# Agriculture, Irrigation, & Hydrology in the U.S. Great Plains

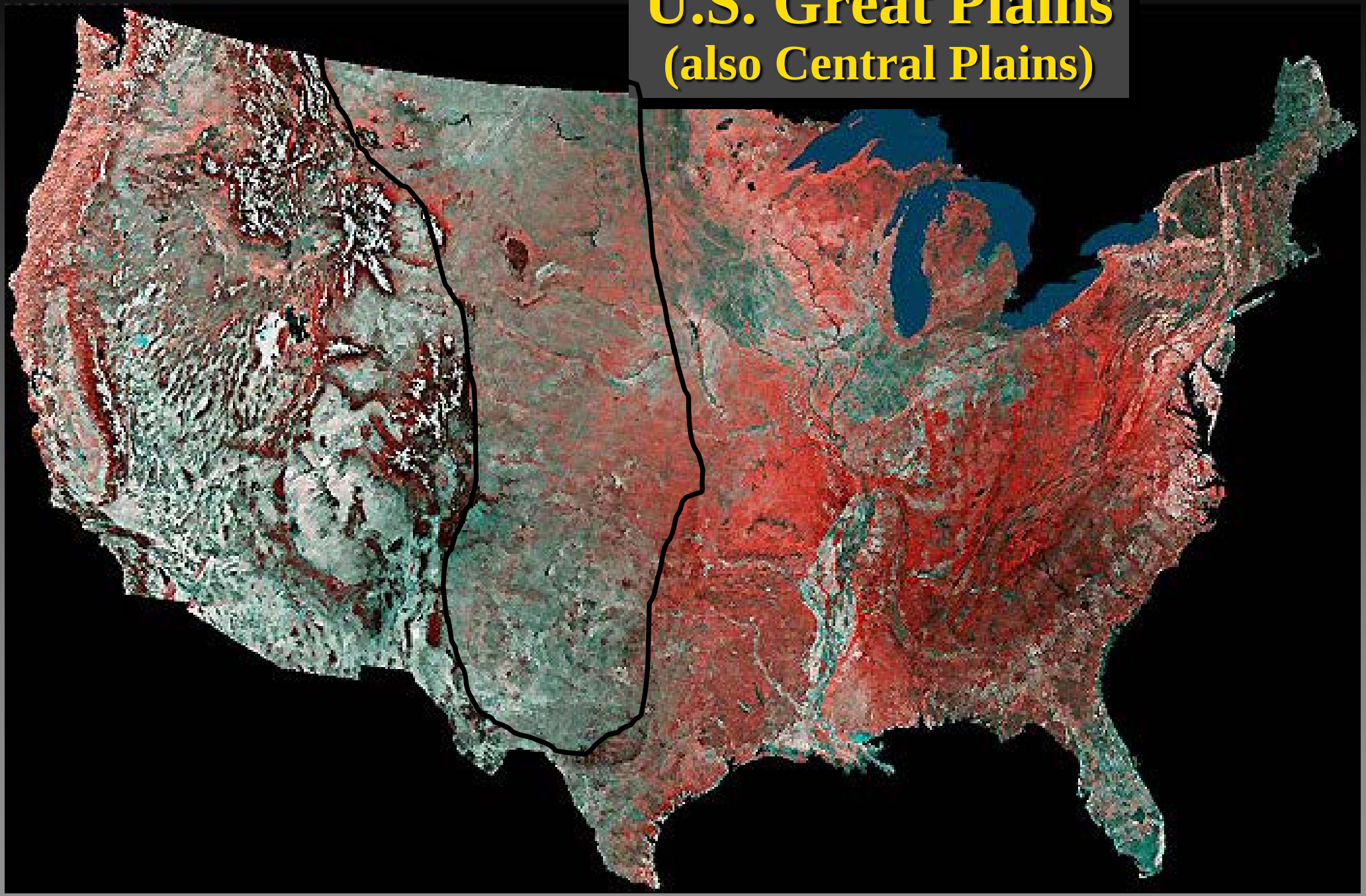

## Tom Trout

**Water Management Research Unit**

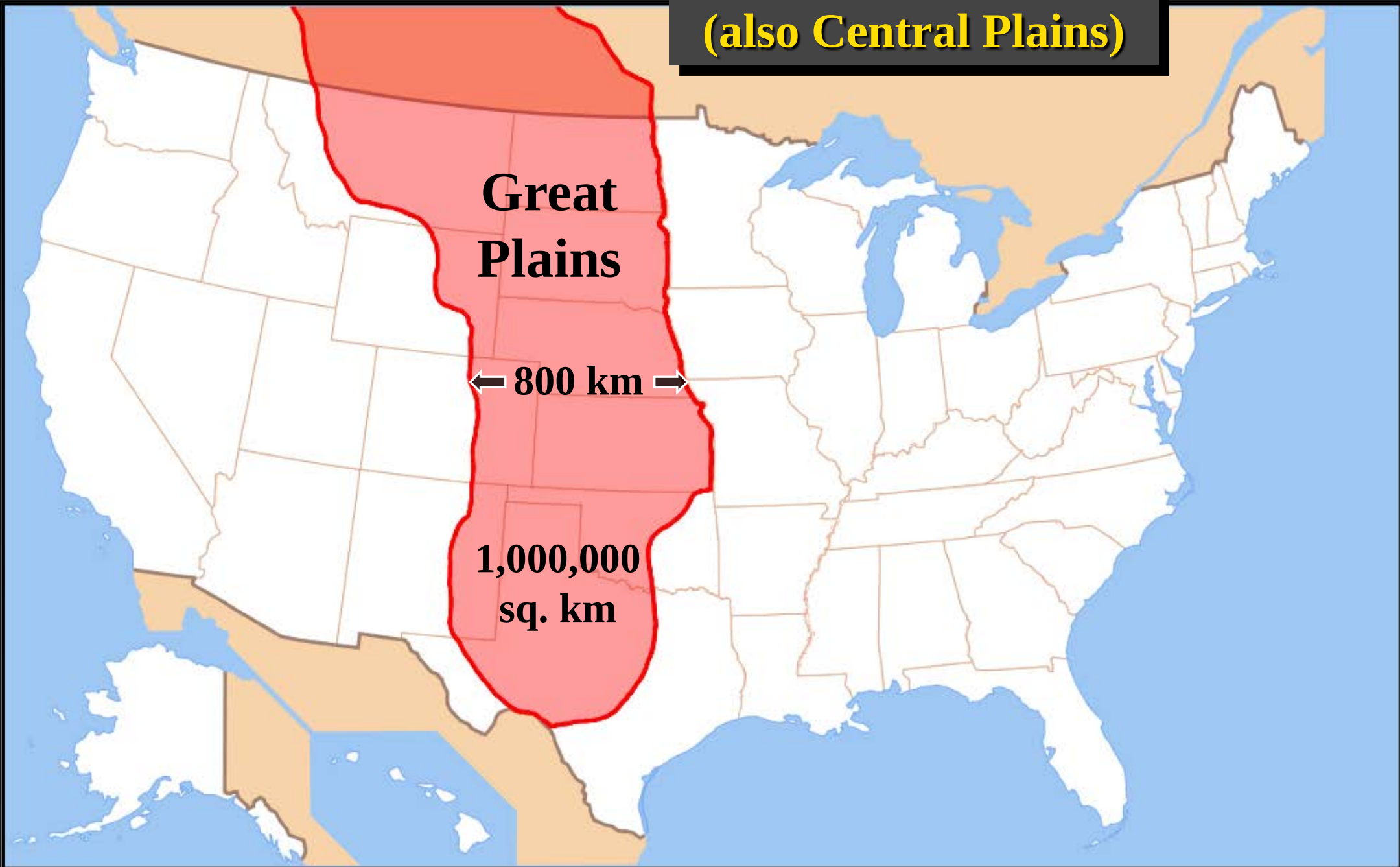
Fort Collins, CO

United States Department of Agriculture
Agricultural Research Service


# U.S. Great Plains
## (also Central Plains)



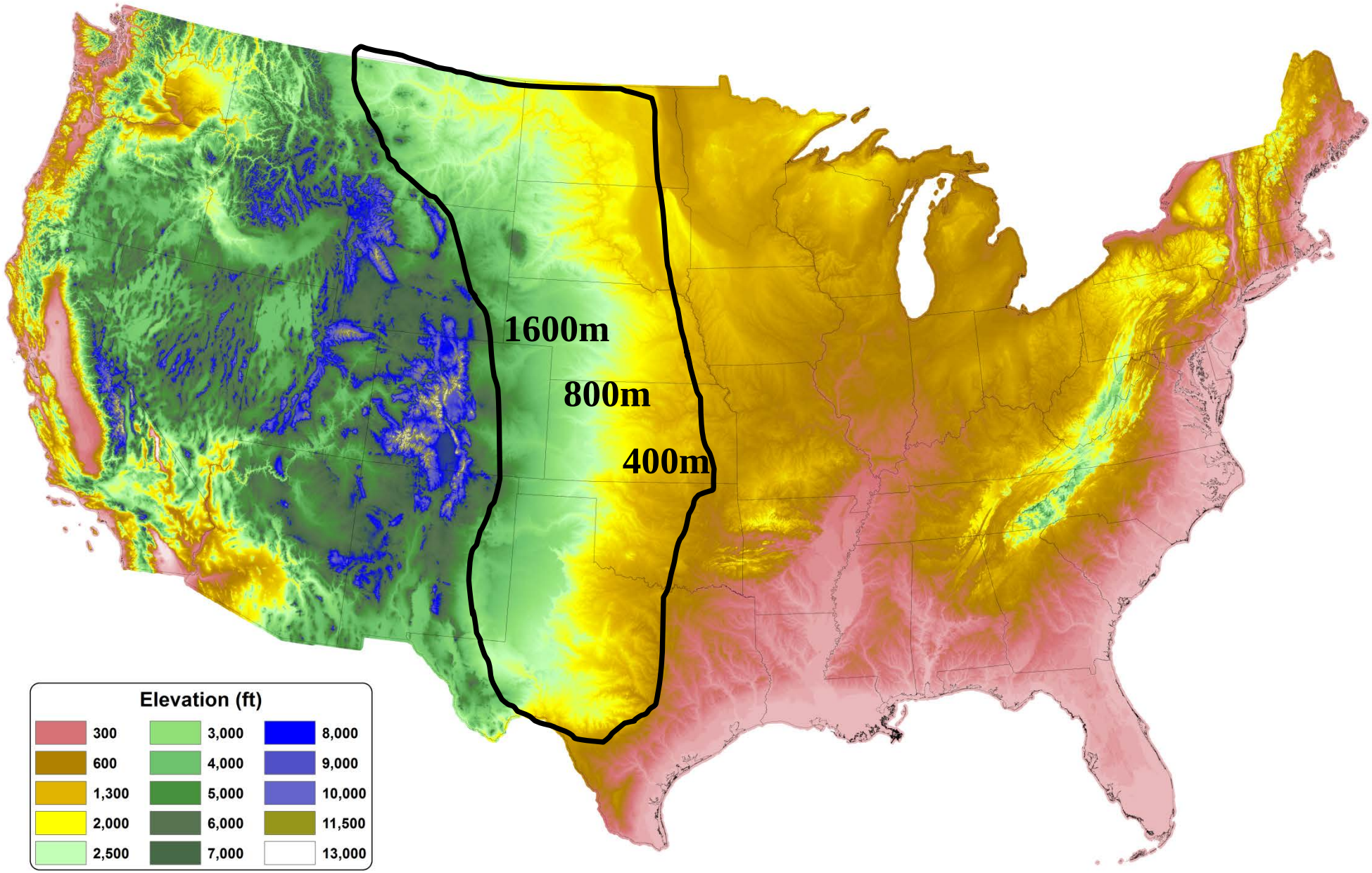
# U.S. Great Plains
## (also Central Plains)



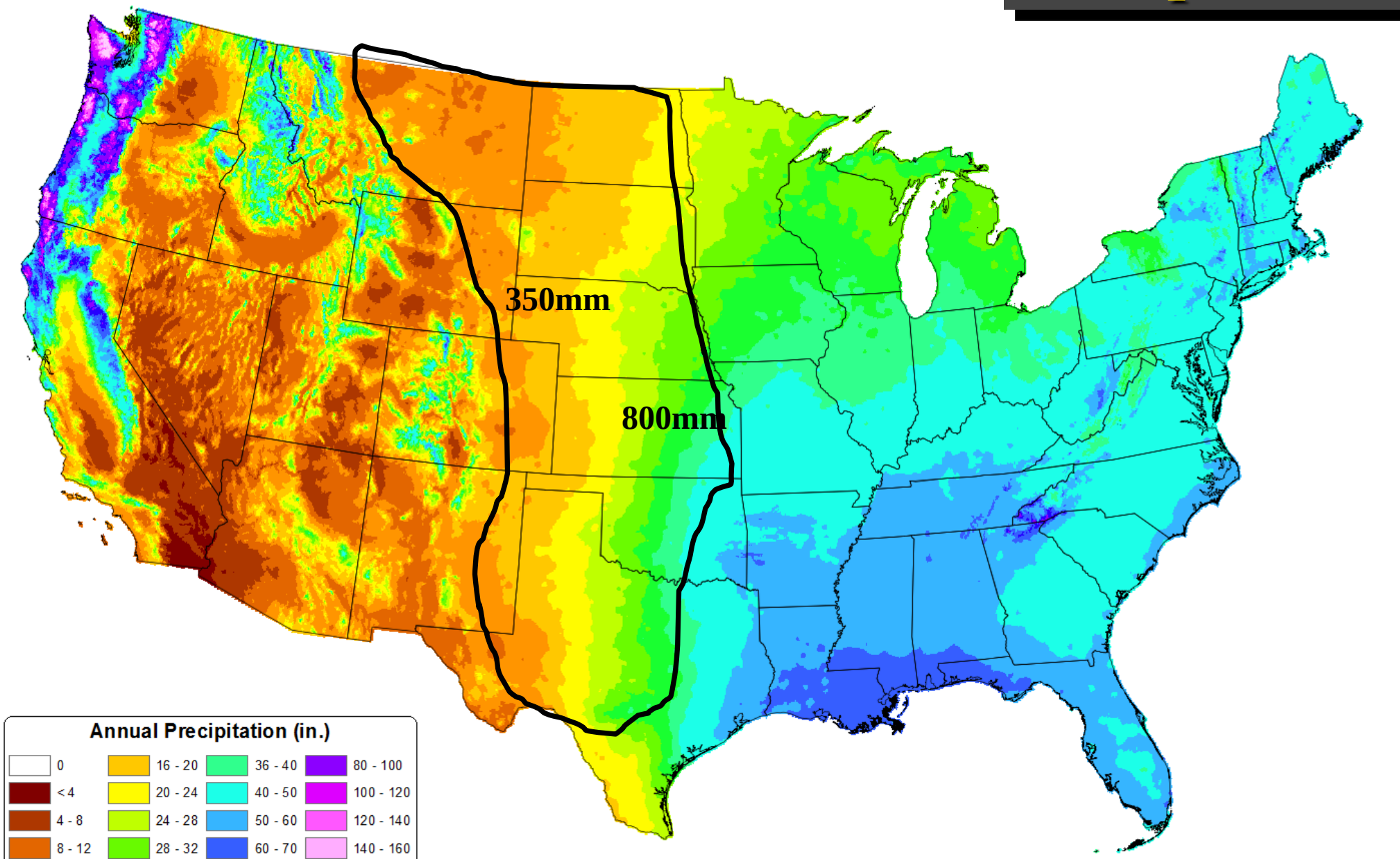
# U.S. Great Plains
## (10 states)

