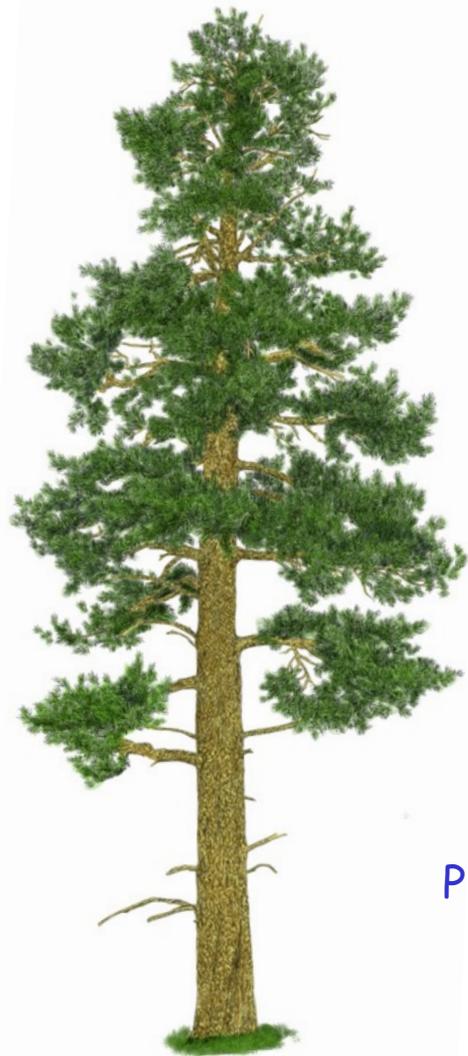


Topic 5

Grassland and Steppe Biomes



Plant Ecology in a Changing World

Jim Ehleringer, University of Utah
<http://plantecology.net>



Great Plains grassland, Nebraska

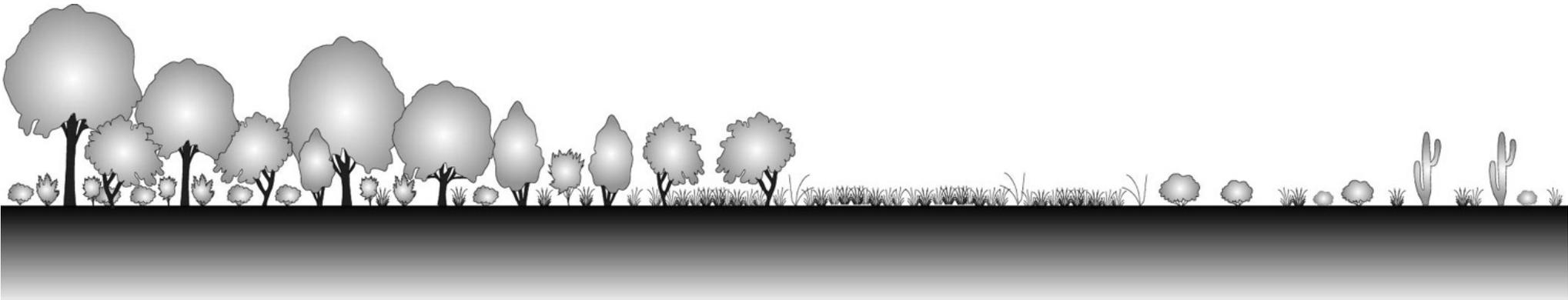


Sagebrush steep biome in southern Idaho



Characteristics of grassland climates

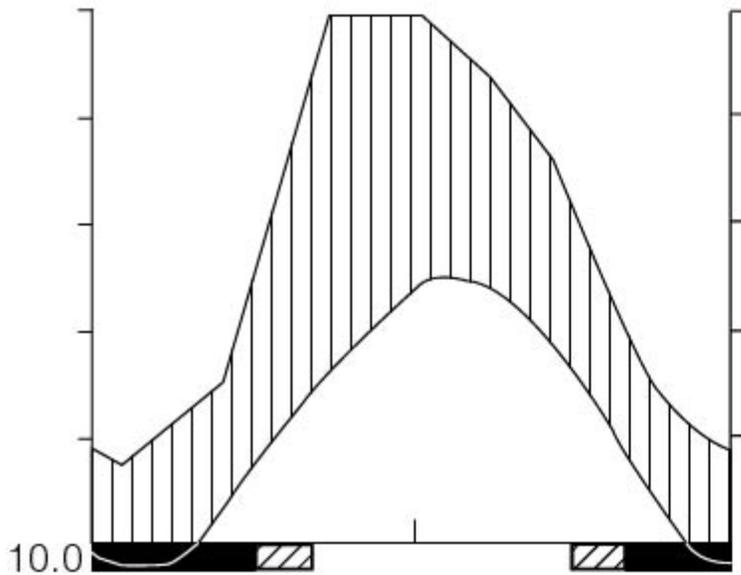
- typically continental climates with hot summers and cold winters
- coastal and near-coastal grasslands are winter active, summer inactive
- precipitation ranges 500 - 1,000 mm per year
- during growing season, precipitation is about the same as evapotranspiration (PET = PPT)



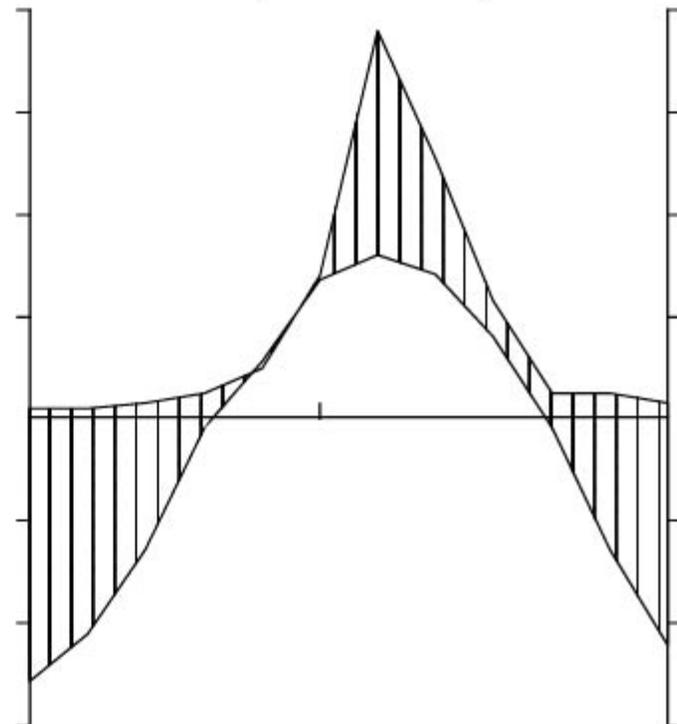
Climate diagrams for grasslands



Lincoln (360m) 10.8° 704

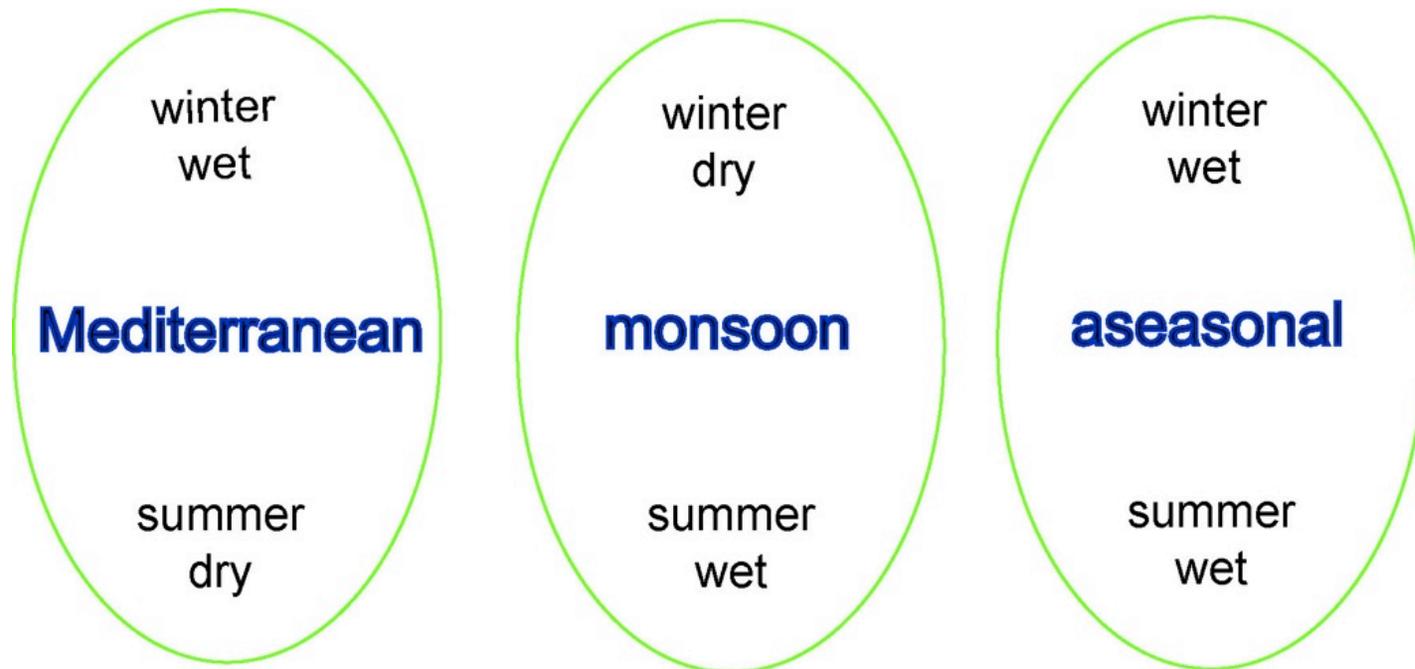


Ulaanbaatar (1325m) -3.2° 213

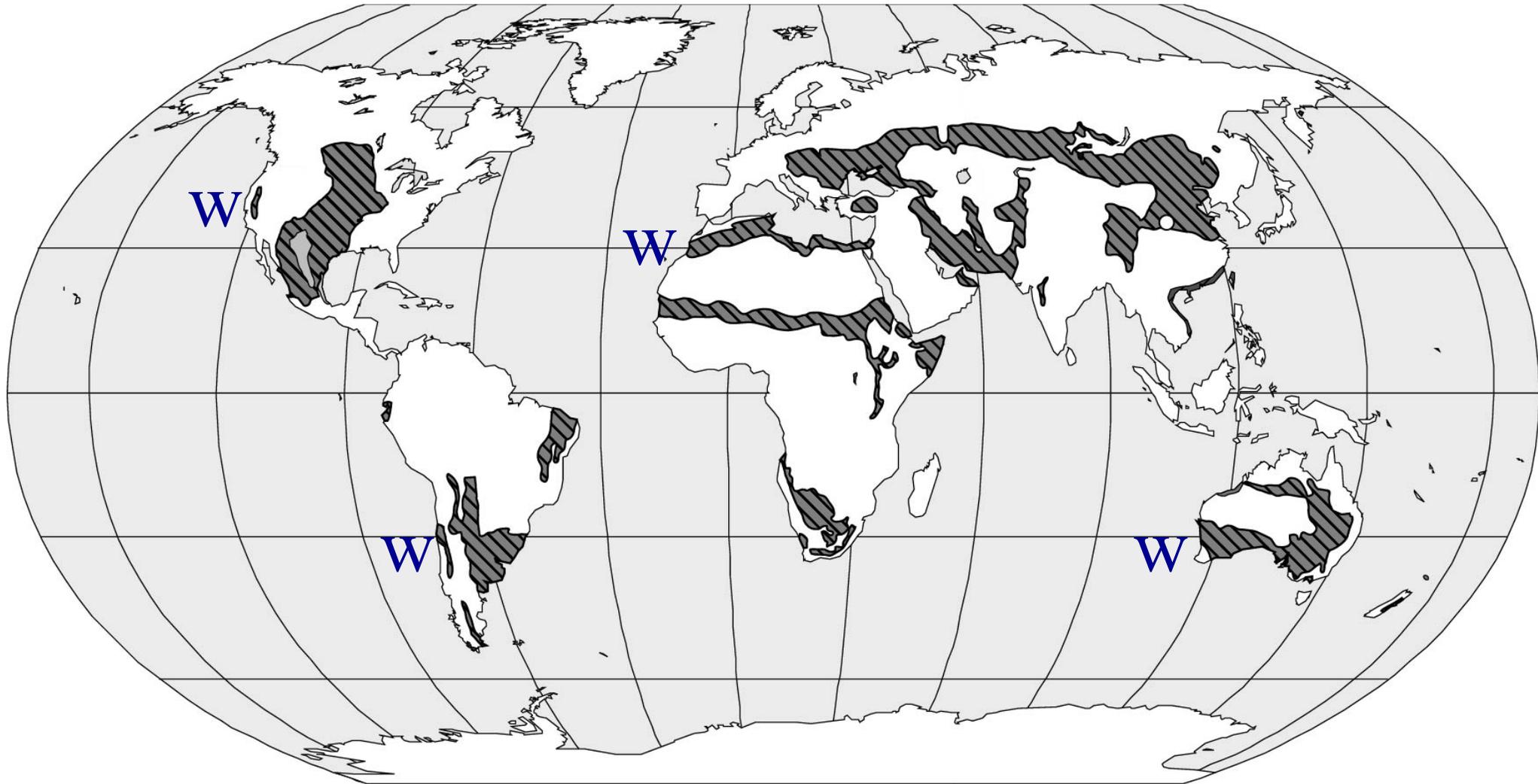


Note differences in wintertime temperatures

In general (but not always), grasslands occur in summer-wet (or monsoon) climate regions



Global distribution of grassland biomes



Terms describing essentially the same biome: grassland, pampa, prairie, puszta, steppe, and veld
“w” indicates a winter-growing season grassland

Grasslands by region

- grasslands of North America
- grasslands of Mongolia and central Asia
- grasslands of Australia
- grasslands of Sahel in northern Africa

