

OGALLALA AQUIFER : DYNAMIC COMPARISON OF GRAIN SORGHUM AND CORN PRODUCTION IN TEXAS COUNTY, OK WITH GROUNDWATER DEPLETION

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Funded by Oklahoma Water Resources Research Institute

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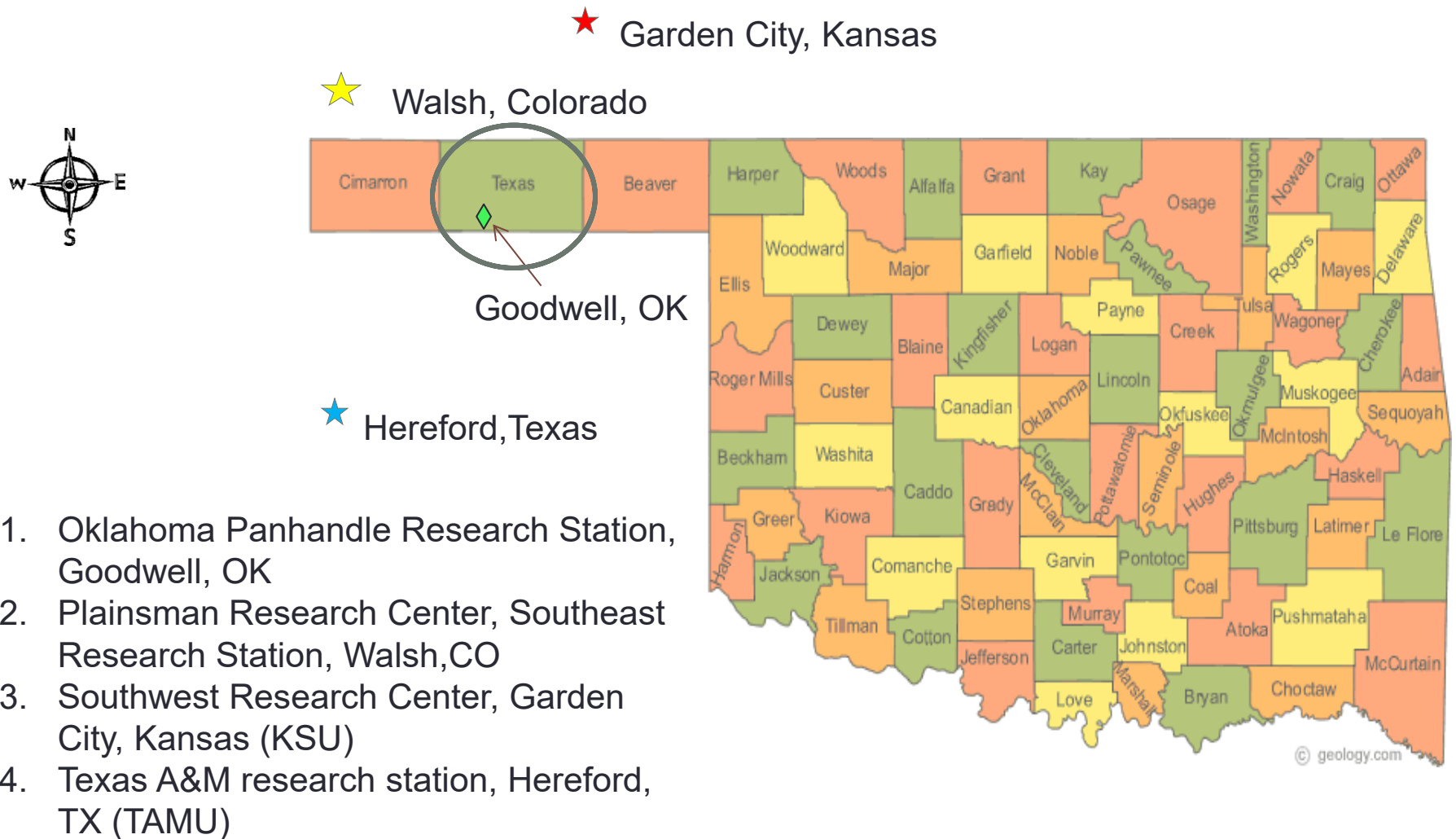
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^{**} Selected Paper for Annual Student Water Conference, OSU, April 11, 2014

Introduction

- The project began on March 1, 2014. This is a preliminary examination of results for finding an alternate solution to irrigated corn production in Texas County, OK and to extend the aquifer life and maximize the value from the remaining groundwater supply.
- Research papers and variety trials have shown that grain sorghum can be a productive and profitable replacement for corn in the future.

