

# Grassland Biomes & Adaptations

Read Ch. 5 in Knight

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## What is a grassland?

An ecosystem where the dominant plants are grasses and sedges (**graminoids**), with other herbaceous plants (**forbs**) and sometimes a low density of woody vegetation.

- Grasslands account for ~25% of global vegetation
- Grasses may make up <20% of the species but >90% of the biomass
- Disturbance (fire) plays a key role in maintaining grassland vegetation

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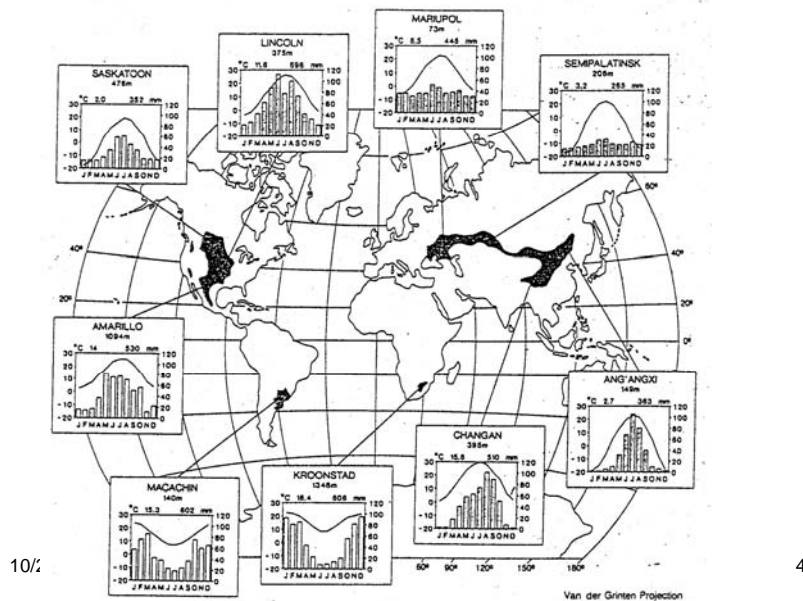
## Geographic distribution

- **Steppe** (Eurasia)
  - Sagebrush steppe occurs in southern Eurasia, from Black Sea to Gobi Desert
- **Veldt** (S. Africa)
- **Pampas** (S. America)
- **Prairie** (N. America)

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## Distribution of temperate grasslands



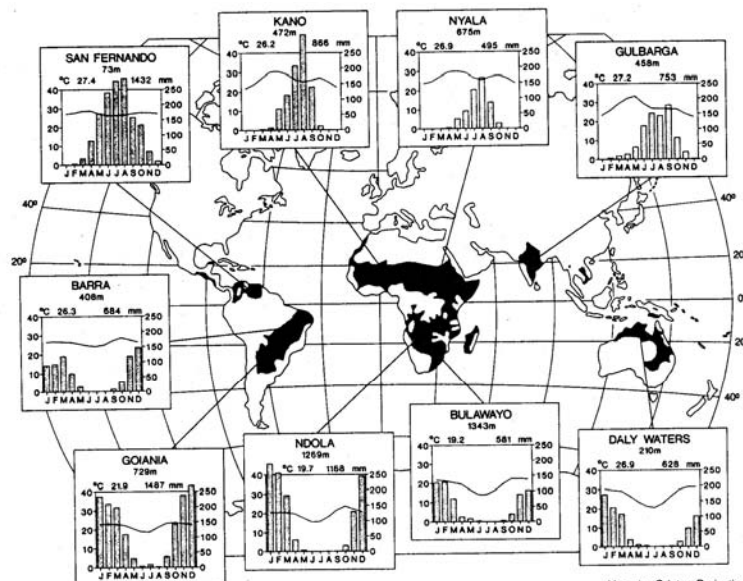
# What about savannahs?

