Forage Sorghum Production with Limited Water

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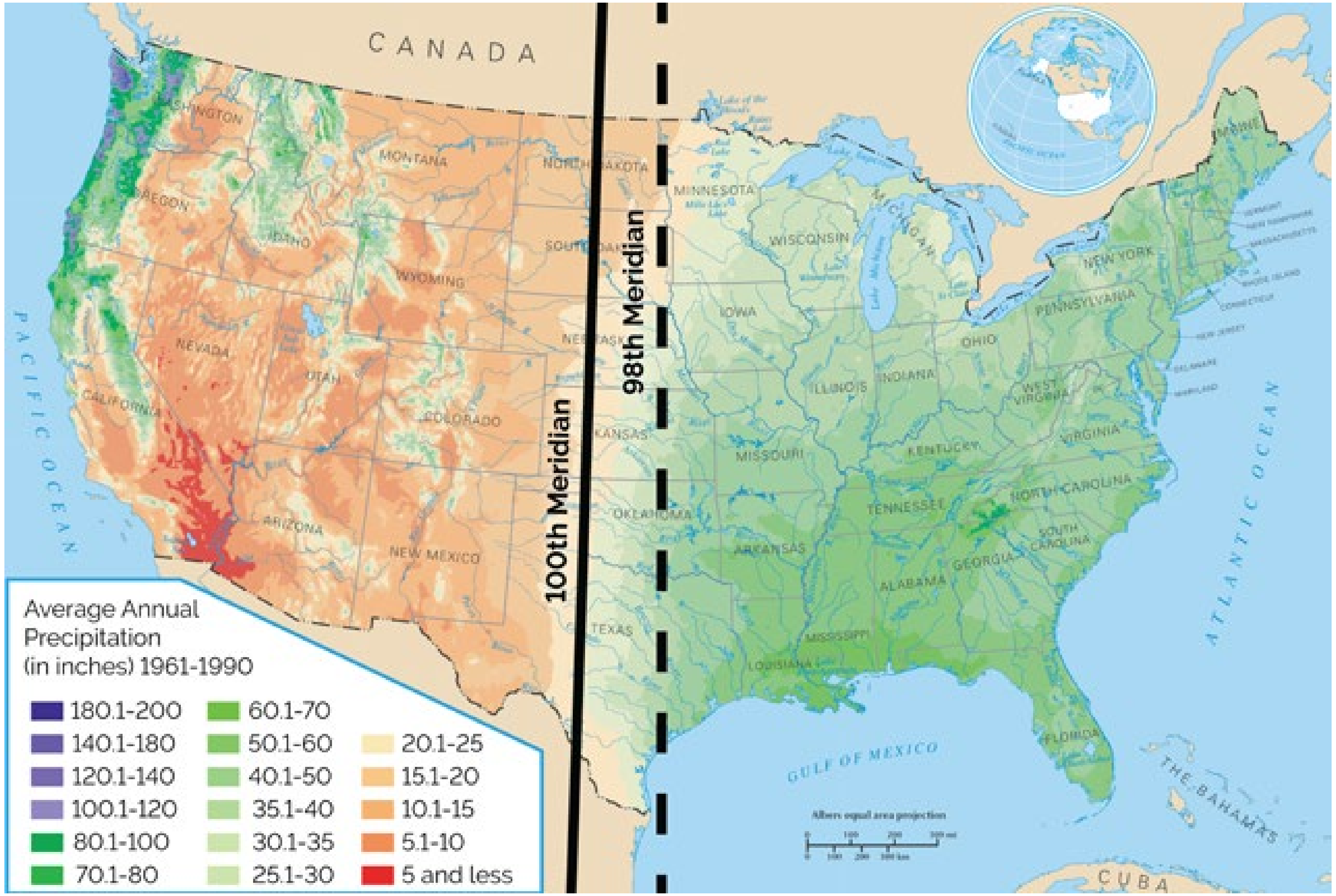
Extension and Research Agronomist
OAP Forage Meeting
December 10, 2024

Hartley County, Texas May 11, 2022
photo credit: Jourdan Bell

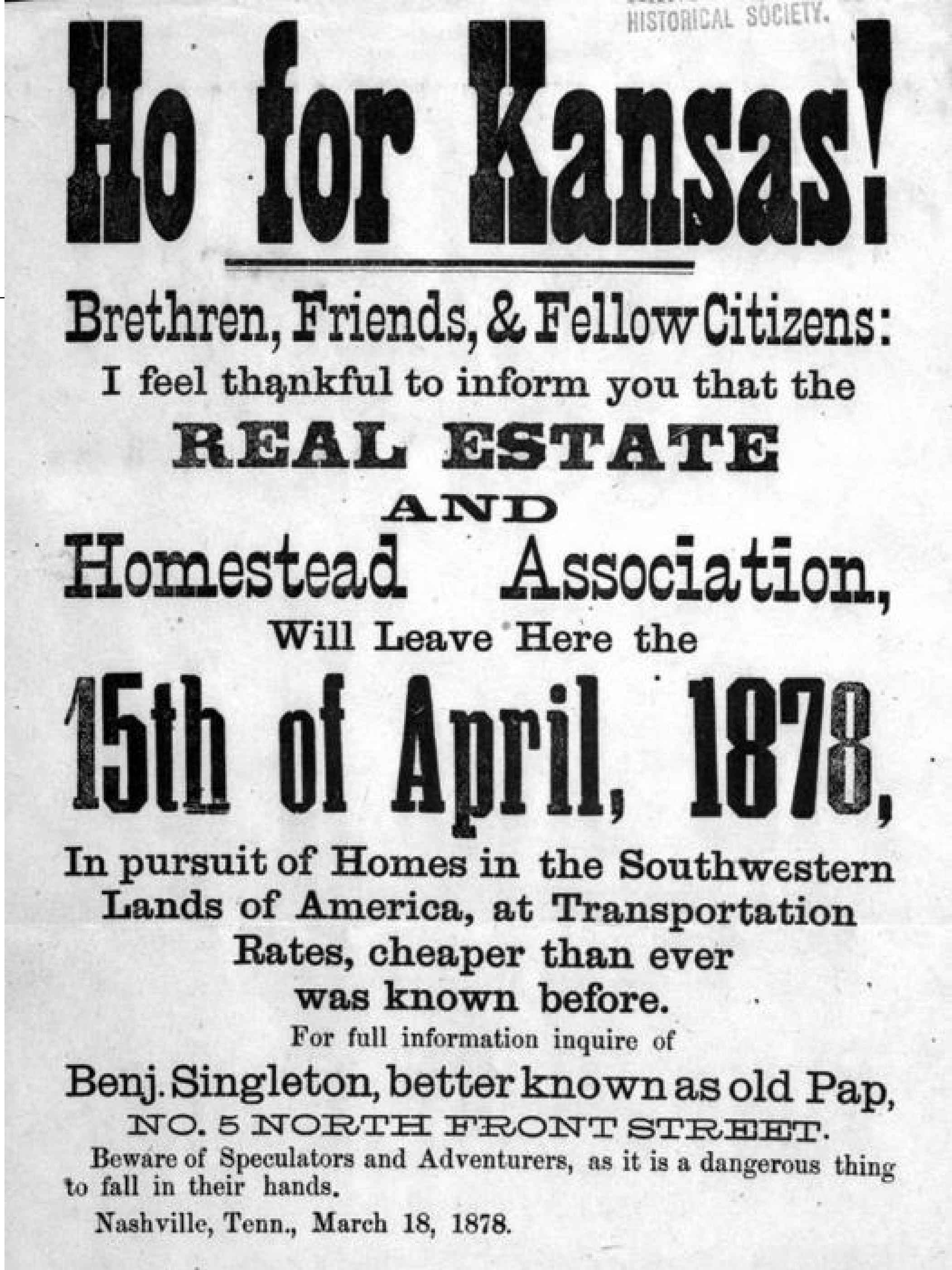
“To know your future, you must know your past” ~George Santayana



Powell's 100th Meridian (1878)

Settlement of the Southern Great Plains

- By 1888, homesteads were filed on 4.2 M acres predominantly in the Plains.
- Between 1888-1892, half the population of western Kansas departed between 1888 and 1892. (Helms, Soil Conservation Service)



https://iowaculture.gov/sites/default/files/primary-sources/images/history-education-pss-migration-kansas-source.jpg

ig. 4. Photo of Briggs in 1933 when he was appointed Director o
the National Bureau of Standards.

Historical Water Use Research Dates to 1910 in Texas Panhandle

- Lyman Briggs (1874-1963): engineer, physicist and administrator
- Appointed director of the USDA Physics Laboratory (Bureau of Soils)
- 1906: soil classification based on the moisture equivalent
- Worked with Homer Shantz on the effect of the environment on the water uptake by plants across the Great Plains

Issued October 31, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 284.

WILLIAM A. TAYLOR, *Chief of Bureau.*

THE WATER REQUIREMENT OF PLANTS.

I.—INVESTIGATIONS IN THE GREAT PLAINS IN 1910 AND 1911.

BY

LYMAN J. BRIGGS,

Biophysicist in Charge of Biophysical Investigations,

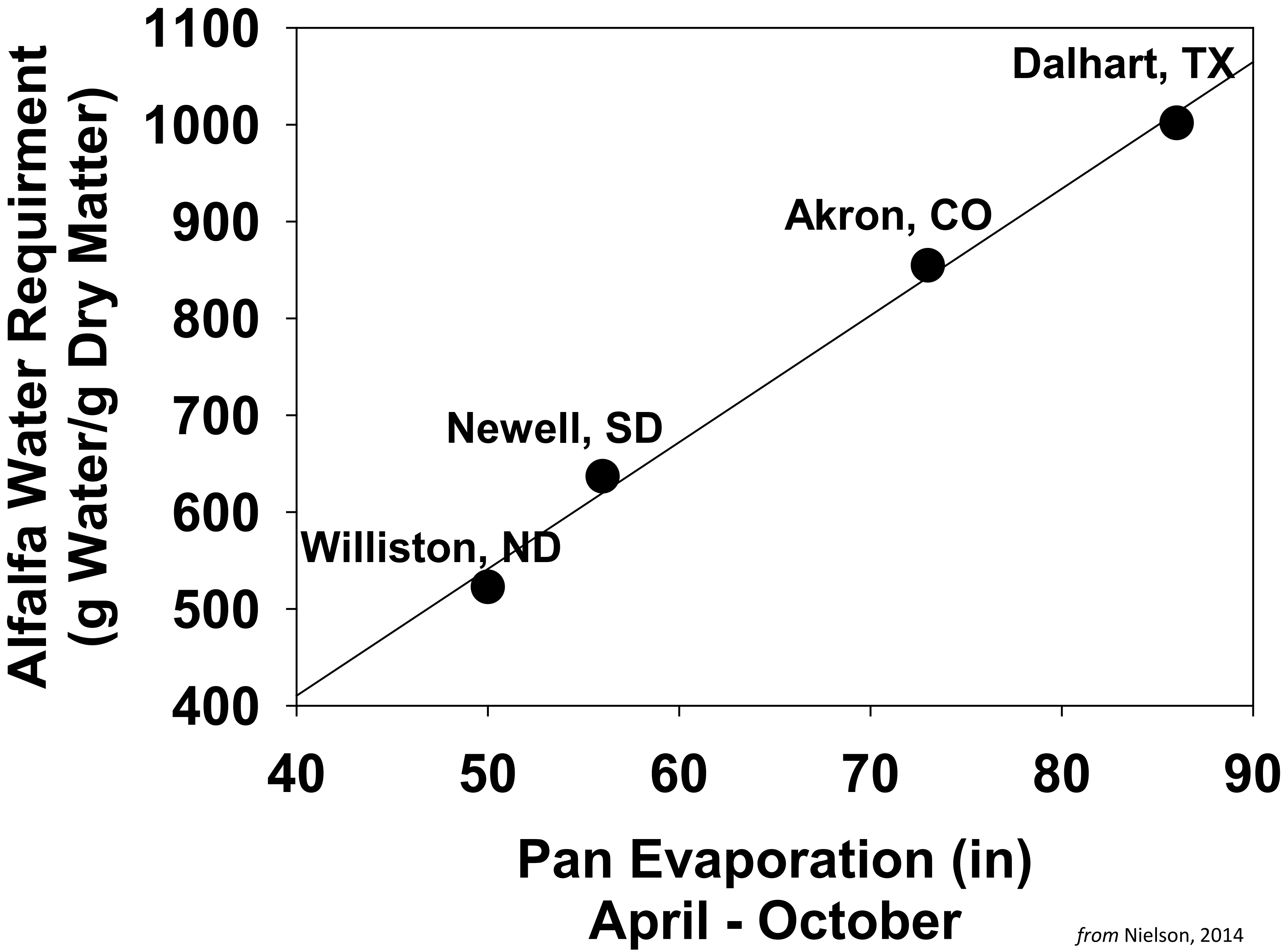
AND

H. L. SHANTZ,

Plant Physiologist, Alkali and Drought Resistant Plant Investigations.

