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OPTIMAL NITROGEN/WATER USE IN THE SOUTHERN SUB-REGION OF THE SOUTHERN OGALLALA AQUIFER

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Ogallala Aquifer
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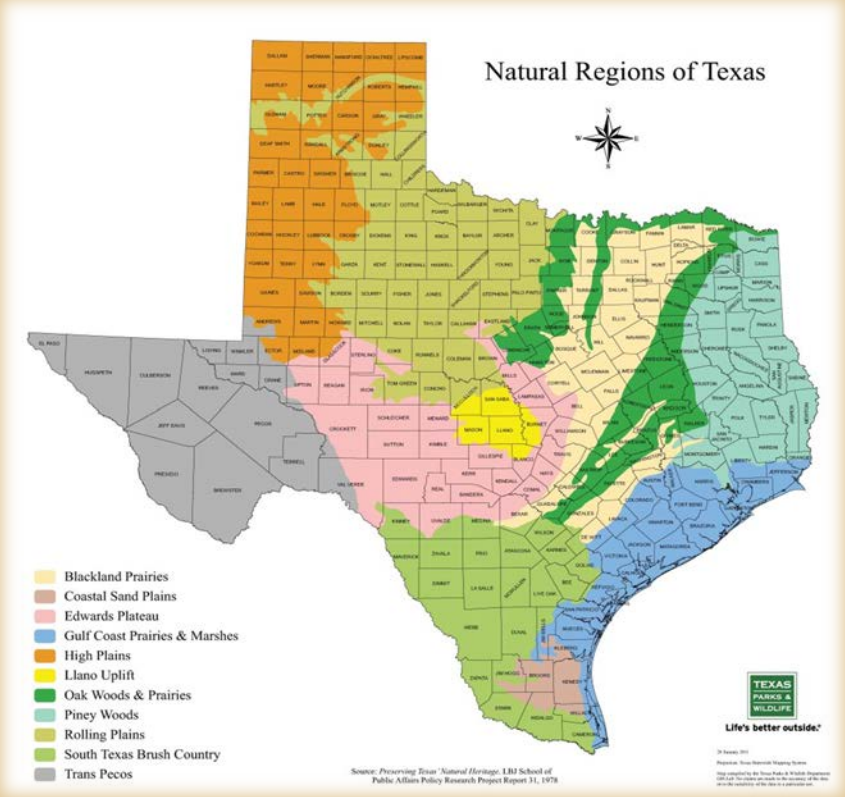
General Problem– Texas High Plains (THP)

- Sustainability in agriculture
  - 7.4 billion people
  - Increase to 10.9 billion by 2050
    - Strains natural resources needed to support a growing population
- Why the Texas High Plains?
  - 25% of U.S. cattle (Johnson et al., 2013)
    - West Texas supports 85% of the state's fed beef (Almas, 2004)
  - 30% of U.S. Cotton (Johnson et al., 2013)
    - 61% of the state's cotton
  - Irrigated agriculture directly accounts for $6.6 billion of industry output (Guerrero and Amosson, 2013)
- Texas High Plains
  - Semi-arid
  - Low annual precipitation
  - Relies heavily on Ogallala Aquifer to meet irrigation needs



Ogallala Aquifer Important Facts

- Covers 174,000 miles across eight states
  - 35,000 square miles in Texas
  - 11% of total land in Texas

- Contains 3.3 billion acres of fresh water
  - Saturated thickness range
    - 1,300 ft in Nebraska
    - <1 ft in Texas
    - Average of 200 ft

- 170,000+ pumping wells
  - 50,000+ in Texas alone

- 90%+ used to irrigate crops
  - $20 billion in food and fiber production each year