- Savannahs form a transition zone between tropical forests and deserts; grasses are conspicuous ground cover, but trees and shrubs may be dense
- 65% of Africa; eastern Brazil cerrado
- Pronounced **wet-dry** seasonality

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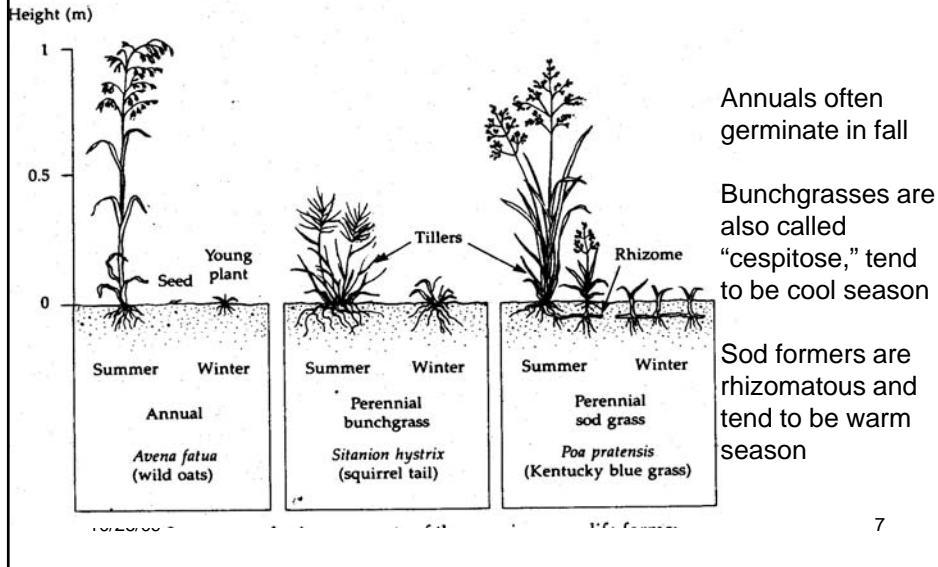
# Savannah distribution map



Van der Grinten Projection

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## Three major grass life forms

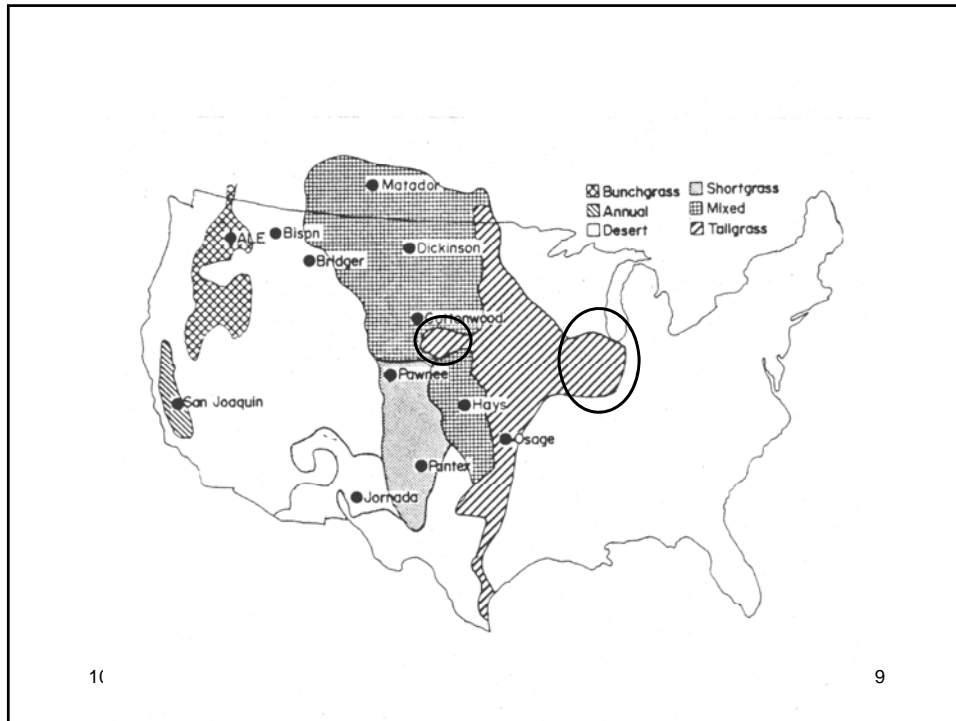


## North American Grasslands

- Northern Mexico to southern Canada; largest biome in US prior to cultivation
- 200-1200 m elevation (up to 2400 m)
- Taller, sod-forming types favored in moister regions or sites (rhizomatous grasses common)
- Shorter bunchgrasses, higher % of annuals, found in drier regions (rhizomatous grasses less common)