Study Area and Sources of Experimental Data

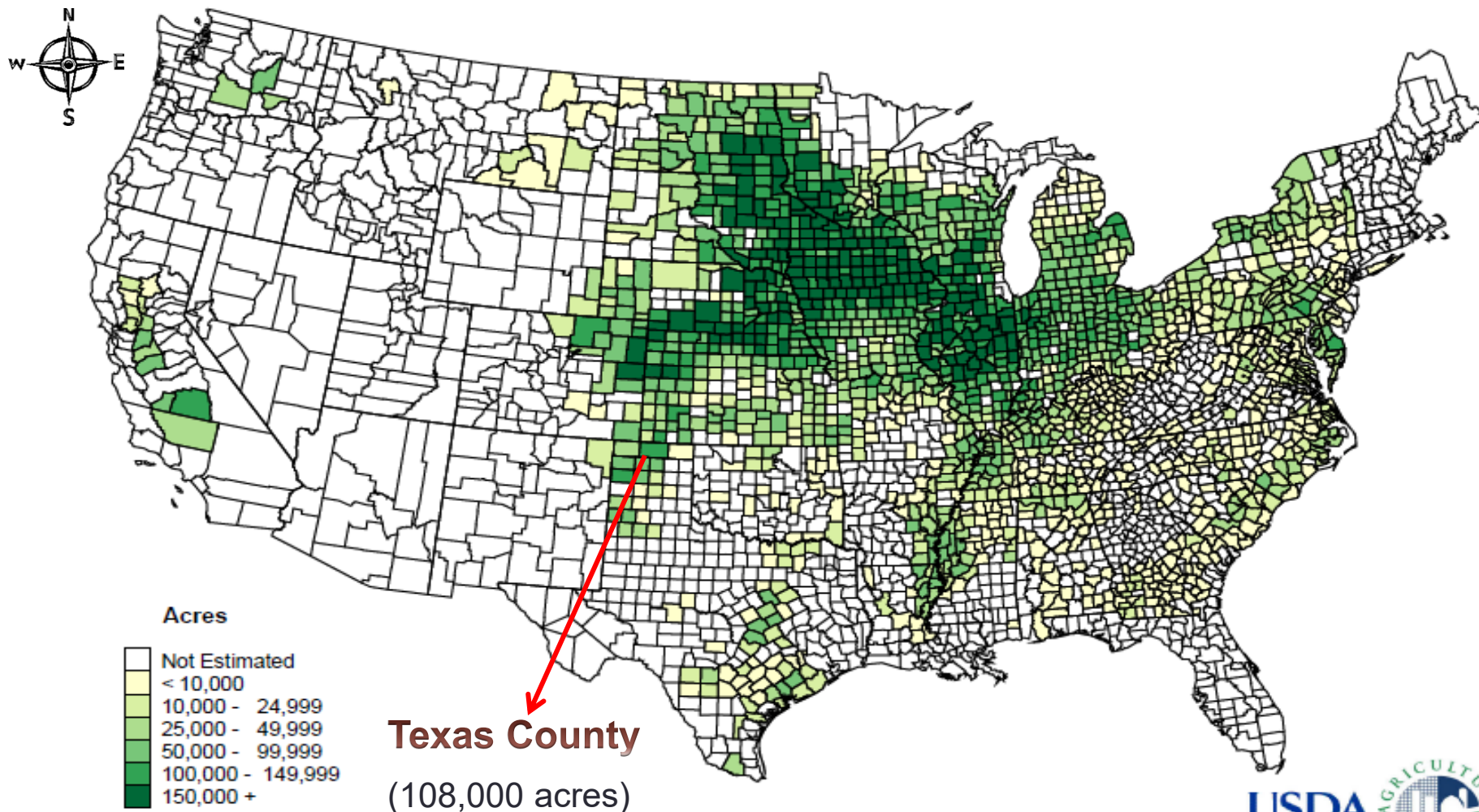


Courtesy: www.Geology.com

The Ogallala Aquifer

- U.S. Geological Survey (USGS), other agencies began to monitor more than 7,000 wells in 1988 to assess annual water-level change in the entire Ogallala aquifer.
- USGS found that the water levels declined by 100 ft and more between 1940s and 1990s. If this prevails, an addition 20-25 ft will decline by 2020 (Luckey, et al. 2000).
- Estimated water use is 167 million gallons per day in Texas County (USGS, 2005)
- Recharge was estimated as .25 to .50 inches/year (Manjula, 2000)