# Terrain Elevation
Resolution: 800m

# Elevation



# Precipitation



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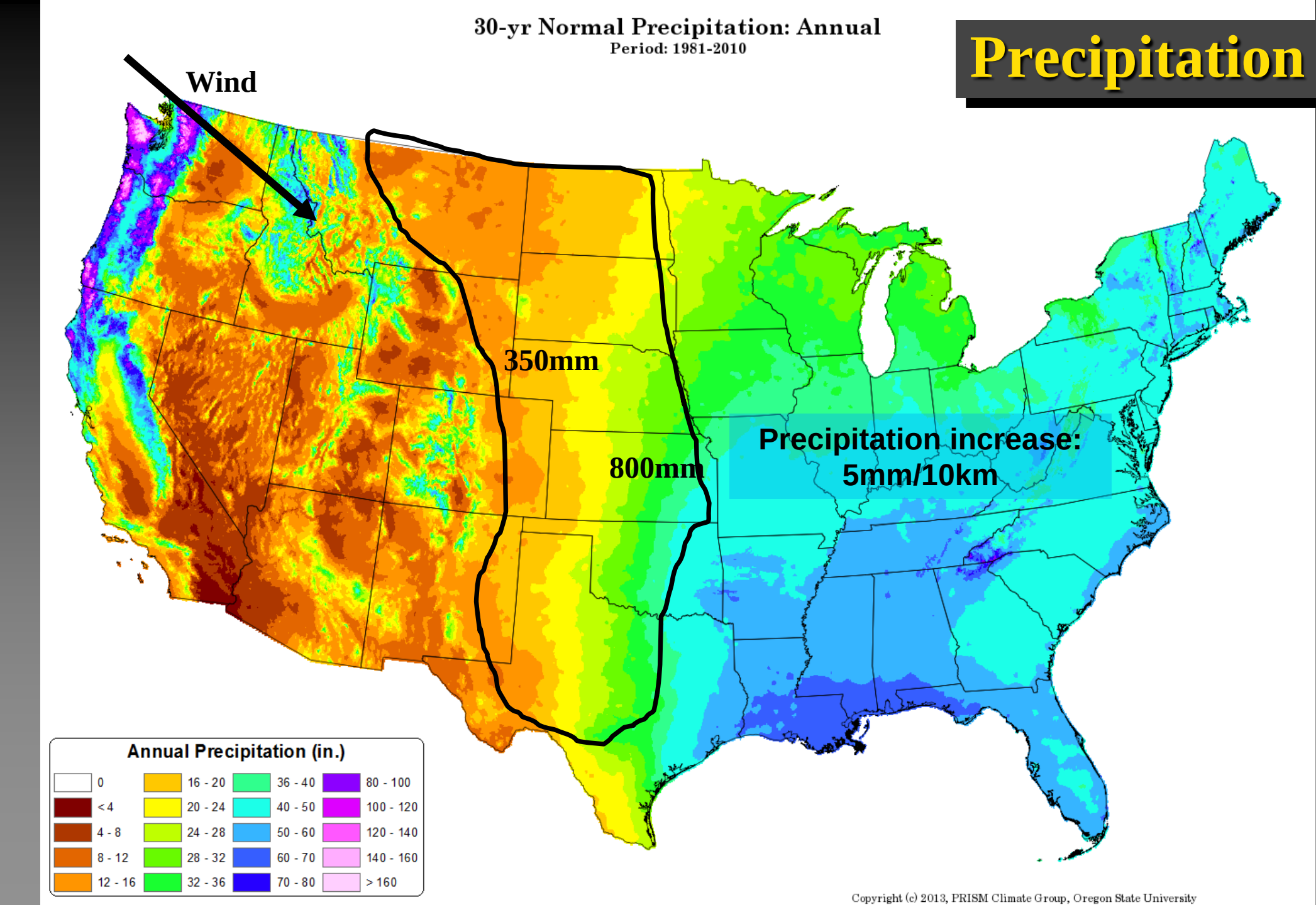

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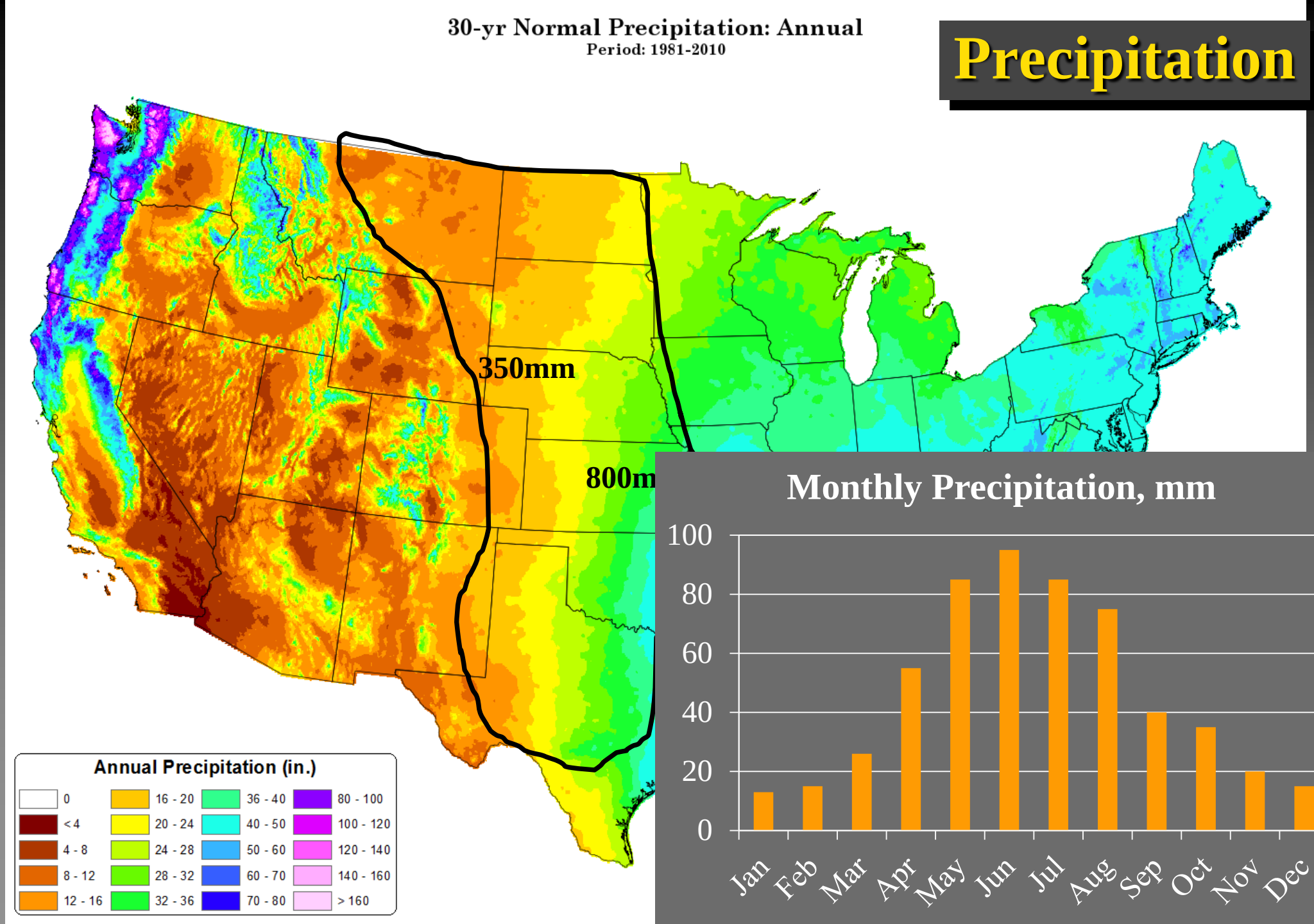
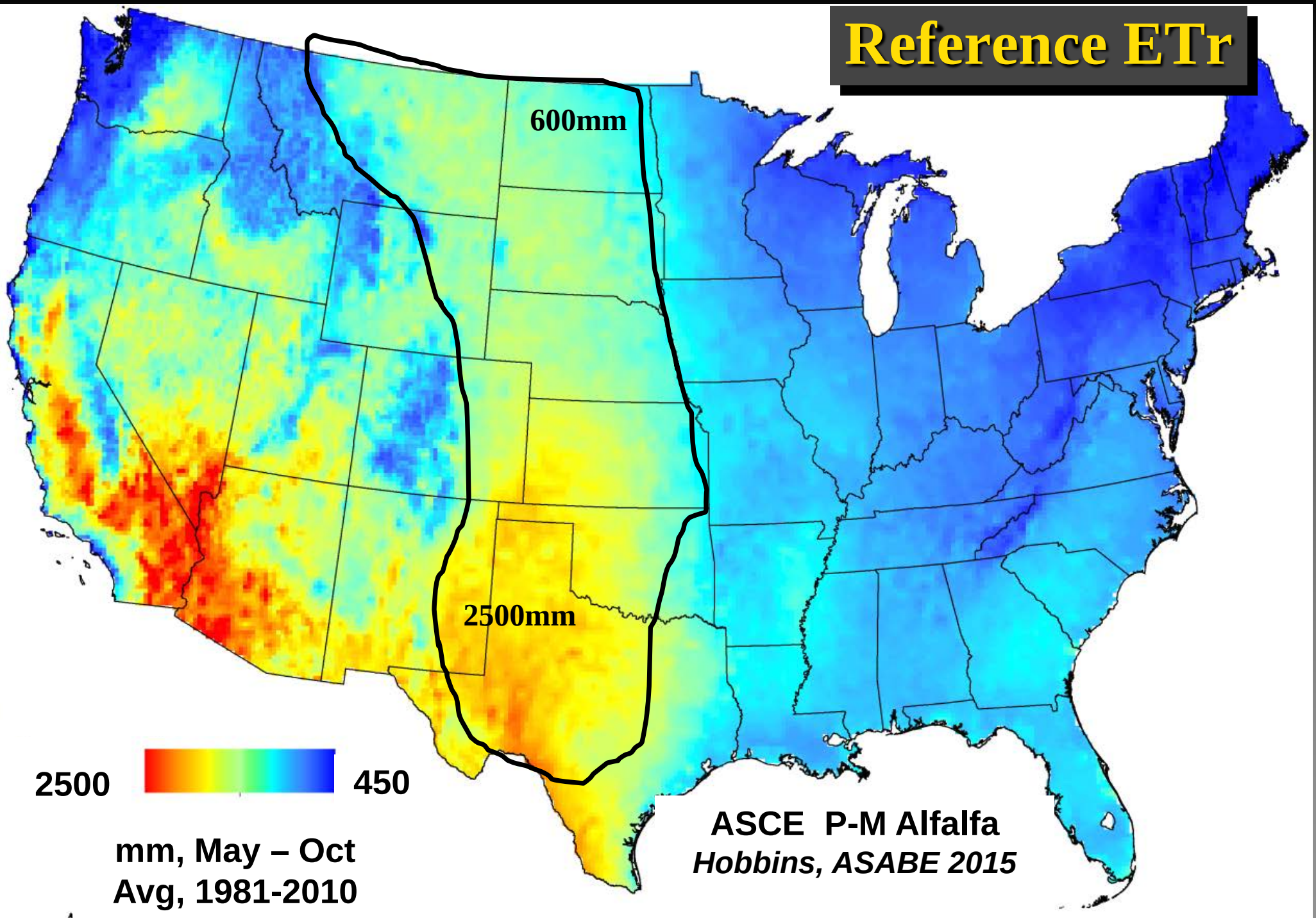
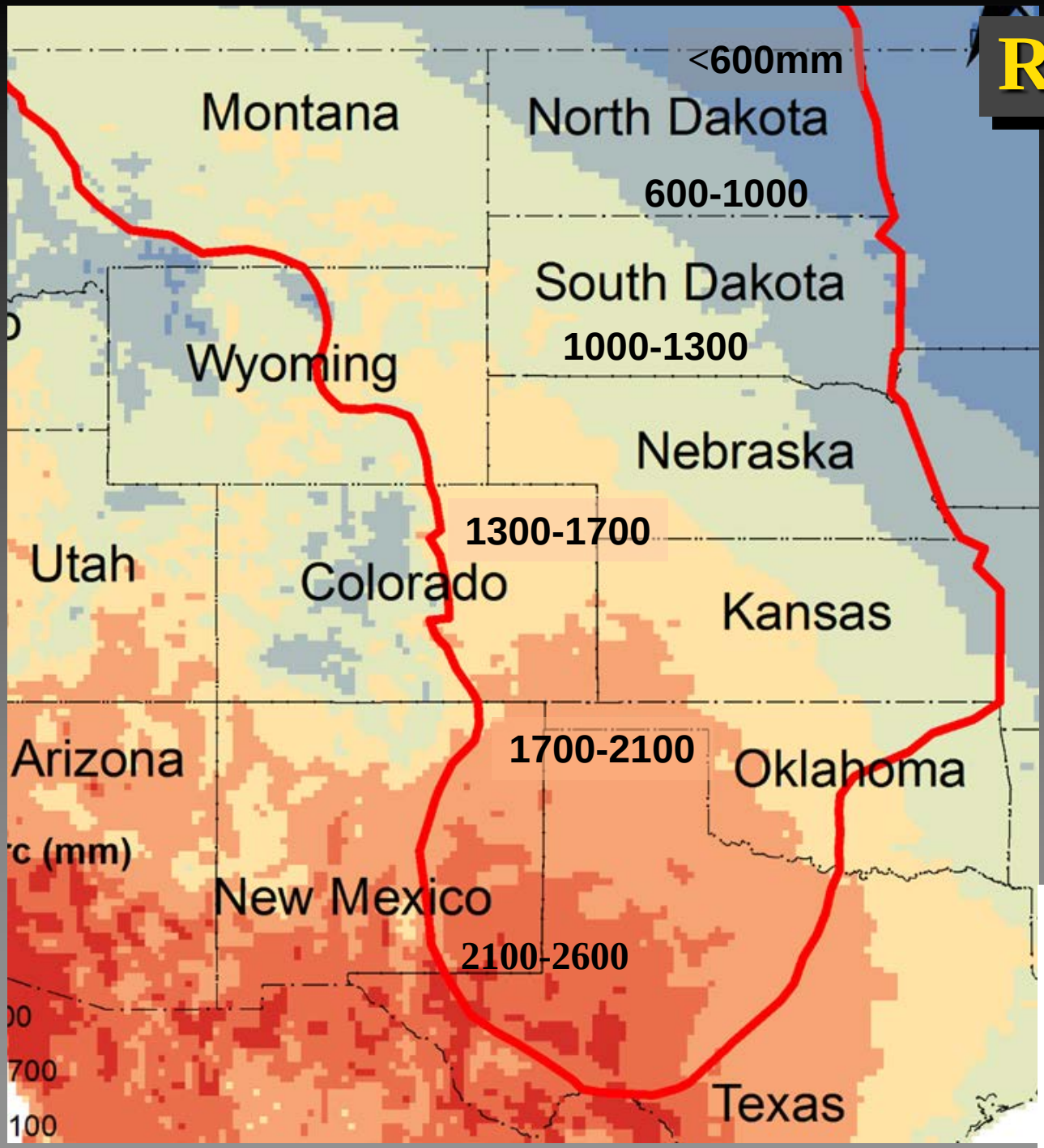
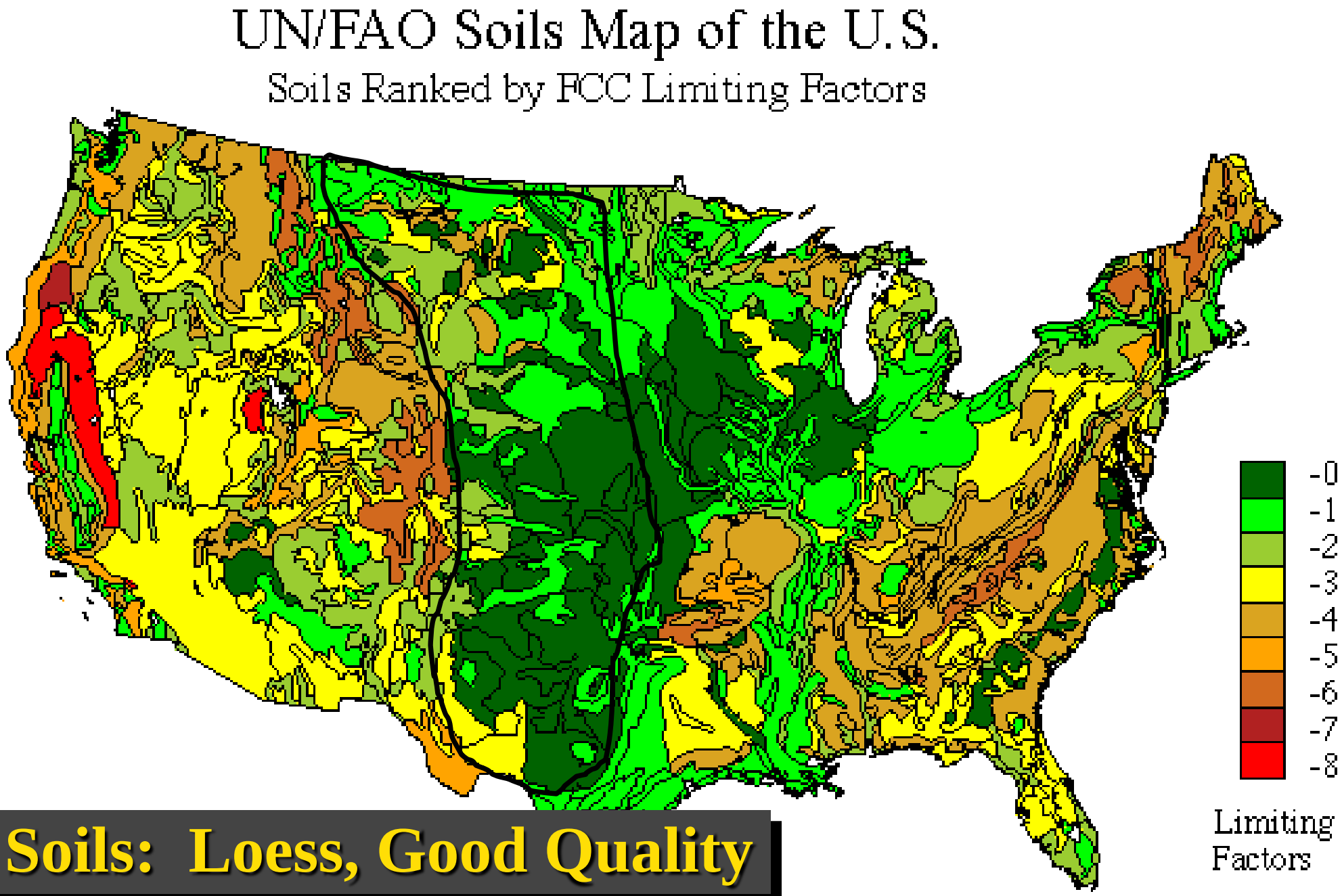