- prairies of North America
- prairie of central France

- pampas of South America

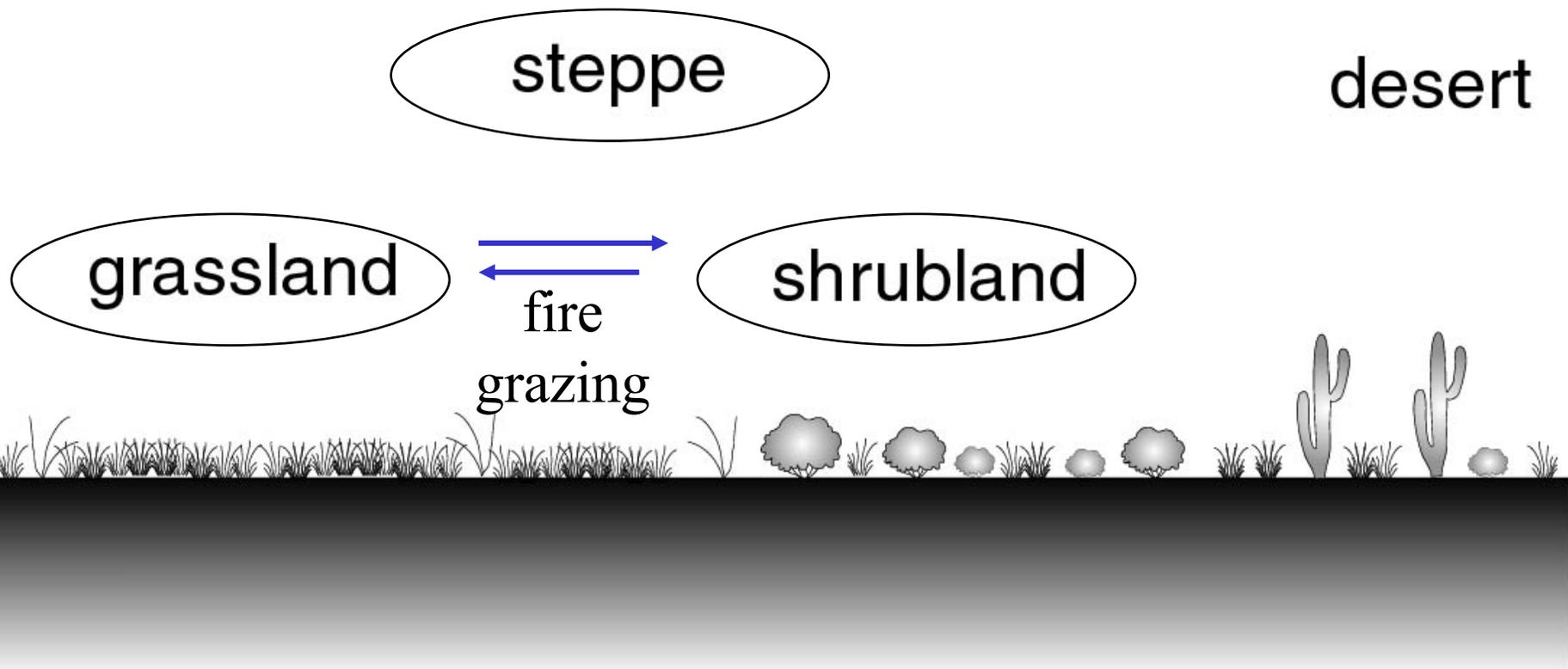
- velds of southern Africa

- puszta of eastern Europe

- steppes of Russia

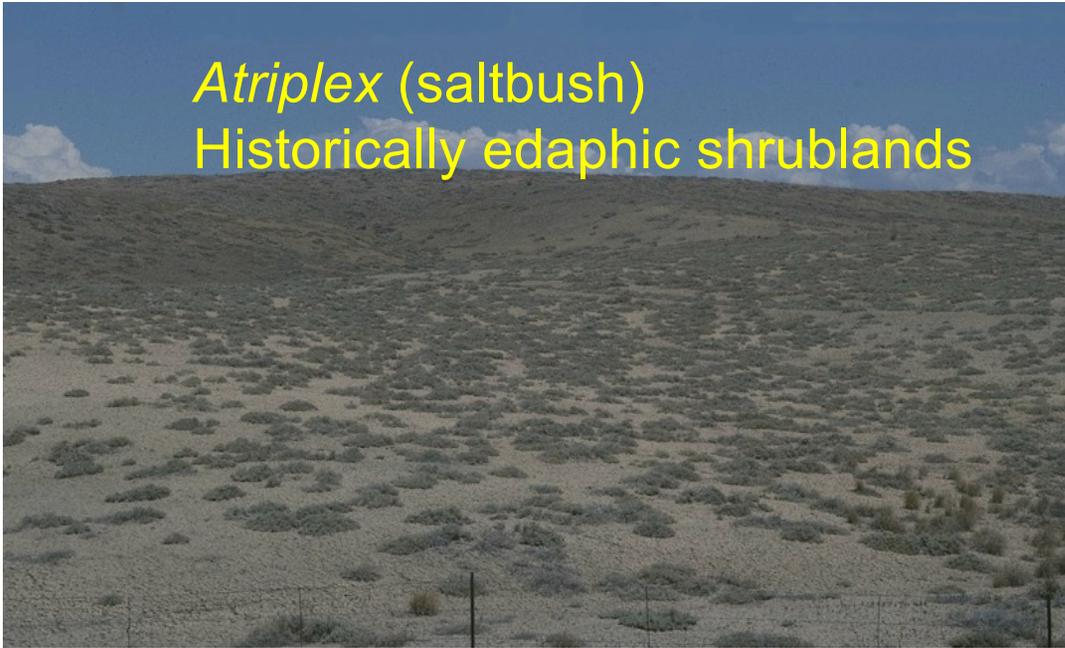
Steppe is a term incorporating both grasslands and shrublands

... often refers to high elevation sites

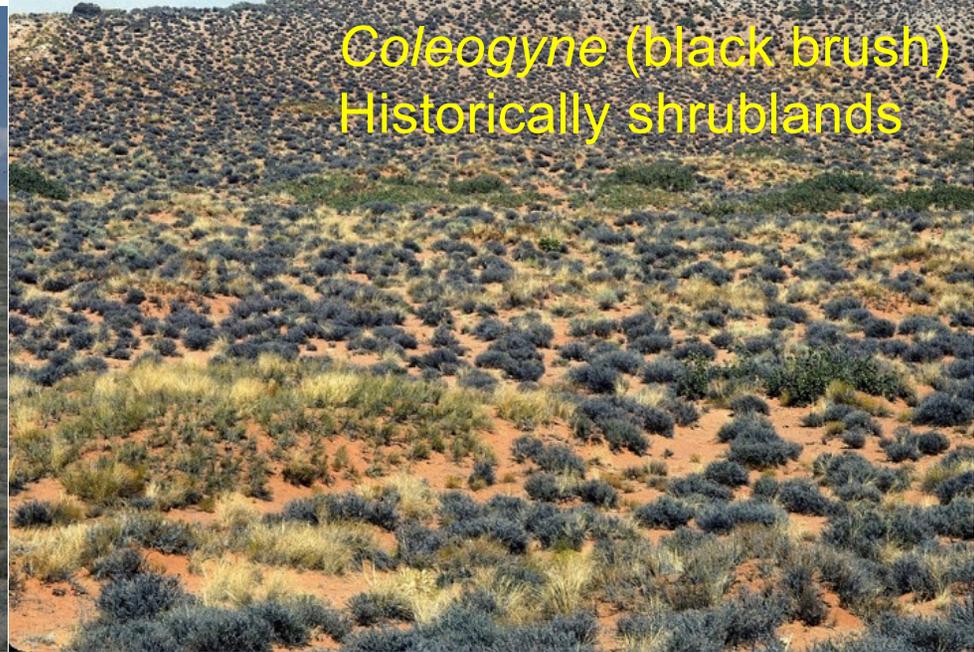


Shrub steppe in Utah

Atriplex (saltbush)
Historically edaphic shrublands



Coleogyne (black brush)
Historically shrublands



Juniperus (juniper)



Sarcobatus (greasewood)



Burr Desert near Hanksville





Distichlis (C_4) grasslands are common in saline basins.

Atriplex (C_4) and *Gutierrezia* (C_3) dominate on both saline and non-saline soils



The relative abundances of grasses and shrubs in ungrazed parts of the Great Basin steppe is a function of precipitation (mostly in winter). However, few locations have not been grazed and often shrubs replaced perennial grasses.

From diaries, we know Mormon pioneers reported extensive grasslands.

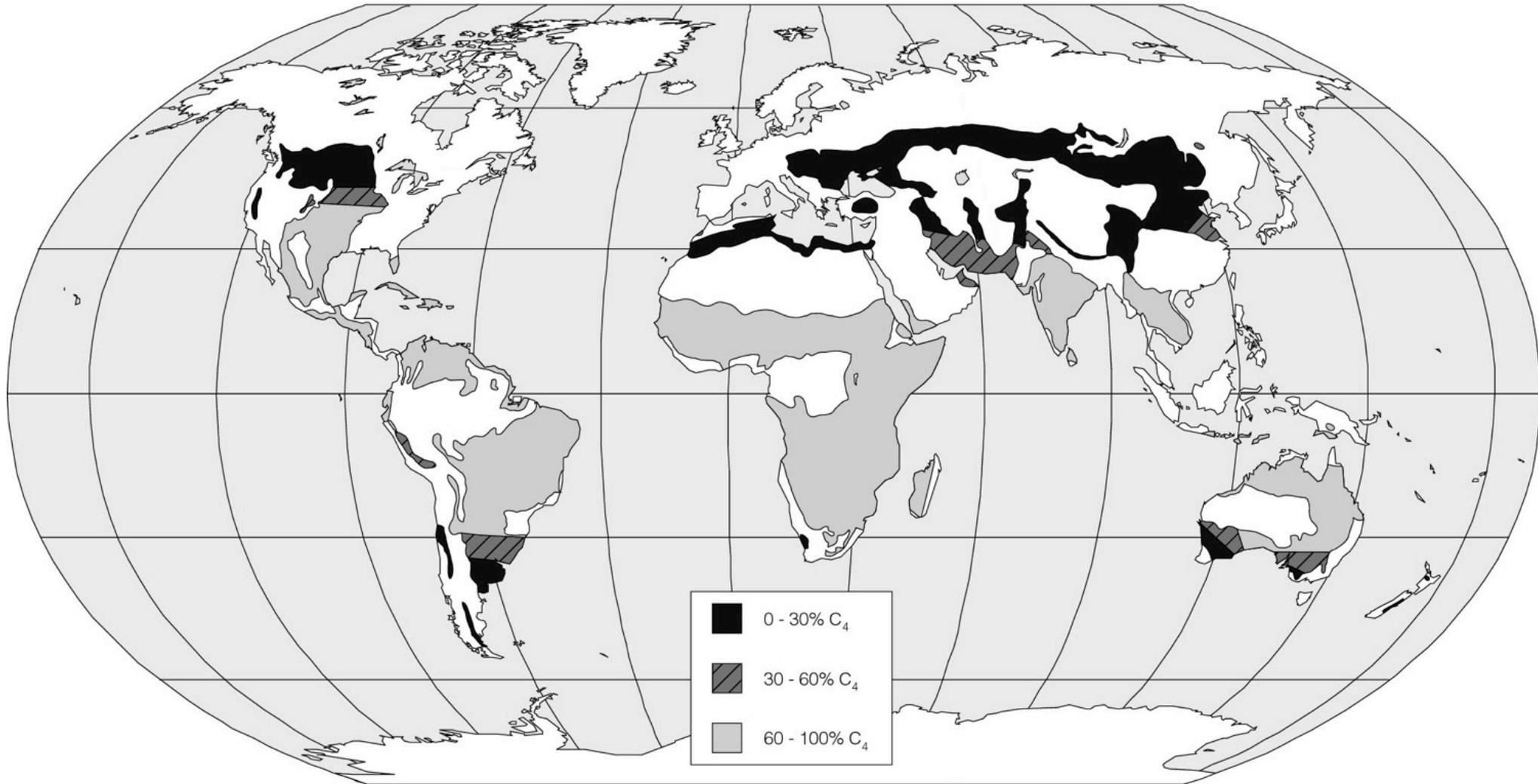
	150 mm	300 mm	500 mm
<i>Artemisia tridentata</i>	14%	14%	0%
<i>Agropyron spicatum</i>	45%	35%	51%
<i>Poa secunda</i>	49%	29%	28%
<i>Festuca idahoensis</i>	0%	24%	38%

Part 2
 C_3 and C_4 grasses

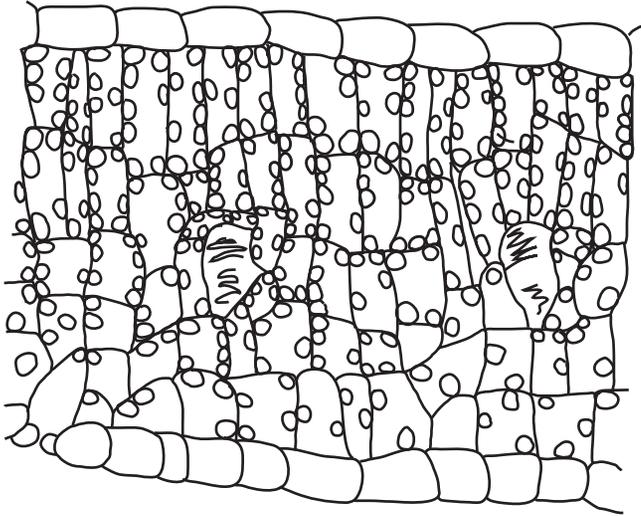


C₄ grasses predominate in warm growing-season habitats

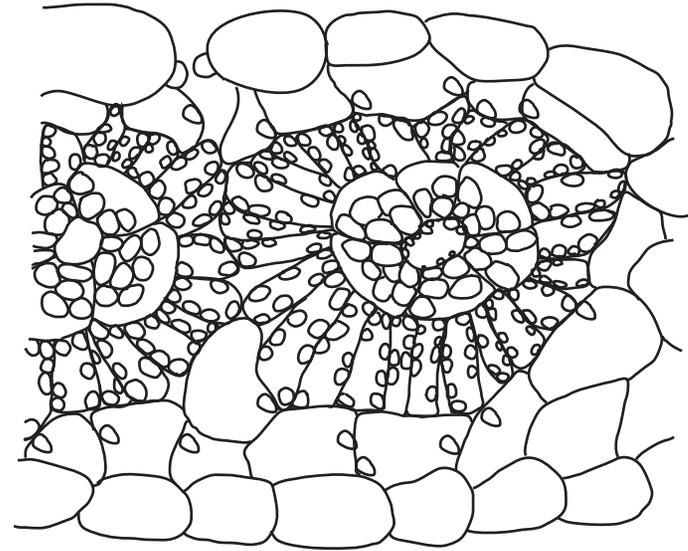
Distributions of C₃ and C₄ grasses in the savanna and steppe ecosystems