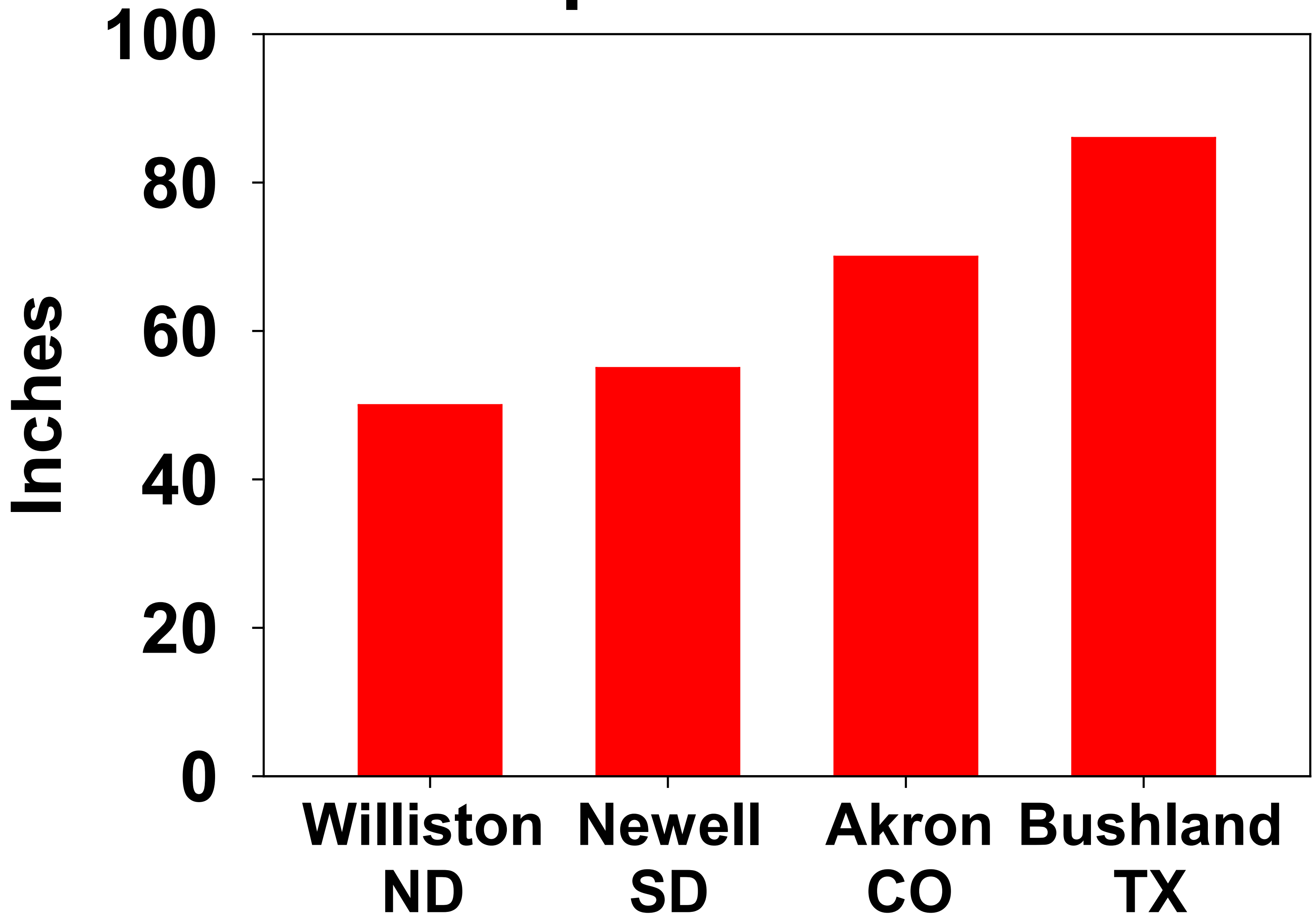
FIG. 3.—METHOD OF WEIGHING CANS.

The water requirement of a given crop, or the transpiration ratio, as it is sometimes called, has long been known not to be constant, but to be dependent upon and influenced by variations in many environmental factors, such as the temperature and humidity of the air, the velocity of the wind, the intensity of the solar radiation, and the fertility of the soil. The water requirement of small-grain crops grown in a cool, humid region is much lower than that of the same crops when grown in a dry region, such as the western part of the Great Plains, where they are subjected also to high winds and greater solar radiation.



from Nielson, 2014

Pan Evaporation
April - October



from Nielson, 2014

1. Early research recognized the impact of limited forage production on the potential settle Southern Great Plains.
2. Irrigation from the Ogallala Aquifer allowed producers overcome high evapotranspiration (crop water) demands and build 20th century communities.

Topics

1. Local Extension Agronomist's perspectives on regional needs
2. Amarillo Agronomy program forage work

Research MUST be Planned Aknowledging Real Water Limitations

- Parts of the Texas Ogallala Aquifer Region are out of water
- Research should take the risk for the farmer
- Most research is irrigated because “we” cannot afford to lose project years --- metrics driven performance (money and publications)
- Research often validates today’s practices rather than looking for future solutions
- Long-term dryland research

PBS: The Rain We Keep

https://www.panhandlepbs.org/Rain/

- Desired Future Conditions (DFCs)
- 50% in 50 Years
- “it will no go to zero…”
- What can a producer do with ≤50 ft of water
  - Planned Depletion

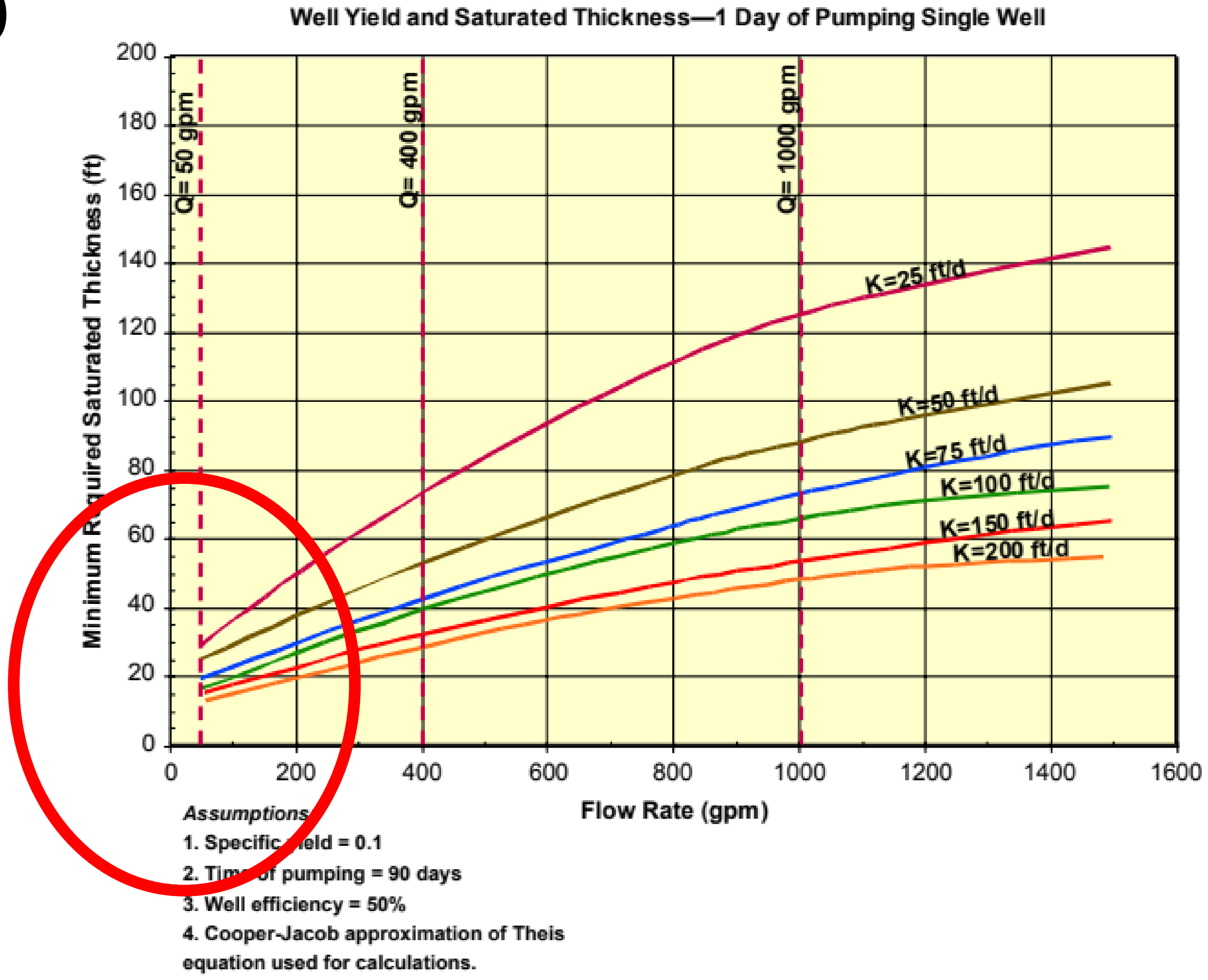
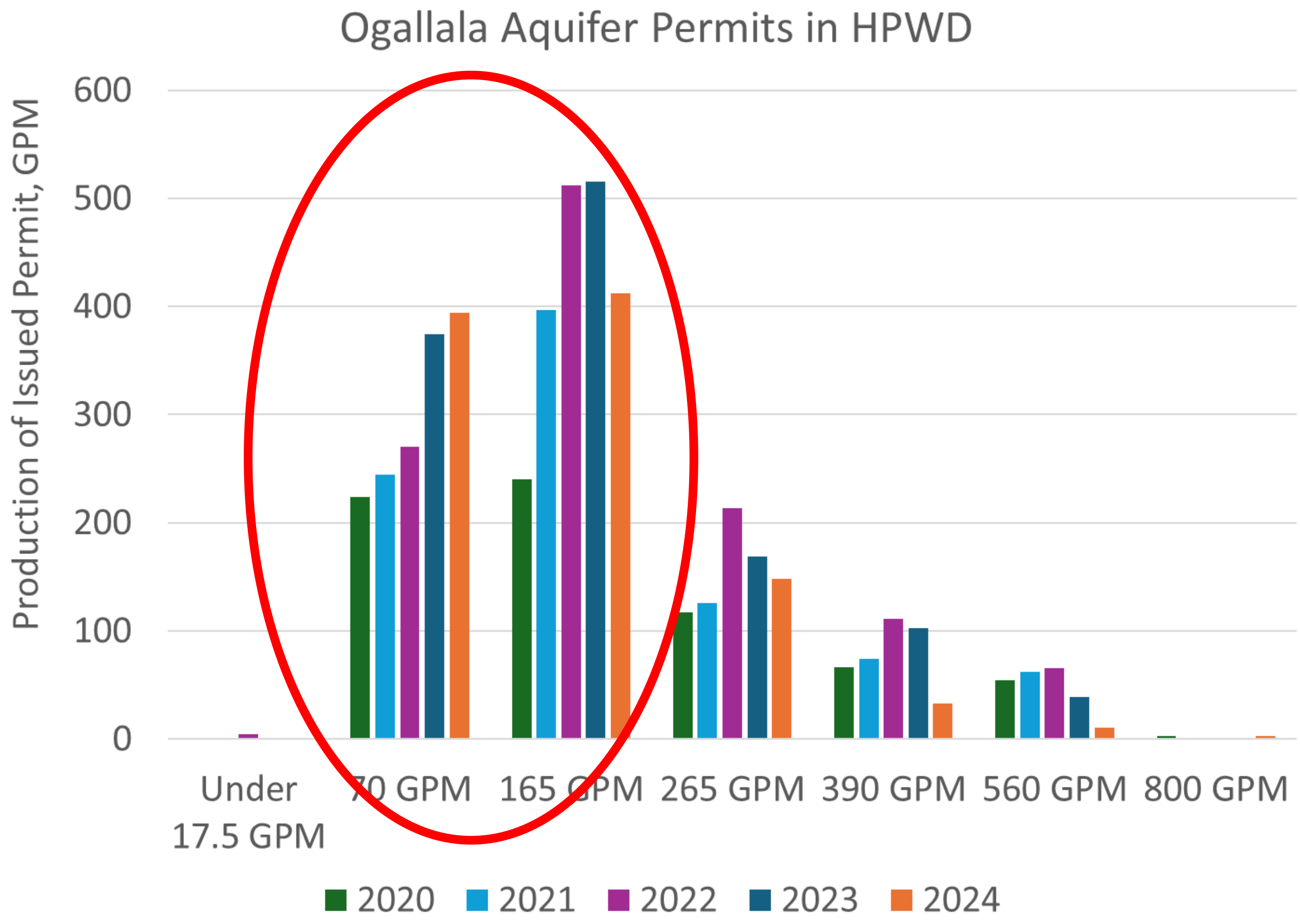


Figure 3. Relationship between Well Yield and Saturated Thickness for Various Hydraulic Conductivity Values, 1 Day of Pumping Single Well

KGS; Hecox et al., 2002



https://www.hpwd.org/reports

HPWD
High Plains Water District
www.hpwd.org

2024 Water Level Measurements

High Plains Water District staff measured approximately 1,340 observation wells in the Ogallala and Edwards-Trinity (High Plains) Aquifers during early 2024 to determine the water level changes since 2023.