Corn for All Purposes 2012 Planted Acres by County for Selected States



Literature

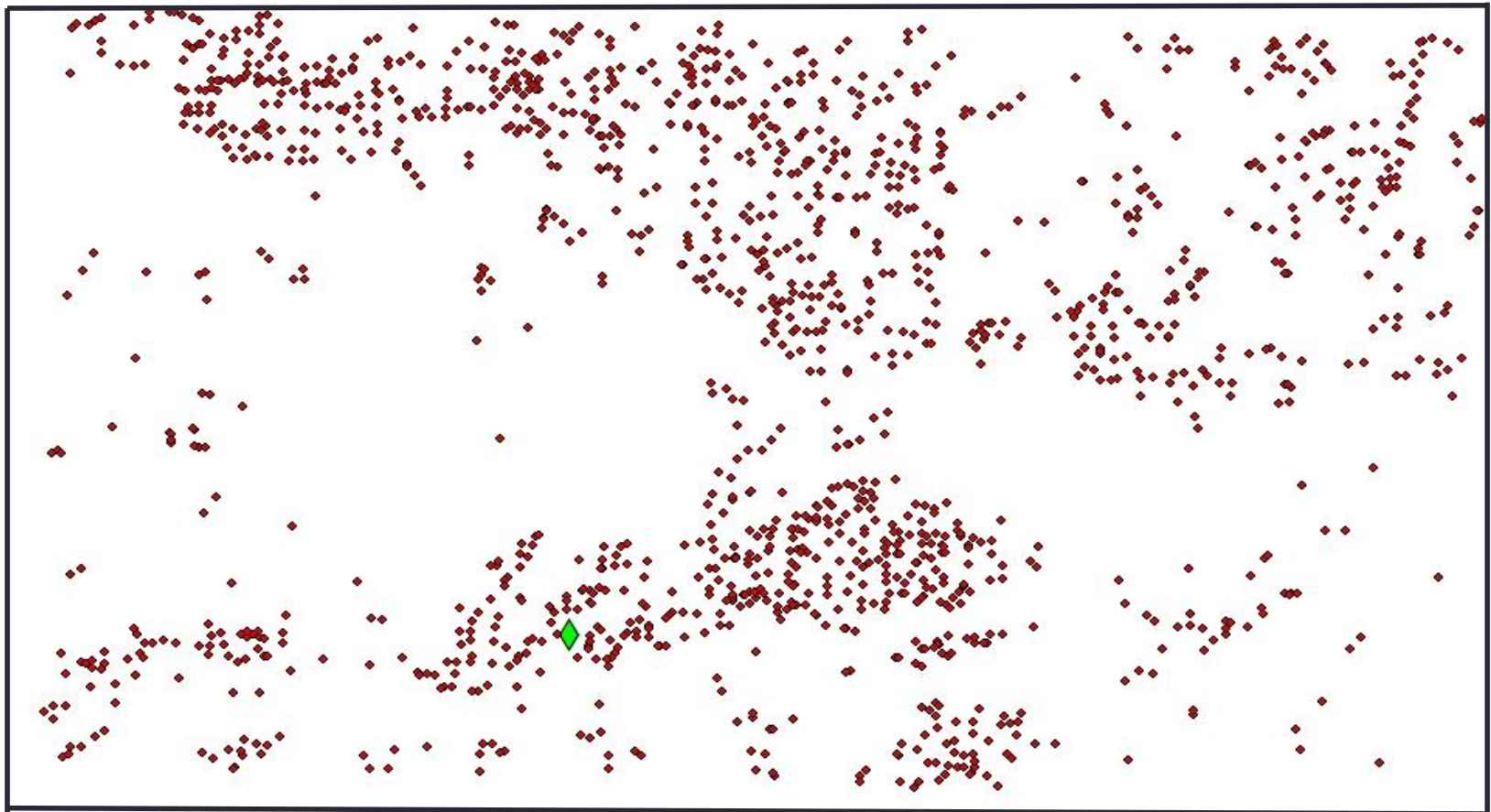
Two of the major articles used are,

1. Stone L.R., Schlegelb A.J., Gwin R.E. Jr., Khana A.H. 1995. “*Response of corn, grain sorghum, and sunflower to irrigation in the High Plains of Kansas*” Agricultural Water Management: Elsevier B.V.
2. Carreira. R.I., Stoecker. A.L., Epplin. F.M., Hattey. J.A and Kizer. M.A., 2006. “*Subsurface Drip Irrigation Versus Center-Pivot Sprinkler for applying Swine Effluent to Corn.*” Journal of Agricultural and Applied Economics, 38, 3: 645-658.

Methodology

Texas County Well Clusters (OWRB)