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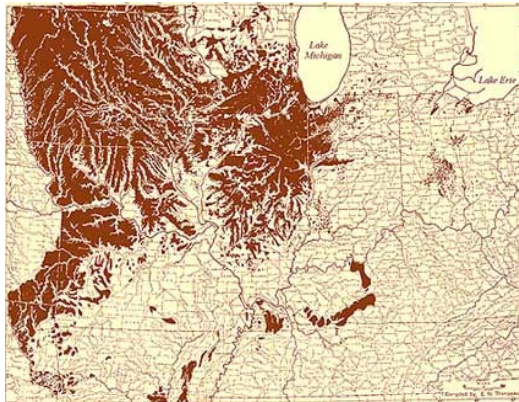
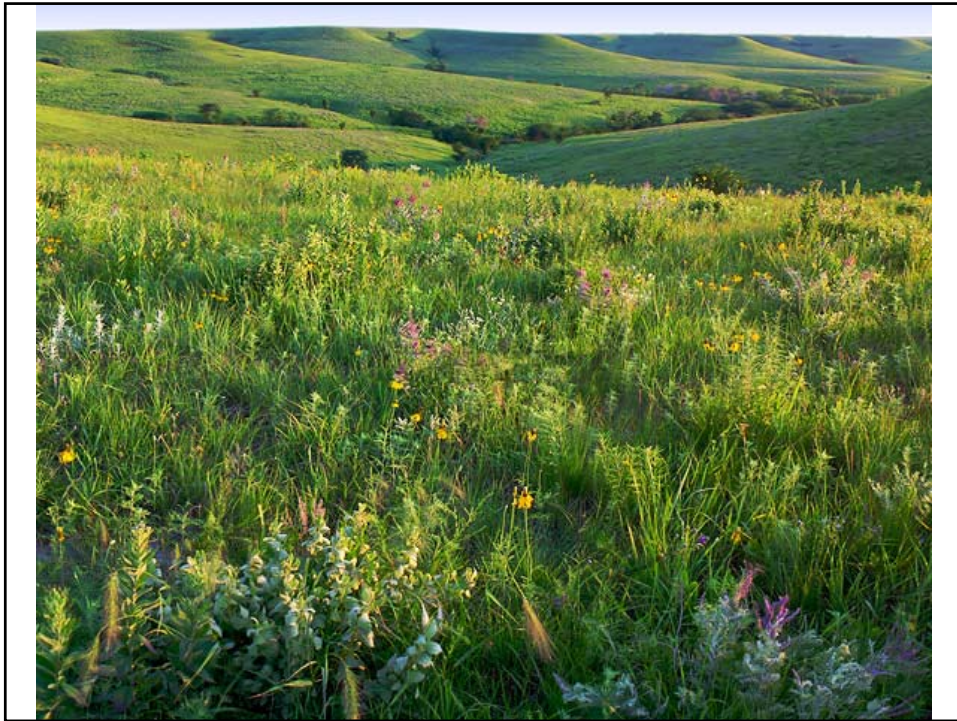


## Tallgrass Prairie

- Up to 2.5 m tall! (most <1m tall)
- Prairie peninsula, Nebraska Sandhills, Konza
- Now dominated by *Zea mays*; 85-99% loss
- Summer rain -> C4's dominate
  - Big bluestem
  - Indian grass
  - Switch grass

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The Prairie Peninsula  
E.N. Transeau  
Ecology v. 16 p.423-437  
1935

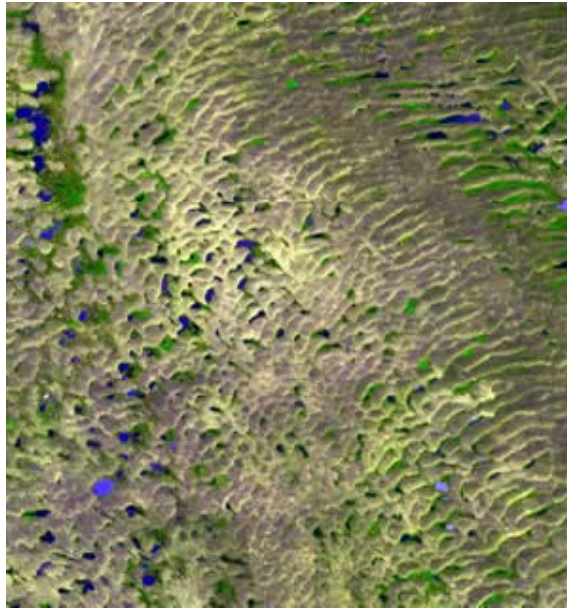
Why did tallgrass prairie  
occur in IL, IN, OH, in  
areas that “should have”  
been climax forests?