Reference ETr
600mm
2500mm
2500
450
mm, May – Oct
Avg, 1981-2010
ASCE P-M Alfalfa
Hobbins, ASABE 2015

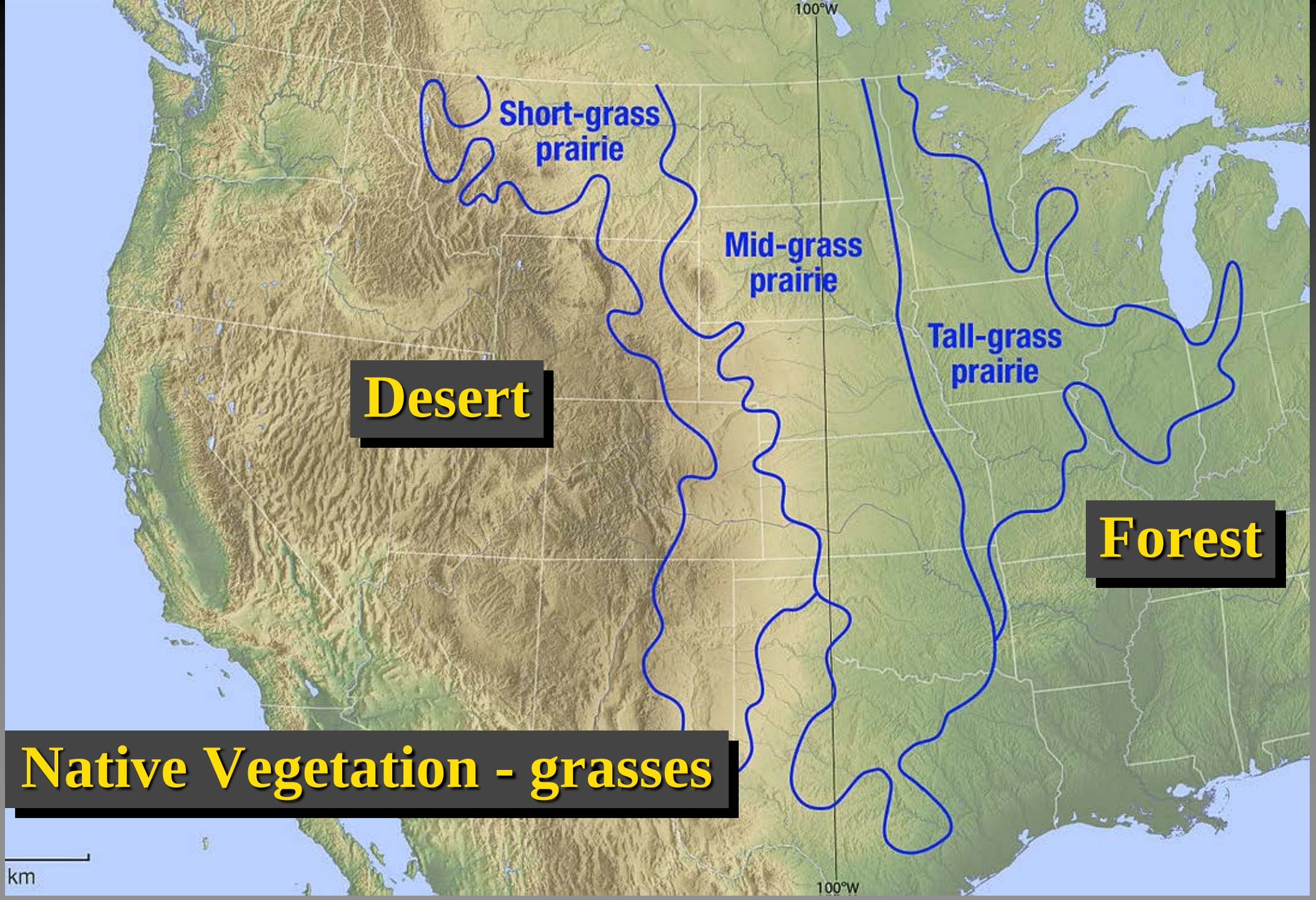
# Reference ETr




**Average Annual ETr**
**1981-2010**
**ASCE P-M Alfalfa**
**NLDAS**
***Hobbins, ASABE 2015***

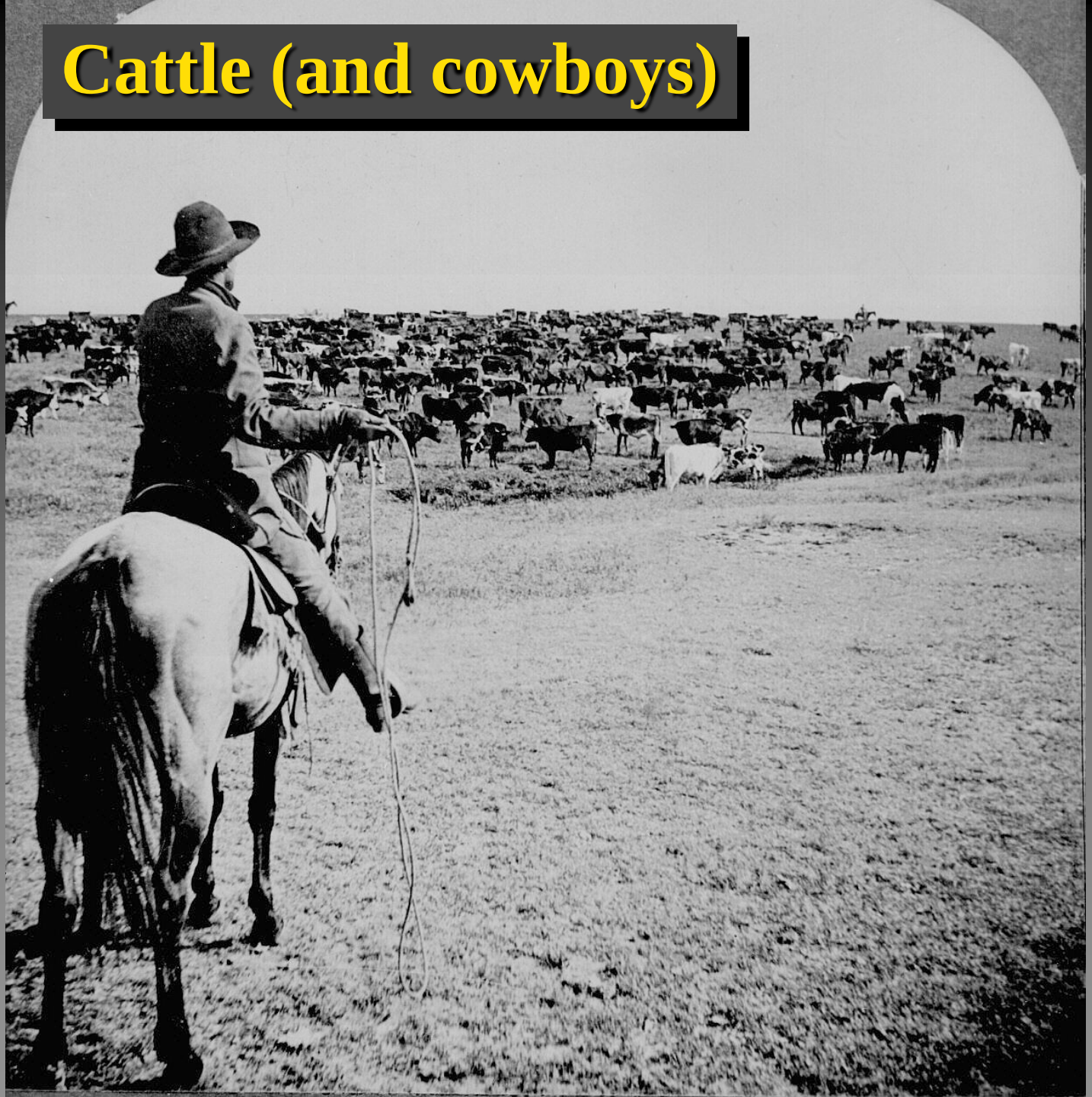



**Soils: Loess, Good Quality**


100°W
Short-grass prairie
Mid-grass prairie
Tall-grass prairie
Desert
Forest
Native Vegetation - grasses
km
100°W

# Buffalo (Bison)

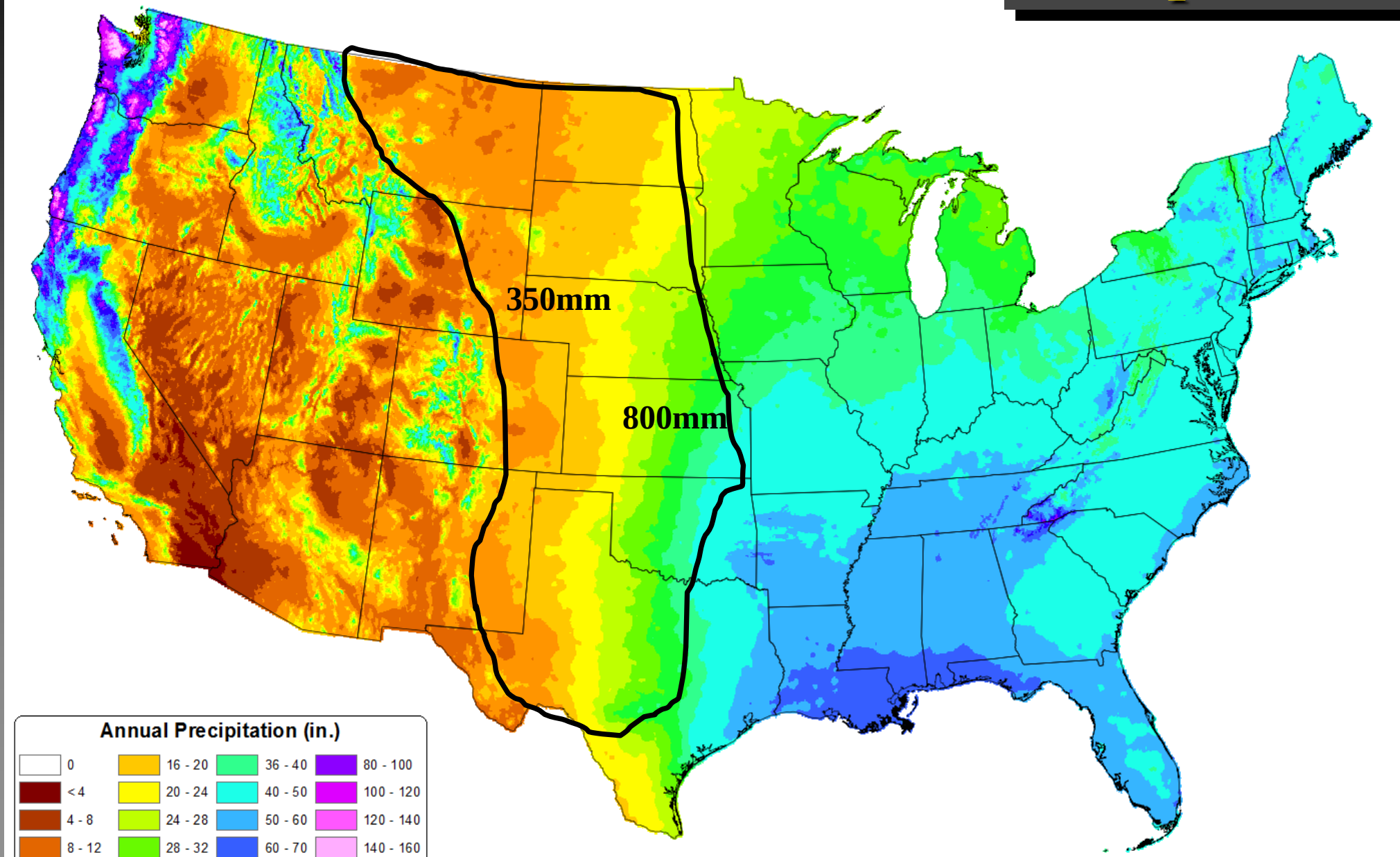
# Cattle (and cowboys)