C₃ plants

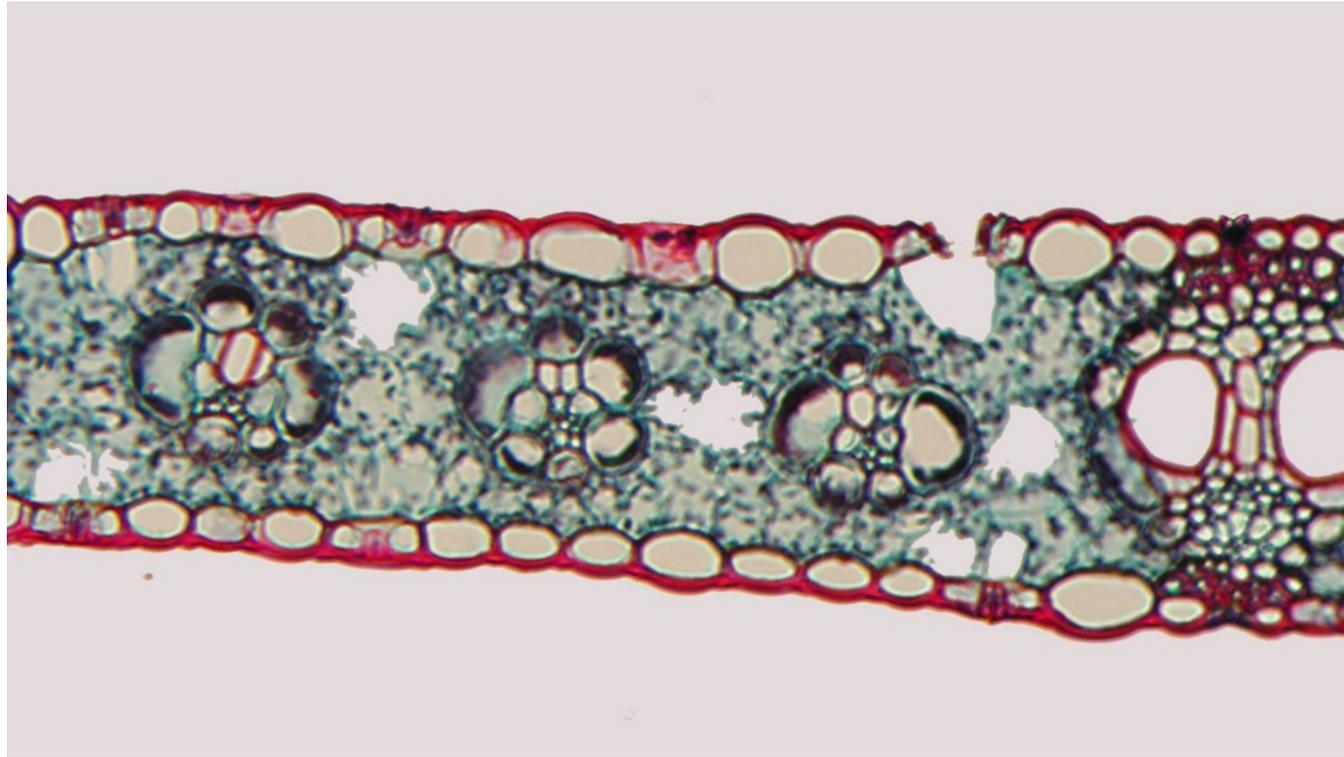


C₄ plants



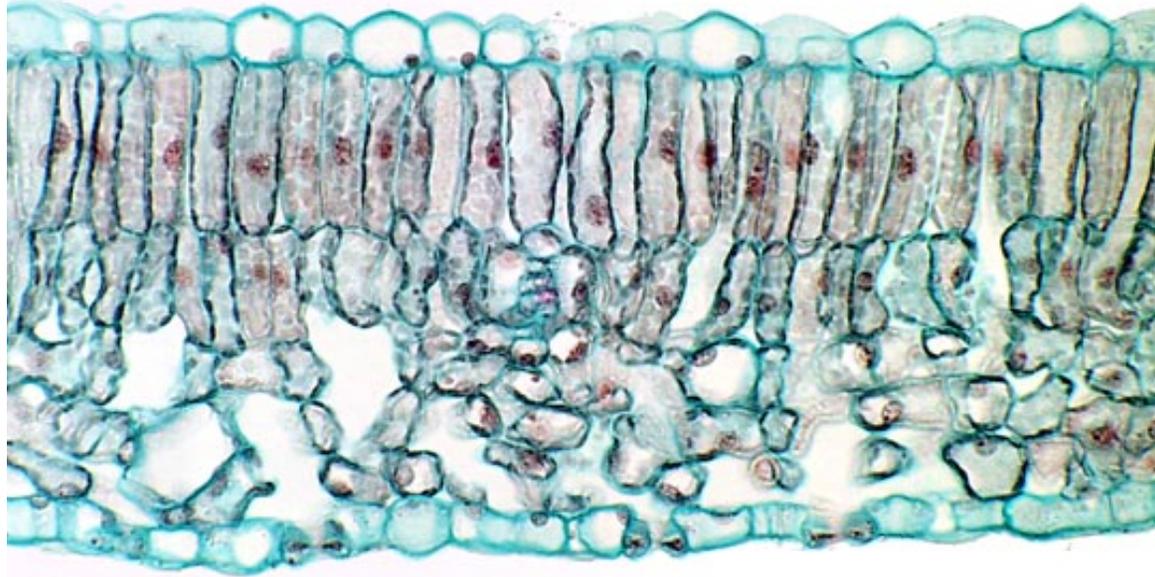
C₄ leaves have a “Kranz anatomy” in which chloroplasts are concentrated in bundle sheath cells

Kranz is German for wreath

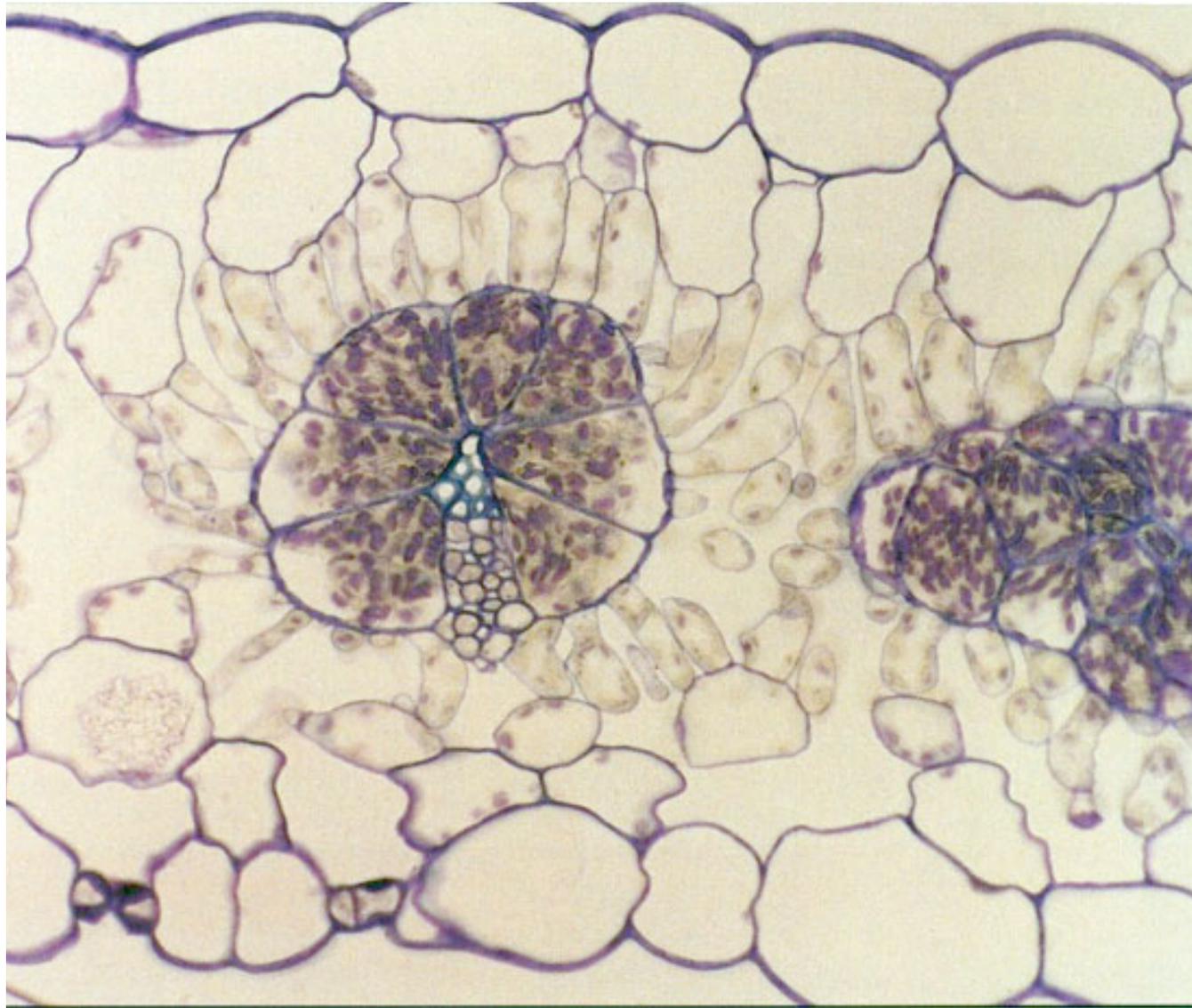


Zea mays (corn) – note Kranz anatomy

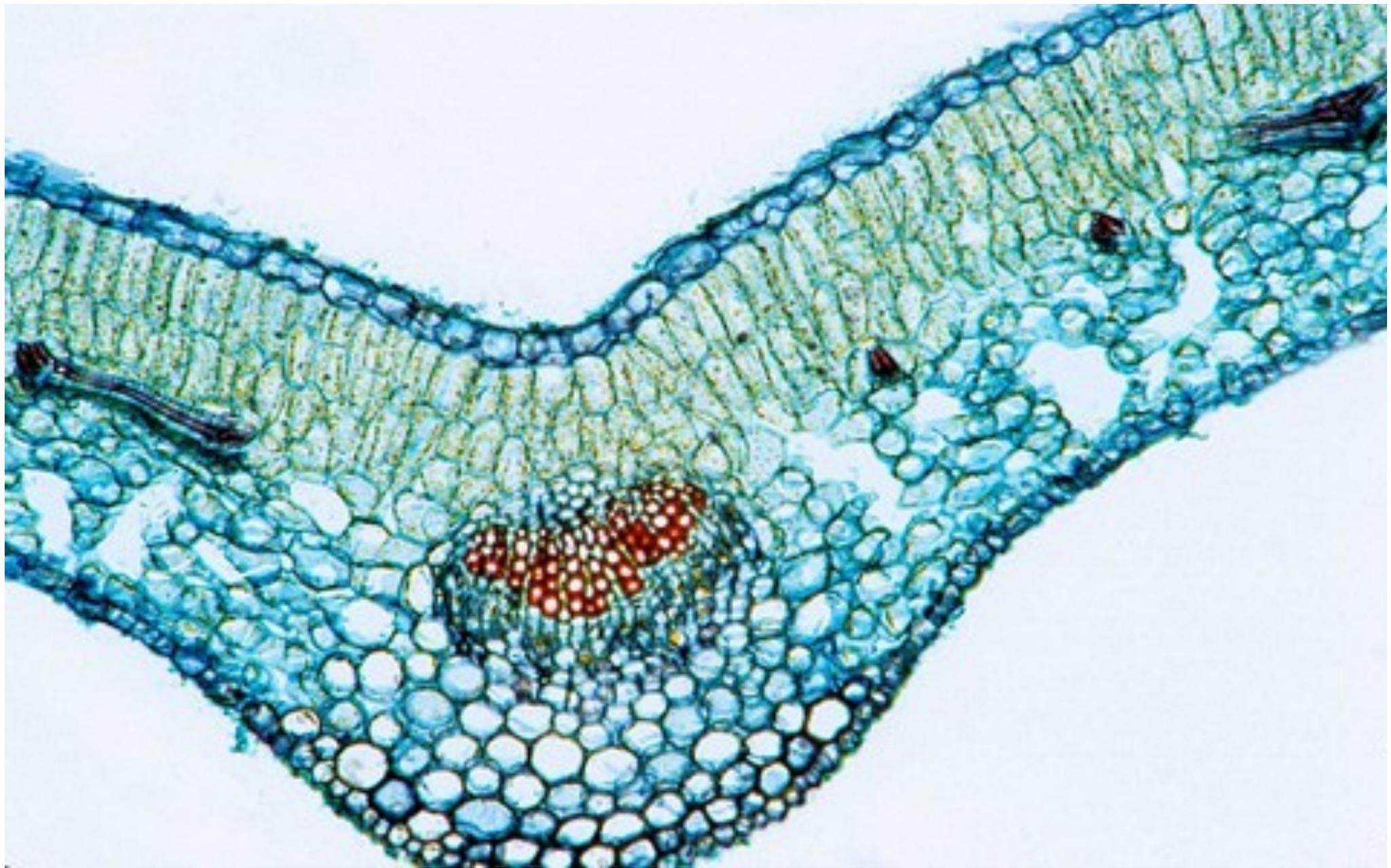




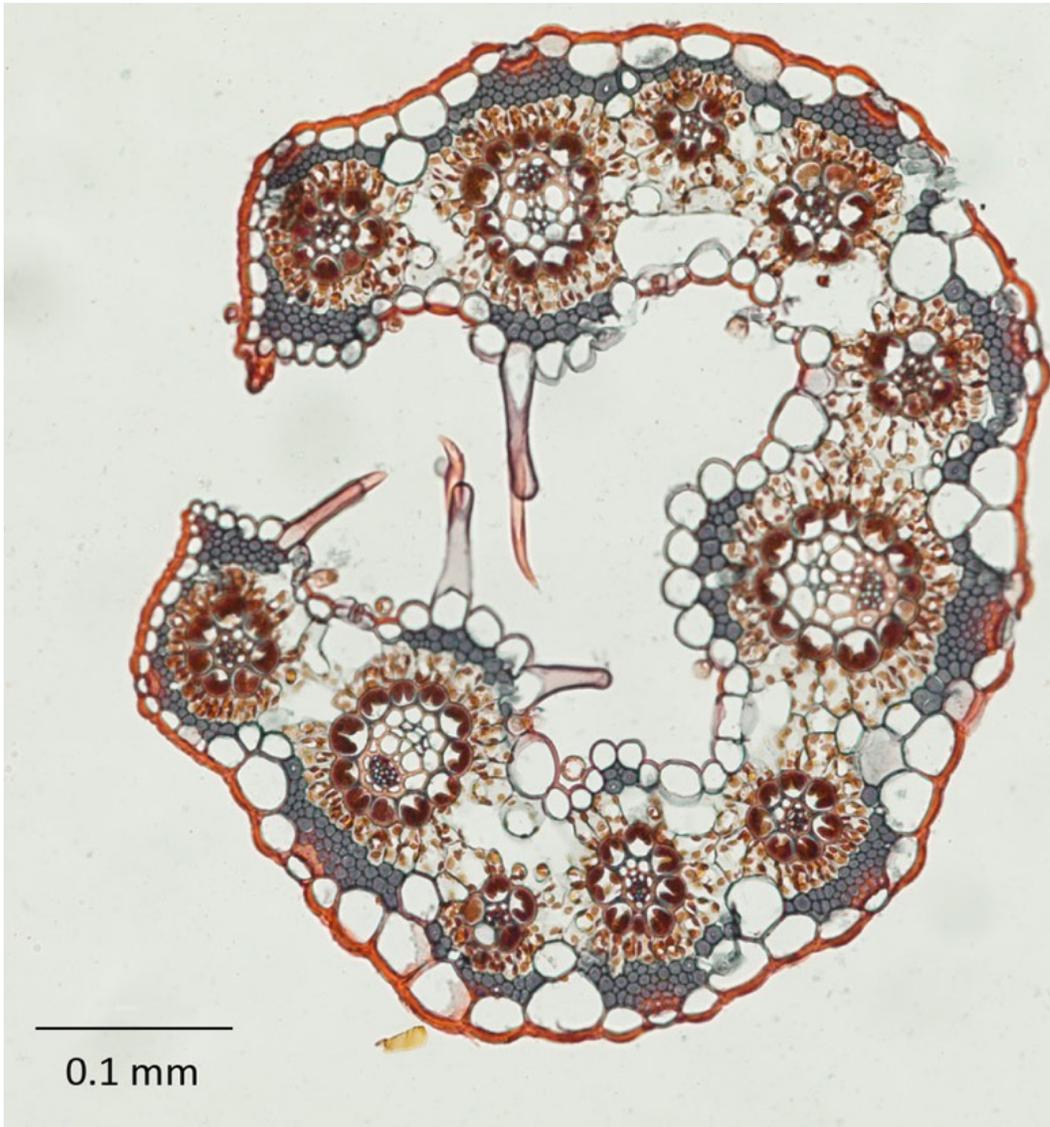
Syringa vulgaris – note lack of Kranz anatomy



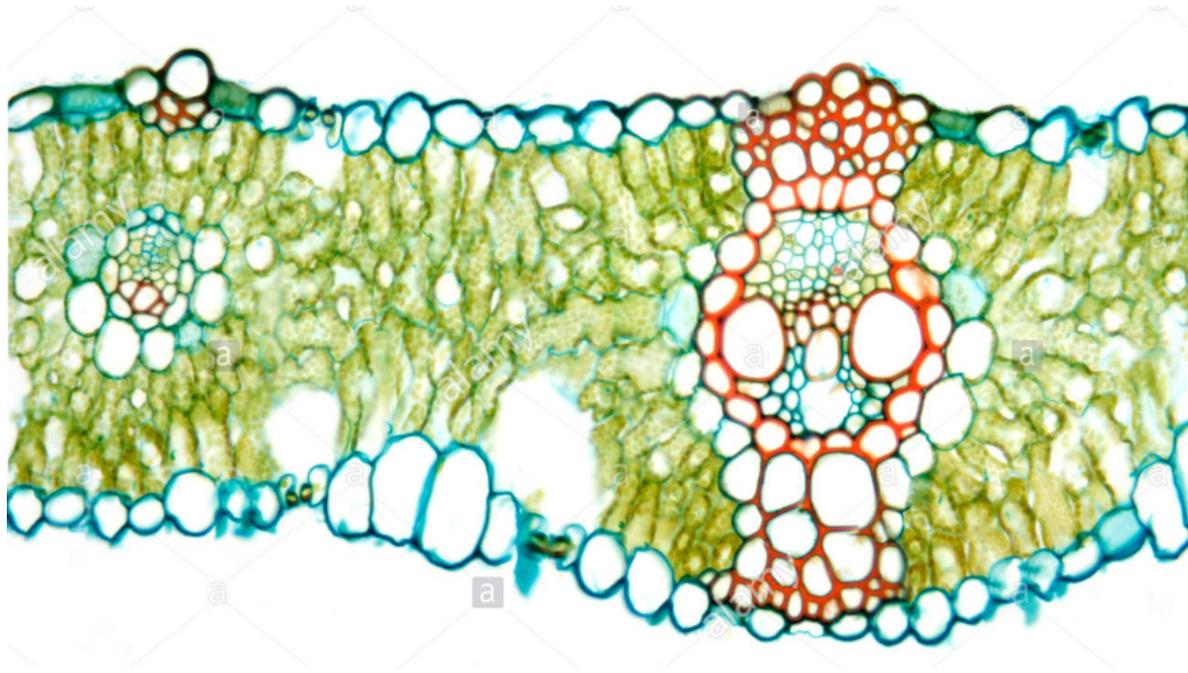
Atriplex rosea (saltbush) – note Kranz anatomy