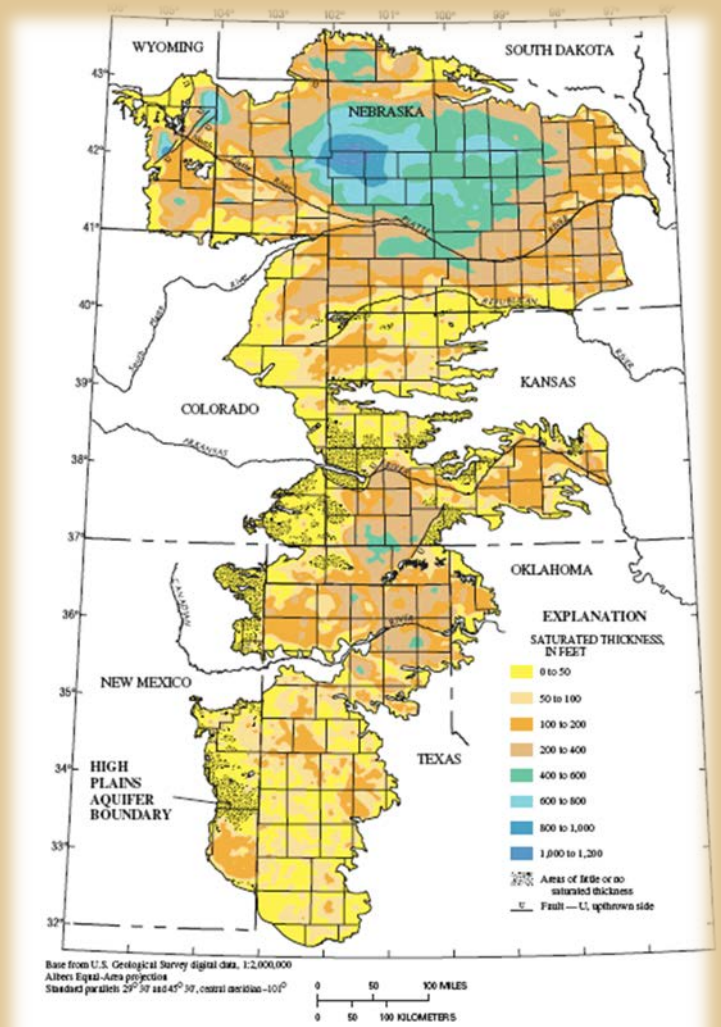


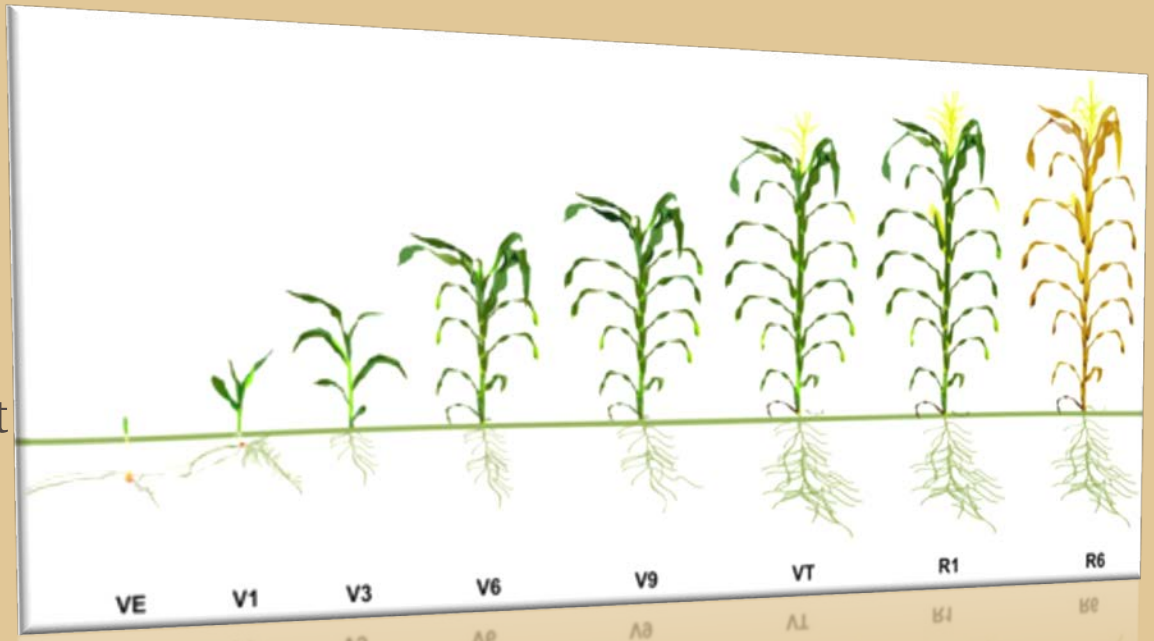
Figure 14. Saturated thickness of the High Plains aquifer, 2000. (Modified from Weeks and Gutentag, 1981.)

Objective

- Determine the economically optimal nitrogen and water use for corn production in the southern sub-region of the Southern Ogallala Aquifer using producer-level data.