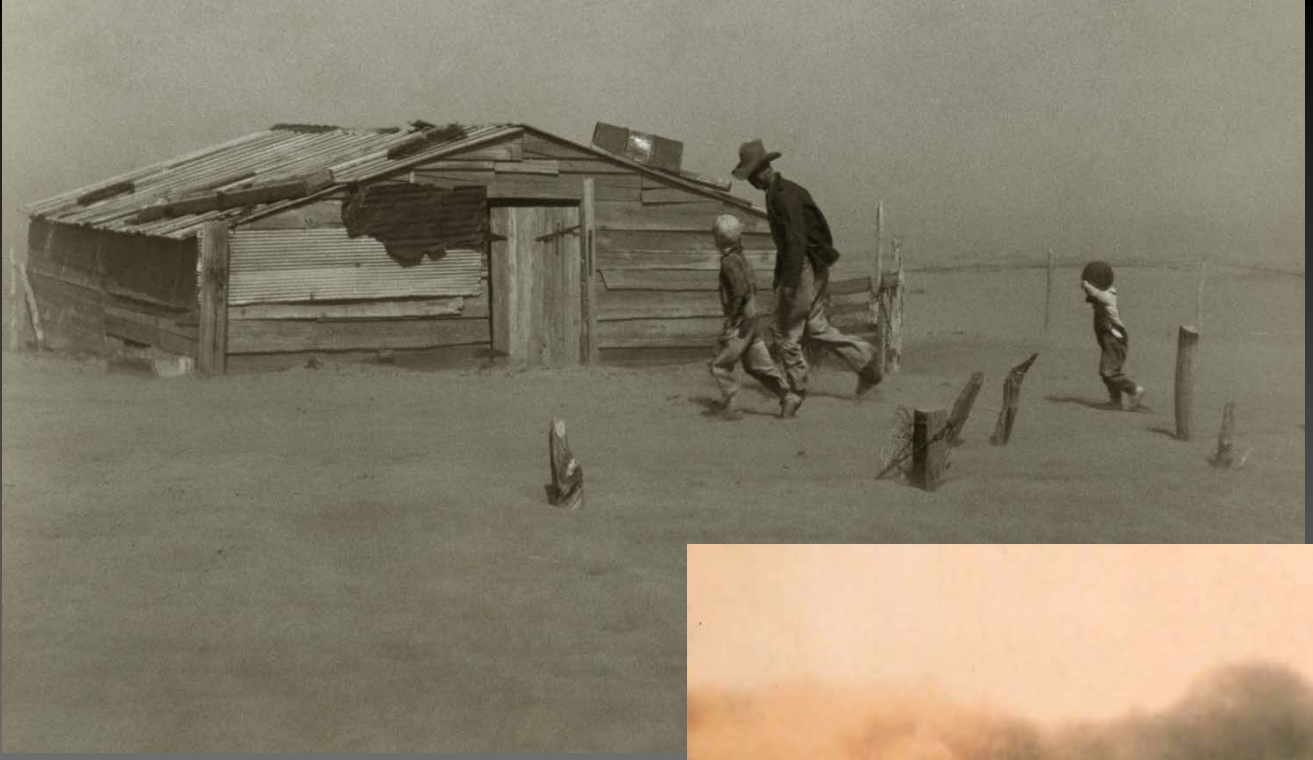
# Homesteaders

**Homestead Act (1862) 160 acres (65 ha)**

# Precipitation



# Dust Bowl 1930s



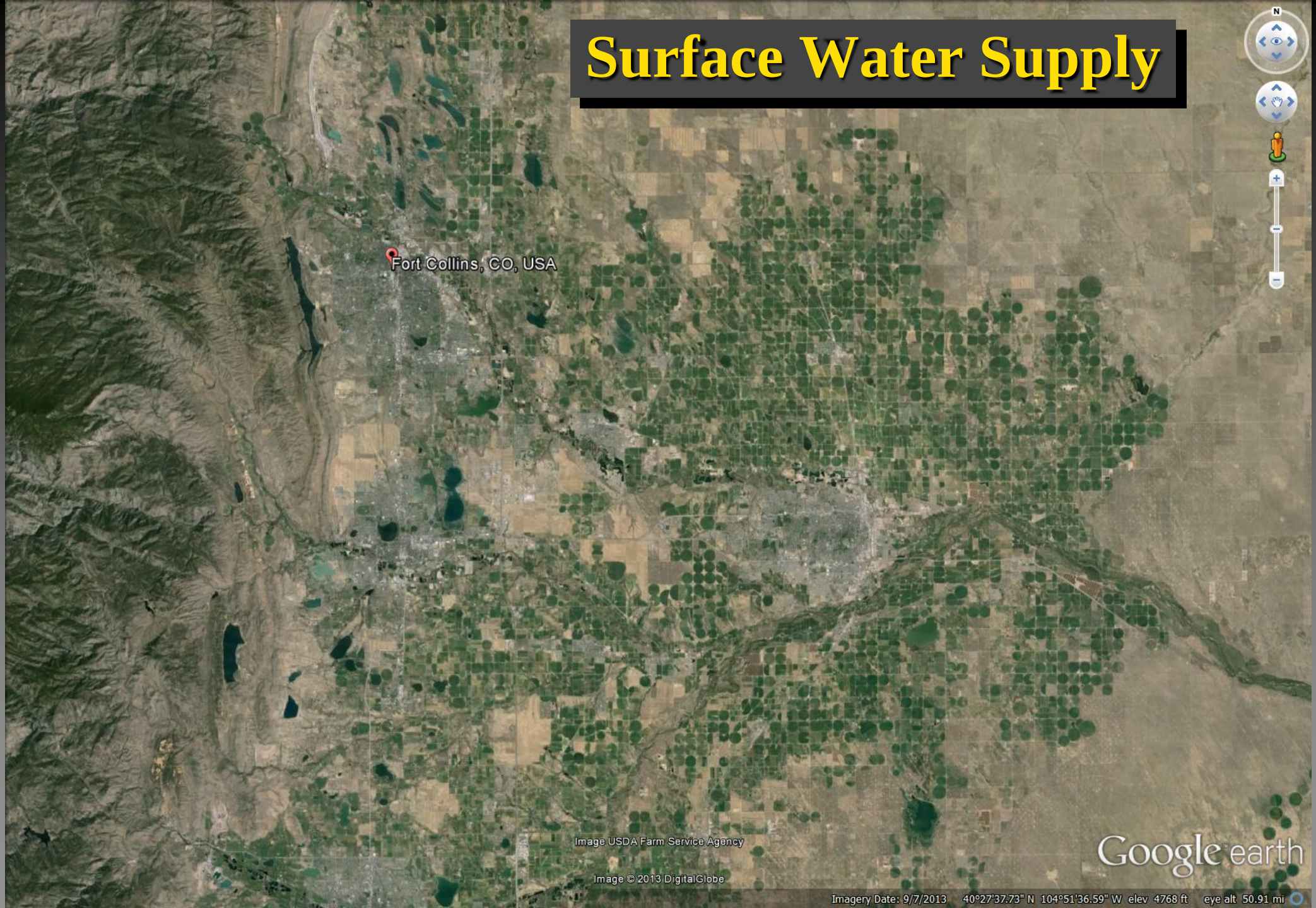
# Surface Water Supply

Arkansas Valley, Colorado

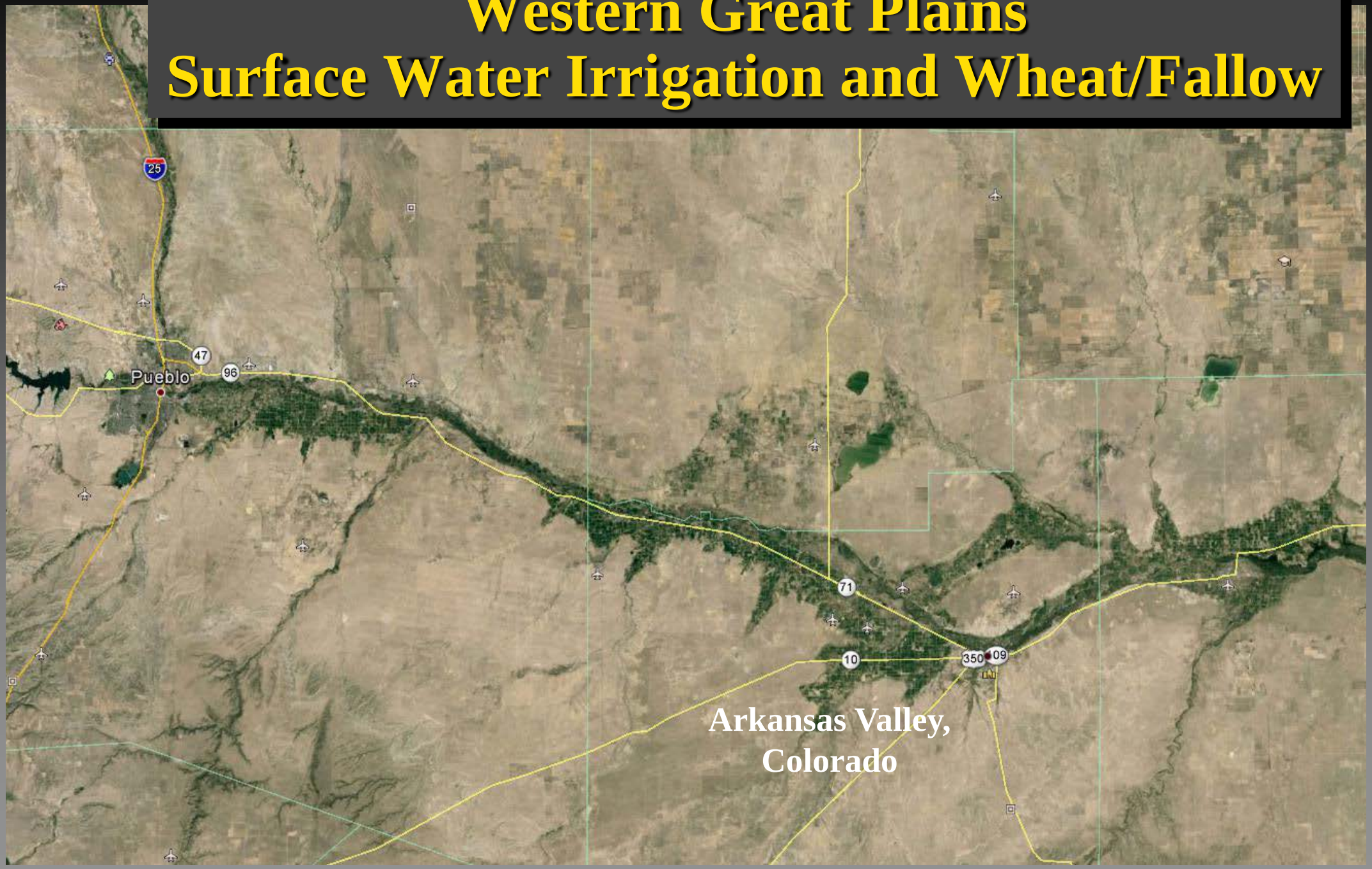


Google earth

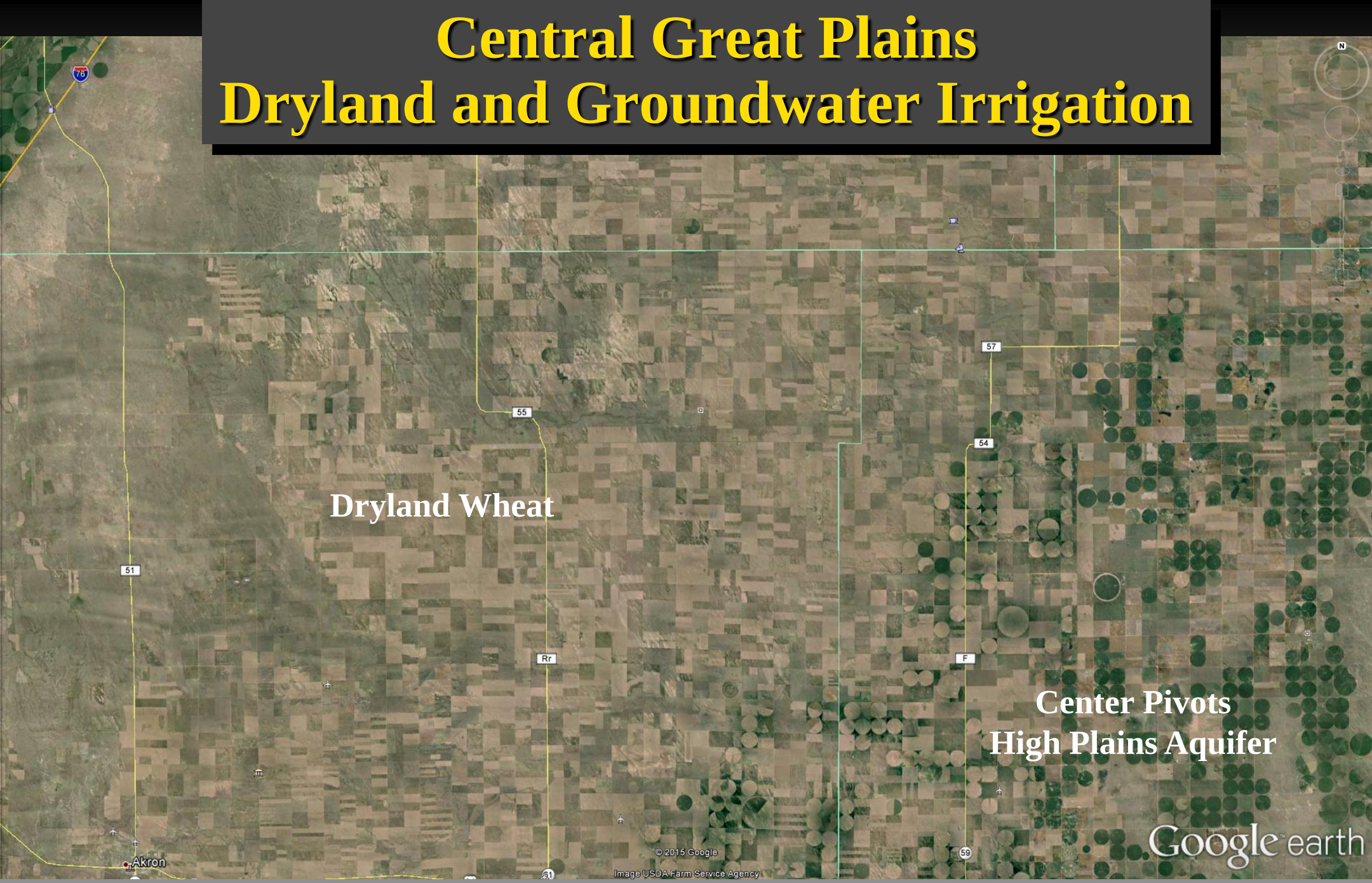