Phaseolus vulgaris (common bean) – note lack of Kranz anatomy



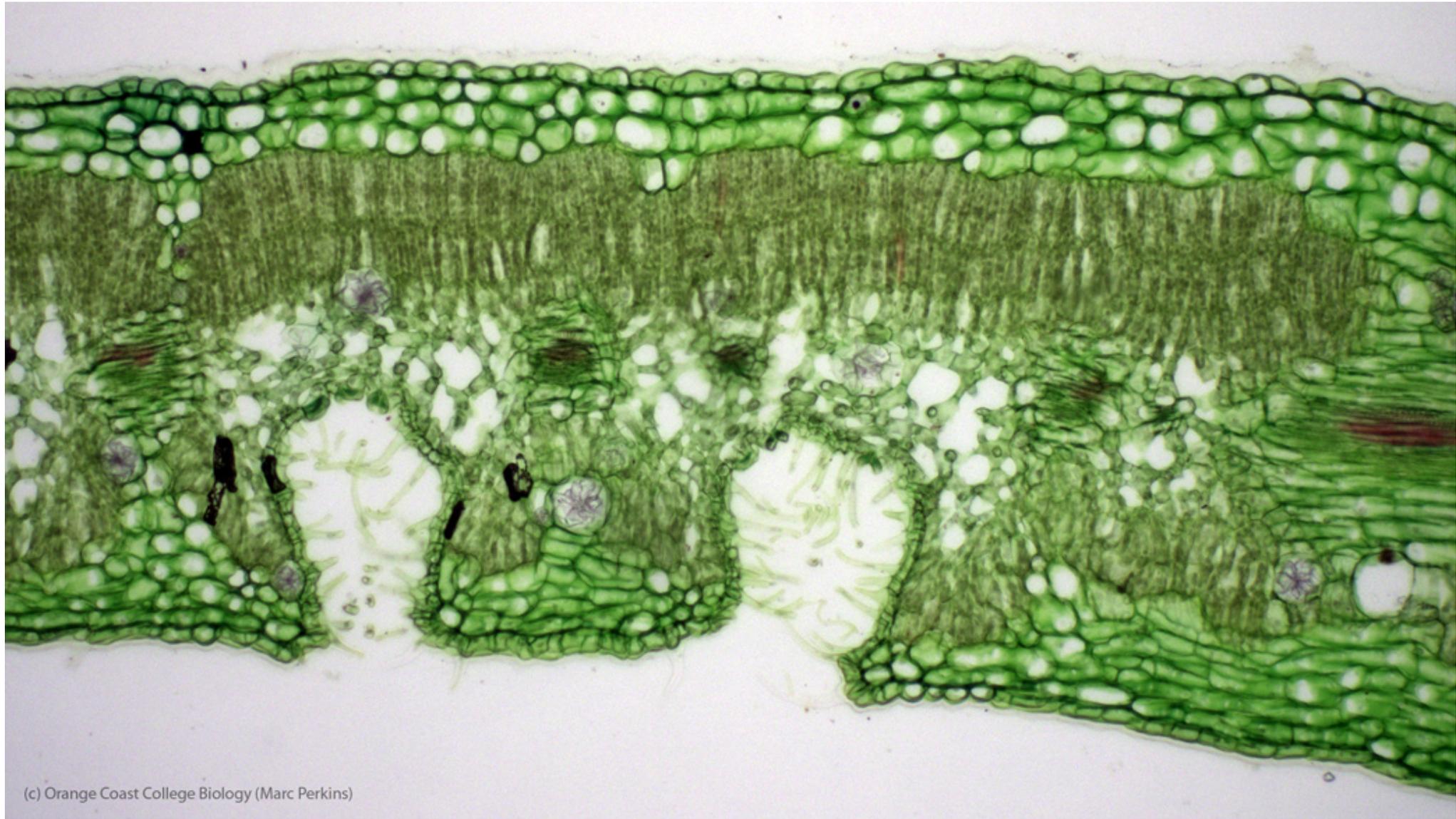
Eriarache ciliata (wanderrie grass)– note Kranz anatomy



Triticum aestivum (wheat) – not lack of Kranz anatomy

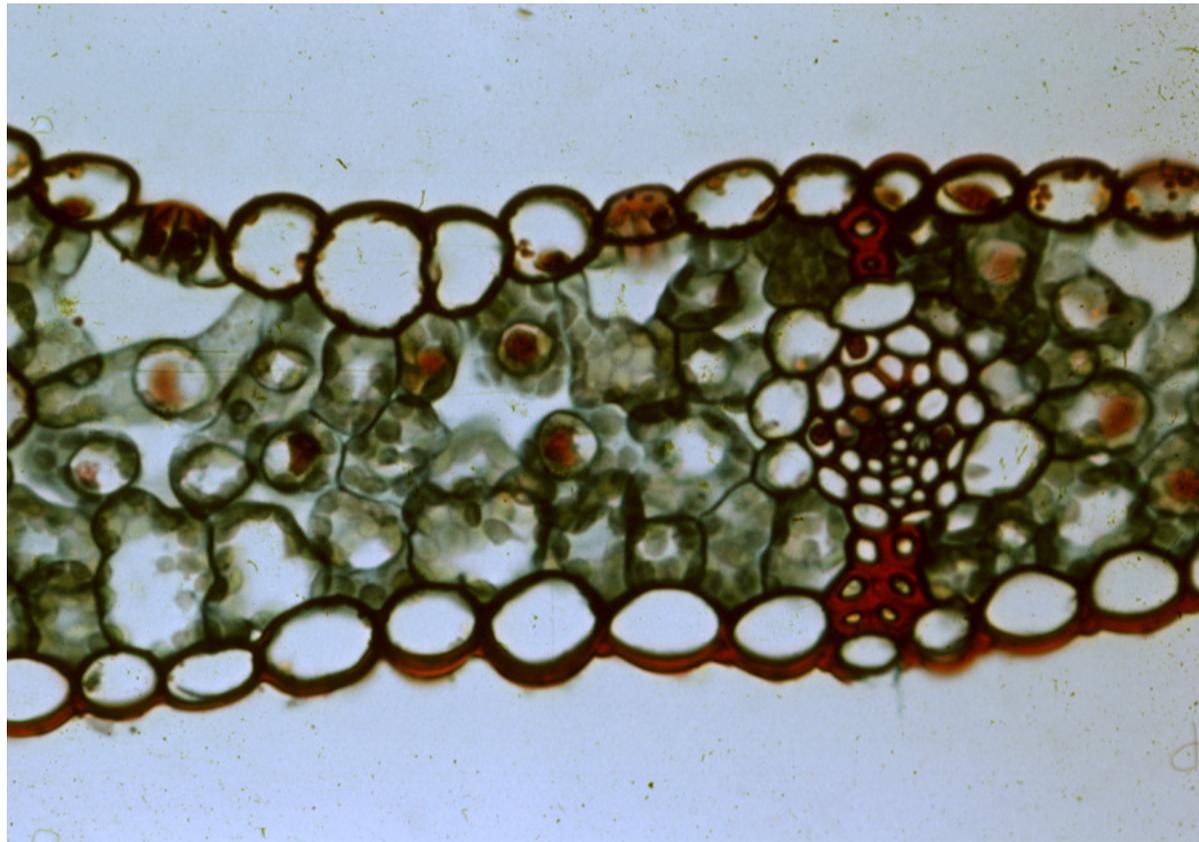


Bouteloua gracilis (blue grama), note presence of Kranz anatomy

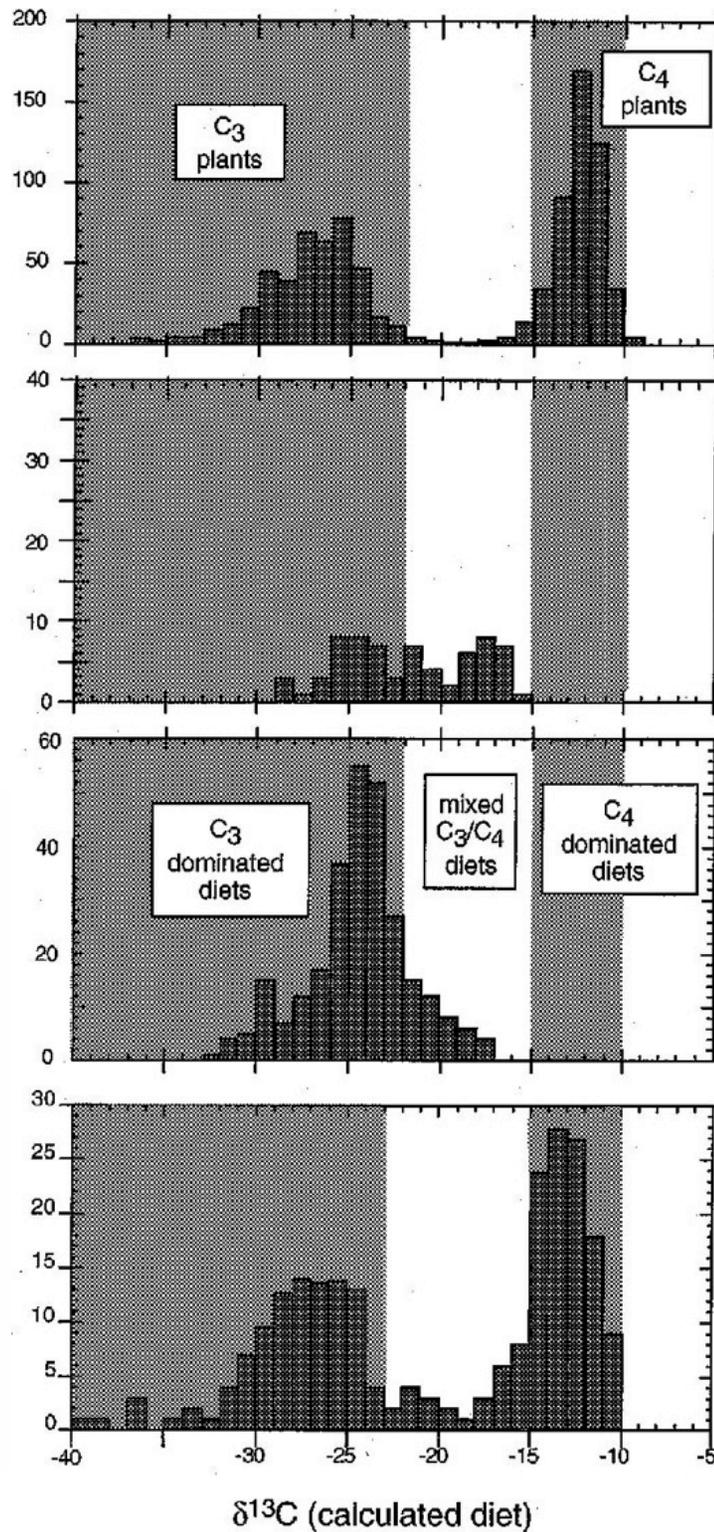
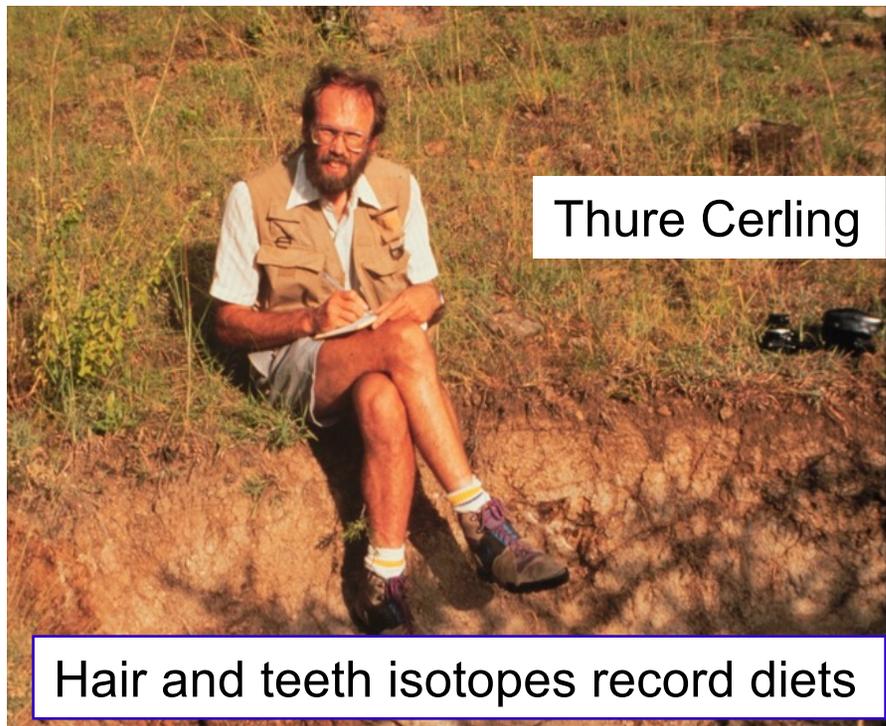


(c) Orange Coast College Biology (Marc Perkins)

Nerium oleander (oleander) – note the lack of Kranz anatomy



Bromus inermis (brome) – note lack of Kranz anatomy



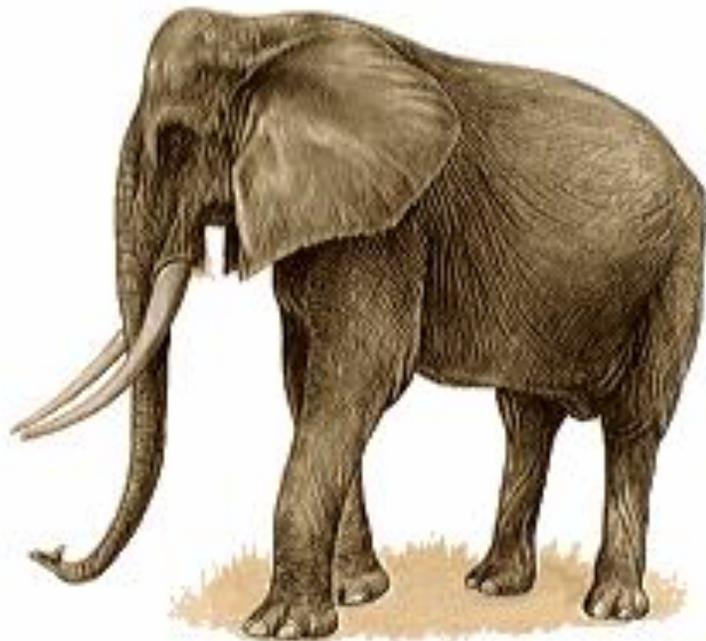
plants
(n = 920)

India
Elephas maximus
(n = 66)

Africa
Loxodonta africana
(n = 287)

modern
African herbivores
(except elephants)
(n = 240)

$\delta^{13}\text{C}$ (calculated diet)



