Biome Distributions

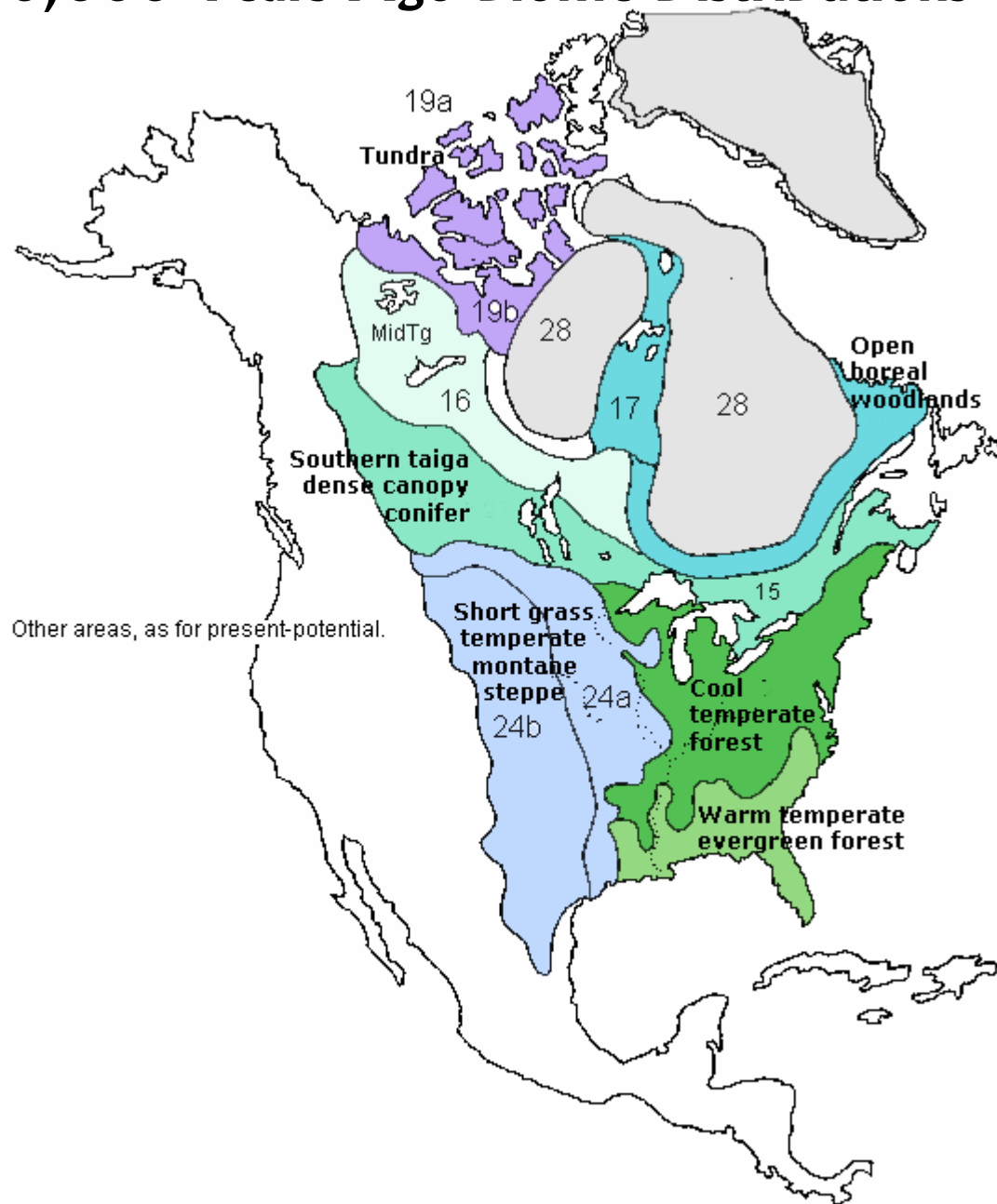


18,000 Years Ago Biome Distributions



Reconstructed vegetation cover, 18000 C14 years ago.