# Surface Water Supply



# Western Great Plains
# Surface Water Irrigation and Wheat/Fallow



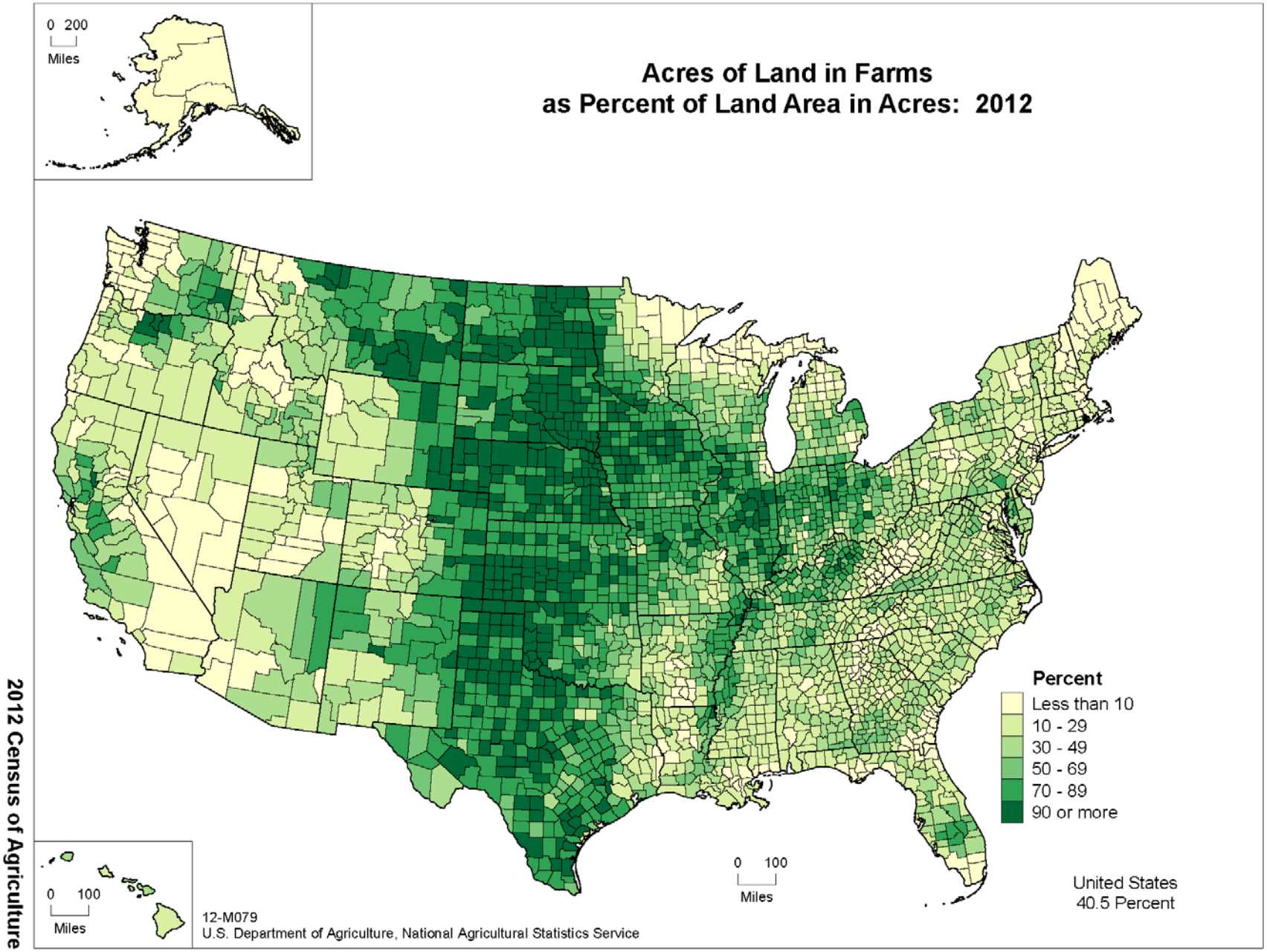
# Central Great Plains
# Dryland and Groundwater Irrigation

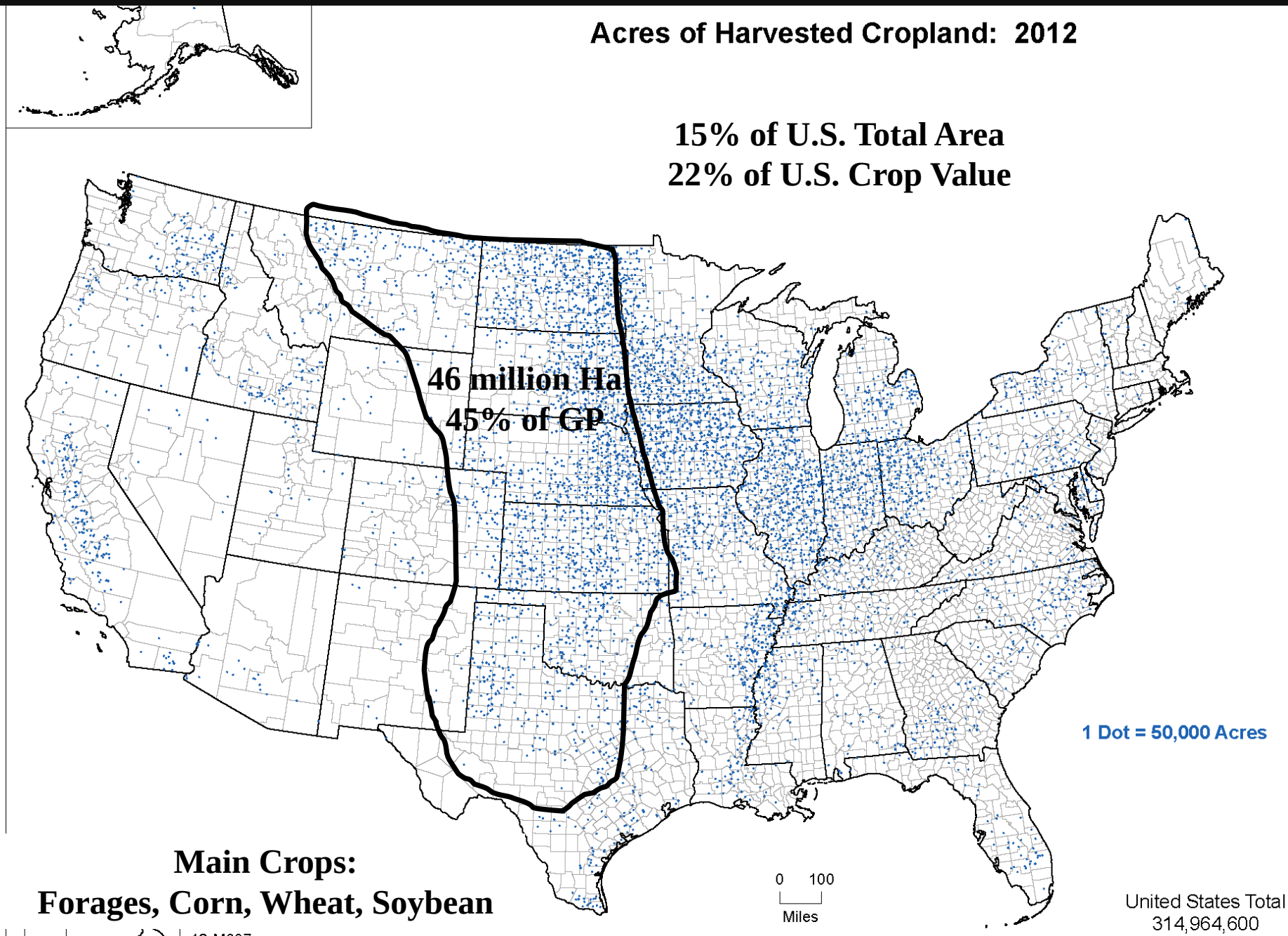


# Central Great Plains High Plains Aquifer

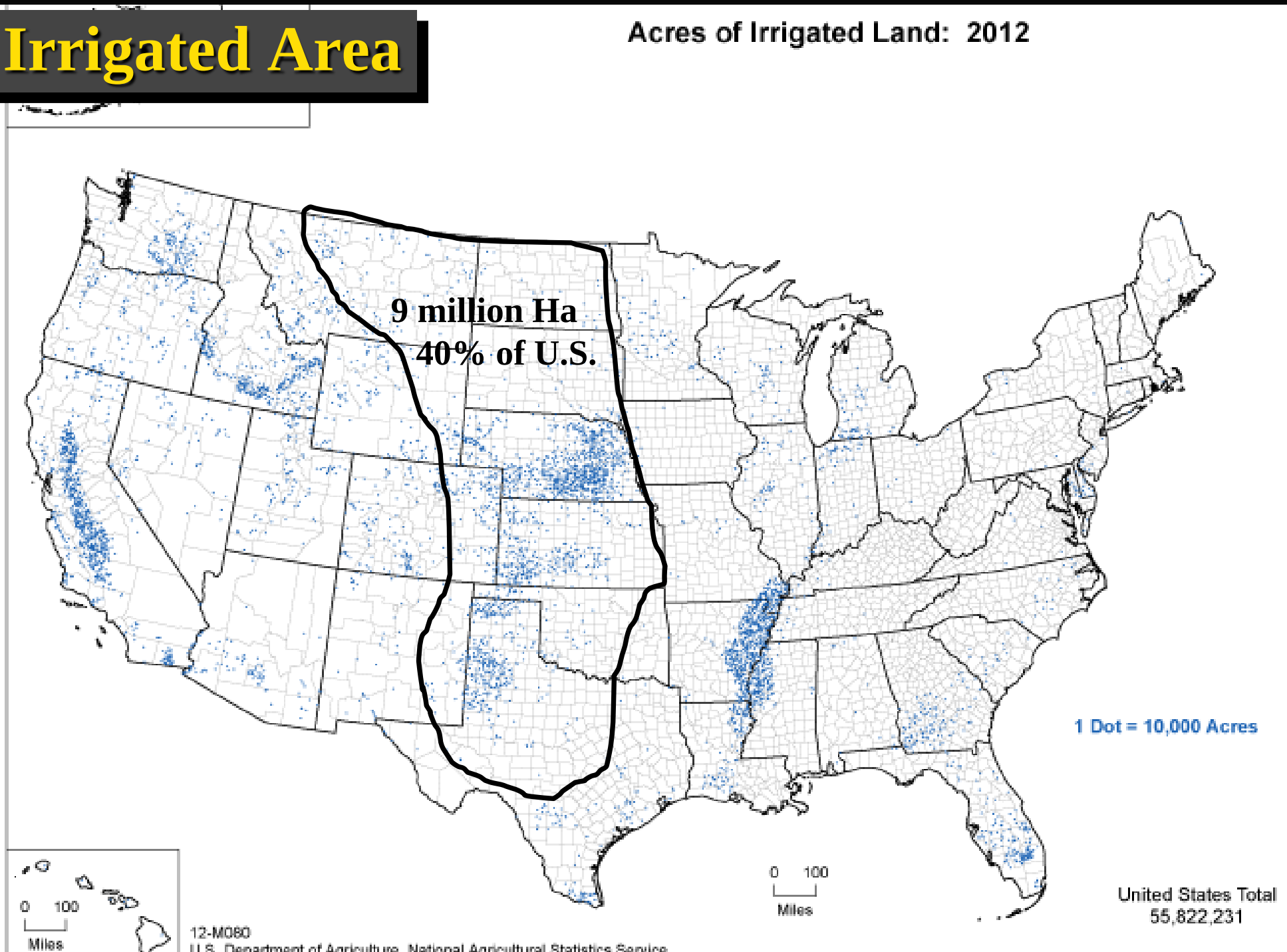
# Eastern Great Plains
# Rainfed and Supplemental Irrigation