Total number of Irrigation Wells = 1588



Goodwell, OK



OWRB Wells

COURTESY: Oklahoma Water Resources Board (OWRB) & Arc GIS

Yield Estimation

- Environment Policy Impact Calculator (EPIC0509) was used to estimate the mean sorghum yields for 50 years with irrigation levels 0, 4, 8, 10, 12, 16 and 20 inches
- Daily Weather Data from MESONET and Climate.gov (NOAA*)
- Basic Quadratic Model was used

- Grain Sorghum Yield (Y_S) (bushels/acre)

$$Y_S = a + bS_M + cI_L + dR_F + eI_L^2 + fR_F^2 + gI_LR_F$$

- Corn Yield (Y_C) (bushels/acre) (from previous studies)

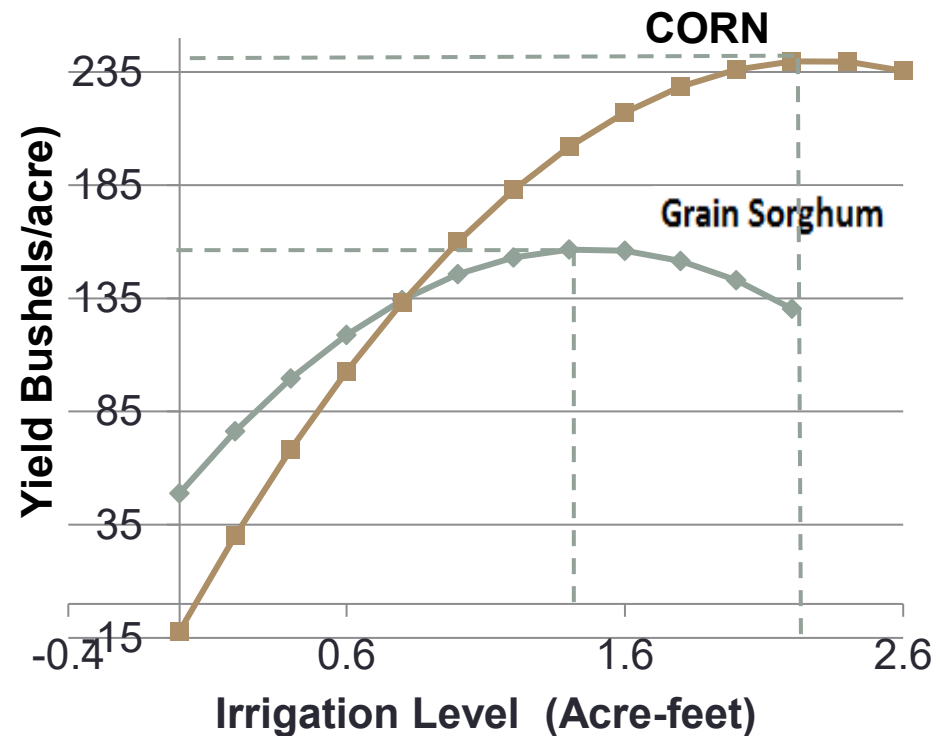
$$Y_C = a + bS_M + cI_L + dR_F + eI_L^2 + fR_F^2 + gI_LR_F$$