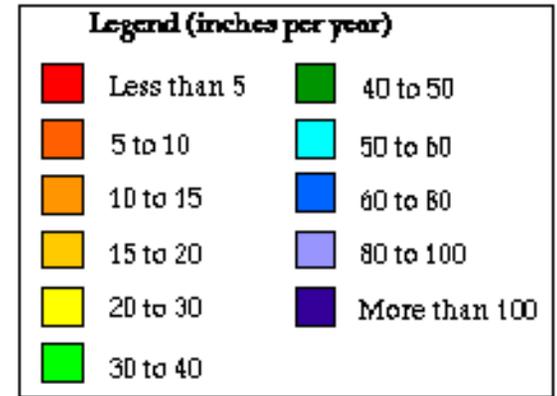
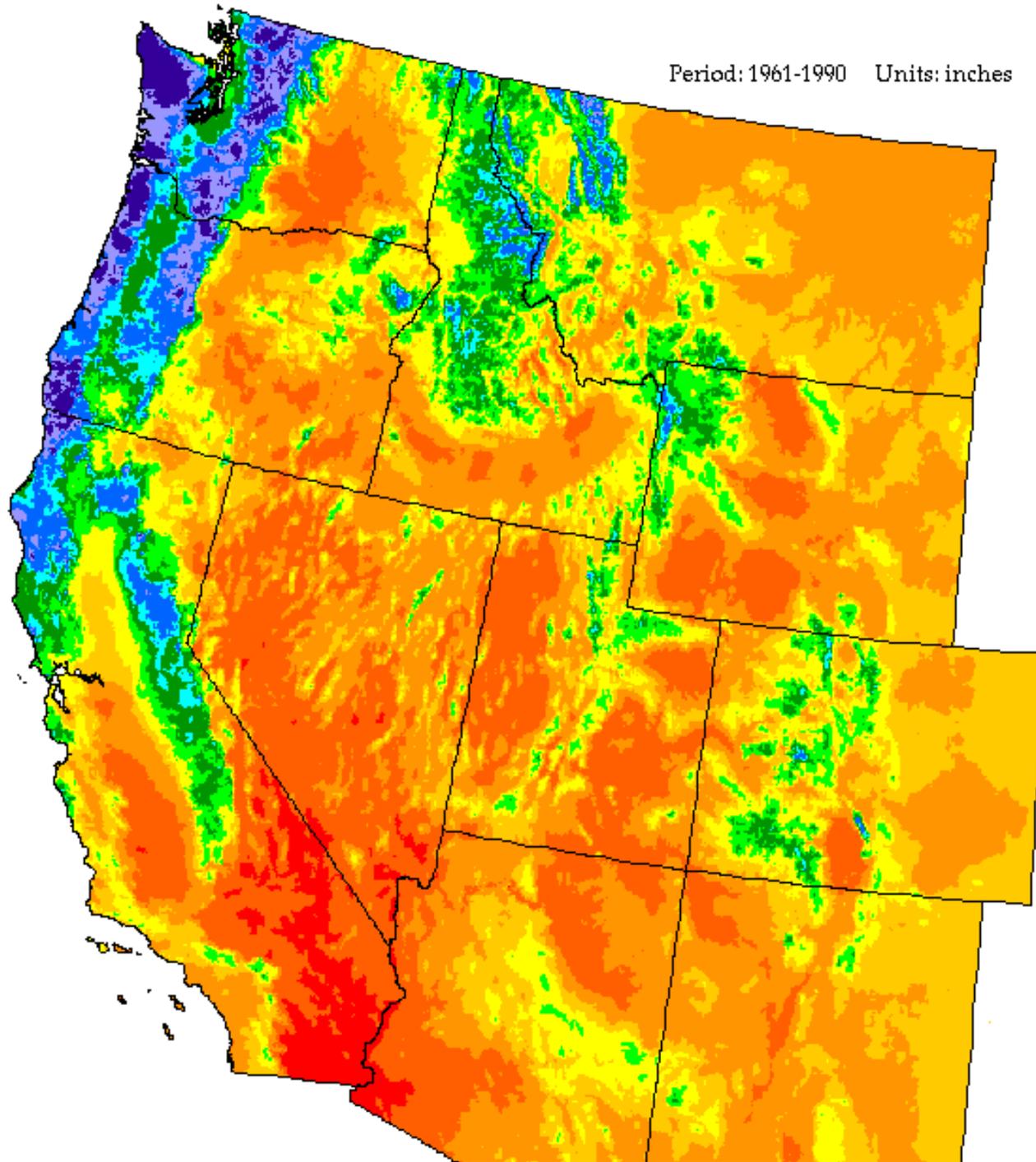
Part 3
Grasslands and steppes of North America

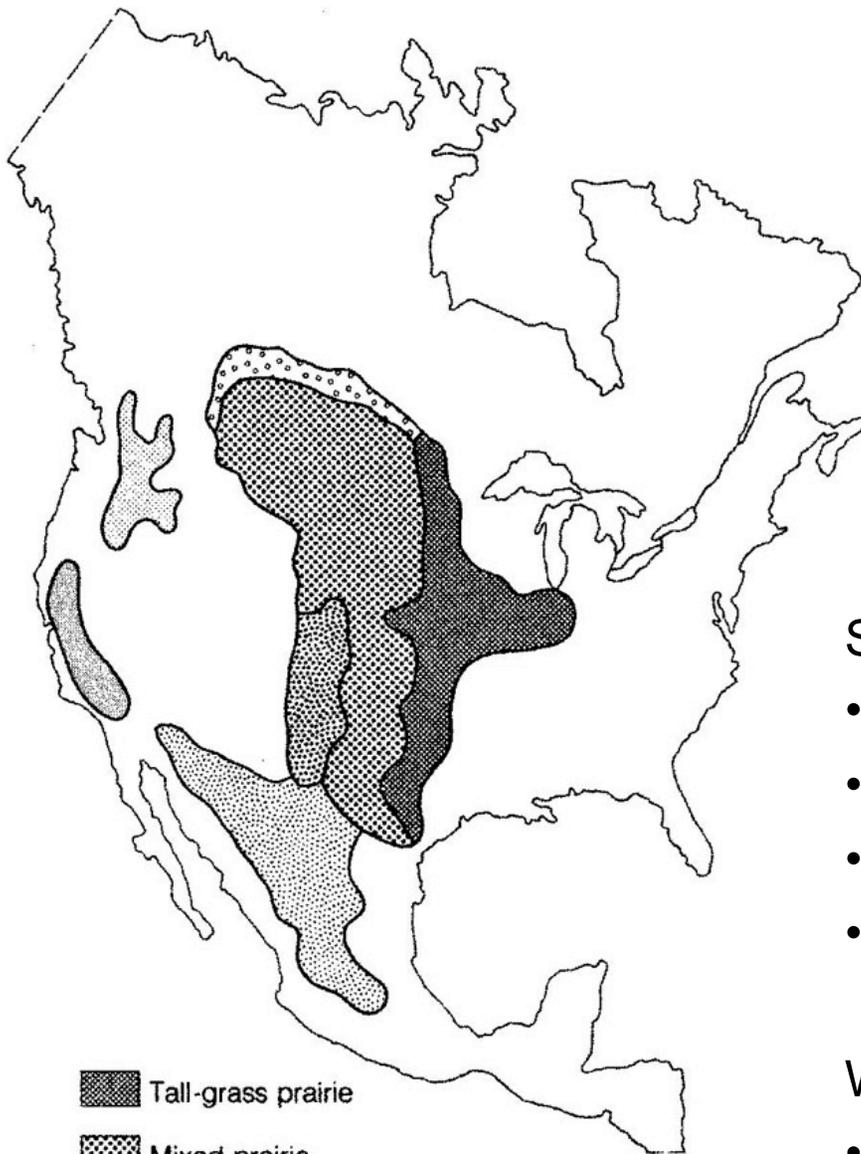


Average Annual Precipitation

Western United States

Period: 1961-1990 Units: inches





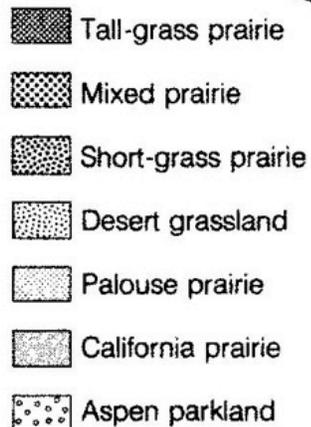
Grasslands of North America

Summer active

- tall-grass prairie (C_3 and C_4)
- mixed-grass prairie (C_3 and C_4)
- short-grass prairie (C_3 and C_4)
- desert grassland (C_3 and C_4) (Chihuahuan)

Winter active

- California grassland (C_3)
- Palouse prairie (C_3)



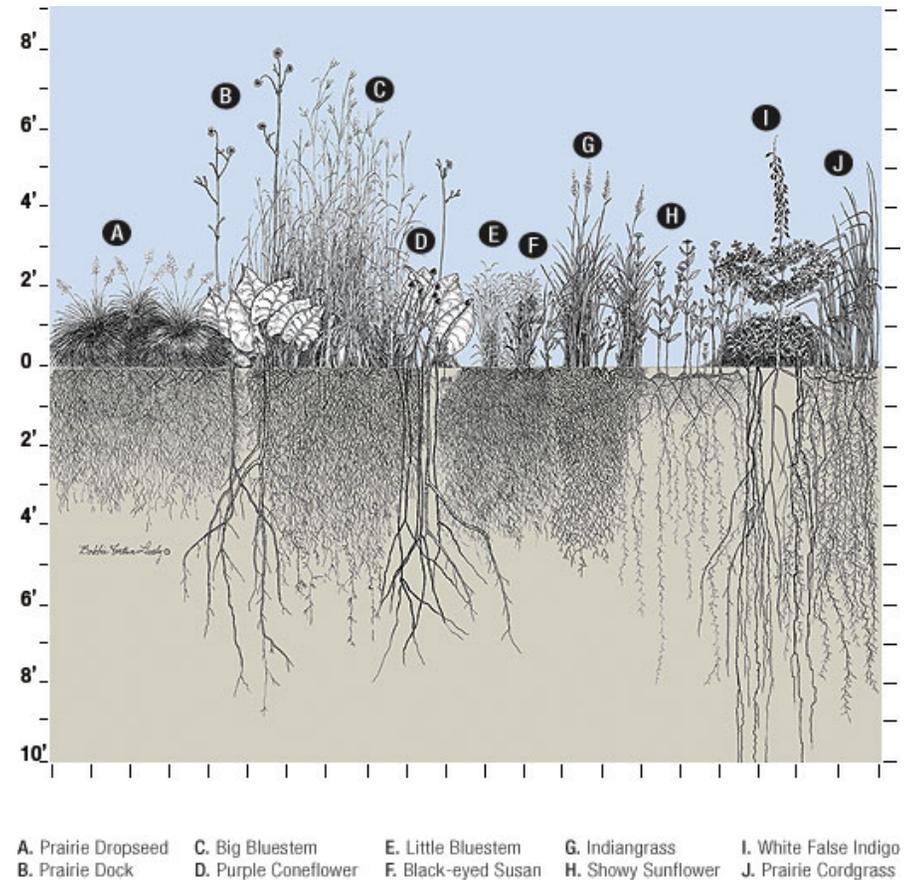
Dominant grassland life forms

Perennials

- predominantly perennial grasses
- herbaceous dicots
- shrubs and trees restricted to depressions
- shrubs and trees at wetter end of the distribution (parklands)