## Nebraska Sand Hills

Largest dunefield in N. America (19000 sq mi)

Wetlands (1.3 M acres)

Why does tallgrass prairie extend so far west into NE?



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About 60x60 km

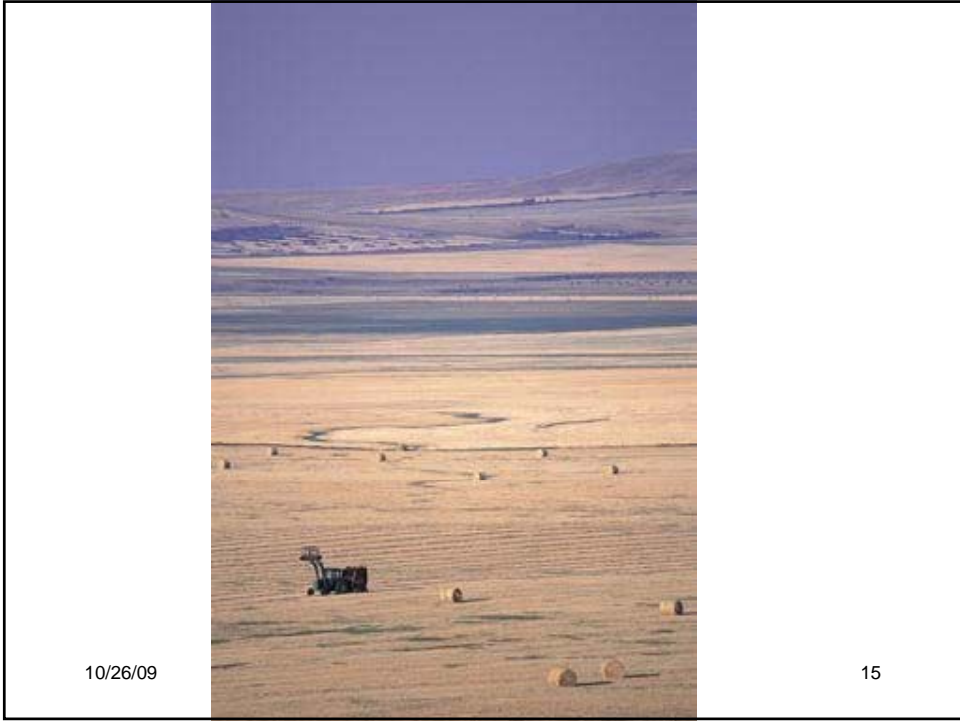
NASA/GSFC/METI/ERSDAC/JAROS,  
and U.S./Japan ASTER Science Team

## Mixed grass (“mid-grass”) Prairie

- 30 to 120 cm tall
- Largest native prairie in NA; 30-99% loss
- Mixture of tall and short grass species, most floristically diverse grassland in NA
- Winter and summer precipitation: C3's & C4's
  - Western wheatgrass
  - Needle-and-thread grass
  - Little bluestem
  - Blue & sideoats grama

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## Shortgrass Steppe

- 20-50 cm tall
- Spring and summer precipitation; more C4's
  - Blue grama
  - Buffalo grass
  - Wheatgrasses
- Co-evolution with native grazers increases resistance to domestic livestock
- Requires irrigation for farming; wheat-fallow is common; 20-85% loss

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## Desert grassland

- 20-50 cm tall, with shrubs to 2+ m
- Occurs at higher elevations in Chihuahuan and eastern Sonoran deserts
- Summer rain; C4's dominate
  - Black grama
  - Galleta
  - Tobosa
- Drought + overgrazing reduce grass cover and promote shrub invasion by mesquite and creosote bush