District Average Change

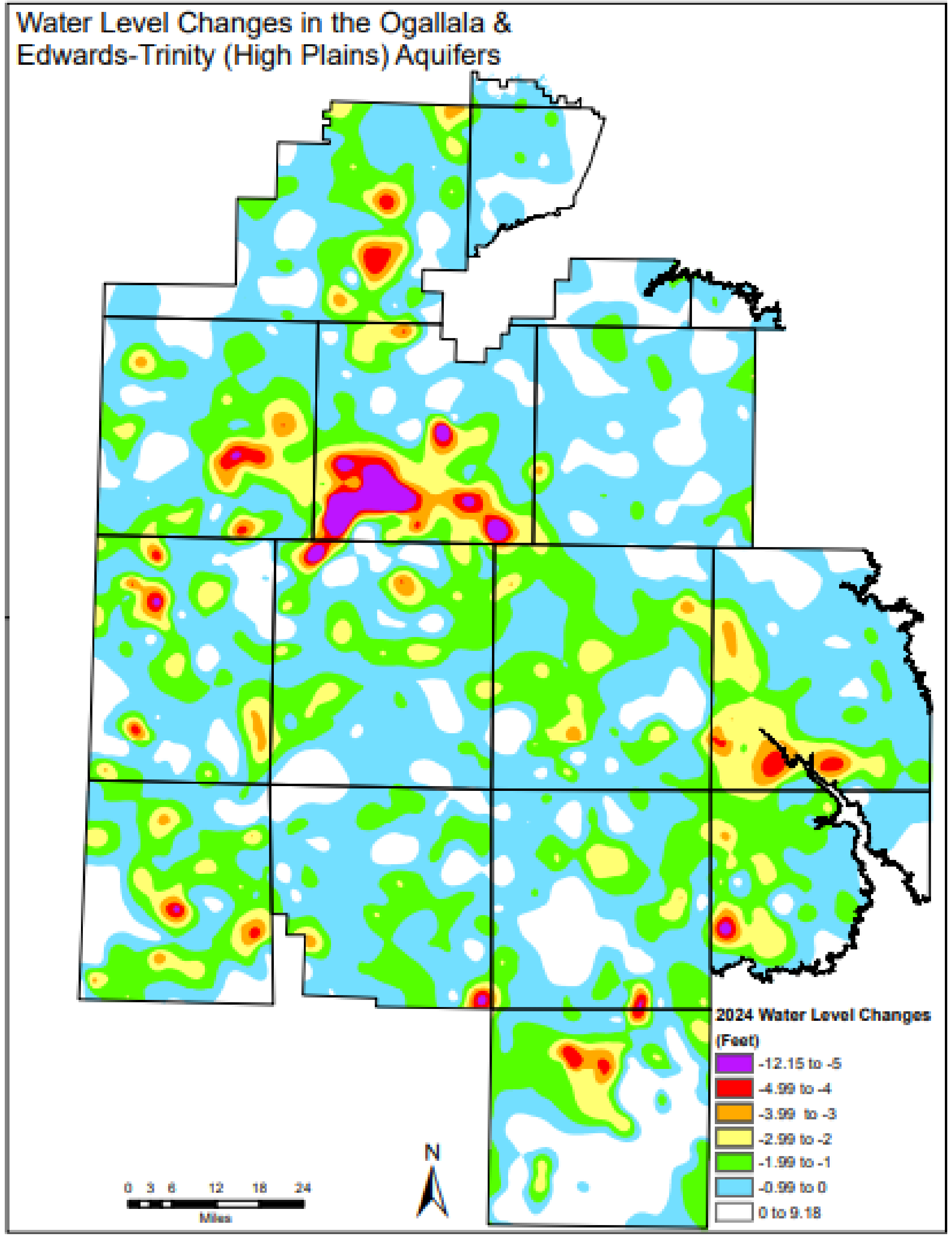
[-0.90 feet]

Average Saturated Thickness

[52 feet]

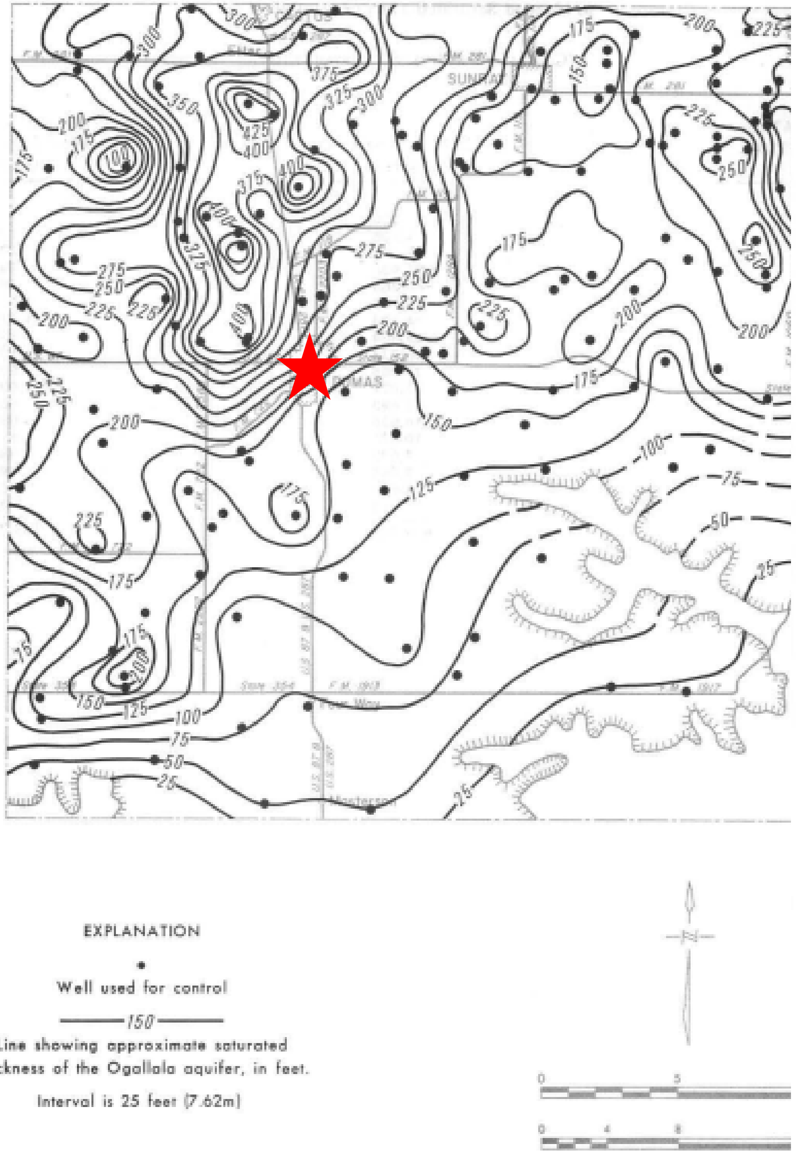
2024 County Summary

County	Observation Well Count	Avg. Water Level Change (ft)	Avg. Saturated Thickness (ft)	5-yr Avg. Change (ft)	10-yr Avg. Change (ft)
Armstrong	10	+0.07	36	-0.16	+2.52
Bailey	99	-0.92	64	-4.19	-5.94
Castro	102	-1.93	50	-10.16	-18.77
Cochran	86	-1.12	42	-3.55	-4.12
Crosby	66	-1.23	81	-2.28	-3.12
Deaf Smith	94	-0.89	58	-4.60	-7.80
Floyd	102	-1.16	63	-3.93	-6.06
Hale	122	-0.86	56	-5.11	-8.95
Hockley	98	-0.71	38	-2.01	-1.91
Lamb	113	-0.84	46	-5.40	-8.94
Lubbock	113	-0.74	57	-1.90	-0.94
Lynn	93	-0.53	49	-4.85	-0.65
Parmer	102	-1.02	45	-6.64	-11.98
Potter	7	-0.39	55	-1.55	-3.09
Randall	50	-0.12	53	-0.67	-0.94
Swisher	87	-0.32	42	-1.88	-2.29