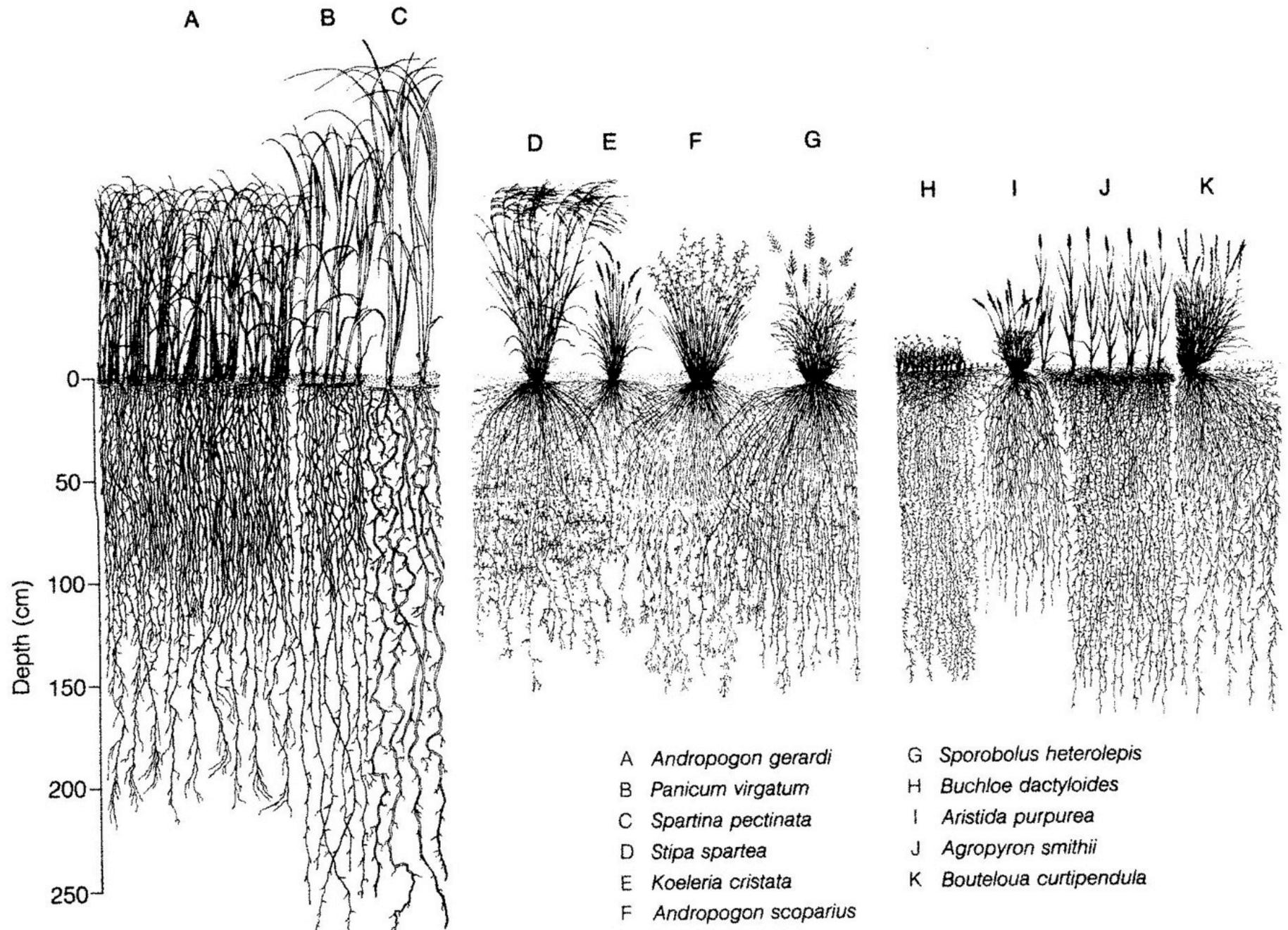
Photosynthesis and growing season

- cool season grasses tend to be C₃
- warm season grasses tend to be C₄



Grasses tend to have fibrous roots penetrating to 1-2 m

Herbaceous dicots tend to have tap roots penetrating to greater depths

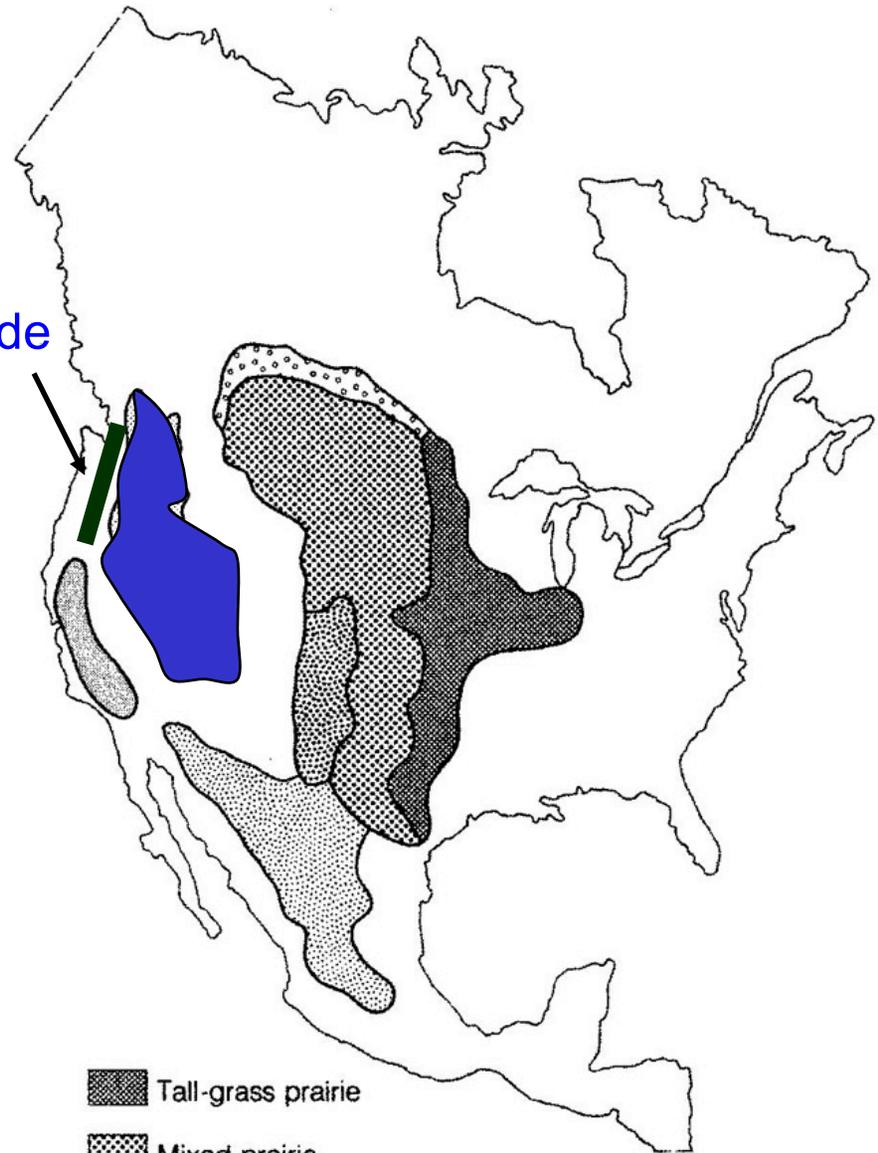


Great Basin

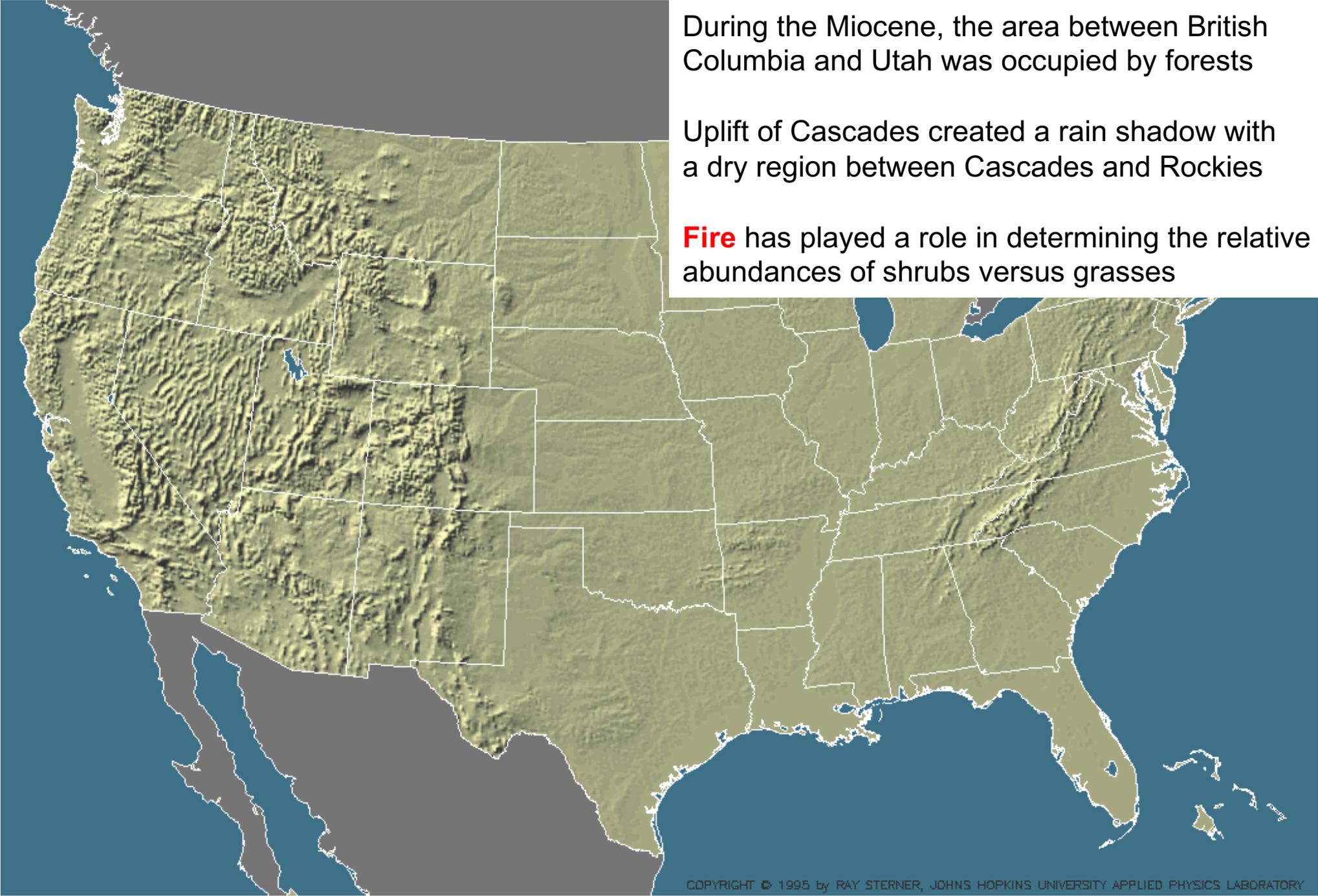
Creation of the steppe region in western North America is geologically recent and associated with the rise of the Cascade Mountains



Cascade



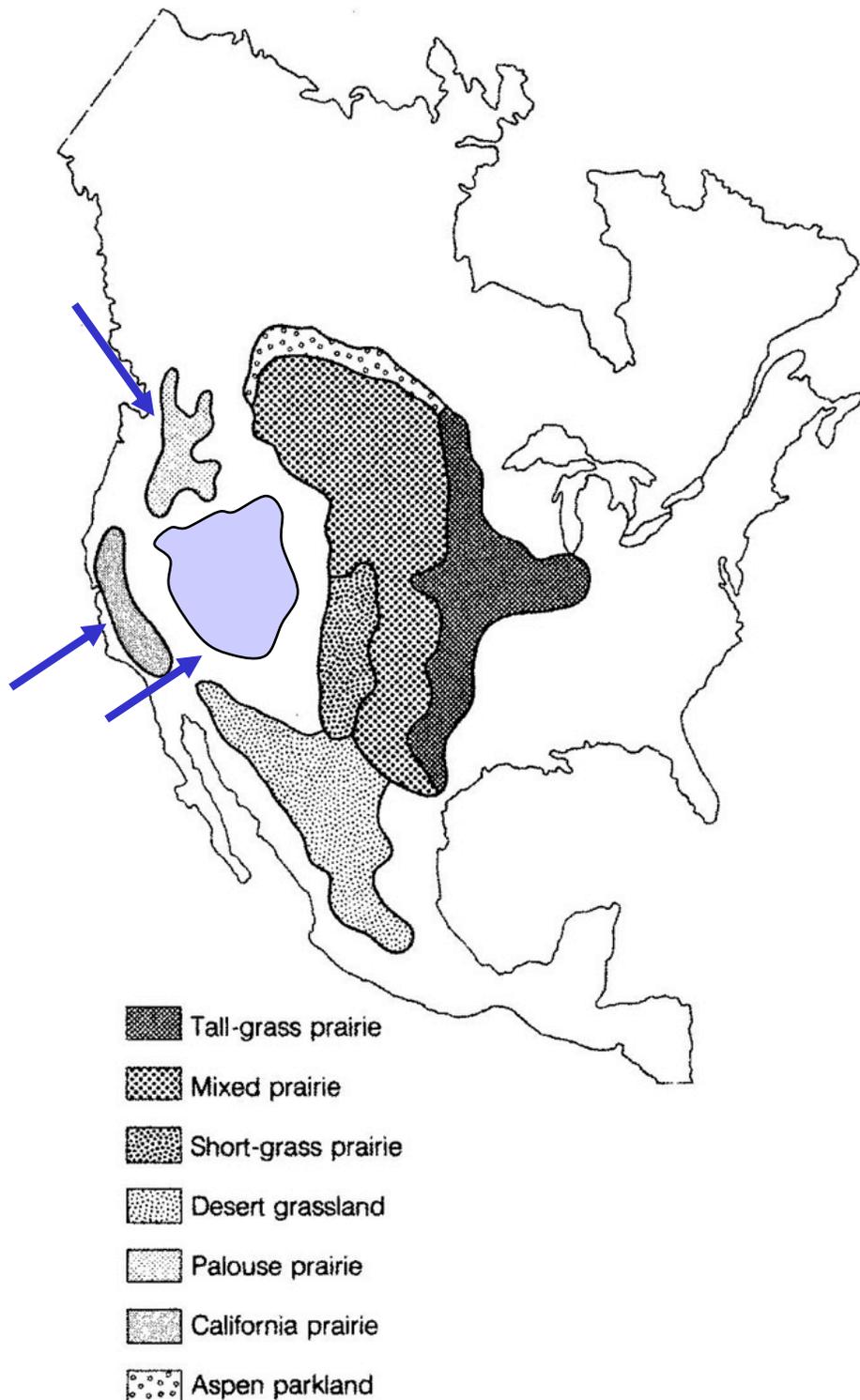
- Tall-grass prairie
- Mixed prairie
- Short-grass prairie
- Desert grassland
- Palouse prairie
- California prairie
- Aspen parkland



During the Miocene, the area between British Columbia and Utah was occupied by forests

Uplift of Cascades created a rain shadow with a dry region between Cascades and Rockies

Fire has played a role in determining the relative abundances of shrubs versus grasses



Grasslands of California, Washington, and the Intermountain West are all dominated by C₃ plants

- primarily winter rain
- today, each is dominated by invasive species
 - California – European
 - Intermountain – central Asia
- California and Washington grasslands have largely been converted to crops

Parkland - US term for landscape mix of forest and grassland in transition regions)



Riparian Cottonwood Forests, Oldman River, AB



Cypress Hills, AB



Part 4

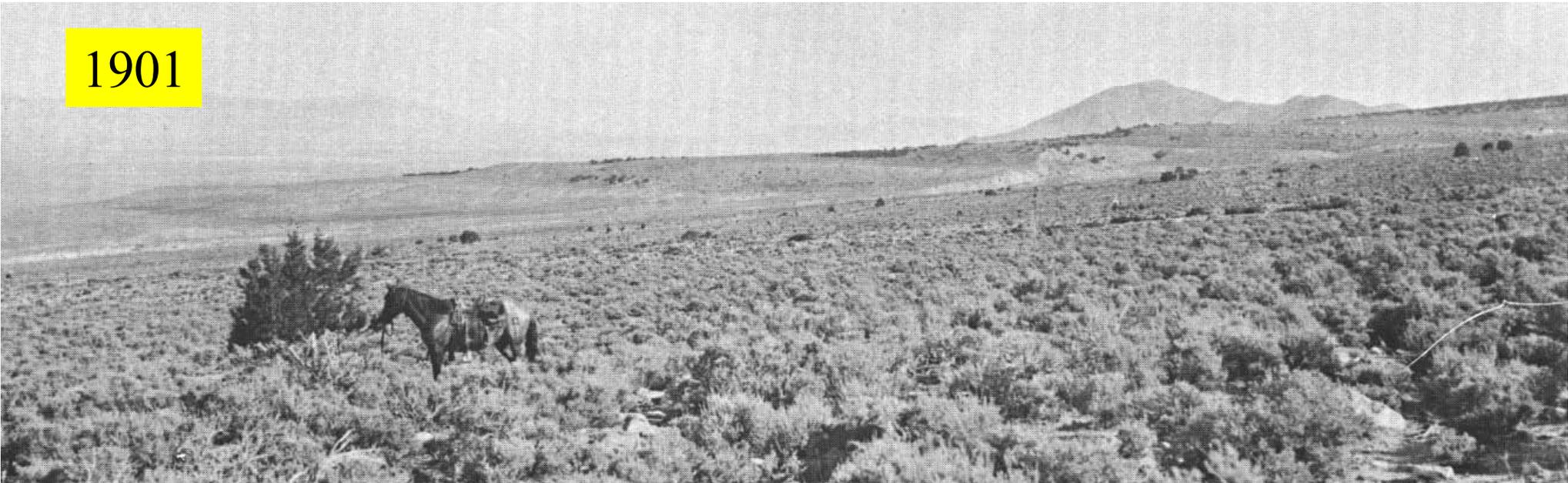
Fire and grazing have influenced the balance between grasses and shrubs



Artemisia tridentata - big basin sage



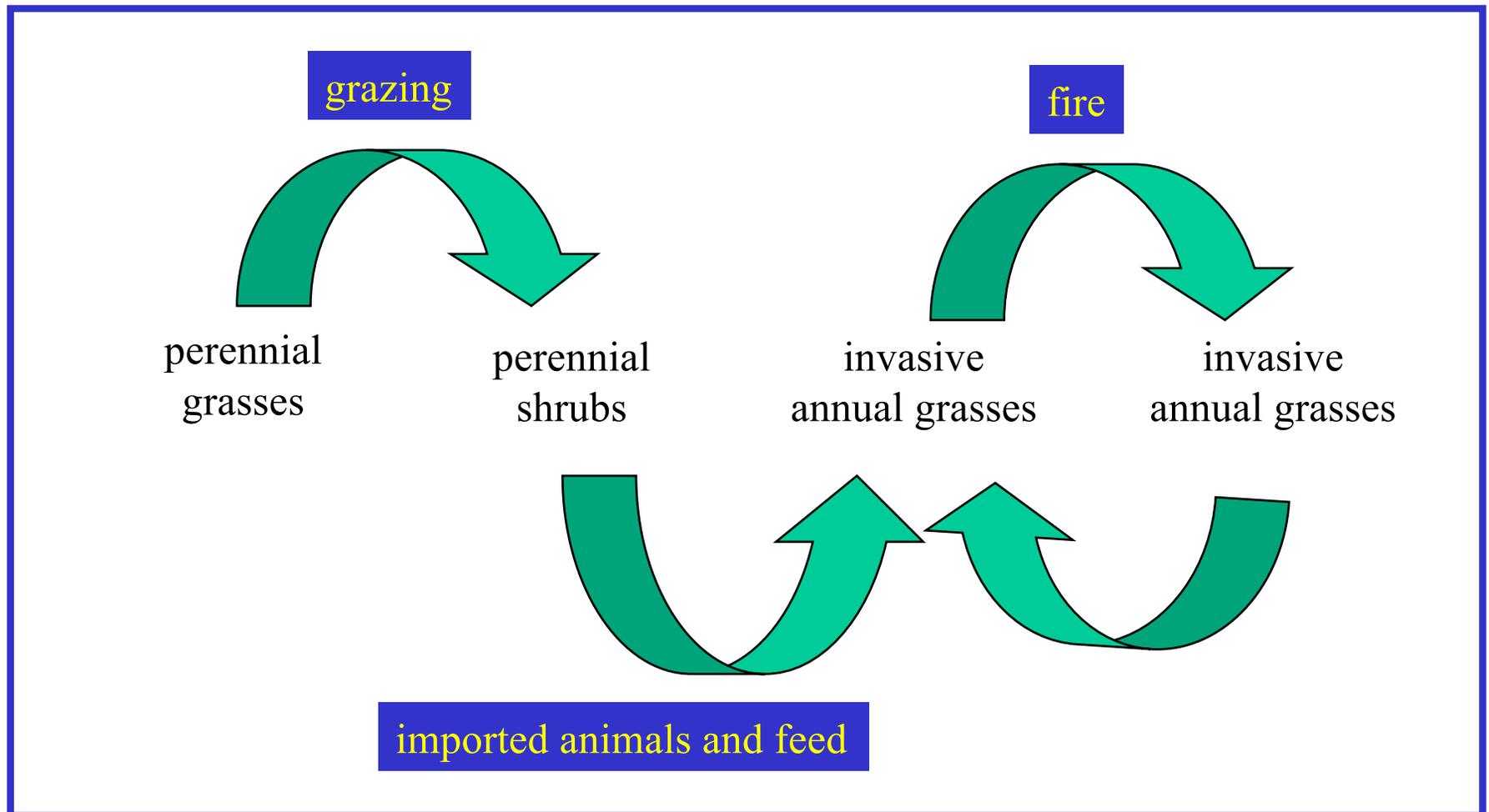
1901



1976



The last two centuries have seen shifts in the dominance of grasses and shrubs as the intensity of cattle and sheep grazing increased