Rationale

- Improved nitrogen and water use efficiency can reduce water use and increase profit.
- Agronomic studies on optimal nitrogen application amounts and timing largely overlook economic impacts (Al Kaisi and Yin, 2003; Bullock and Bullock, 1993).
- This analysis will provide producers with best management practices for nitrogen application for center pivot irrigation systems with varying amounts of water availability



Corn Requirements

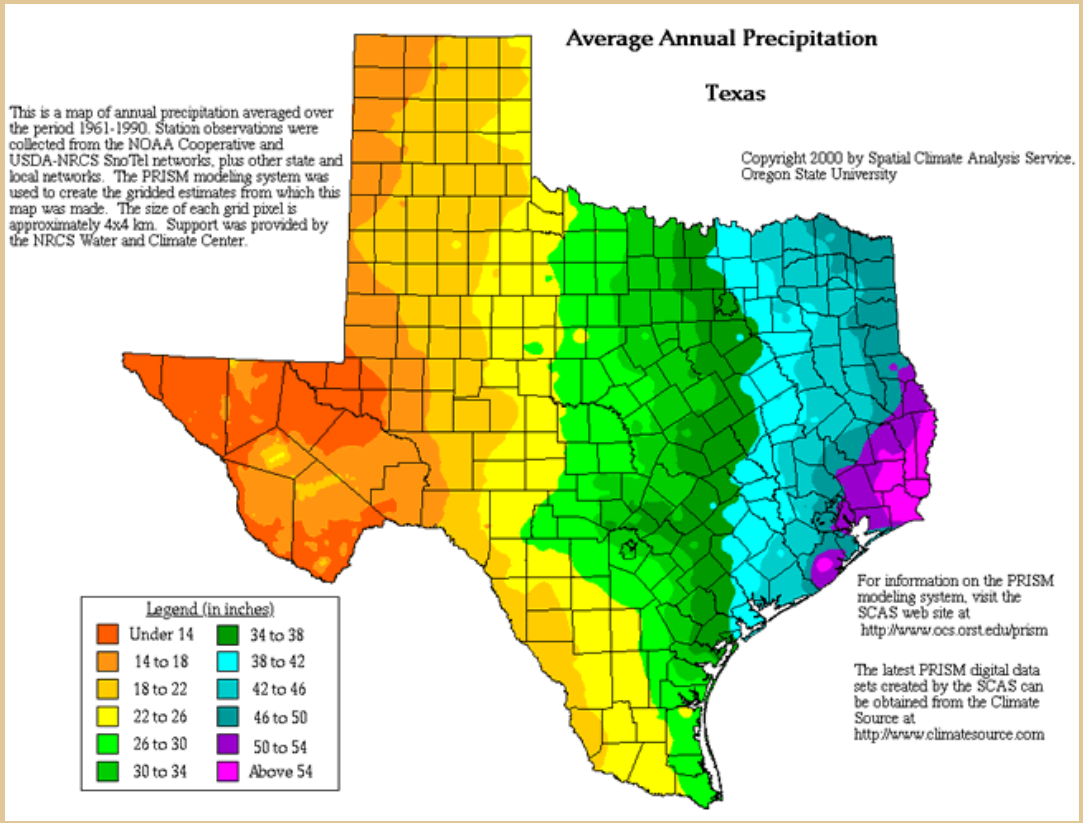
- Water
  - Average 22 inches
  - Range 20-25 inches