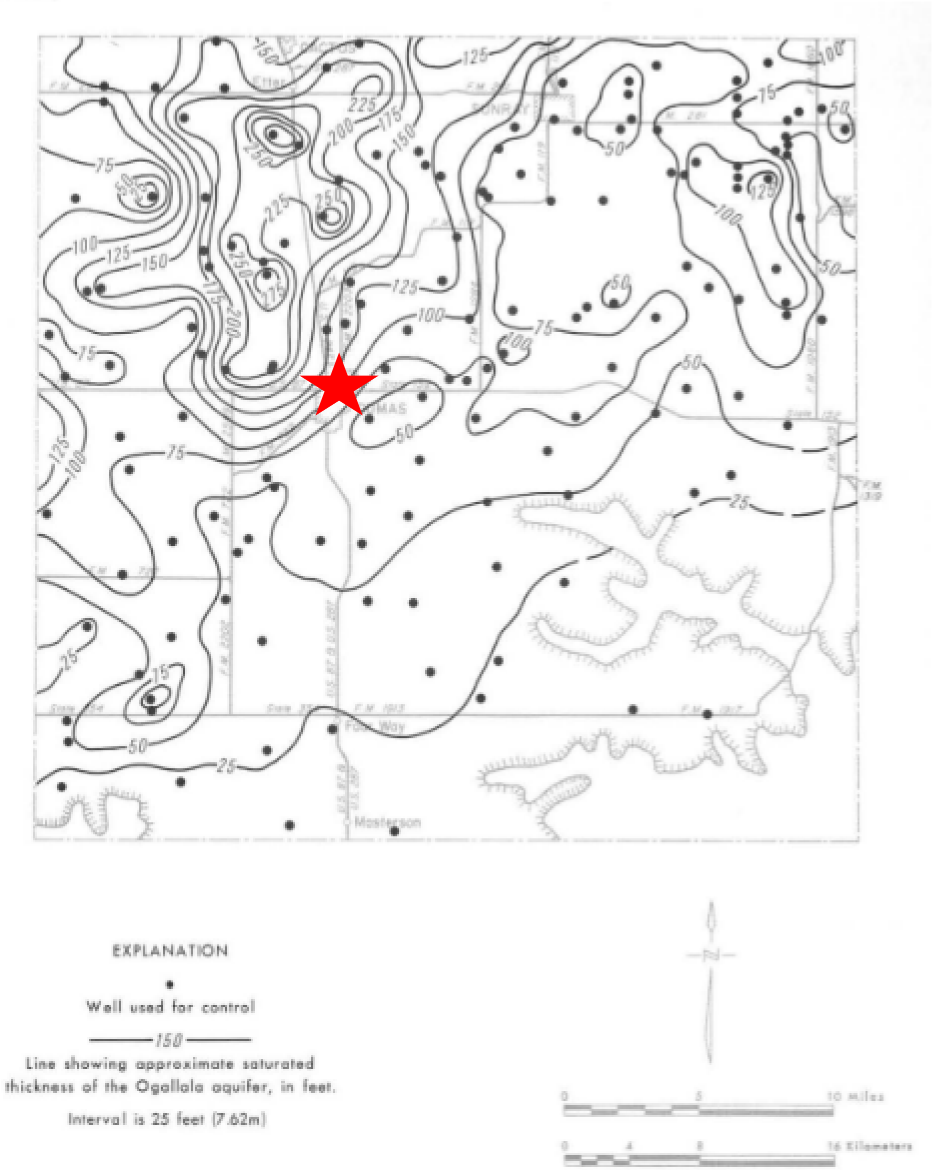


NPGCD

1974 TWDB est. saturated thickness and projected saturated thickness.

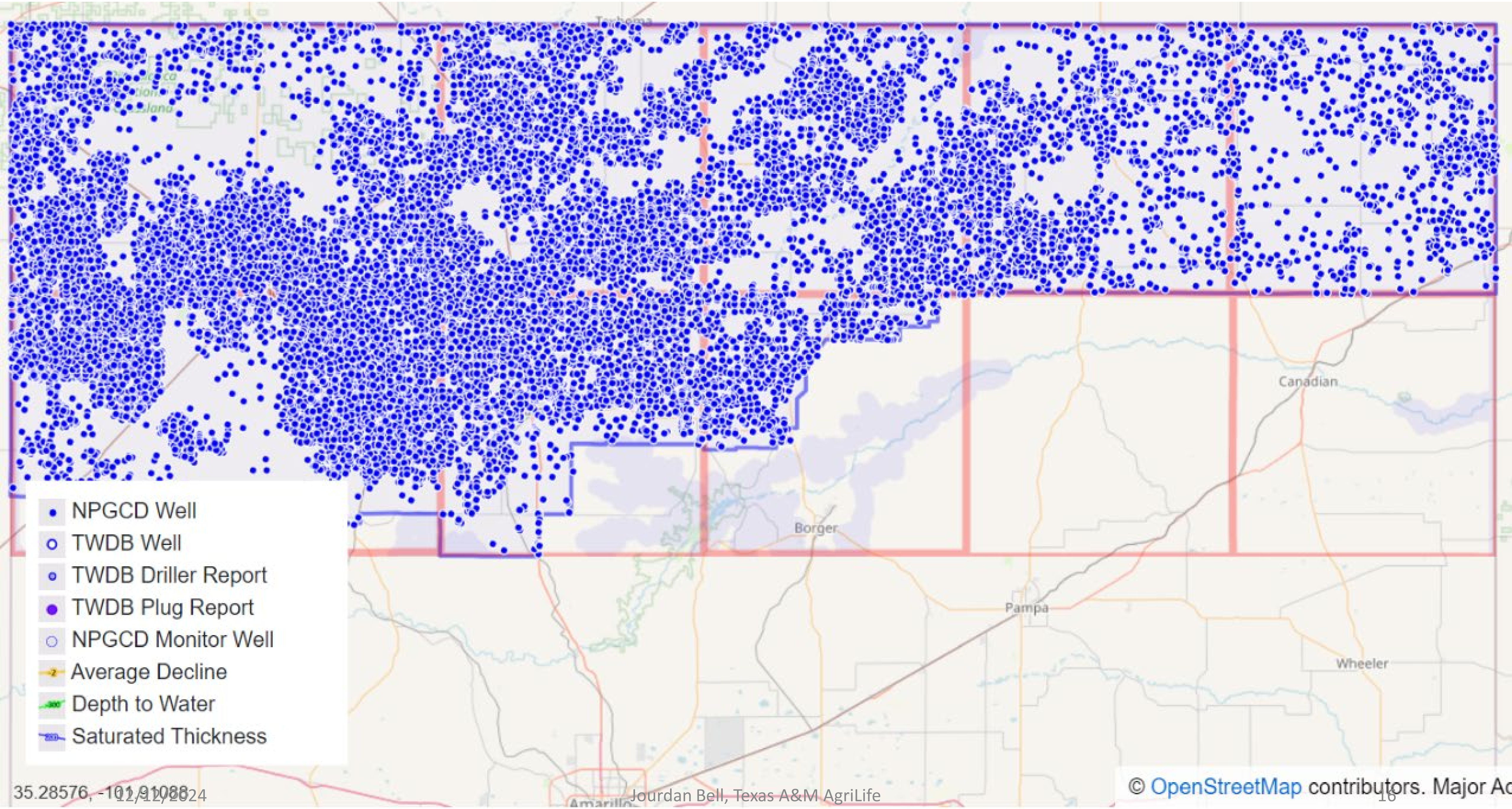


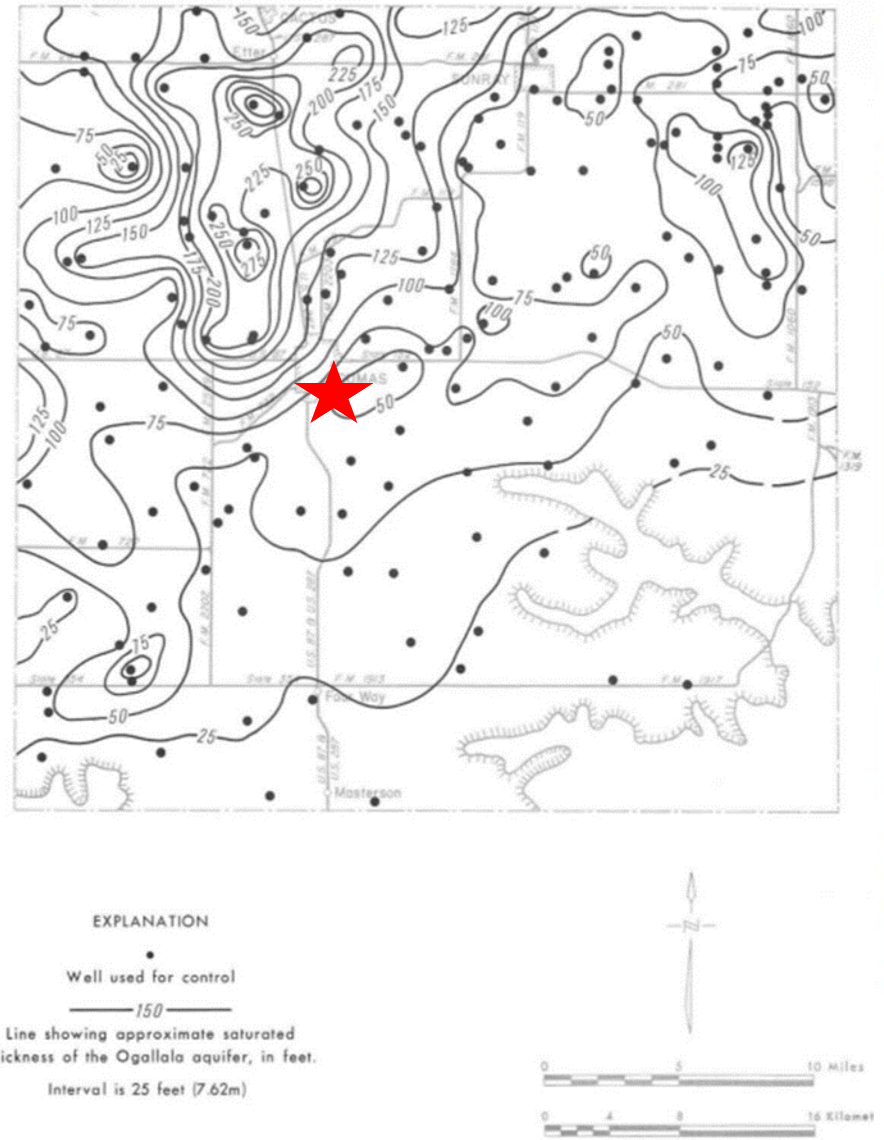
1974
Estimated Saturated Thickness



2020
Projected Saturated Thickness

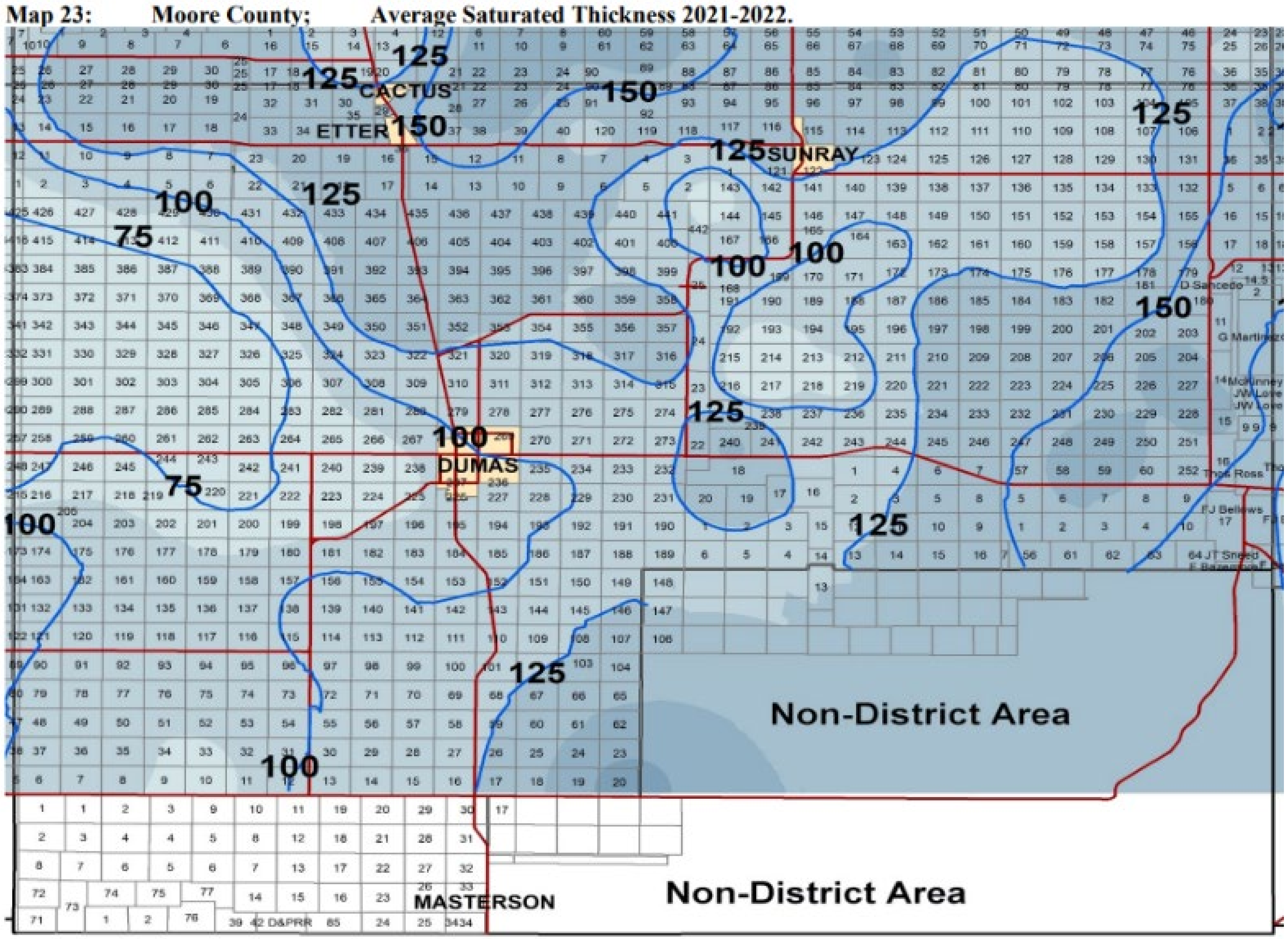
http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/r252/r252.pdf


NPGCD Well
TWDB Well
TWDB Driller Report
TWDB Plug Report
NPGCD Monitor Well
Average Decline
Depth to Water
Saturated Thickness
Canadian
Borger
Pampa
Wheeler
35.28576, -101.91088
© OpenStreetMap contributors. Major Ac

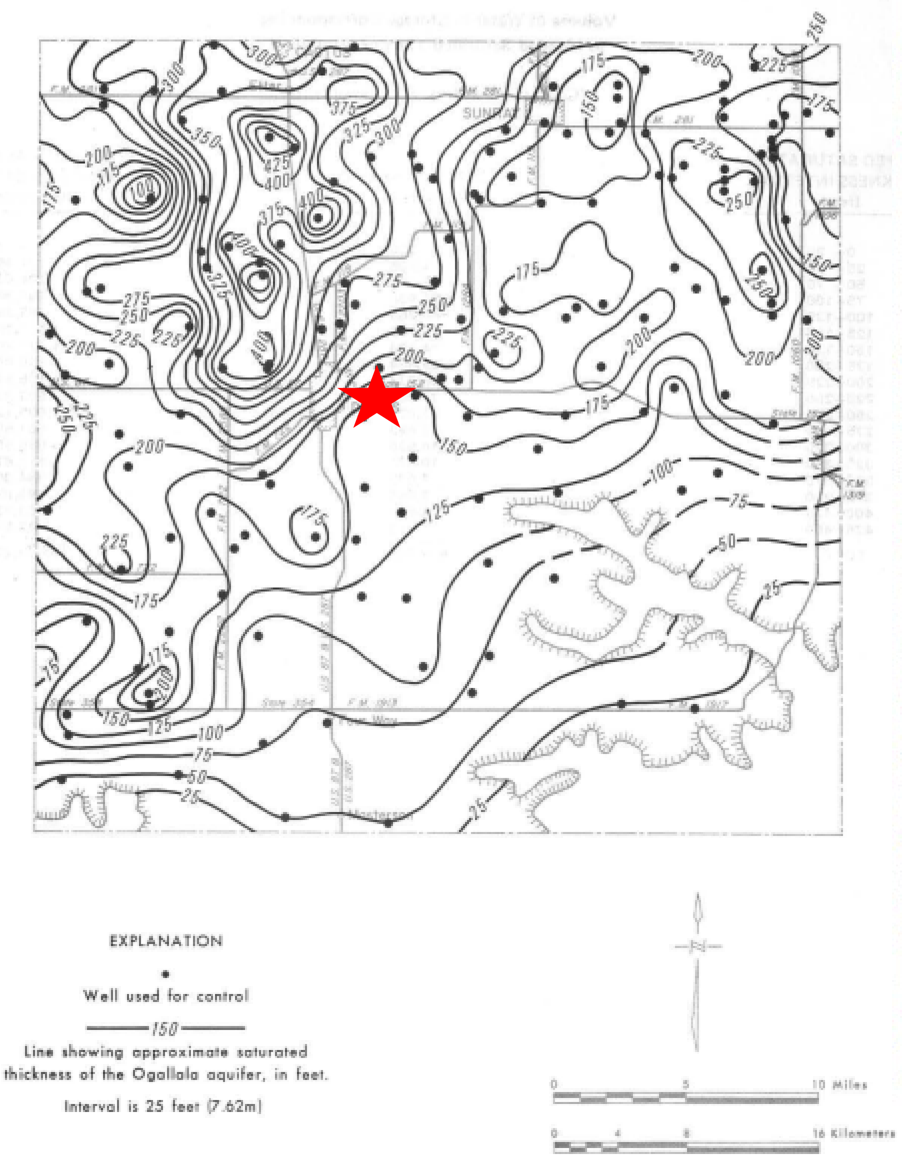


2020
Projected Saturated Thickness

http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/r252/r252.pdf



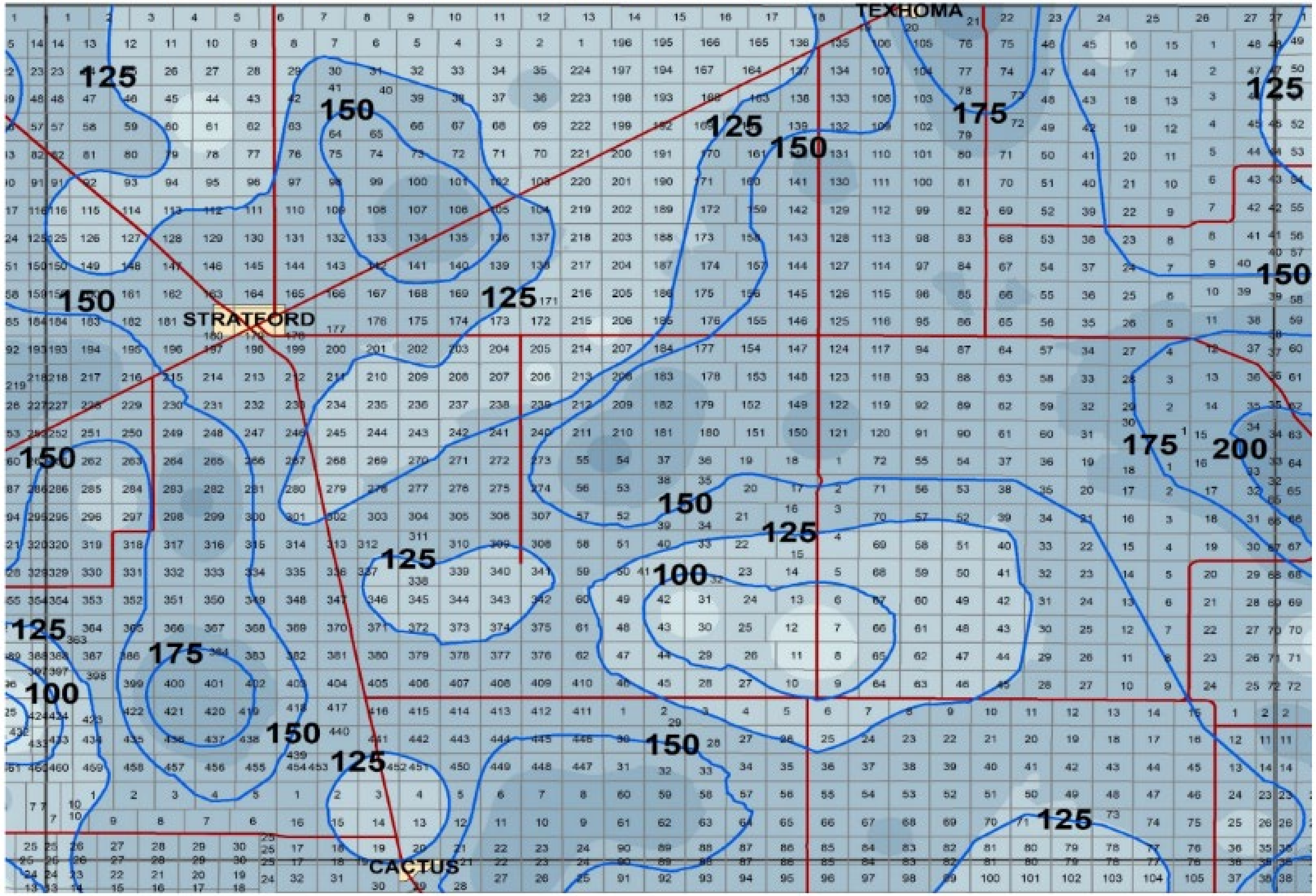
From 2021 annual report: http://northplainsgcd.org/wp-content/uploads/2021-Hydrology-and-GW-Resources-Double-Side.pdf



1974
Estimated Saturated Thickness

http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/r252/r252.pdf

Map 22: Sherman County; Average Saturated Thickness 2021-2022.