## Eastern Nebraska

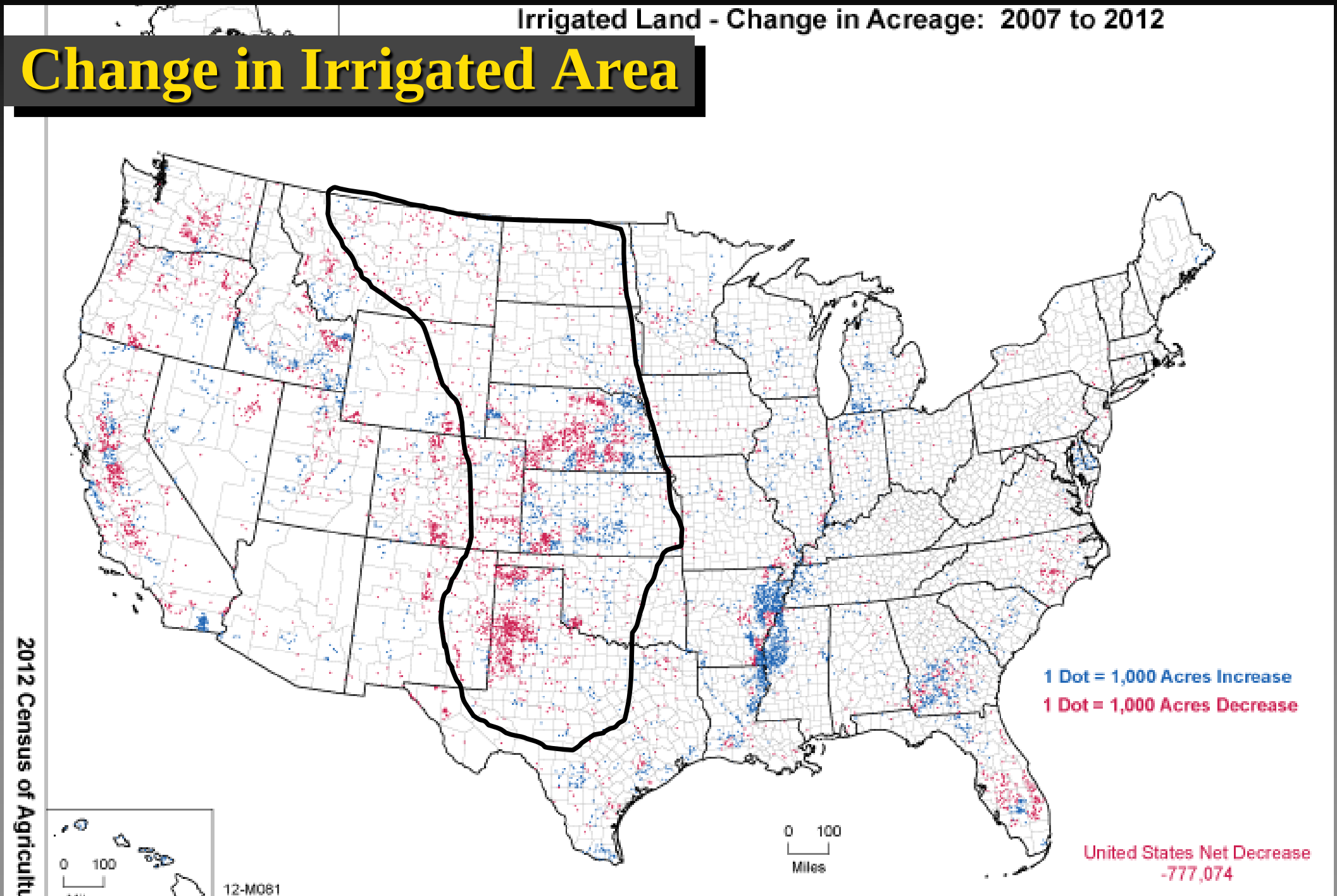

Acres of Land in Farms
as Percent of Land Area in Acres: 2012
0 200
Miles
Percent
Less than 10
10 - 29
30 - 49
50 - 69
70 - 89
90 or more
0 100
Miles
United States
40.5 Percent
0 100
Miles
12-M079
U.S. Department of Agriculture, National Agricultural Statistics Service
2012 Census of Agriculture


Acres of Harvested Cropland: 2012
15% of U.S. Total Area
22% of U.S. Crop Value
46 million Ha
45% of GP
1 Dot = 50,000 Acres
Main Crops:
Forages, Corn, Wheat, Soybean
0 100
Miles
United States Total
314,964,600
Miles
12-M087
U.S. Department of Agriculture, National Agricultural Statistics Service
2012 Census of Agriculture

# Irrigated Area



# Change in Irrigated Area



# Great Plains Irrigated Crops and Yields

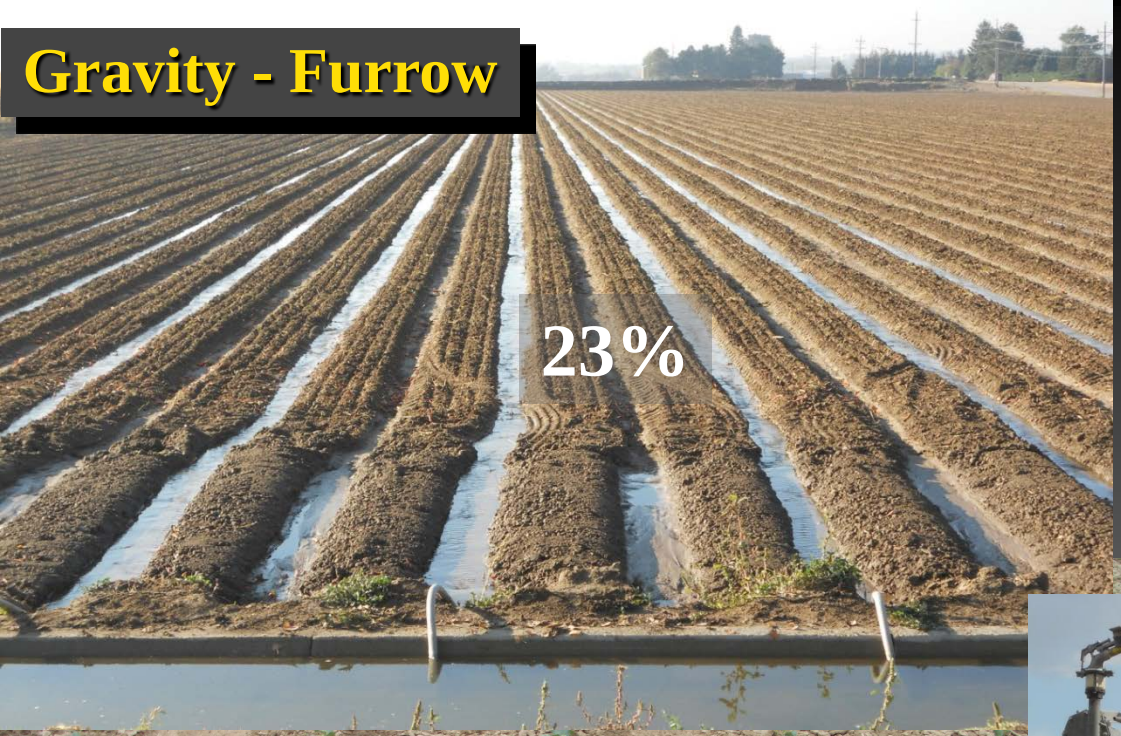
NASS 2012

| Crop | Area *(Million Ha)* | Yield *(Mg/Ha)* |
|---|---|---|
| Corn - Grain | 3.5 | 12.3 |
| Soybean | 1.0 | 3.6 |
| Alfalfa | 0.9 | 5.0 |
| Wheat | 0.6 | 4.3 |
| Cotton | 0.4 | 0.1 |
| Corn - Silage | 0.3 | 25.0 |
| Sorghum | 0.3 | 6.0 |

# Irrigation Impact on Yield

- Corn
  - Irrigated: 9 – 15 Mg/Ha
  - Unirrigated: 1 – 8
- Wheat
  - Irrigated: 3 – 6 Mg/Ha
  - Unirrigated: 1 – 2.5

# G.P. Irrigation Methods by Area (NASS 2012)

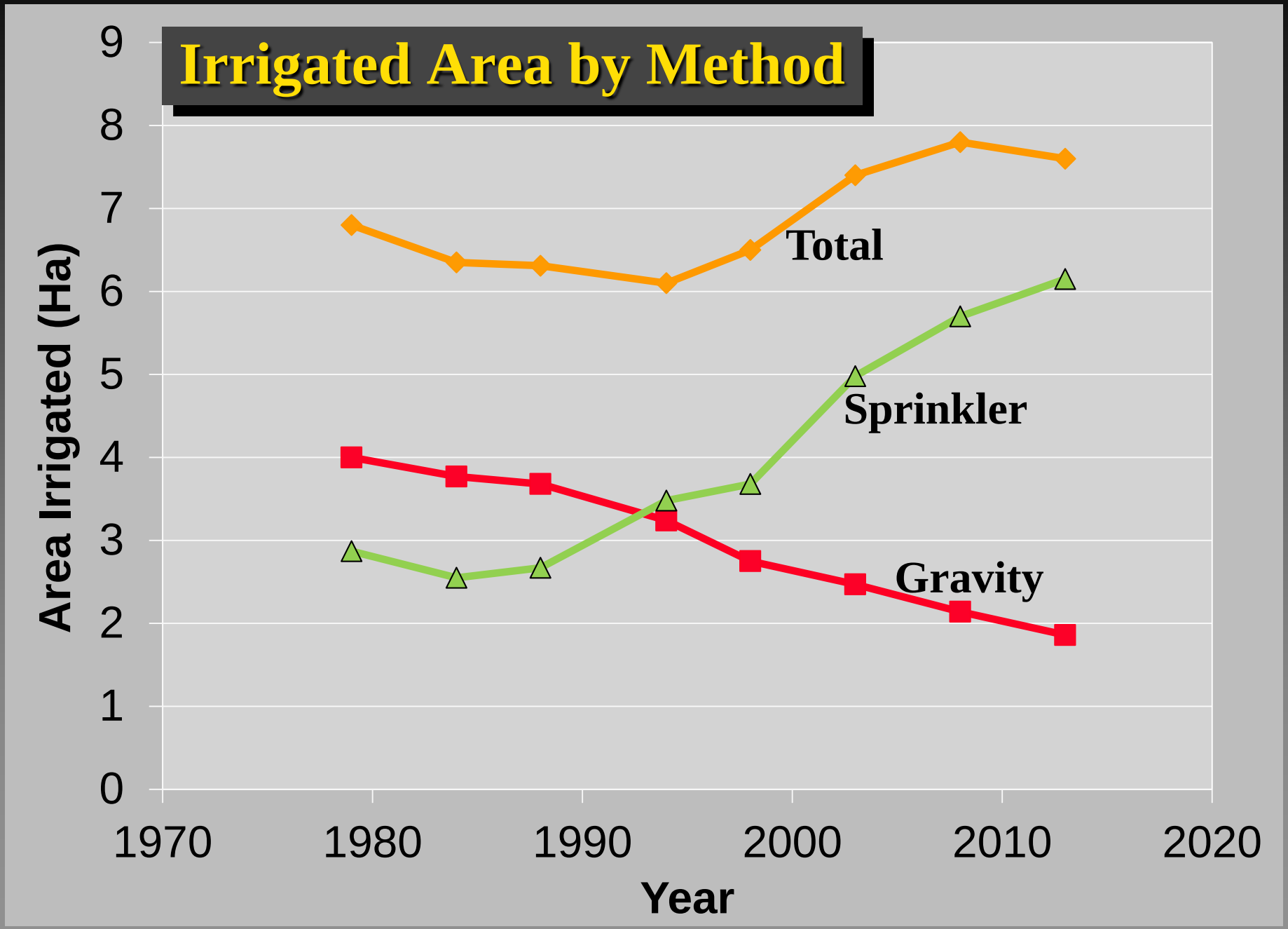




# Great Plains Irrigation Method

| Method | Great Plains | U.S. |
|---|---|---|
| Gravity | 23% | 39% |
| Sprinkler | 76%* | 63% |
| Drip/Micro | 1% | 9% |
| | *96% Center Pivot | |

NASS 2012


Irrigated Area by Method
Area Irrigated (Ha)
9
8
7
6
5
4
3
2
1
0
1970
1980
1990
2000
2010
2020
Year
Total
Sprinkler
Gravity

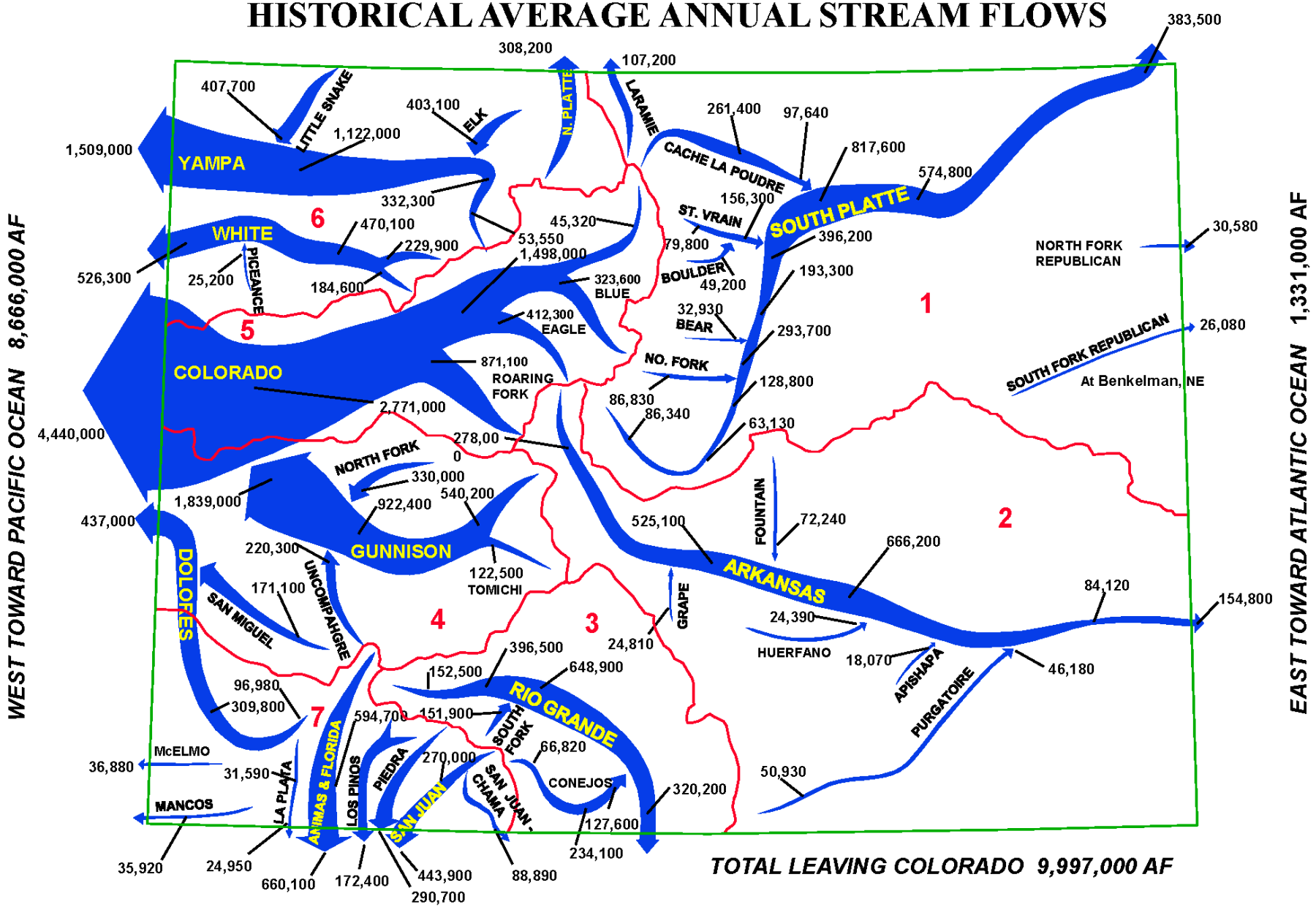
# Great Plains Irrigation Water Source

| Source | Great Plains | U.S. |
|---|---|---|
| Groundwater | 77% | 65% |
| Surface: Off Farm | 17% | 24% |
| Surface: On Farm | 6% | 11% |
| | | |