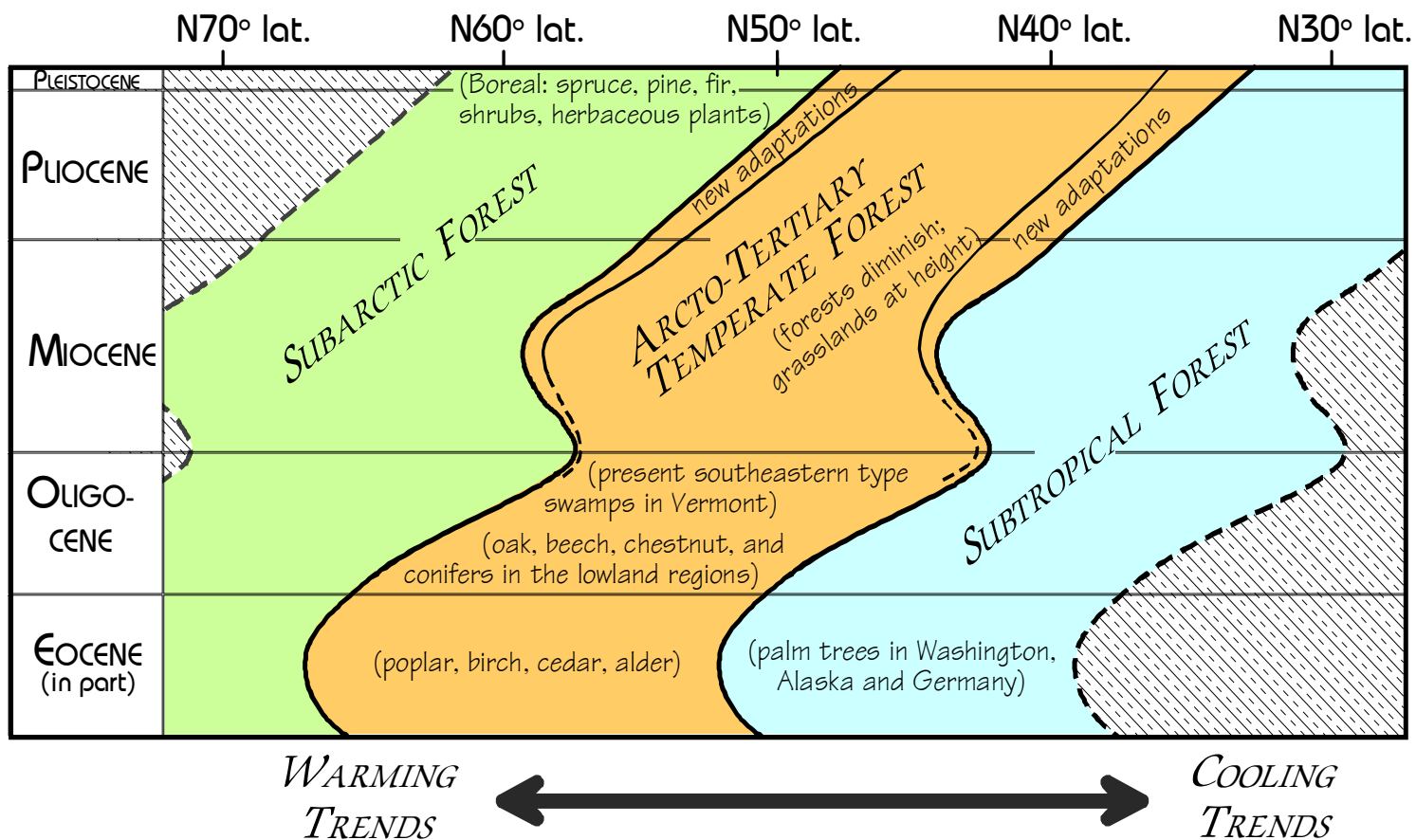
8,000 Years Ago Biome Distributions



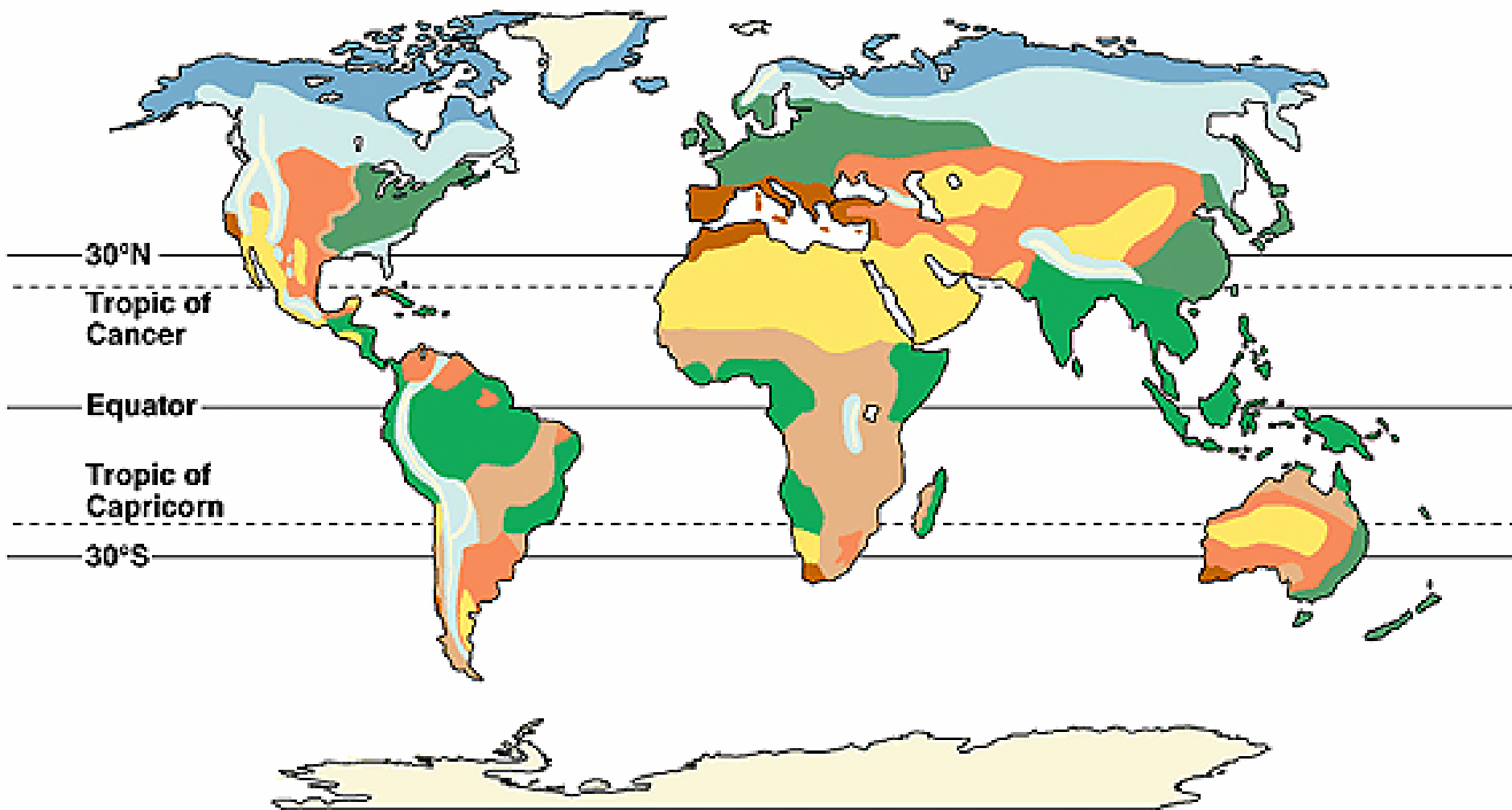
Reconstructed vegetation cover, 8000 C14 years ago.










MIGRATION OF FORESTS DURING THE TERTIARY IN WESTERN NORTH AMERICA

Adapted from Dorf, E., 1964, in A.E. M. Naim, ed., *Problems in Paleoclimatology*: Wiley, New York, p 13. As seen in Seyfert and Sirkin, 1979, *Earth History and Plate Tectonics*.



Ple Pli M O C (ir)



- | | | |
|---|---|--|
|  Tropical forest |  Polar and high-mountain ice |  Temperate deciduous forest |
|  Savanna |  Chaparral |  Coniferous forest |
|  Desert |  Temperate grassland |  Tundra (arctic and alpine) |

Copyright © Pearson Education, Inc., publishing as Benjamin Cummings.