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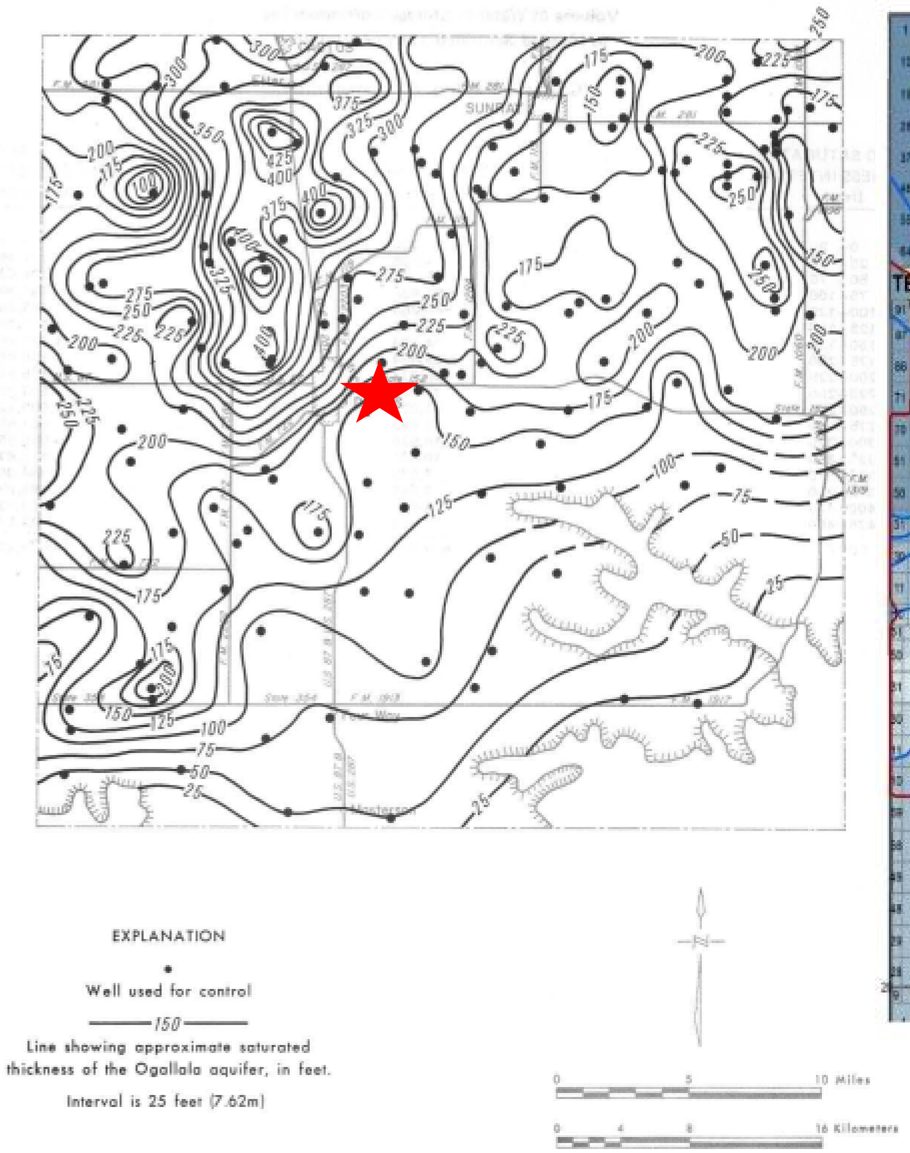
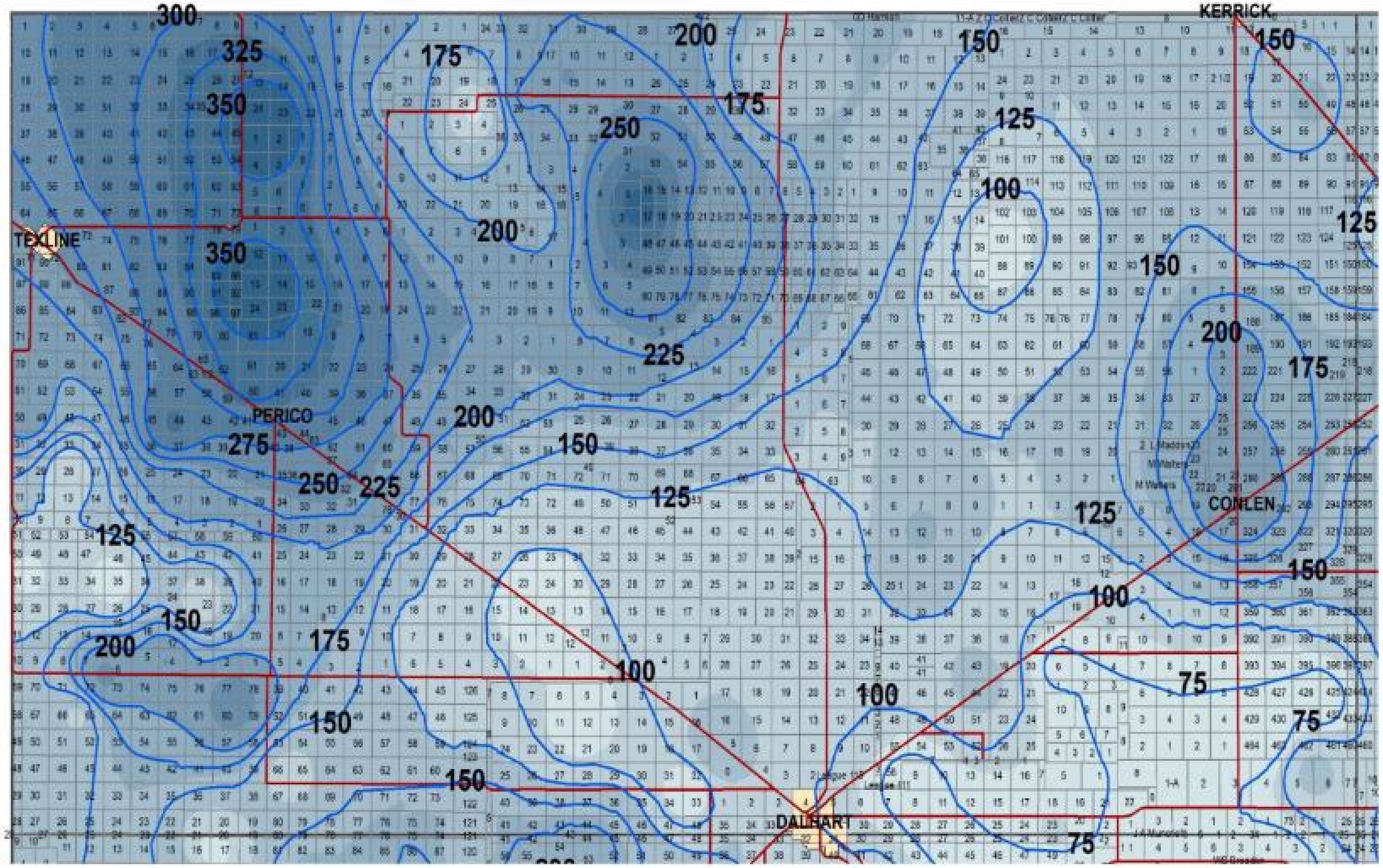


1974
Estimated Saturated Thickness

http://www.twdb.texas.gov/publications/reports/numbered_reports/doc/r252/r252.pdf

Map 20: Dallam County; Average Saturated Thickness 2021-2022.



From 2021 annual report: http://northplainsgcd.org/wp-content/uploads/2021-Hydrology-and-GW-Resources-Double-Side.pdf

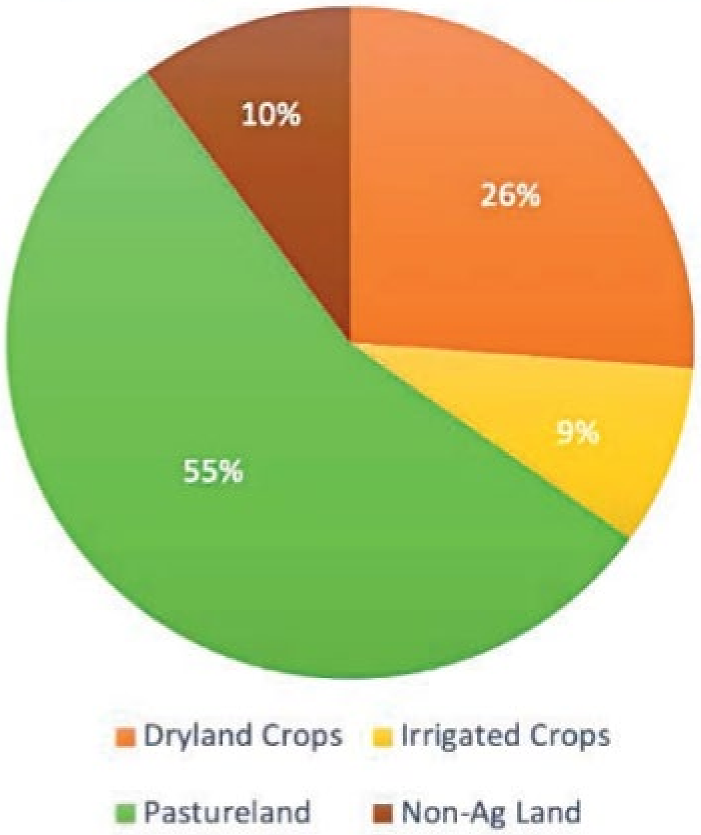
Reality Check

- Few producers cannot irrigate at 100% ET
- Most producers tying numerous low capacity wells together to achieve ~300 GPM
- Most feedgrains can be imported
- Most forages cannot be imported

Regionally, how much forage is needed?

- Dairy
  - ~25 lbs DM/day/cow x 750K cows = 18.8M lbs or 9,400 tons forage/day
- Beef Cattle Finishing
  - ~5 lbs DM/day/head x 2.5 M cattle on feed = 12.5M lbs or 6,250 tons forage/day
- 15,650 ton/day NEEDED
  - 12 ton DM/acre non-stressed corn silage = 1304 acres/day = ~476K acres per year
- Realistic: 8 ton DM/acre limited irrigated silage = 1,956 acres/day = ~714K acres per year in silage
- Estimate does not include stockers or other livestock sectors.
- Future forage production is going to require strategic management of water resources.
- Problems with forages – soil conservation???

Figure 2. High Plains Trade Area Land Use



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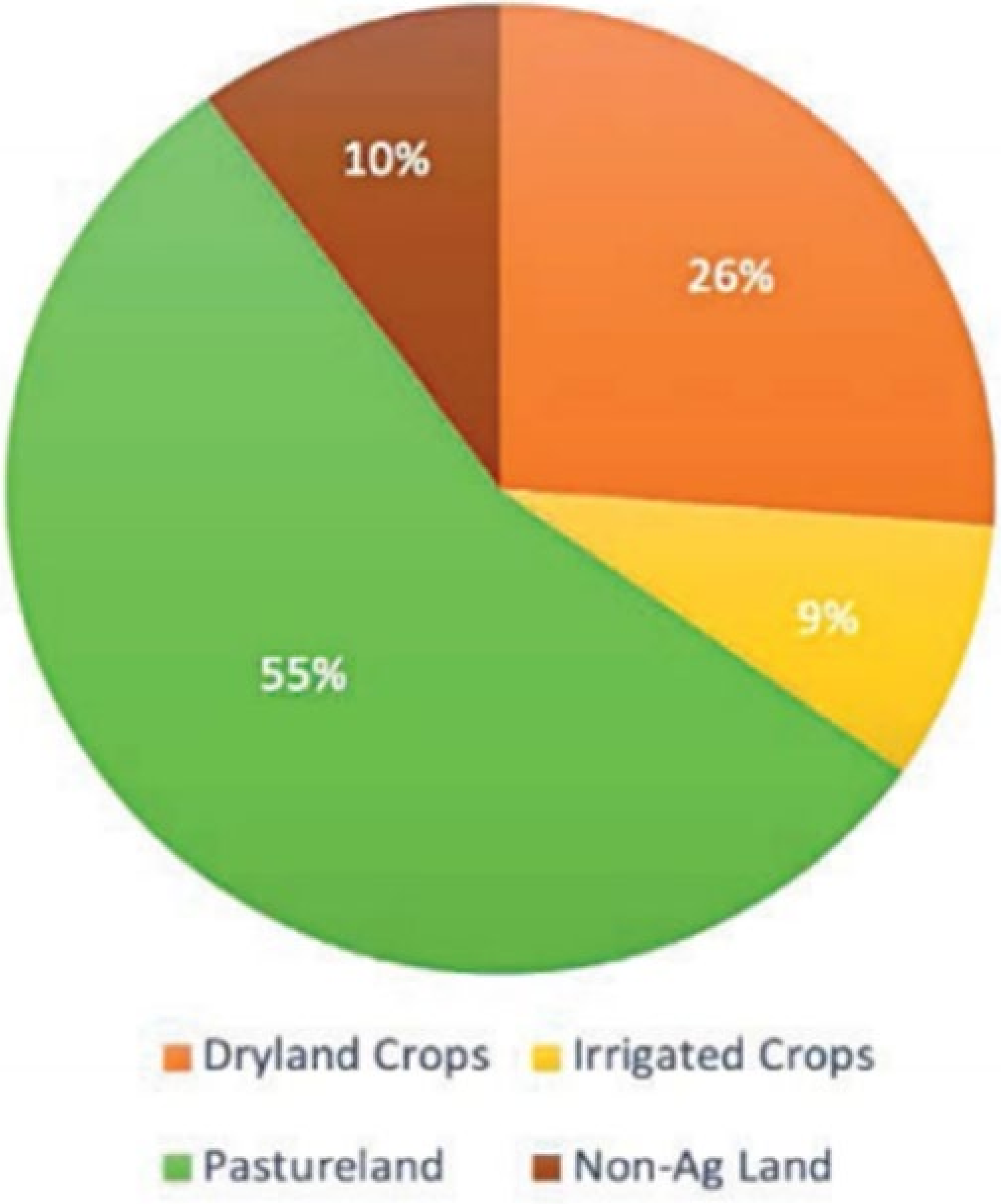