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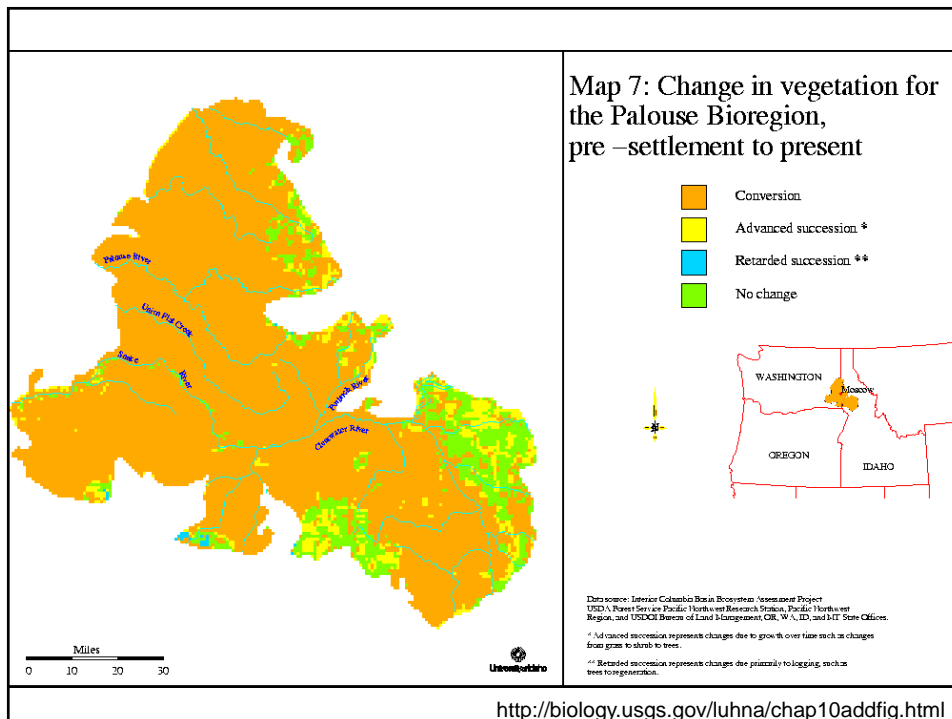
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# Bunchgrass (Palouse) grassland

- Sagebrush steppe region
- Most (94%) has been converted to crops or pasture
- Invasion by cheatgrass (downy brome) has strongly altered this grassland
- Winter rain/snow: C3's dominate
  - Bluebunch wheatgrass
  - Fescues
  - Poa spp.

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## Annual grassland of California

- Formerly perennial bunchgrasses, some similarities to Palouse
- Now dominated by Eurasian **exotics**
  - <5% of original area retained perennial grasses as of 1950
- Mediterranean climate; winter rain: **C3's only**
  - Wild oats and barleys
  - Bromes

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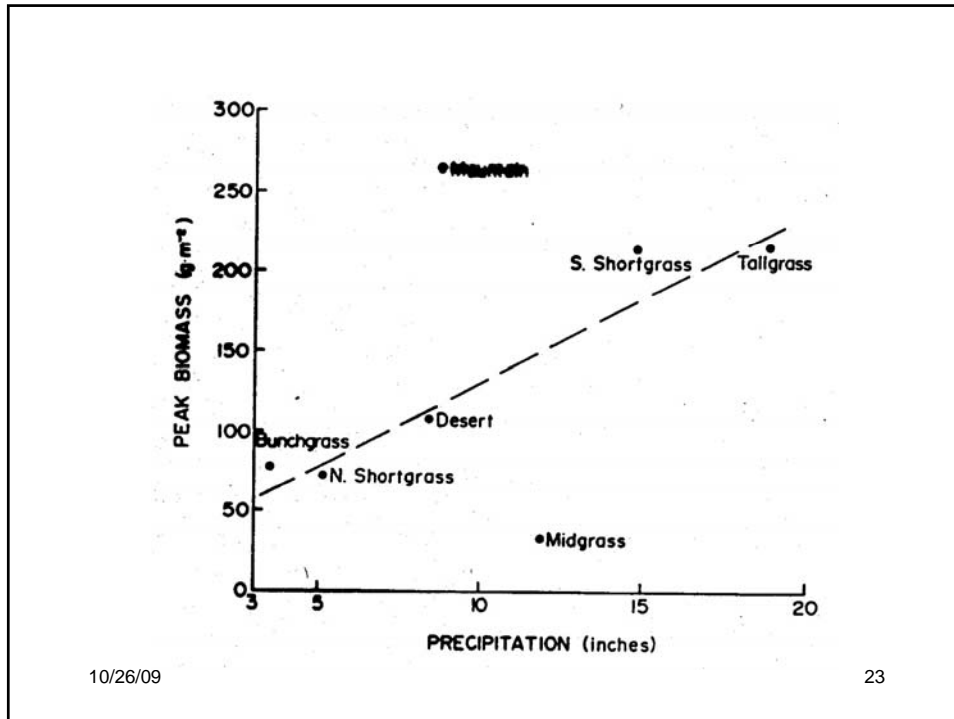
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## General Climate in Grasslands