1. S_M Soil Moisture during planting (m/m)
2. I_L Irrigation Level (Acre-feet/year)
3. R_F Rainfall/year (Acre-feet/year)

Yield Estimation (Cont)

- The estimated Coefficients are

Irrigated GRAIN SORGHUM			Irrigated CORN	
Variable	Parameter Estimate	Pr> t	Parameter Estimate	Pr > t
Intercept	-35.35	<.0001	-24.01	<.0001
Irrigation	146.48	<.0001	195.44	<.0001
Rainfall	40.73	<.0001	13.72	<.0001
Soil Moisture	208.48	<.0001	127.33	0.0418
Irrig sq	-49.73	<.0001	-40.21	<.0001
Rain sq	5.57	0.616	8.41	0.7377
Irrig Rain	19.39	0.866	21.10	0.7907

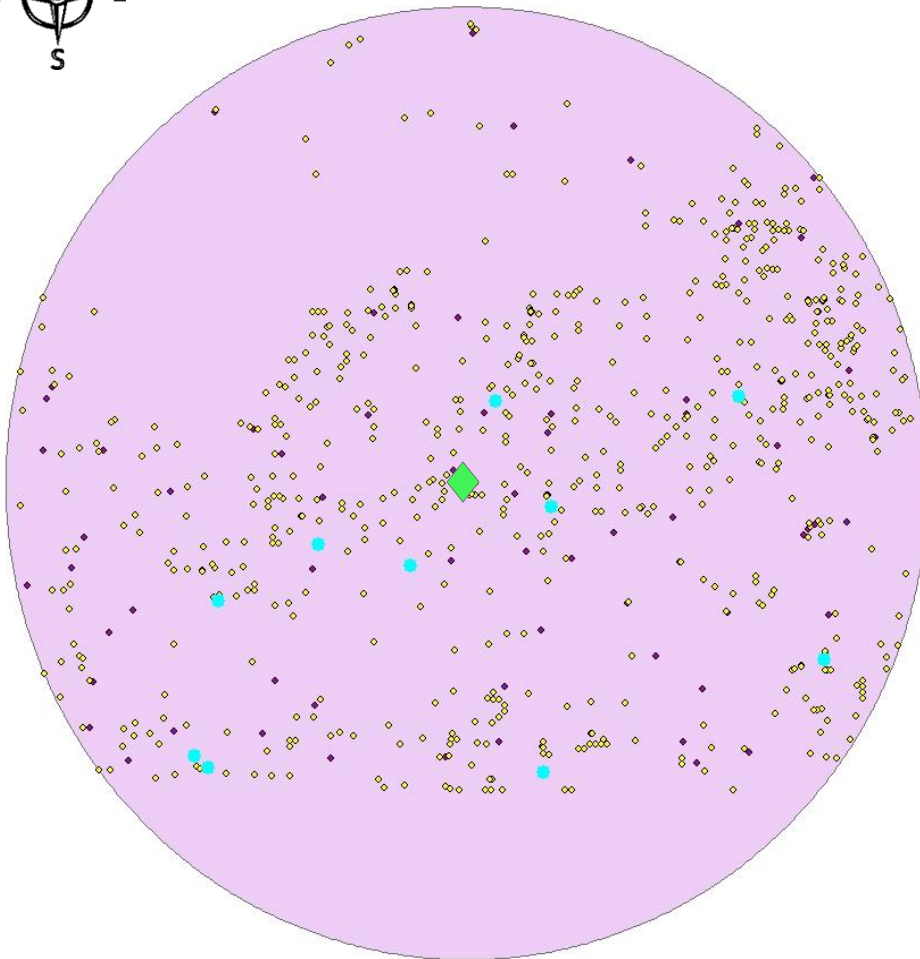


Max. Yield for Grain Sorghum at 1.4 acre-feet of irrigation = 157 bushels/acre

Max. Yield for Corn at 2.2 acre-feet of irrigation = 241 bushels/acre

Water Level Estimation

10 mile radius buffer



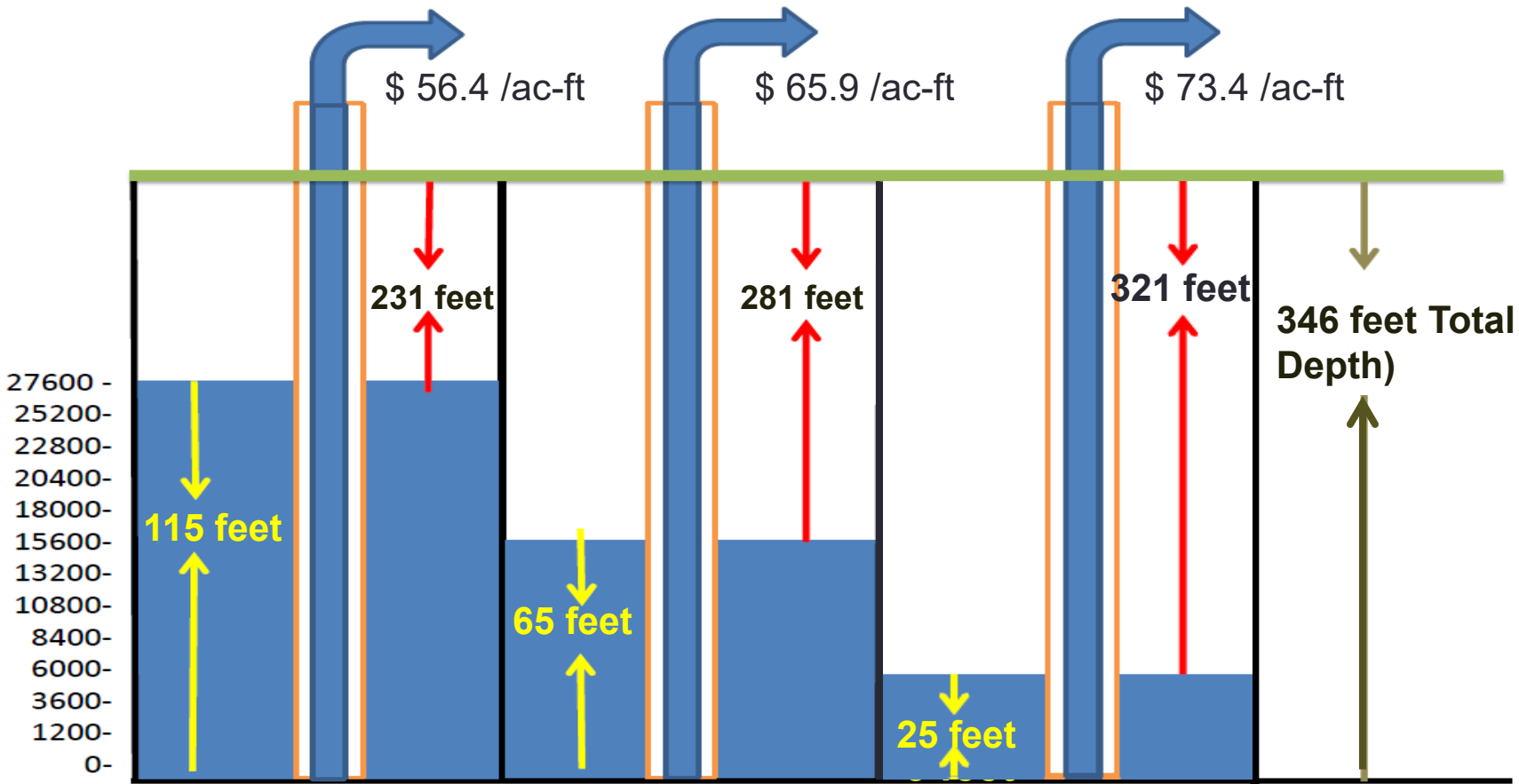
- ◆ Goodwell, OK City
- OWRB Wells
- USGS Wells
- USGS Measured Wells