Many of the aridland ecosystems, especially west of Salt Lake Valley, experienced a transition from shrubland to annual grassland with the invasion of *Bromus tectorum* (cheatgrass)





Grasslands are heavily impacted by grazing



Part 4

Grain agricultural impacts are extensive,
replacing most natural grasslands



Cattle grazing exclosures allow for visual assessment of cattle grazing impacts

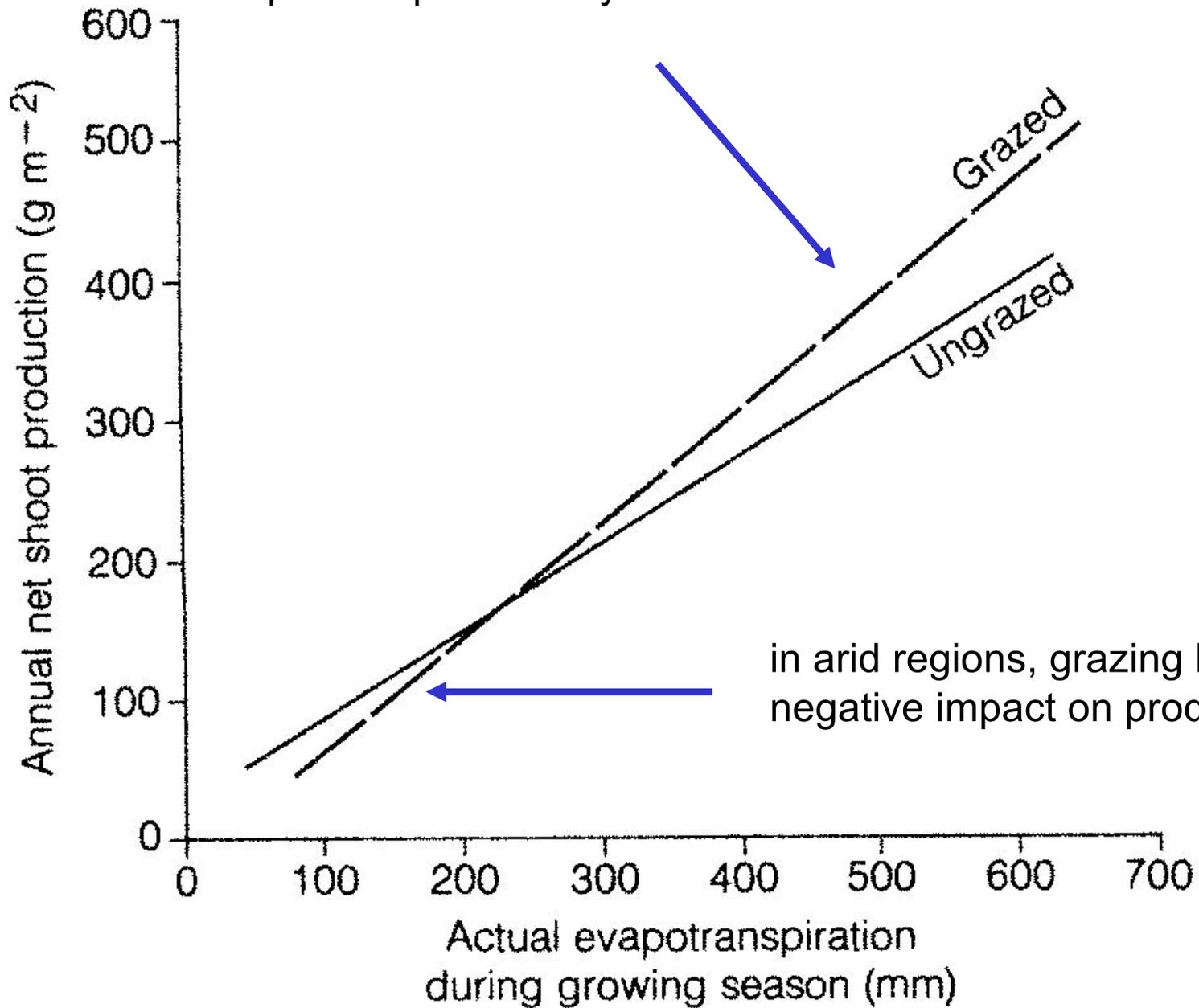


Gardiner, MT



San Juan County, UT

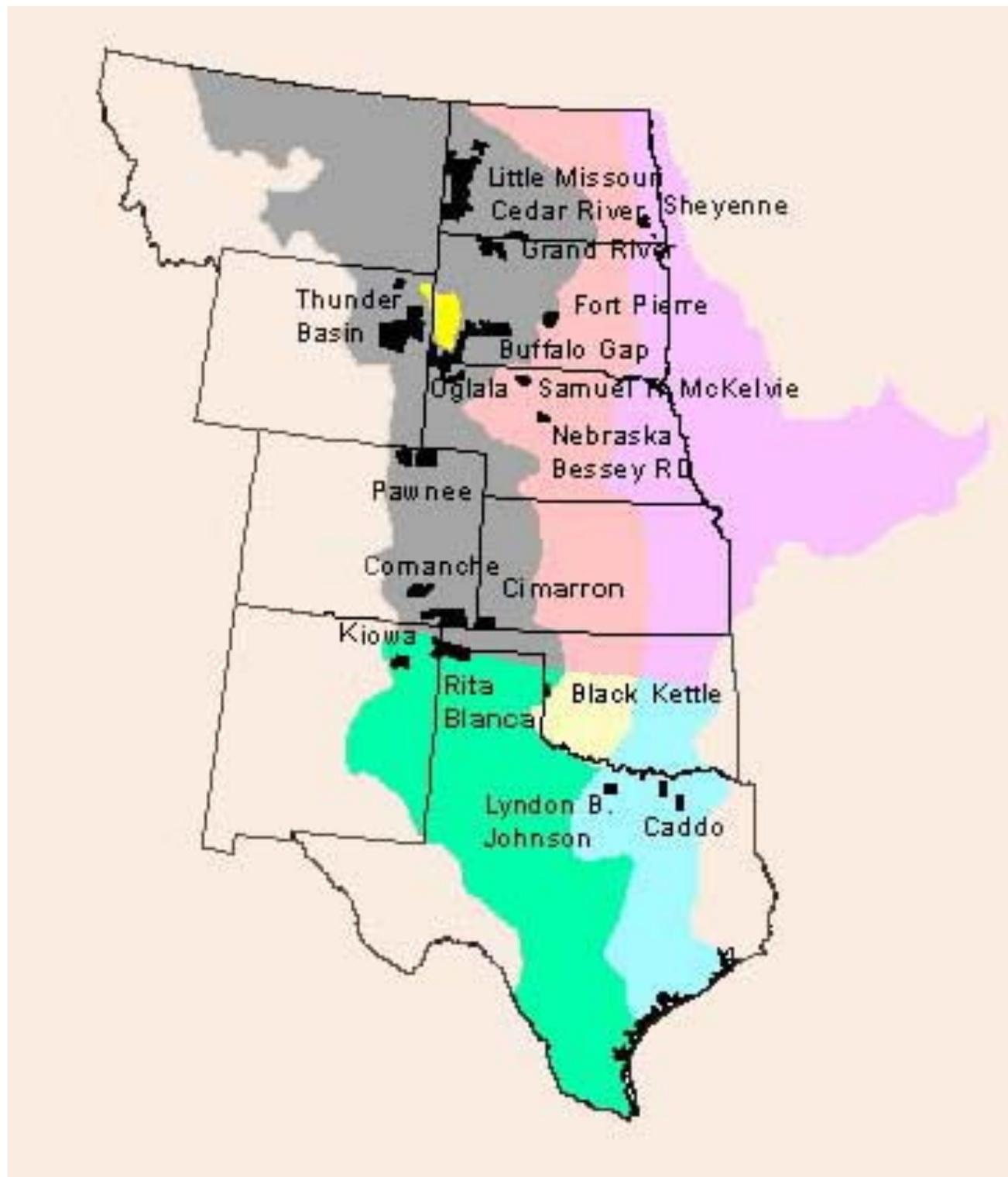
in mesic regions, grazing has a positive impact on productivity



in arid regions, grazing has a negative impact on productivity



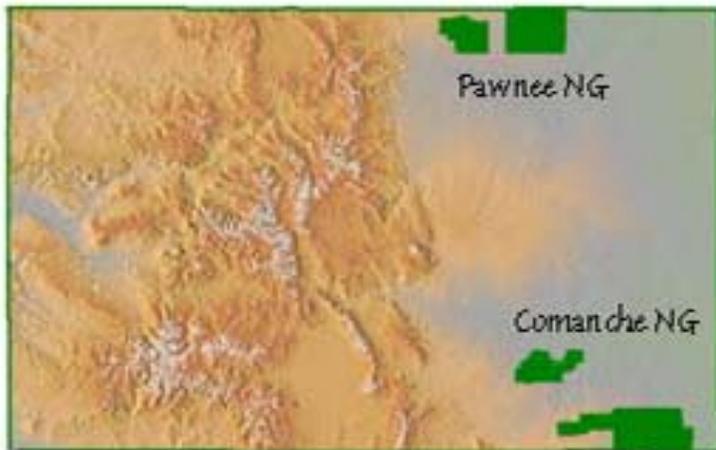
**North American
Grassland Regions**



How much remains of the original grasslands of North America?