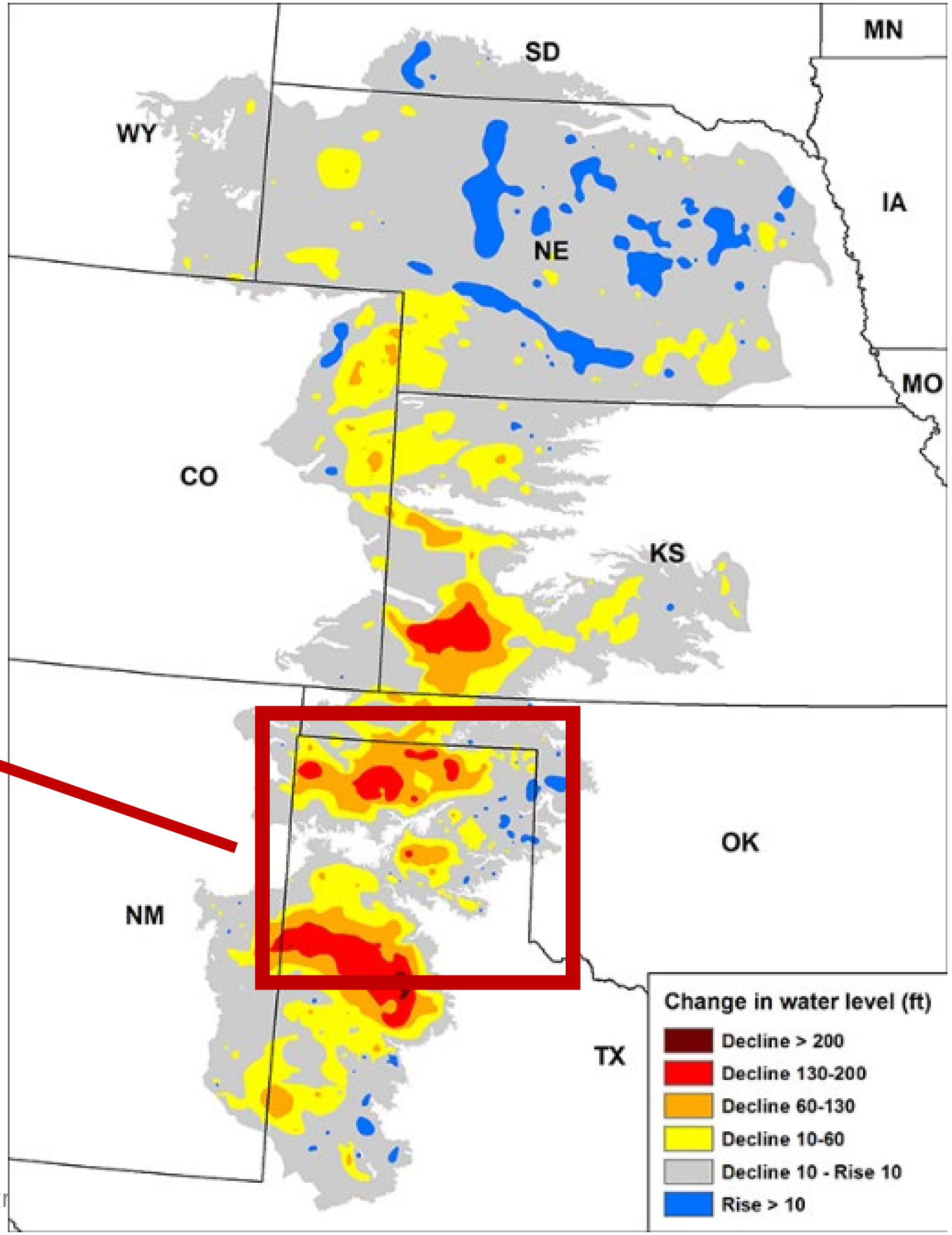

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Moore County: Residue from Irrigated Corn vs. Dryland Corner – Snow January 8 and Picture taken January 25, 2024

That said, silage makes money and can be grown with limited irrigation.

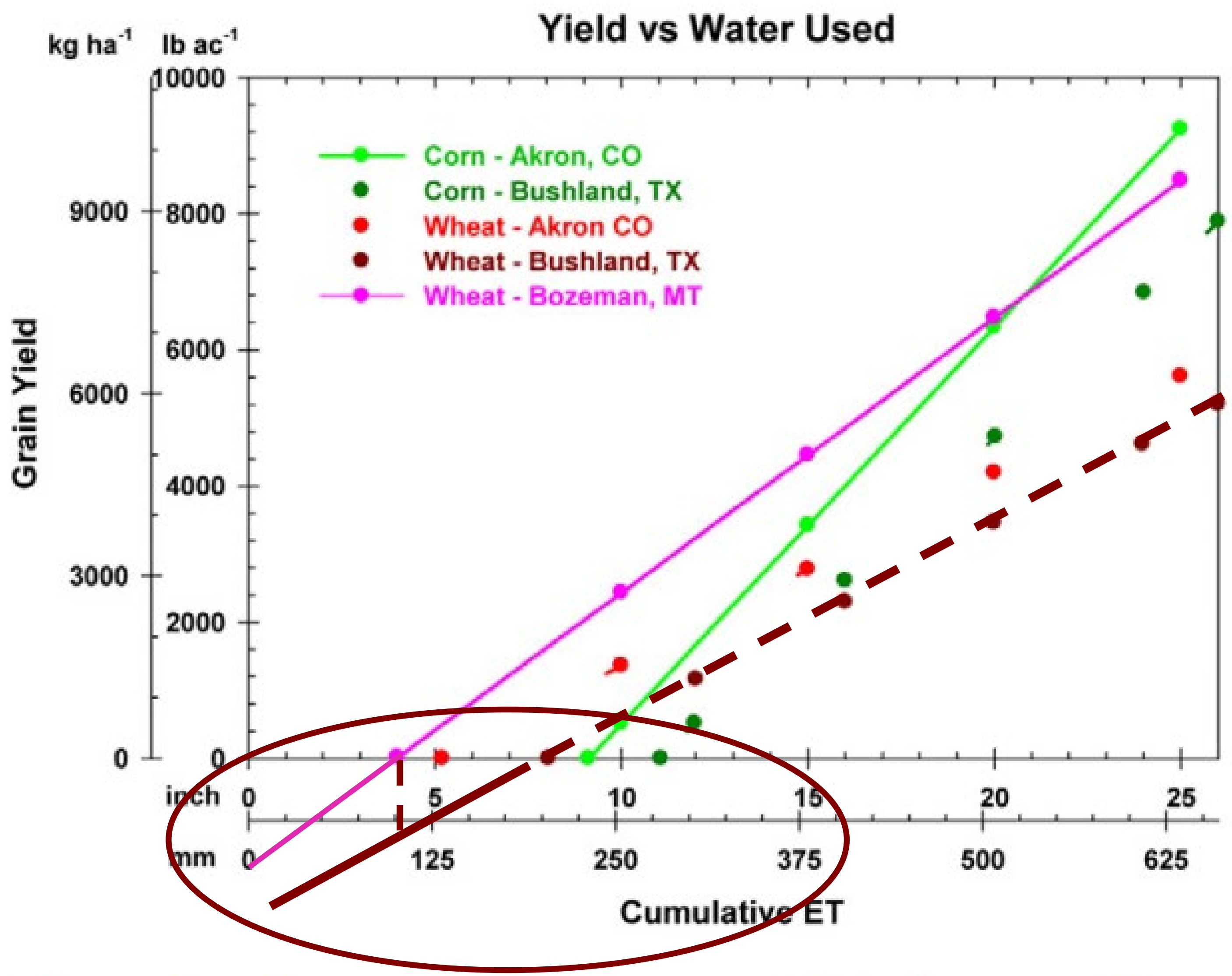


Fig. 7. Cumulative evapotranspiration (ET) and grain yield at Akron, CO; Bozeman, MT; and Bushland, TX.

Source: D.C. Nielsen

Why are forages a viable option with limited water?

Forage is the X-axis intercept:

- Wheat at Bushland = 8”
- Wheat at Akron = 5”
- Wheat at Bozeman = 4”

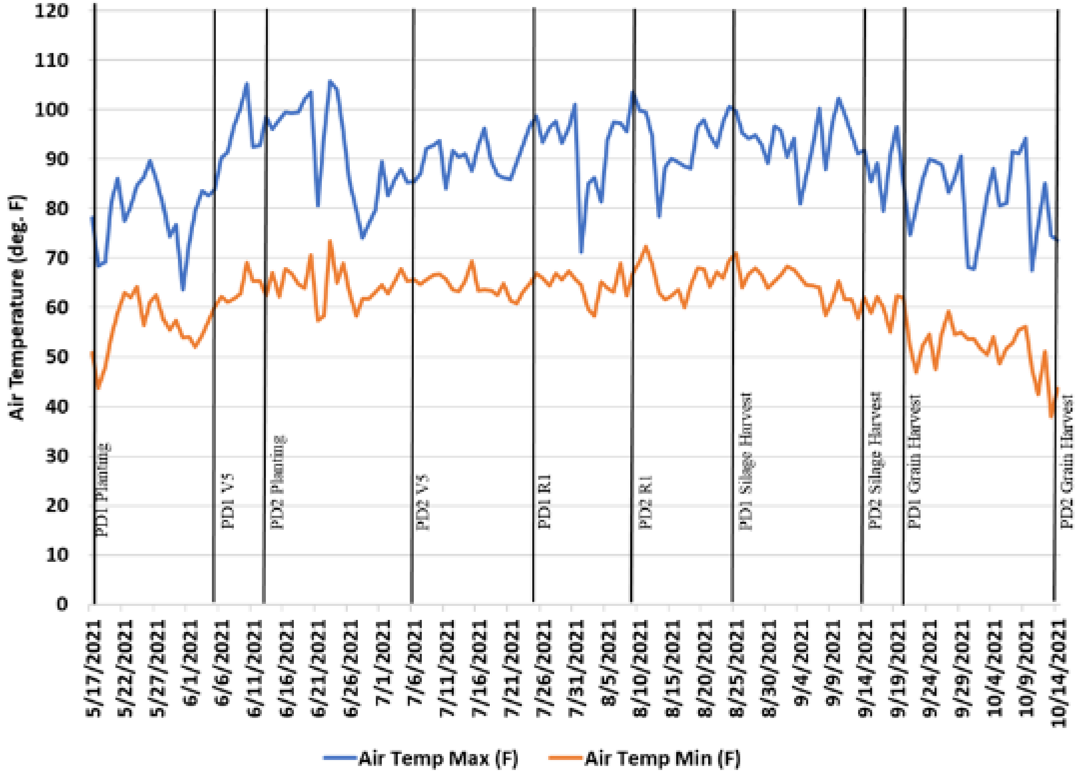
-With forage, we can focus on water for biomass rather than water for grain.