**Irrigation consumes >90% of developed water in GP**

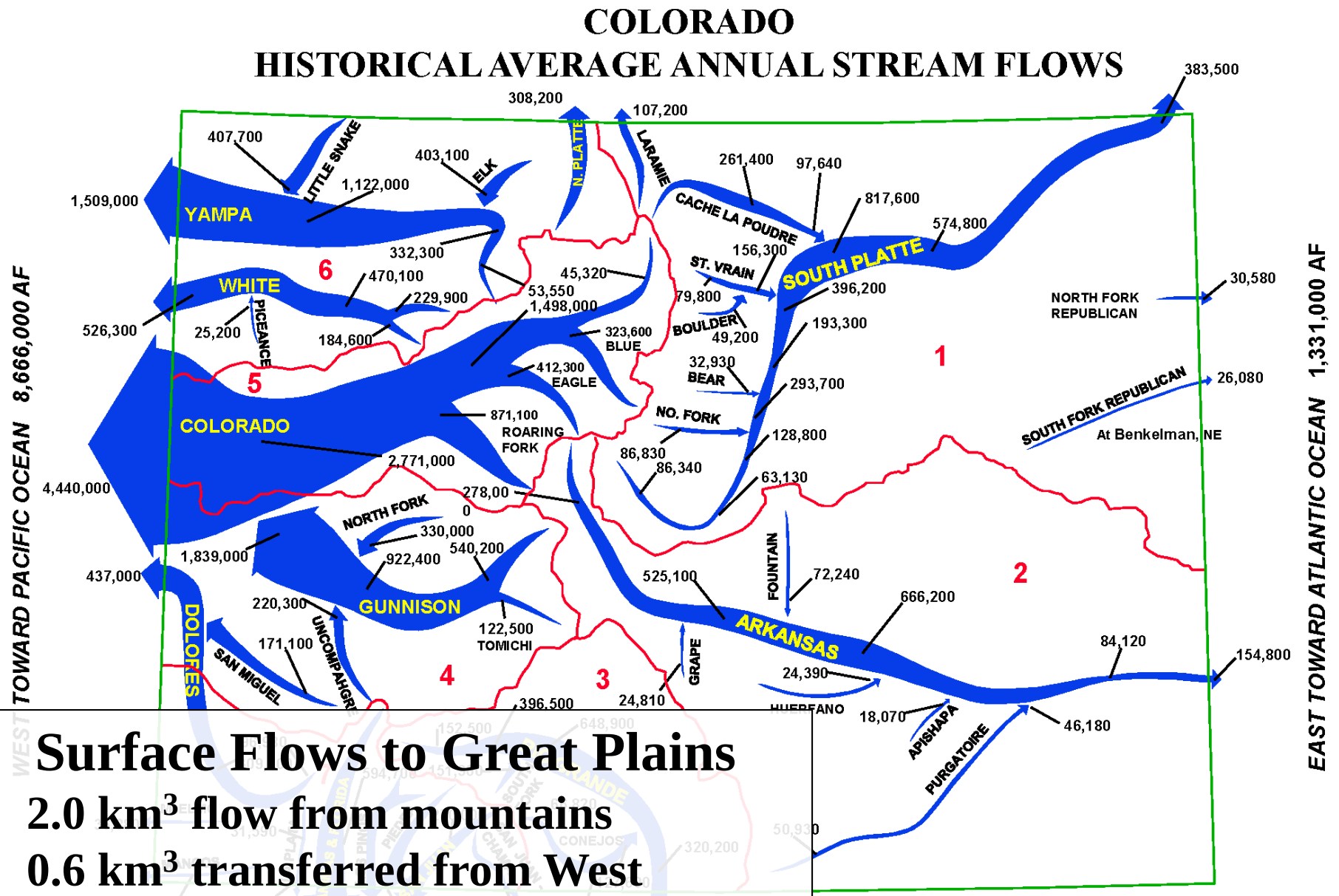
NASS 2012

# COLORADO
# HISTORICAL AVERAGE ANNUAL STREAM FLOWS




Prepared by the Hydrographic Branch (2011 Revision)
[all values in acre feet (AF)]

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

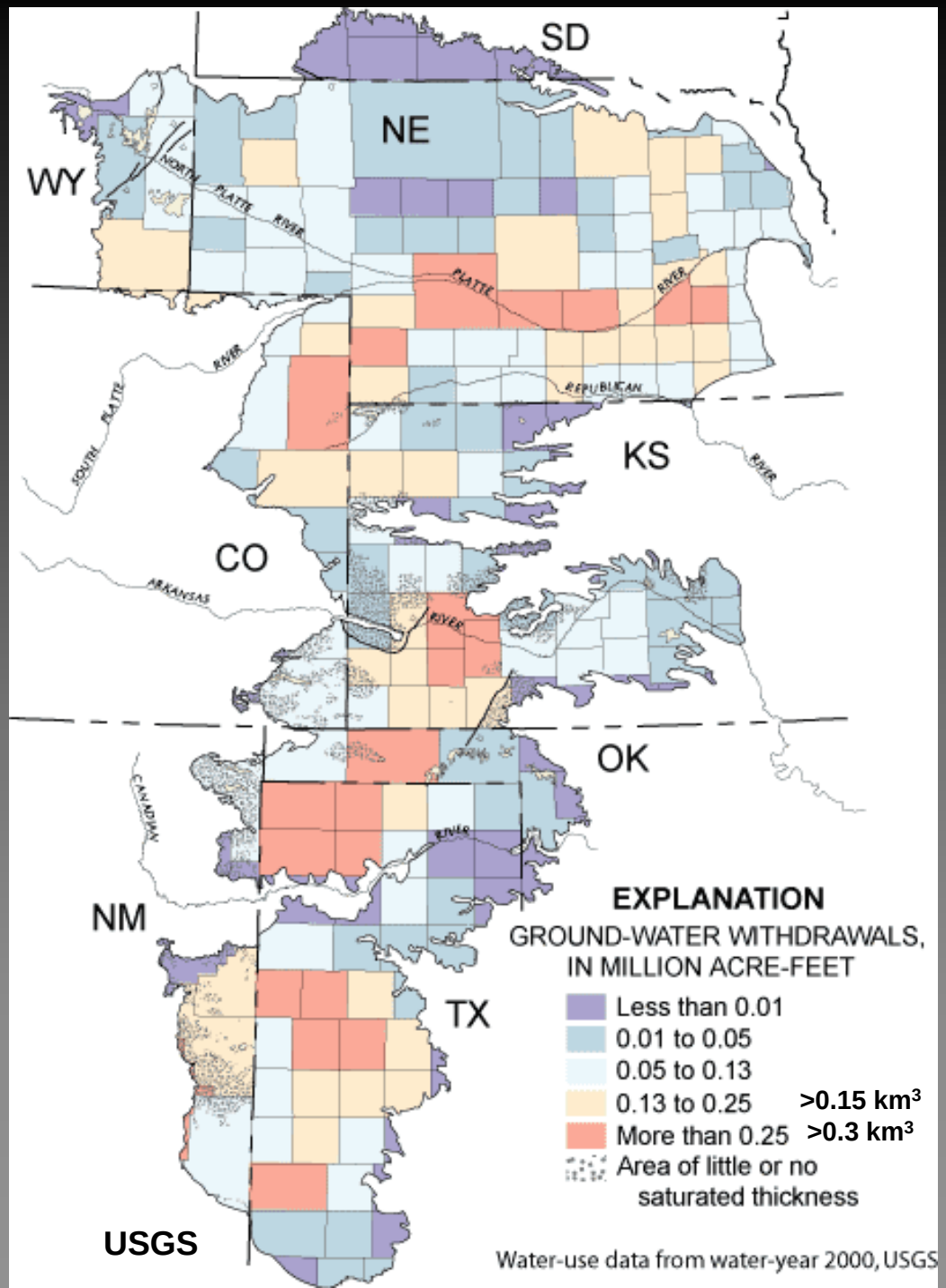



# Surface Flows to Great Plains

- 2.0 $km^3$ flow from mountains
- 0.6 $km^3$ transferred from West
- 7.4 $km^3$ delivered to users (1.5 $km^3$ CU)
- 1.2 $km^3$ flows out of state

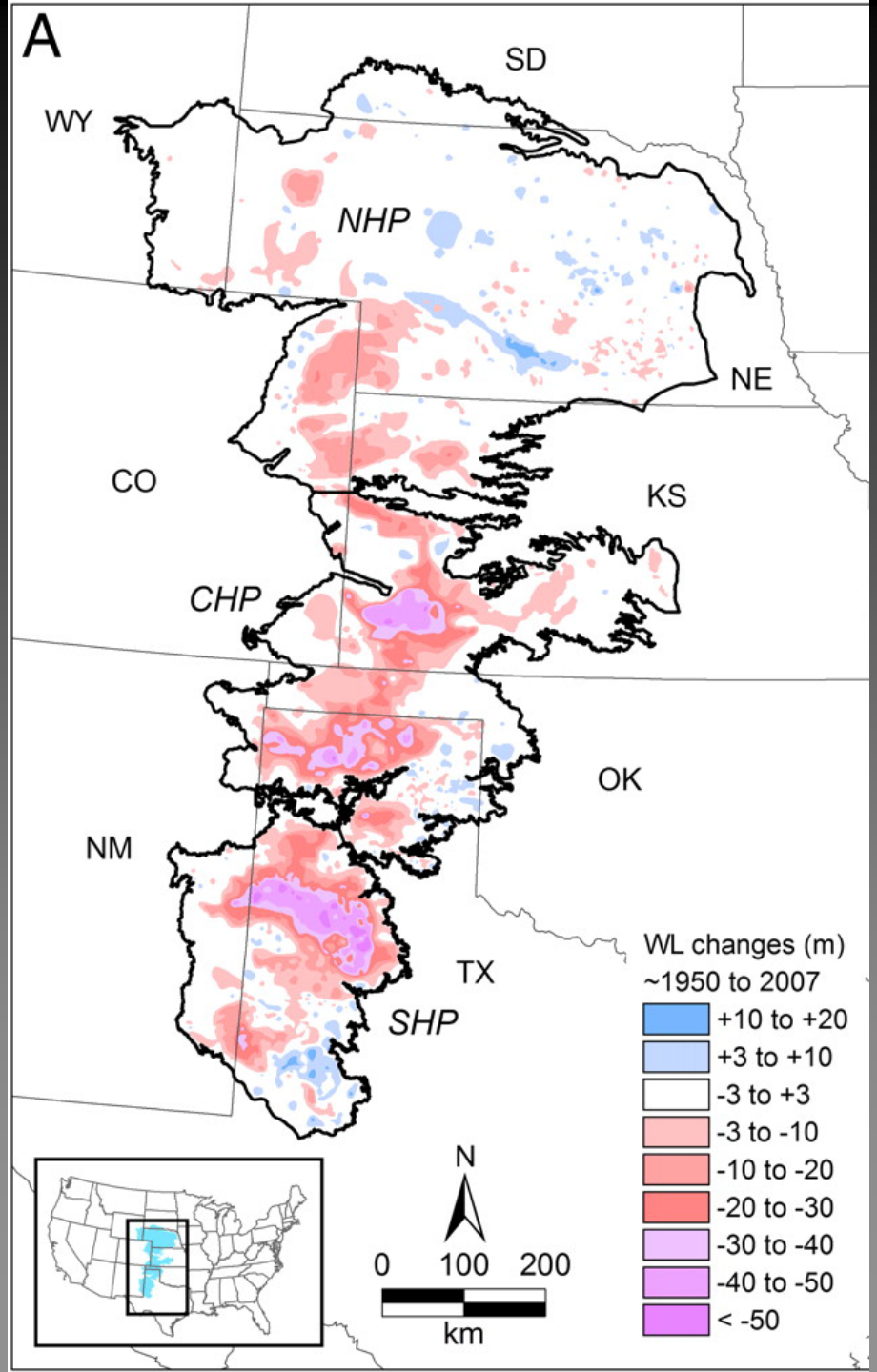
# HP Aquifer Pumping

- 450,000 km2 (about 50% of Great Plains
- 39% Cropland, 1/3 irrigated
  - 6.2 million ha Irrigated Cropland
  - 70% of GP Total irrigated area
  - Remainder: grassland, shrubland
- $35 billion crop value (10% of U.S.) (50% of GP)




USGS

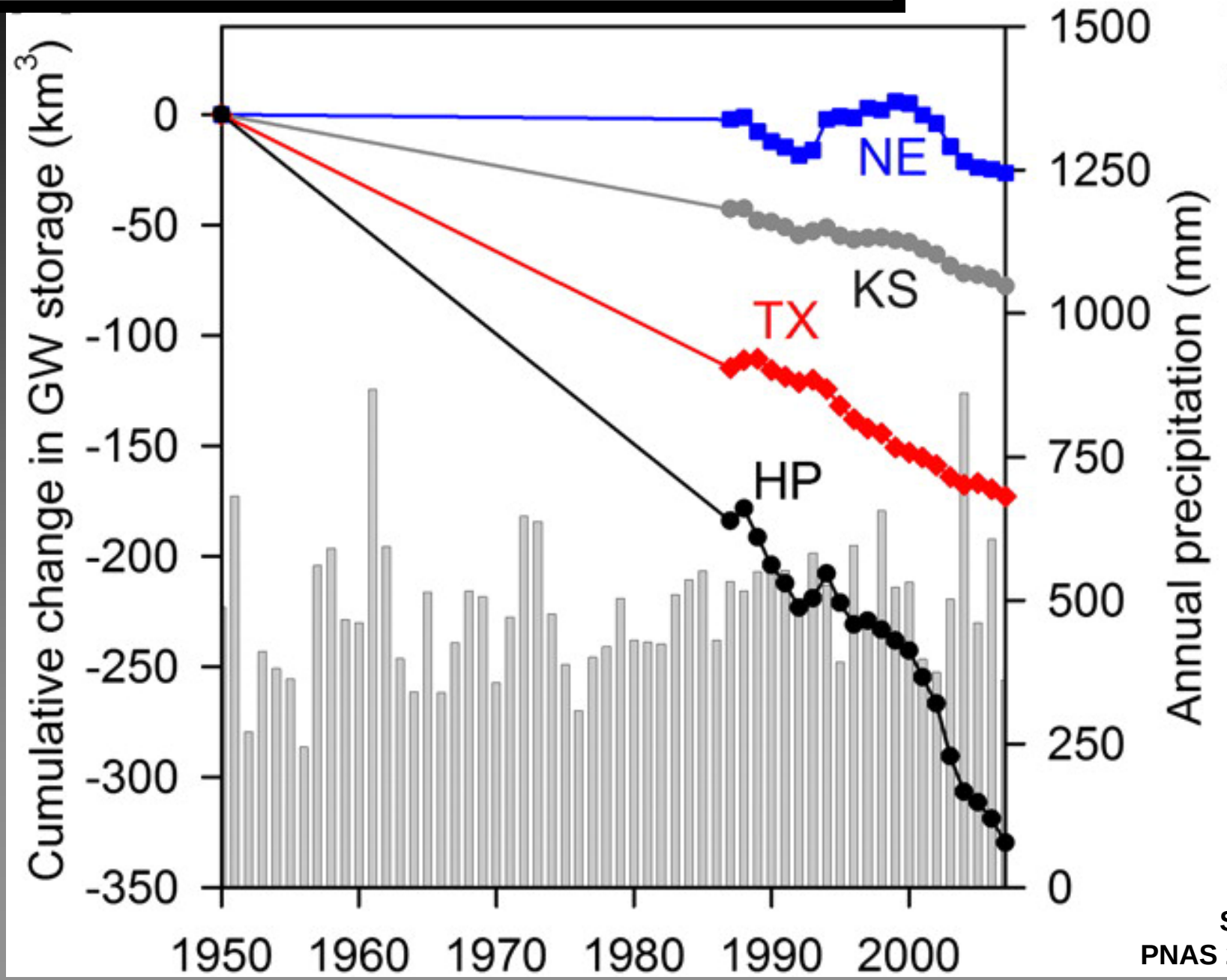
# High Plains Aquifer




- Total pre-pumping storage (1950): 4000 $km^3$
- Cumulative depletion (60 yrs): 400 $km^3$ (10%)
- Current depletion rate:
  - 7 $km^3$/yr
- Storage Change - Area
  - 4% in Accretion
  - 68% Stable
  - 28% Depletion (>3 m)
  - 12% Moderate Depletion (>15m)
  - 4% Serious Drawdown (>30m)