... very little

Colorado



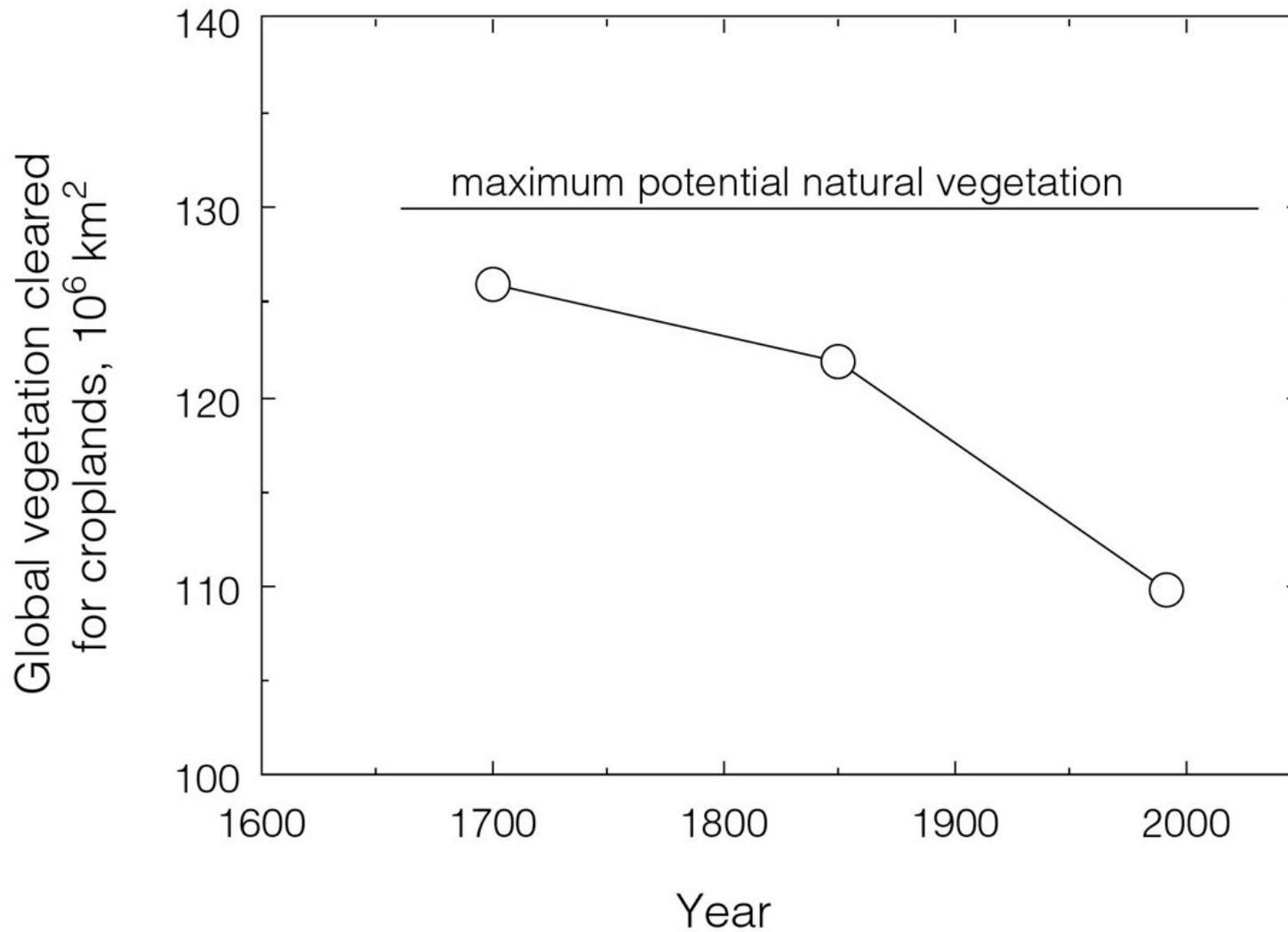
South Dakota



Kansas



Since 1700, grasslands, savannas, and forests have decreased by ~ 15 %

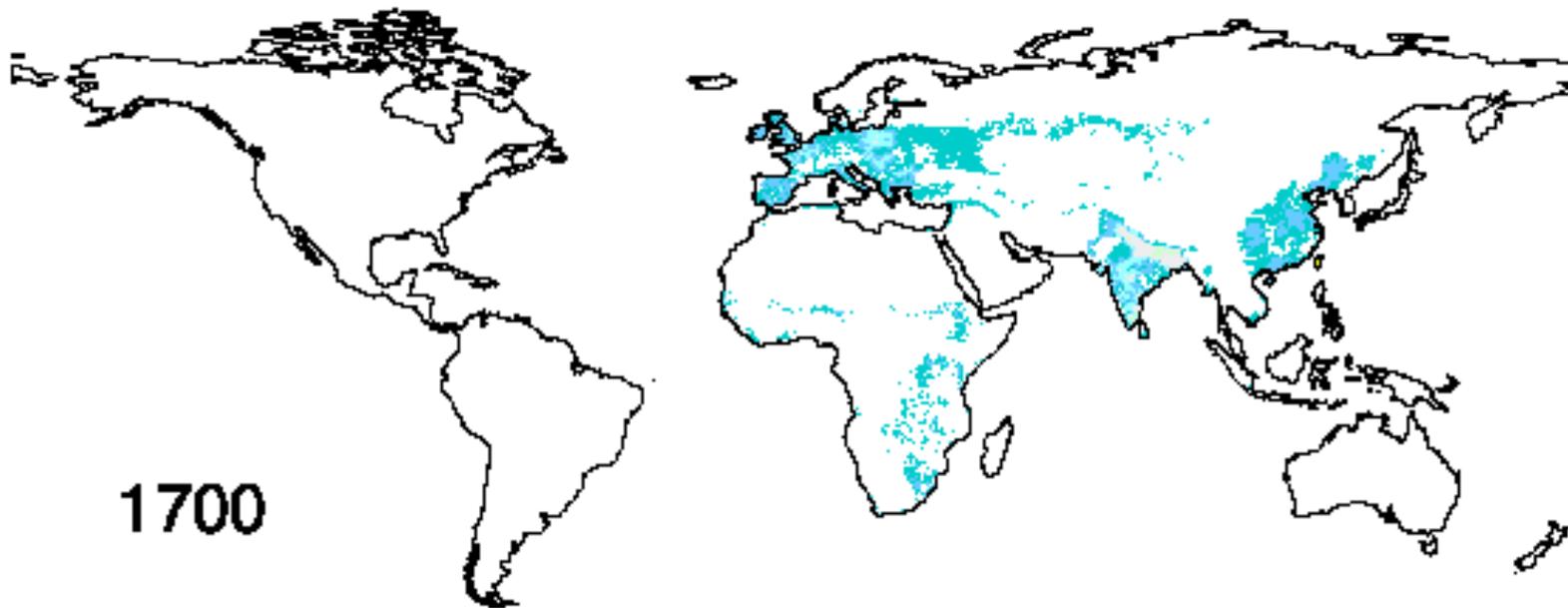


Human modification of grasslands

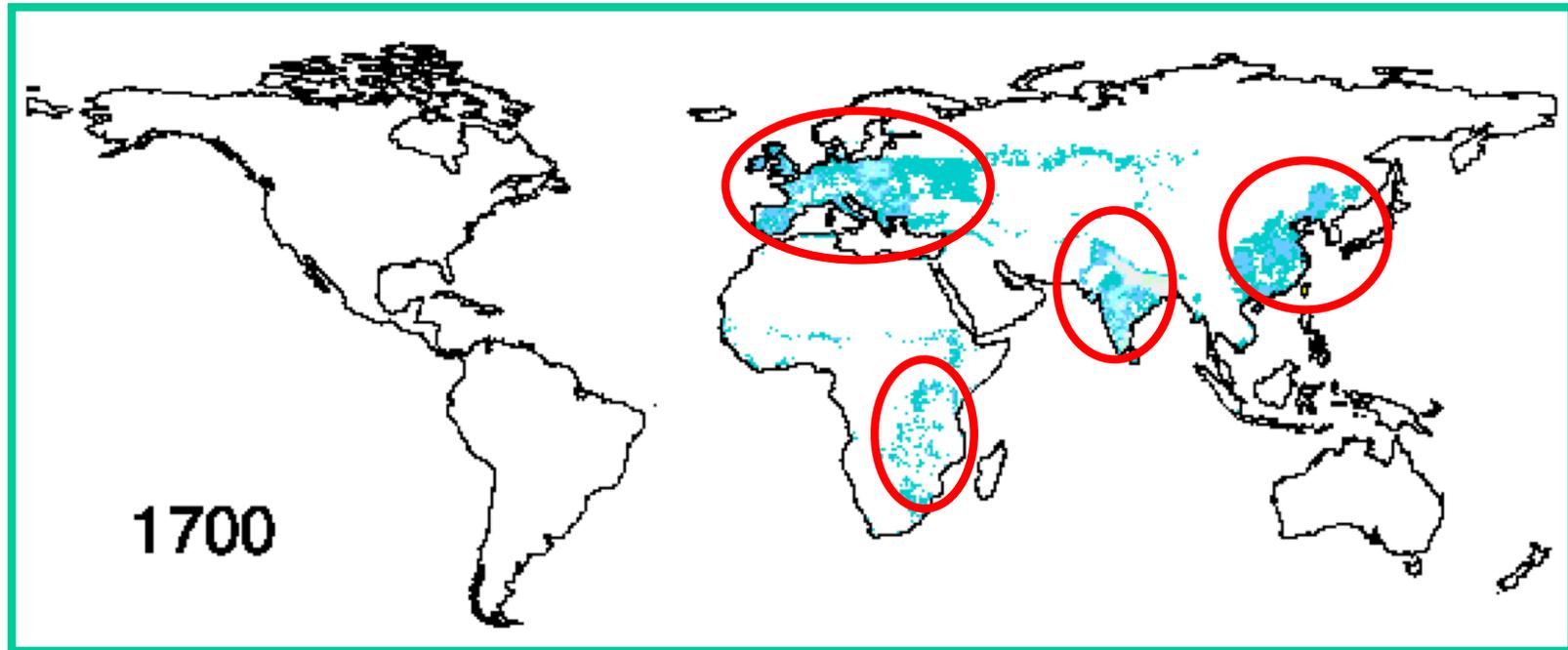


- Extensive clearing of forests and prairies ~ 8 million km²
- In the USA, annual consumption of water exceeds volume of Lake Huron
- Since 1850:
 - » Need for grain and water has tripled
 - » fossil-fuel use increased four-fold
 - » corn is a major crop for feed, food, and sugar source

Agricultural modification of the land surface was already a significant part of the landscape in 1700

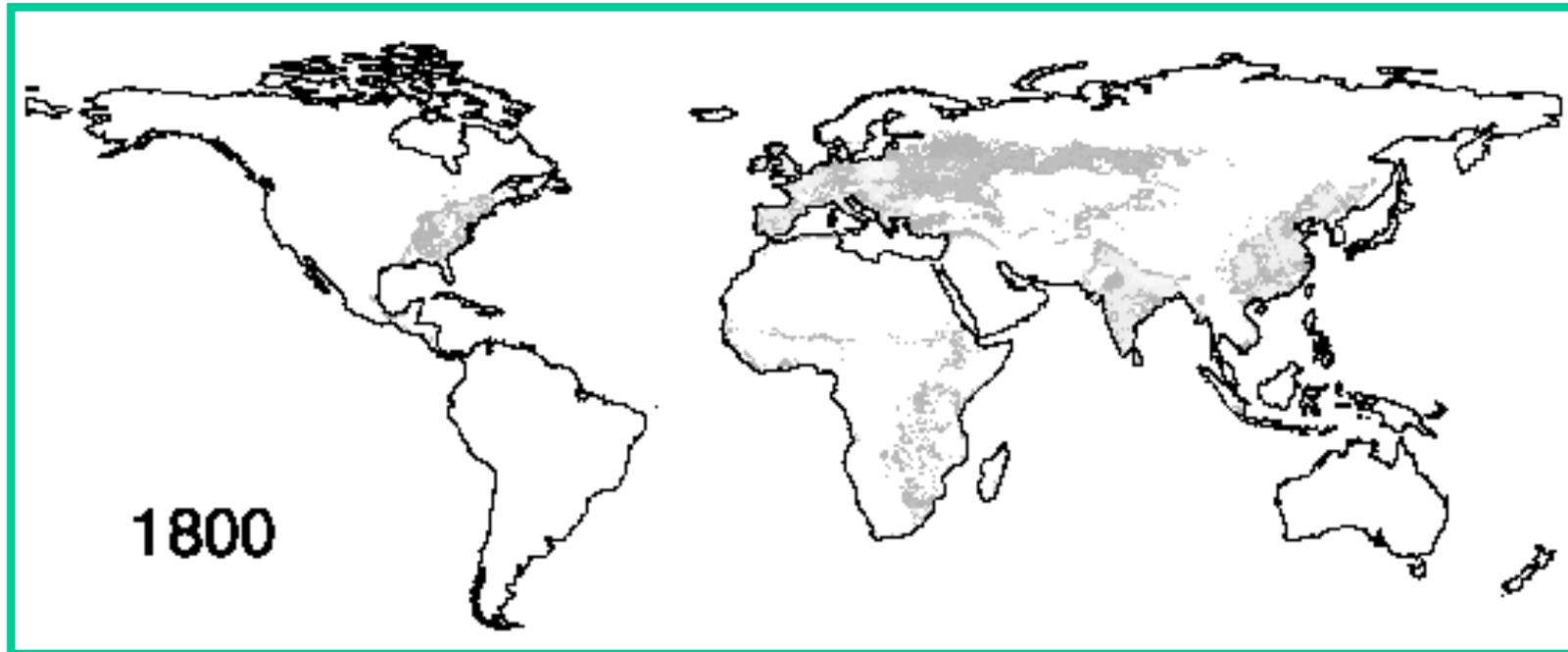


Global Cropland Distributions



Source: Ramankutty & Foley, 1999

Global Cropland Distributions



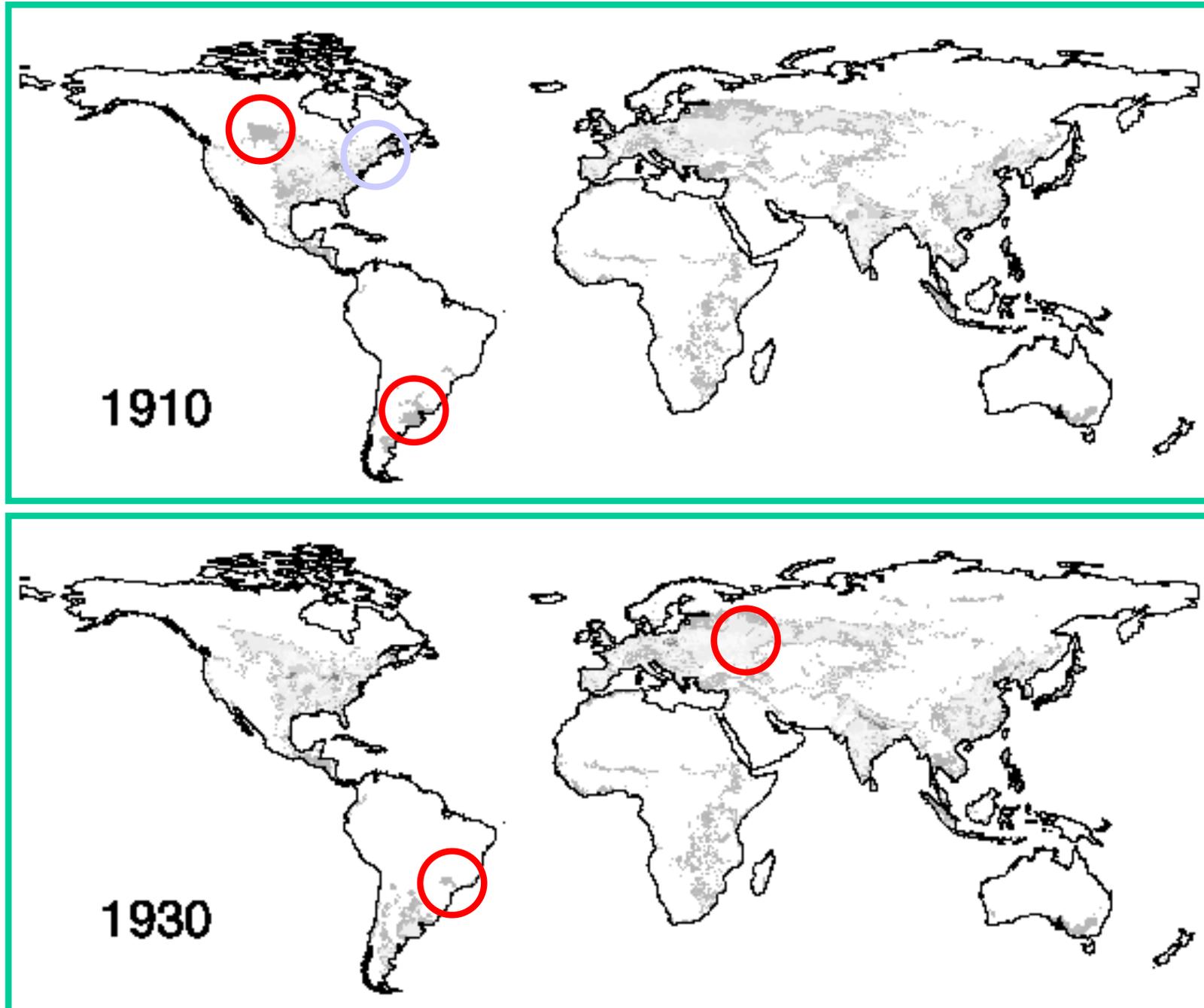
Source: Ramankutty & Foley, 1999

Global Cropland Distributions



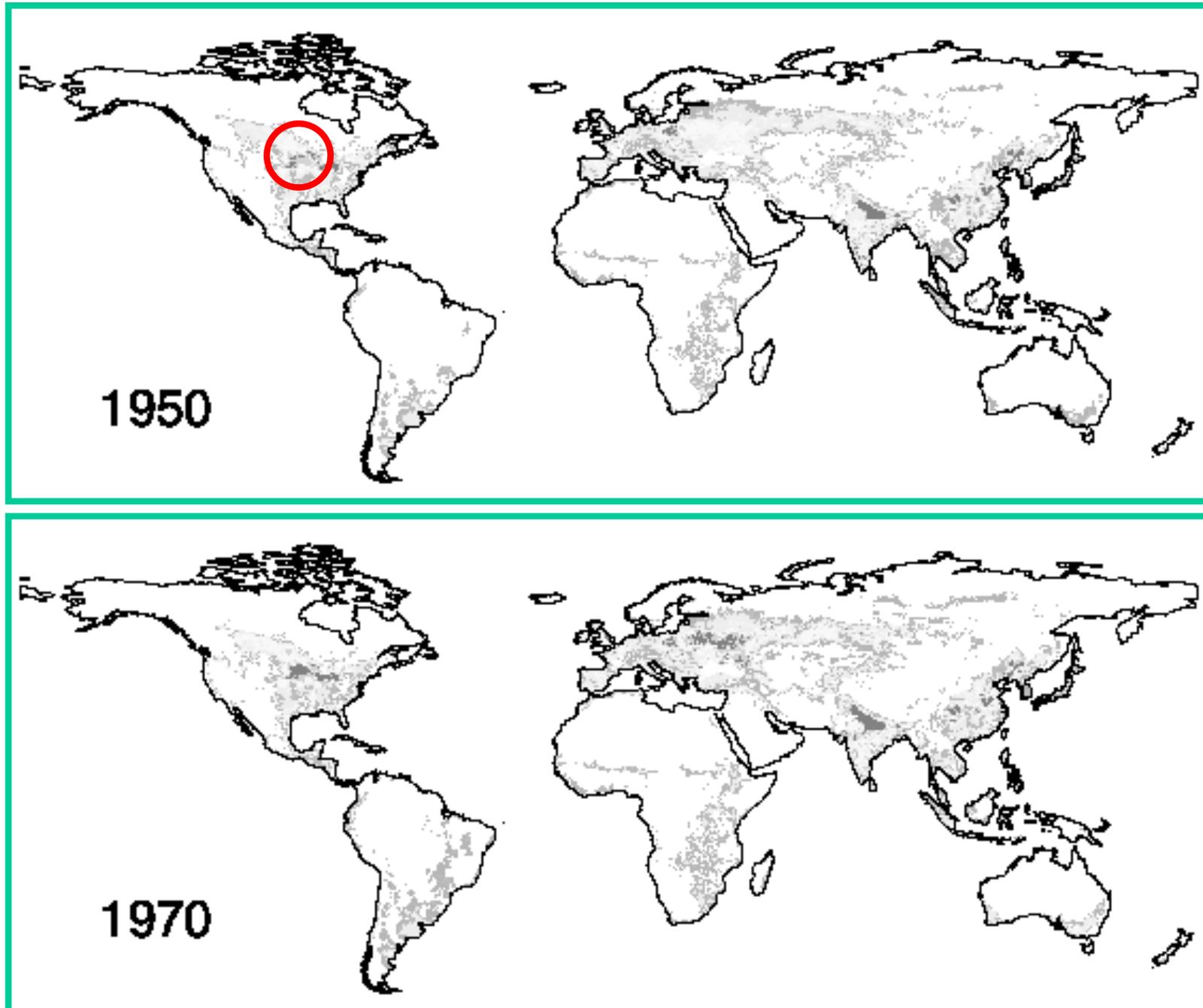
Source: Ramankutty & Foley, 1999

Global Cropland Distributions



Source: Ramankutty & Foley, 1999

Global Cropland Distributions



Source: Ramankutty & Foley, 1999