Forage Options

- Annual Forages
  - Corn Silage
  - Wheat Silage
  - Sorghum Silage
- Perennial Forages
  - Improved Perennials
  - Native Grasses

Deficit Irrigated Corn Silage – 2GPMA

Bell, Marek, Xue, Heflin, Naylor



Planting Date	Forage Harvest	Grain Harvest	In-season Irrigation	In-season Precipitation to Silage Harvest	In-season Precipitation to Grain Harvest
			inches		
5/17/2021	8/26/2021	9/21/2021	6.8	8.0	8.7
6/15/2021	9/15/2021	10/14/2021	6.3	7.2	7.2

Corn Silage and Limited Water

PD	Hybrid and Targeted Seeding Rate	Grain Yield	Silage Yield	Grain Price*	Silage Price	Diff.
		bu./ac 15.5% GM	tons/ac 65% Moist.	$/ac		
1	1366Q 22K	133.9	18.0	854.41	1169.85	315.45
1	1366Q 16K	129.7	18.3	827.53	1187.53	360.00
1	DKC70-64 22K	137.1	20.0	874.74	1296.81	422.07
1	DKC70-64 16K	146.4	19.0	934.14	1232.79	298.65
	p-value	0.3362	0.2003			
2	1366Q 22K	81.5	14.1	503.81	918.44	414.63
2	1366Q 16K	76.9	14.9	572.35	967.36	395.01
2	DKC70-64 22K	61.1	14.9	415.44	967.28	551.85
2	DKC70-64 16K	66.5	15.0	411.54	977.29	565.75
	p-value	0.7023	0.3189			

*Corn grain price calculated using the Jan. 2022 cash price at $6.38/bu; Corn silage price calculated using $65/ton forage at 65% moisture

Corn Silage and Limited Water

PD	Hybrid and Targeted Seeding Rate	Grain Yield	Silage Yield	Grain Price*	Silage Price	Diff.
		bu./ac 15.5% GM	tons/ac 65% Moist.		$/ac	
1	1366Q 22K	133.9	18.0	854.41	1169.85	315.45
1	1366Q 16K	129.7	18.3	827.53	1187.53	360.00
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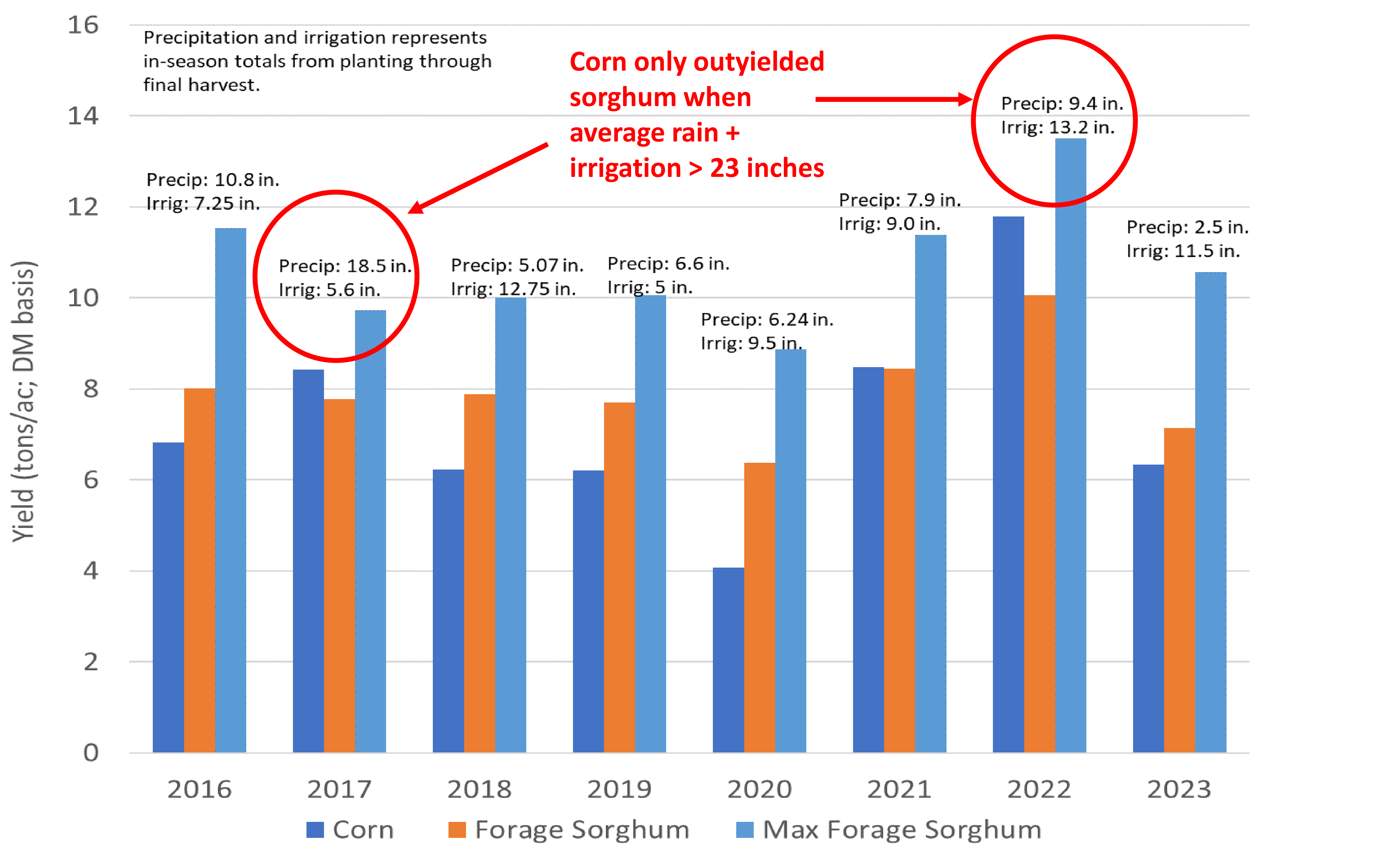
Corn silage increases production risks in limited water environments….

Drought Damaged Corn Silage

- Poor ear development
- Decreased tonnage
- Increased shrinkage in the silage pit due to high DM
  - High DM can create issues with fermentation losses
- Were labeled pesticides used?
  - Corn for grain harvested for silage
- Potential Nitrate Poisoning
  - Water stressed forages accumulate nitrates
- Reduced quality and quantity of forage … harvested and packed

Message to producers: If there is a risk for drought damaged corn, consider forage sorghums.

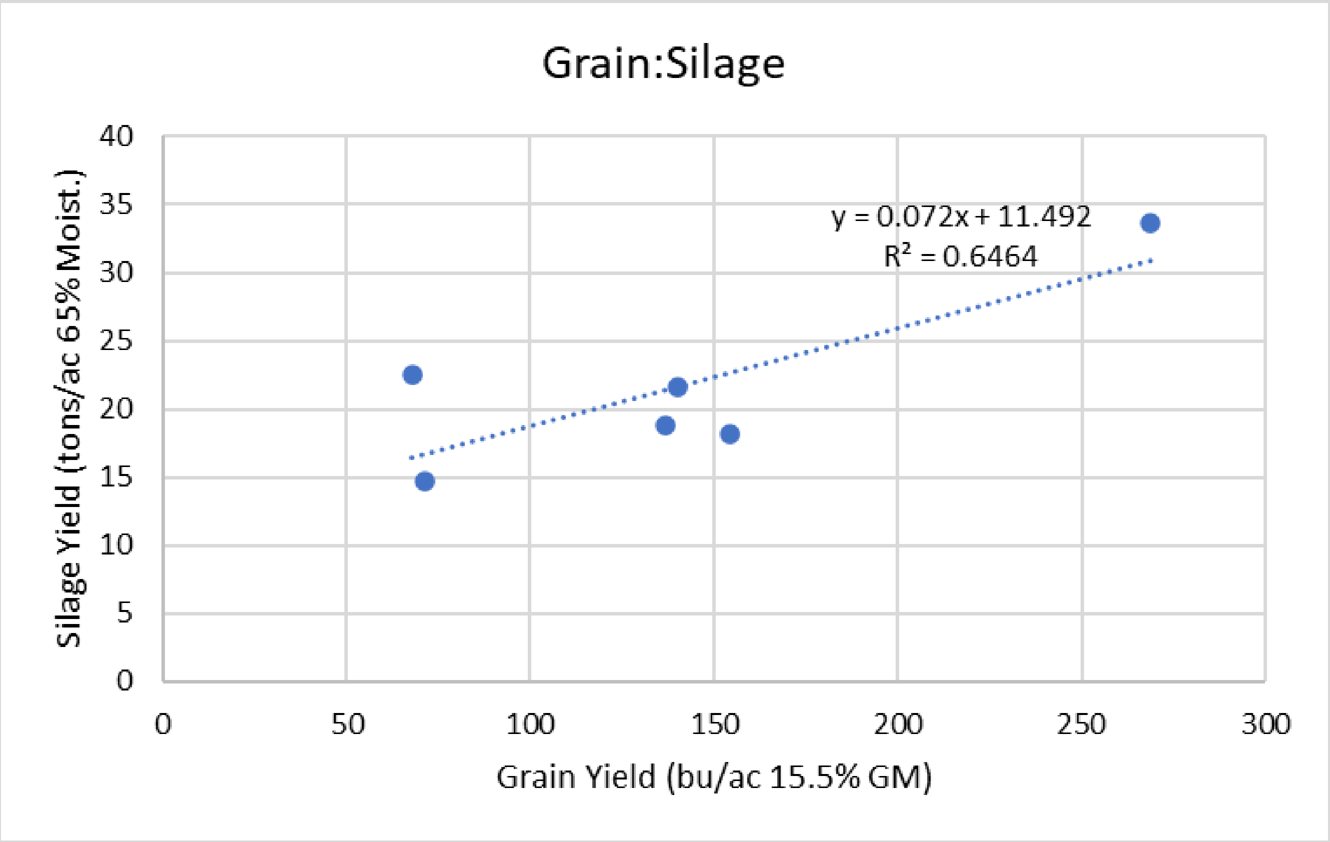


Jourdan Bell, Texas A&M AgriLife

Corn Silage – Grain:Silage Ratio

- ROT: 9 to 10 bushels/ton
- This is under IDEAL conditions
- If you do not have the water for grain, you will not have the water for tonnage.

Grain Yield (bu/ac)	Silage Yield (Tons/ac)	Ratio
150	22.3	6.7
200	25.9	7.7
225	27.7	8.1
300	33.1	9.1



Texas A&M AgriLife Forage Sorghum Program

- Research goal is to address both quality and quantity
- Public Forage Sorghum Silage Trial
  - ~80 entries per year

  https://amarillo.tamu.edu/amarillo-center-programs/agronomy/forage-sorghum/

  Google: AgriLife Amarillo Forage Sorghum
- Sorghum harvest timing and berry processing
- Forage sorghum herbicide trial – (Heflin)
- SCA Management in Forage Sorghums
- Sorghum-sudan management

Why Forage Sorghum?

- Forage sorghum is a drought and heat tolerant forage option.
- Reduced cost of production.
- But….It must be managed properly for water limited environments.
  - We do not have a product problem; We have a management problem.
- Forage sorghum provides producers in ALL regions opportunities to sustain forage during periods of water stress.

Picking Sorghum Hybrids to Optimize Production

1. Yield Potential
2. Nutritive Value (Energy and/or Digestibility)
3. Harvest Timing
4. Water Availability

Picking Sorghum Hybrids to Optimize Production

1. <u>Water Availability</u>
2. Harvest Timing
3. Yield Potential
4. Nutritive Value (Energy and/or Digestibility)

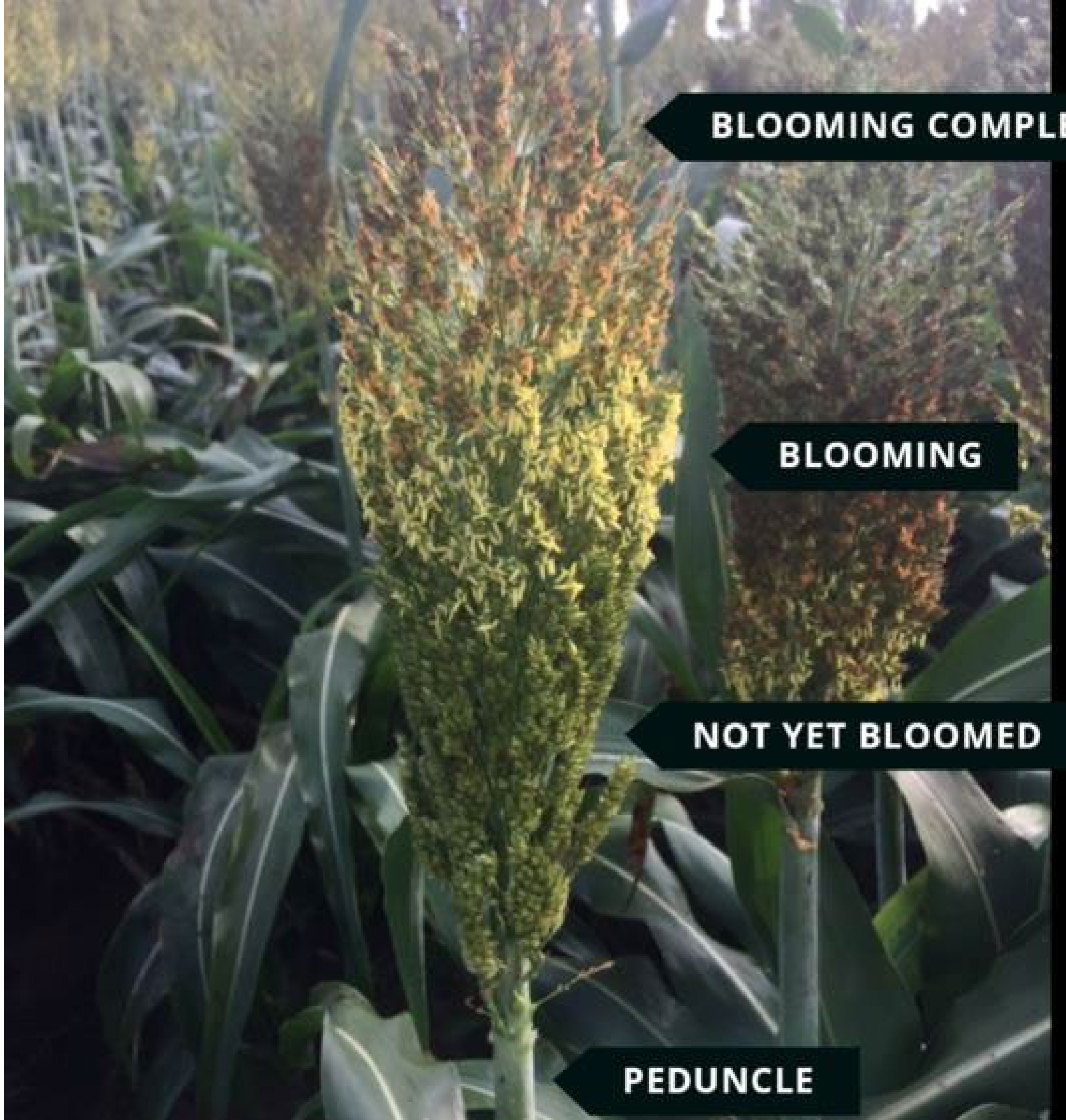
Quality Forage Sorghum Silage Begins with Hybrid Selection

- Not all sorghum equal
- Evaluate variety trials from multiple locations
- Hybrid and **maturity class** should match production system and end-user goals
- Later maturity class hybrids have greater yield potential, but do you have the water to meet the demand?
- Late season hybrids more prone to lodging under late season moisture and high fertility
- Choose hybrid based on hybrid specific characteristics not forage type

Sorghum Maturity

Maturity Class	Days to HB
Early	<70
Med-Early	70-79
Medium	80-85
Med-Late	86-90
Late	91-100
PS	>100

High yielding hybrids can have high yield potential, but they have a longer duration of water use.