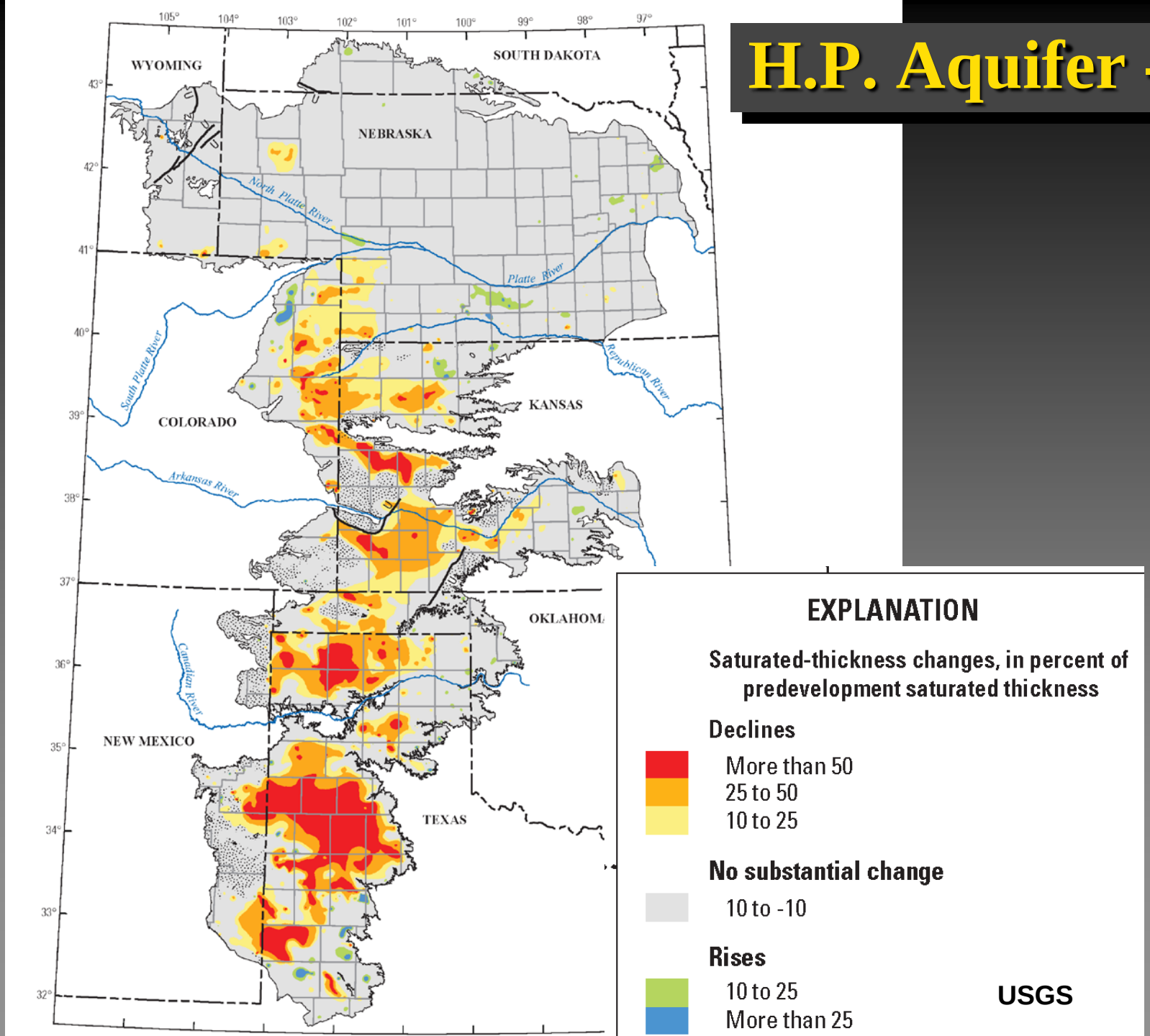
Scanlon et al. PNAS 2012;109:9320-9325

# High Plains Aquifer - Depletion




Scanlon et al.
PNAS 2012;109:9320-9325

# H.P. Aquifer - Depletion




## EXPLANATION

**Saturated-thickness changes, in percent of predevelopment saturated thickness**

**Declines**

- More than 50
- 25 to 50
- 10 to 25

**No substantial change**

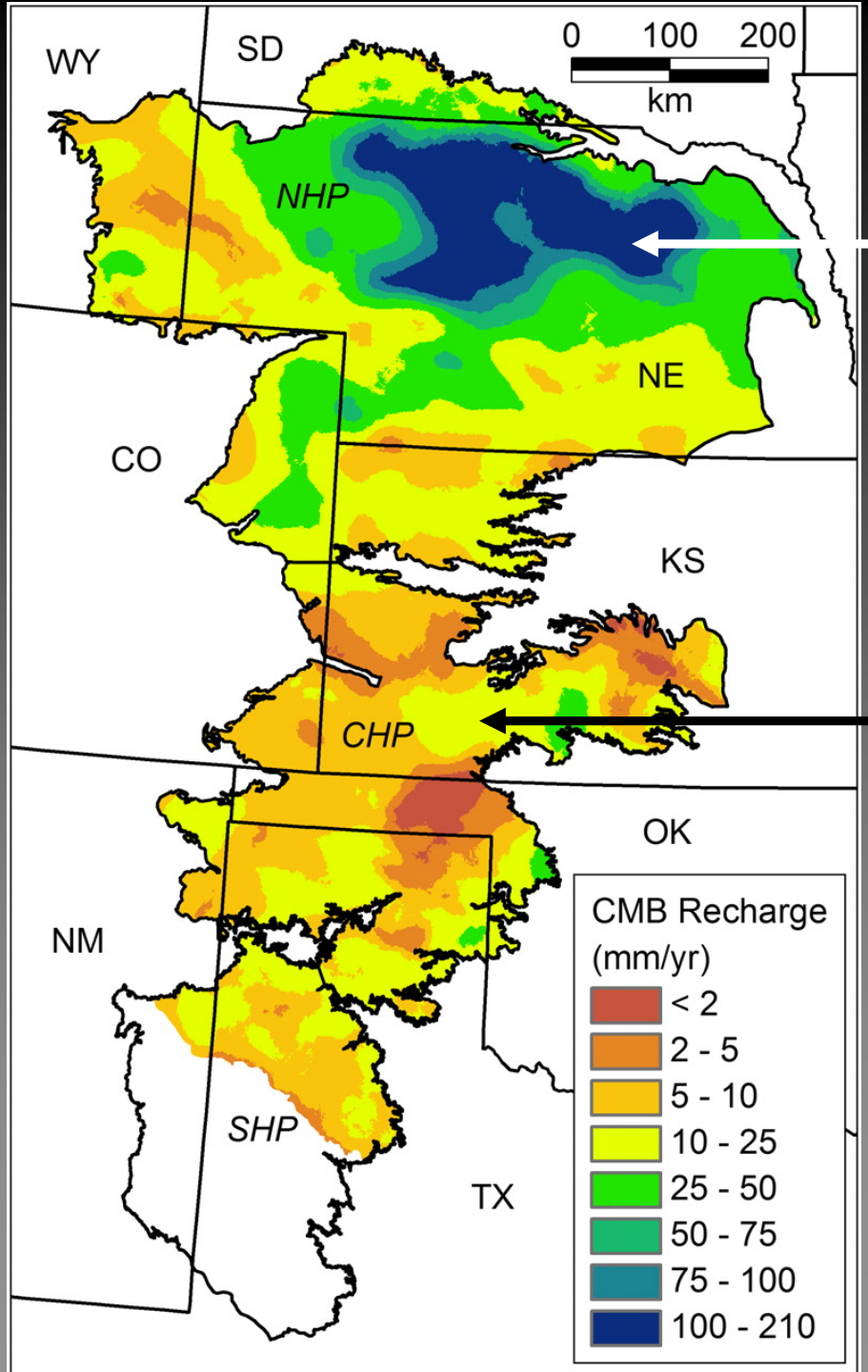
- 10 to -10

**Rises**

- 10 to 25
- More than 25

USGS

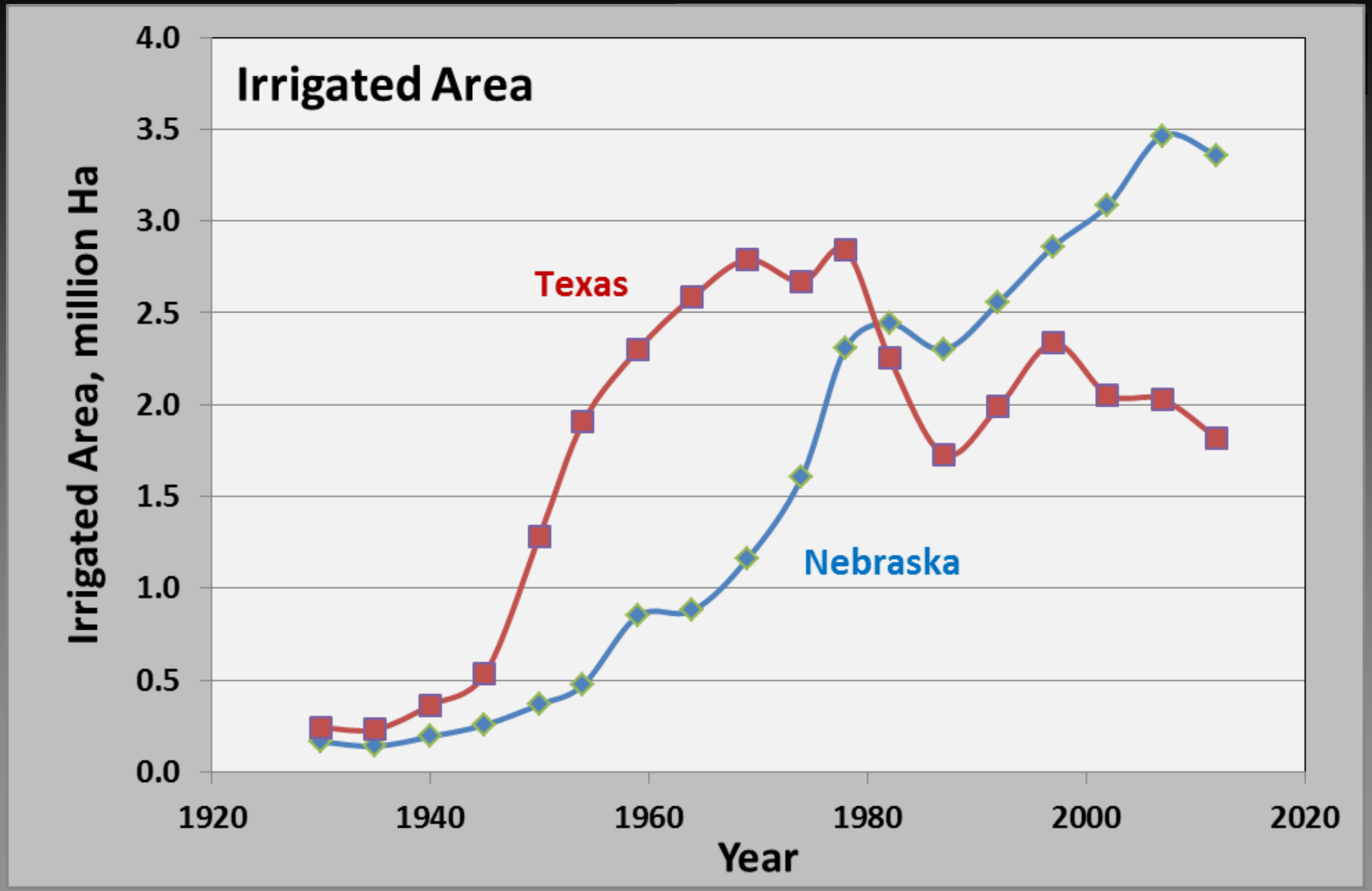
# H.P. Aquifer - Recharge




**Northern HP: 10 $km^3/yr$**

**Central HP: 1.3 $km^3/yr$**

Scanlon et al. PNAS 2012;109:9320-9325


Irrigated Area
Irrigated Area, million Ha
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1920
1940
1960
1980
2000
2020
Year
Texas
Nebraska

# Reduced Pumping

- Reduced well yields (pumping rates) due to depletion
  - Center pivot (50 ha) design flow: 50 L/s (8 mm/day)
  - Current well yields: 20 – 40 L/s
- Drawdown, deeper pumping depths, increased pumping costs
  - Increase from 30 to 60 m pumping depth, 50% increase in pumping costs.
- Regulated reduction due to impact on river flows
  - Well flows are metered, and limited by volume pumped
  - 300 mm/yr or 1500 mm per 5 yrs
  - No expansion in irrigated area

# Water Quantity Regulation

- Controlled by the States
  - Interstate Compacts
- Surface Water Law – Prior Appropriation
  - First in time, first in right
  - Colorado:  170,000 Water Rights
- Groundwater – varies widely
  - Often regulated by basin or district
  - Generally requires a well permit
  - Increasing recognition that groundwater and surface water interconnect

# Current Conditions
## *Reduced water supply for irrigation*

- Reduced well yields in portions of the HP Aquifer
- Reduced well pumping of aquifers connected to surface water due to competition among irrigation water users
- Increasing Environmental Interests and Needs
  - Leave more water in the river (Central Platte Recovery Improvement Program
- Increasing Urban/Industrial Water Demand
  - Mainly Colorado Front Range – surface water
- Climate Change???

# Responses

- Declining irrigation in areas with limited water supply
  - Convert back to rainfed crops and rangeland grasses
  - Increased supplemental irrigation in areas with higher precipitation.
- Changes in crops grown
- Improving irrigation technology and efficiency
  - Pressurized irrigation systems
  - Improved irrigation scheduling
- Improving water productivity
- Improving conjunctive use of surface and groundwater

# Obrigado

## Tom Trout

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