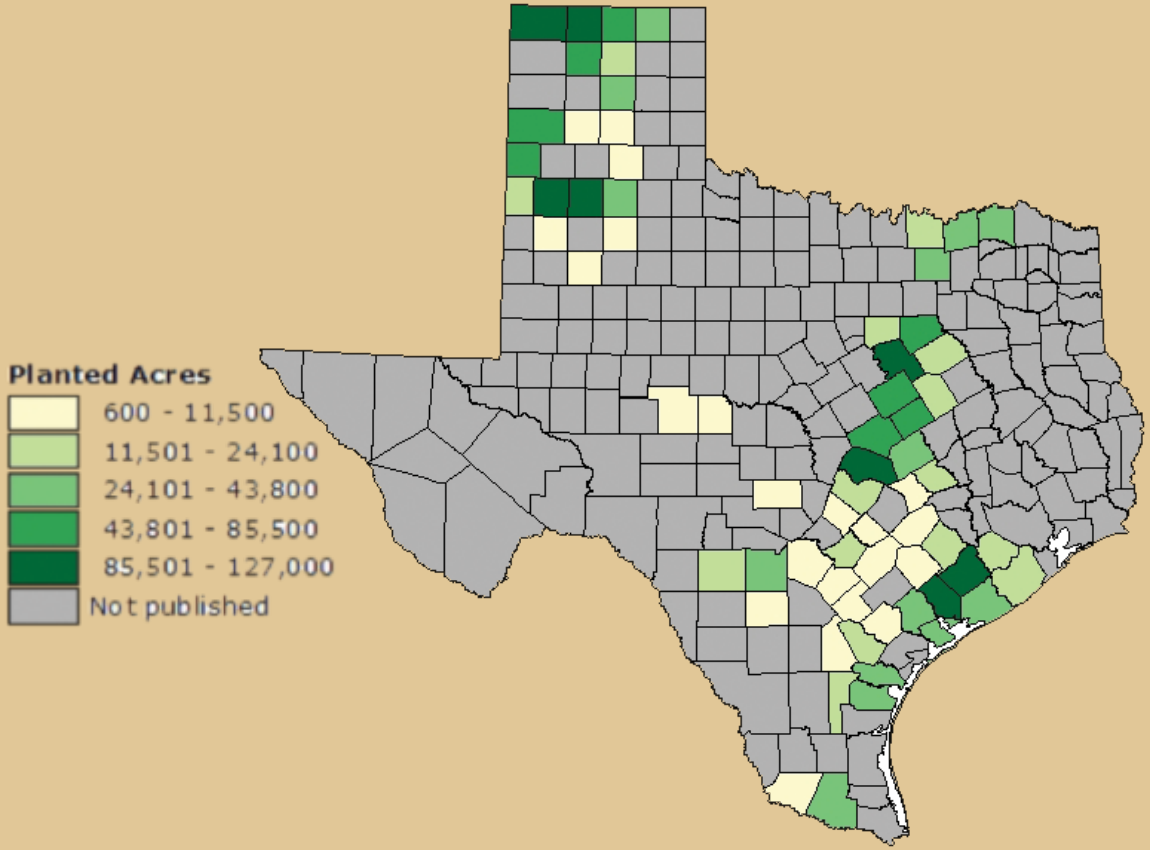
  *More vulnerable to water stress

  - Limited resource in Texas High Plains
    - Producers must become more water efficient
      - Genetic improvements
      - Better irrigation scheduling
      - Adoption of conservation tillage
      - Adoption of more efficient irrigation systems

- Nitrogen (N)
  - The most commonly applied nutrient
  - Costliest
  - Benefit to Cost Ratio exceeds that of other nutrients
  - Increases strength of individual plants and yield of the crop
  - Requires good management (best management practices) to reduce environmental consequences
    - Oxygen depletion aquatic ecosystems
    - Biodiversity losses
    - Water and air pollution

Corn Production in Texas





Data

Texas High Plains Counties

- 7 counties (Dallam, Deaf Smith, Hartley, Moore, Ochiltree, Sherman, Stanton)
  - data ranging over the years 1998-2016
  - 42 -762 observations per county

- Data includes:
  - Yield (bu/ac)
  - Water Applied
  - Nitrogen Applied

Methodology

- Lu, Camp, and Sadler (2004)
  - Quadratic Production Functions by County by Year
    - OLS
      - Yield = $\beta_0 + \beta_1 W + \beta_2 W^2 + \beta_3 N + \beta_4 N^2 + \beta_5 W * N + \varepsilon$
  - Use estimated coefficients to determine optimal Water/Nitrogen given a range of prices for Corn, Water, and Nitrogen

Results

- Expected Signs for Quadratic Production Functions

Intercept	Water	Water^2	Nitrogen	Nitrogen^2	Water*Nitrogen
-	+	-	+	-	+

- 2 Counties with correct signs
  - Dallam (‘07, ‘09, ‘10)
  - Sherman (‘00)

Results

		Price of N-Fertilizer								
Price of corn	Price of Water	30 cents lb/acre			40 cents lb/acre			50 cents lb/acre		
$/bushel	ac-in	Water	N	Net Return	Water	N	Net Return	Water	N	Net Return
4	5	52.0094	76.61997	676.4583	22.47112	76.801	669.2743	18.942	76.9814	661.5852
4	7.5	12.6542	-11.6012	660.2565	9.1256	-11.4205	652.5861	5.5957	-11.239	644.8943
4	10	-0.6957	-99.8222	610.1991	-4.2237	-99.6415	602.5323	-7.7534	-99.4607	594.8389

Next Step

- A different functional form will need to be used to evaluate the optimal level of Water/Nitrogen for Corn production in the Southern Sub-Region of the Ogallala Aquifer
- The following authors support the use of Stochastic Linear Response Plateau as the correct functional form for modeling crop response to Nitrogen input.
  - Grimm, Paris, and Williams (1987)
  - Tumusiime, Brorsen, Mosali, Johnson, Locke, Biermacher (2011)
  - Boyer, Larson, Roberts, McClure, Tyler, and Zhou (2013)
  - Ouedraogo and Brorsen (2014)
  - Rodriquez and Bullock (2015)

Questions?