Mean Well depth = 370 feet
Mean Water level = 231 feet
Saturated Thickness = 115 feet
Altitude = 3304 feet above sea level

Current Ground Water Supply Estimation

For each 640 acre section of crop land, assume

- Only 40% of total area is irrigated
- Porosity of water saturated sand = 0.15
- Current saturated thickness = 115 feet
- Therefore, supply of groundwater/640 acres
= $(640/.4)(115)(.15) = 27,600$ acre feet



Total Head_i (TDH_i) = Water Level_i + PSI*2.31/S.G

Brake Horse Power (BHP_i) = $\frac{(GPM)*(TDH_i)*(S.G.)}{(3960) / (Pump Efficiency)}$

Cost (\$/ac-ft) = (BHP_i) * (0.746) * (hrs/ac-in) * (Pelec)

Pounds Per Square inch (PSI)	30
Gallons Per Minute (GPM)	750
Pump Efficiency	0.66
Specific Gravity (Water)	1
Hours per Acre-in (hrs/ac-in)	13.57
Price of Electricity (Pelec)	10cents

Other Variable Cost Estimation

CORN	Vary with acres	Vary With each Bushel
Seed	17.89	0.44
Herbicide	61.00	0.021
Insecticide	11.54	0.62
Fertilizer	0.81	0.19
Crop Consulting	6.50	0.13
Crop Insurance	14.13	0.43
Drying	0.00	0.04
Miscellaneous	10.00	
Custom Hire	67.90	
Non Machinery Labor	18.00	
Irrigation	98.43	
Total	277.94	1.89

GRAIN SORGHUM	Vary with Acres	Vary with each bushel
Seed	4.44	0.13
Herbicide	52.4	0.02
Insecticide	11.54	0.63
Fertilizer	0.91	0.30
Crop Consulting	6.25	0.13
Crop Insurance	17.12	0.44
Drying	0	
Miscellaneous	10	
Custom Hire	60.88	
Non Machinery Labor	18	
Irrigation	91.29	
Total	238.58	1.81

Sources: Oklahoma State University, Enterprise Budgets 2014
 Kansas State University, AgManager.info, 2014

Variable Cost Estimation (Cont)

- Grain Sorghum Variable Cost for each acre = \$ 238.58
- Grain Sorghum Variable Cost for each bushel = \$ 1.81
- Corn Variable Cost for each acre = \$ 277.93
- Corn Variable Cost for each additional bushel = \$ 1.89
- Current Crop Prices per bushel,
 Corn = $5.14 - 1.89 = \$ 3.25$
 Grain Sorghum = $4.75 - 1.81 = \$ 2.94$

Sources: Oklahoma State University, Enterprise Budgets 2014
Kansas State University, AgManager.info, 2014
www.agweb.com/CashGrainBids

Long-term Profit Maximization

NET DISCOUNTED PROFIT (NDPR) (\$) =

$$\sum \frac{A_C [(P_C) E(Y_C) - VC_{CA} - P_{cst}] + A_S [(P_S) E(Y_S) - VC_{SA} - P_{cst}] + RD_S}{\beta^T}$$

A_C = Total Irrigated Corn (acres)

P_C = Price of Corn (\$)

VC_{CA} = Variable Cost for each Acre Corn (\$)

Y_C = Yield of Corn (bushels/acre)

P_{cst} = Corn Pumping Cost (\$)

A_S = Total Irrigated Grain Sorghum (acres)

P_S = Price of Grain Sorghum (\$)

VC_{SY} = Variable Cost for each Acre GS (\$)

Y_S = Yield of Grain Sorghum (bushels/acre)

P_{cst} = Grain Sorghum Pumping Cost (\$)