- **Wet/dry** seasonality, with temperature extremes
- Most precipitation falls during growing season (except CA and Palouse)
- Precipitation 100 cm/yr in tallgrass, 50 cm/yr in mixed grass, to 20 cm/yr in desert grassland
- **P/E ratio** decreases from ~1 in tallgrass, to ~0.3 in desert grassland
- Where late summer droughts occur, tallgrass prairie is favored over deciduous forests
- Growing season is initiated by temperature in the spring, but is terminated by summer drought, not cold (except desert grassland)

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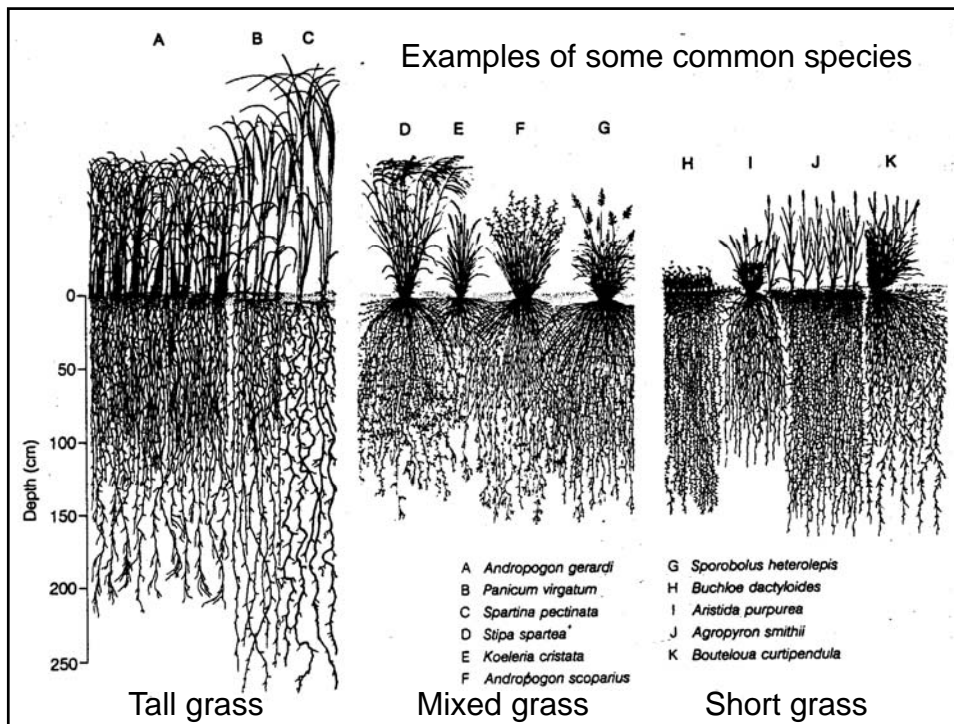


## Grass adaptations

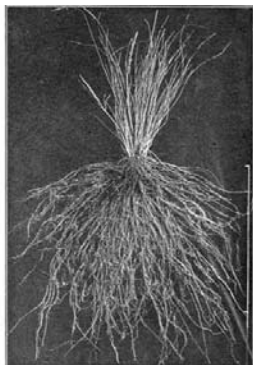
- Grasses have high phenotypic plasticity (morphology and physiology)
- Grow fast when moisture is available
- Huge root systems allow rapid and efficient water and nutrient uptake
- Use **stored starch** (in roots) to recover from grazing or drought
- Water use efficiency can be high, allowing drought tolerance