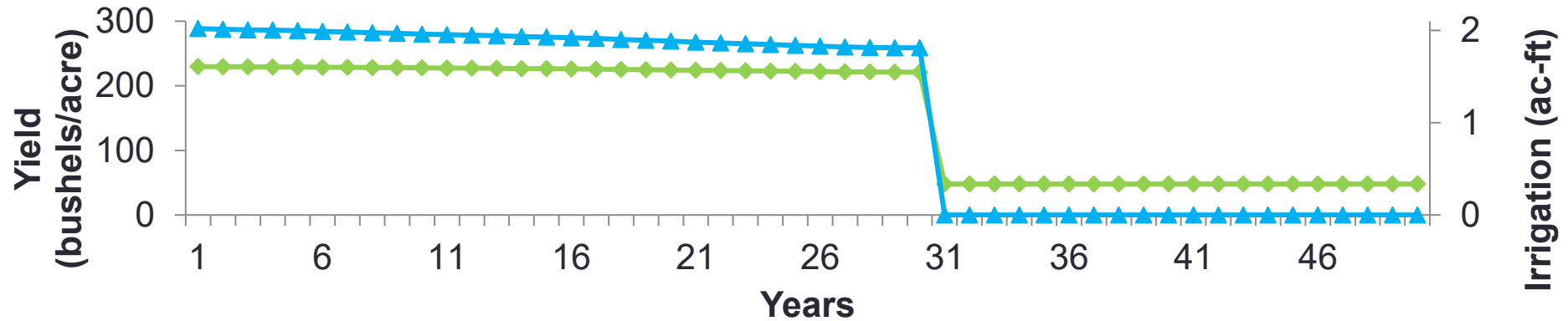
RD_S = Returns from Dryland Grain Sorghum (\$)

β = (1+i), Where i is the discount rate

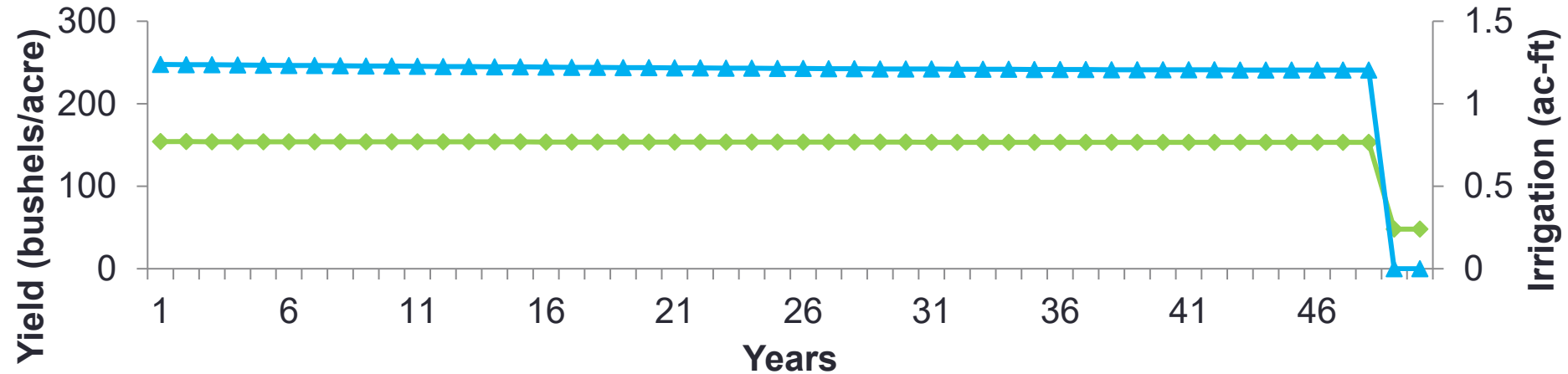
T = 100 (Number of Years)

Results

Corn



Grain Sorghum



Results

- General Algebraic Modelling System (GAMS) Calibrated:

Corn

Discount Rate	Net Discounted Profits	Years Irrigated
2%	\$ 3,771,000*	32 Years
3%	\$ 3,247,000	31 Years

Grain Sorghum

Discount Rate	Net Discounted Profits	Years Irrigated
2%	\$ 3,764,000	48 Years
3%	\$ 3,091,000	48 Years

*Cost of pivot system replacement are not subtracted

Parameters yet to be examined

List of Parameters excluded from the cost function,

- Cost of Re-pivots
 - Cost of Restaging Wells
 - Cost of Drilling New Wells
 - Subsurface drip Irrigation
-
- The above parameters will be estimated and included as the project advances.

Thank You

Questions?

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