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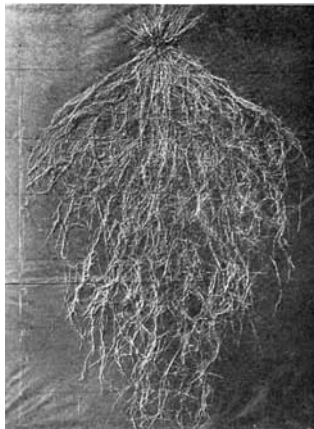
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## Bunchgrass root systems



- June grass (KOGR)**
- Roots to ~60 cm
  - Seeds in June, then senesces
  - C3, cool season



- Needle-and-thread (HECO)**
- Roots to ~150 cm
  - Very branched root system
  - C3, cool season

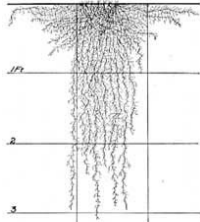
Bunchgrasses can form sod!

- Big bluestem

For more info, see: USDA-NRCS PLANTS Database, <http://plants.usda.gov/>  
<http://www.soilandhealth.org/01aglibrary/010139fieldcroproots/010139ch4.html>

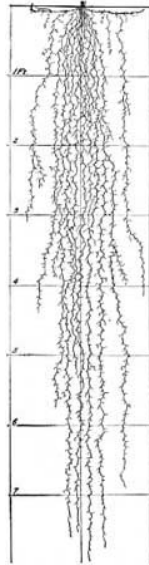
## Rhizomatous root systems

### Vegetative propagation by rhizomes



- Blue grama (BOGR)
- Most roots/rhizomes in top 15 cm
  - Dense sod former
  - Few roots to ~90 cm
  - C4, warm season

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- Western wheatgrass (ELSM)
- Deep roots to 2m+
  - Rhizomes common in upper 10 cm
  - C3, cool season

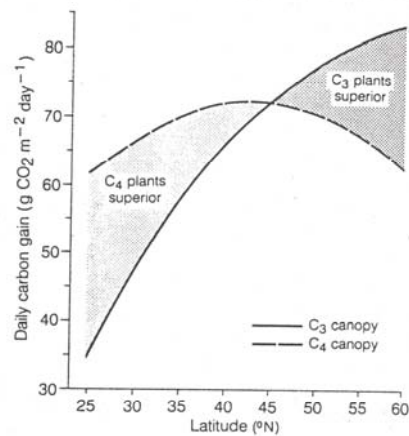
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## More adaptations

- Photosynthesize at low water potentials
- Close stomata, roll leaves
- **Propagules** and meristems withstand drought, fire, herbivory
- **Intercalary meristems** at nodes and root crowns can re-sprout
  - Hemicryptophytes
- **Lignin** and **silica** in stems provide support, and **reduce digestibility** and decomposability
- Standing litter is highly **flammable**

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C3 (cool-season) and C4 (warm-season) species provide broad range of temperature and moisture tolerance

**Figure 7.20** Calculated rates of total daily carbon gain for C<sub>3</sub> and C<sub>4</sub> grass canopies at different latitudes within the Great Plains of North America during July. (After Ehleringer, 1978.) (Reproduced with permission from J. R. Ehleringer, Implications of quantum yield differences on the distributions of C<sub>3</sub> and C<sub>4</sub> grasses. *Oecologia*, 1978, **31**, 262.)

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## Grassland soils

- Tallgrass prairie has mostly been converted to cropland because Mollisols are so productive
- Why are they so fertile and black?
  - Root/shoot ratio is high; 70-80% of biomass is belowground
  - Roots contribute fertility (N) and organic matter, which makes Mollisols black
  - About 33% of roots are sloughed off each year in tallgrass prairie
  - High lignin content slows decomposition
- Further west, soils are Aridisols, less fertile and less productive (lower organic matter content)
- Aridisols are the soils underlying most rangelands

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