Maturity Class and Irrigation - 2023

2 inches more irrigation takes up to 20 days to apply with a 300 gallon well to 120 acres

Maturity	Harvest Date	Planting to Harvest	
		Precip. (in)	Irrigation (in)
Early	9/14/2023	1.72	9
Medium-Early	9/27/2023	2.46	9
Medium	10/3/2023	2.52	10
Medium-Late	10/13/2023	2.52	10
Late	10/19/2023	2.52	11
Photoperiod	10/24/2023	2.52	11

Maturity Class and Irrigation - 2024

Hybrid	Maturity	Soil Water Use	Irrig.	Precip.	Total Crop Water Use (ETc)
		inches			
F71FS72 BMR	Early	9.2	9.2	6.0	24.3
23015+	Med-Early	8.7	9.2	8.1	26.1
F27	Medium	9.5	9.2	8.1	26.8
SS405	Late	9.2	10.9	9.3	29.4
S473	PS	9.3	10.9	9.3	29.5
				Avg.	27.2
				p-Value	<.0001
				CV (%)	0.6
				LSD	0.3

Maturity Class and Yield - 2024

Hybrid	Maturity	Days to HB	HB Date	Days to Harvest	Days to Harvest	Yield (tons/ac) 65% Moist.ǂ	WUE lbs/inch
F71FS72 BMR	Early	65	8/10/2024	84	8/29/2024	14.8 ± 0.7	1215
23015+	Med-Early	71	8/16/2024	90	9/4/2024	17.4 ± 1.0	1332
F27	Medium	84	8/29/2024	102	9/16/2024	26.9 ± 2.8	2002
SS405	Late	102	9/16/2024	113	9/27/2024	25.0 ± 3.0	1699
S473	PS	125		125	10/9/2024	27.5 ± 1.7	1863

Sorghum maturity class drives water use…

Forage Type	Harvest Date	Soil Water Use	Precip to Harvest	Irrig to Harvest	Crop Water Use (in.)	Forage Yield (65% DM, tons/ac)
Corn	8/24	6.1	4.7	9.0	19.8	18.2
PS SxSu	10/24	9.0	7.3	10.8	27.0	22.4

- Sorghums can use more water than corn.
- Photoperiod Sensitive Forage Sorghum harvested 2 months after corn silage resulting in greater water use.
- If water is limited, use an early maturing hybrid to minimize risk.

Balancing Stress with Multiple Maturity Classes

- Crop Stress (water, heat, insect)
- Split planting dates – hard to manage
- “Same” planting date but split Harvest Dates:
  - Early Sorghum and Later Sorghum
    - One hybrid may “miss” period of stress mitigating yield loss across the whole farm
    - Flexibility with harvest
    - Minimizes risk associated with water stress at critical stages
    - Preserves quality of harvested forage

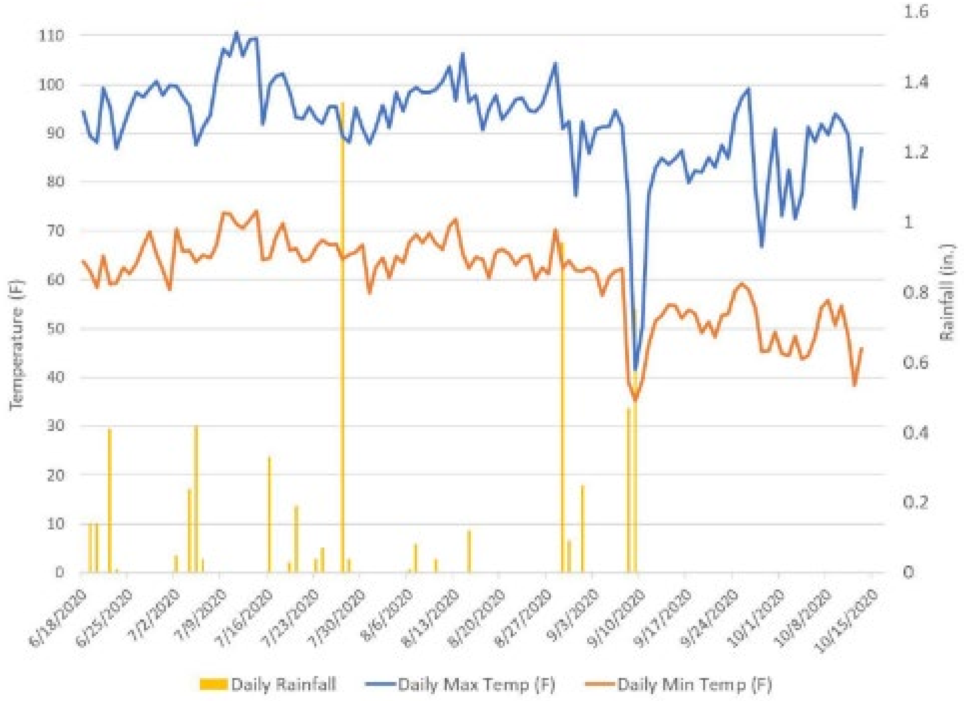
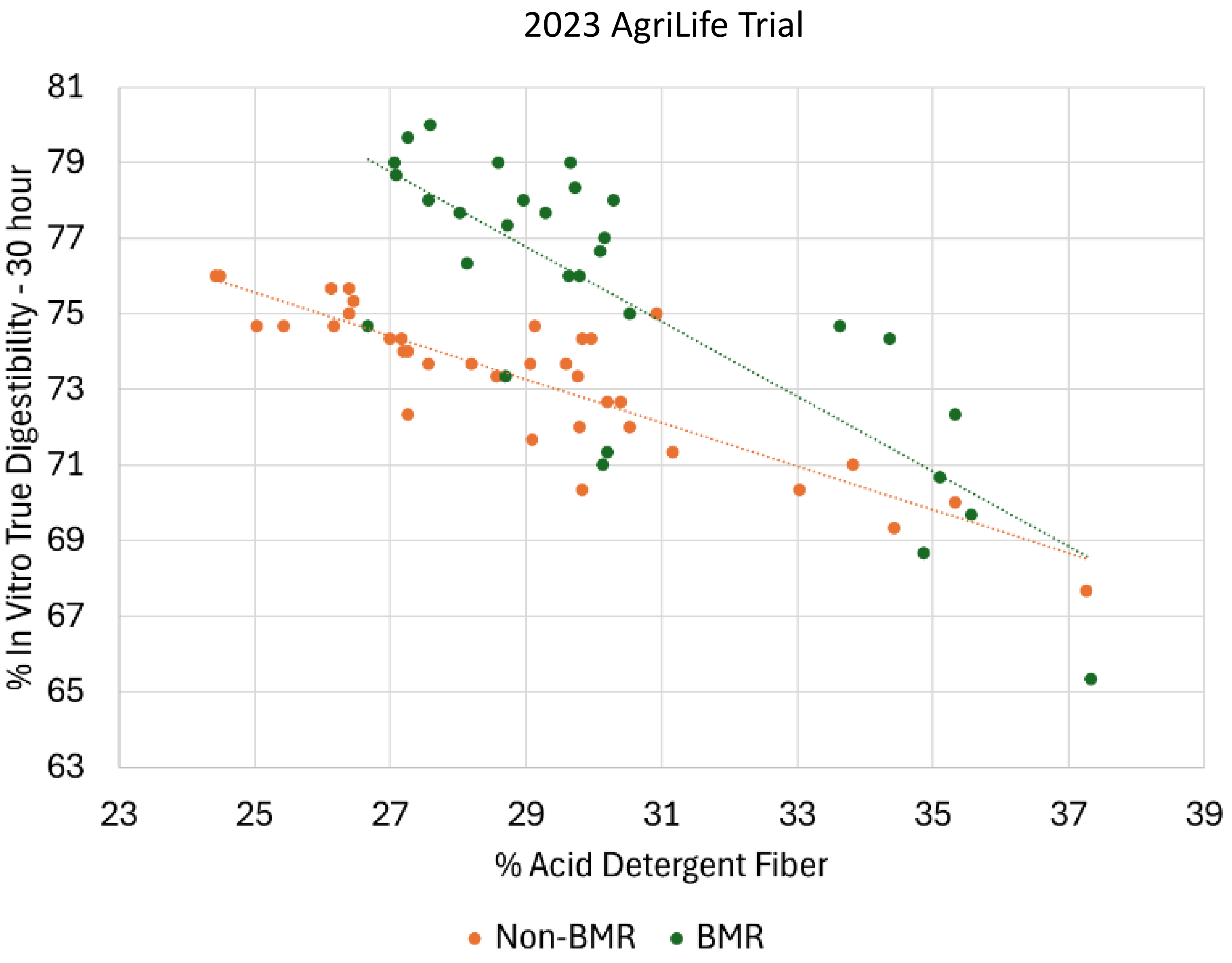
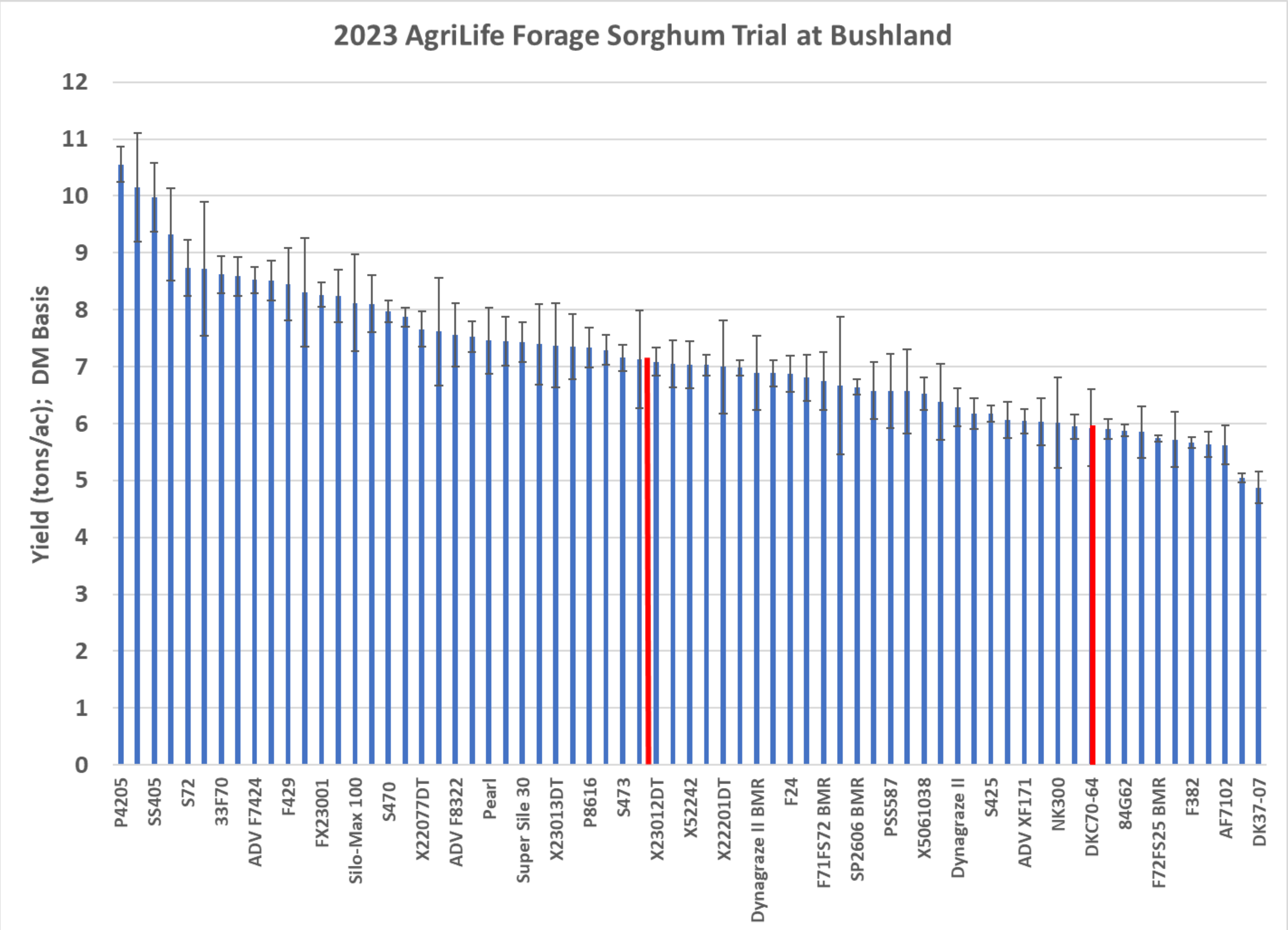


Figure 2. Examples of varying pollination in the trial. All plots were evaluated for pollination with scored from 1 to 3 as represented by images from left to right. 1: ≥90% pollination (Good), 2: 50-90% pollination (Fair), 3: ≤90% pollination

Nationwide Confusion about Forage Sorghum Quality

Variety trial data demonstrates differences in forage sorghum hybrids



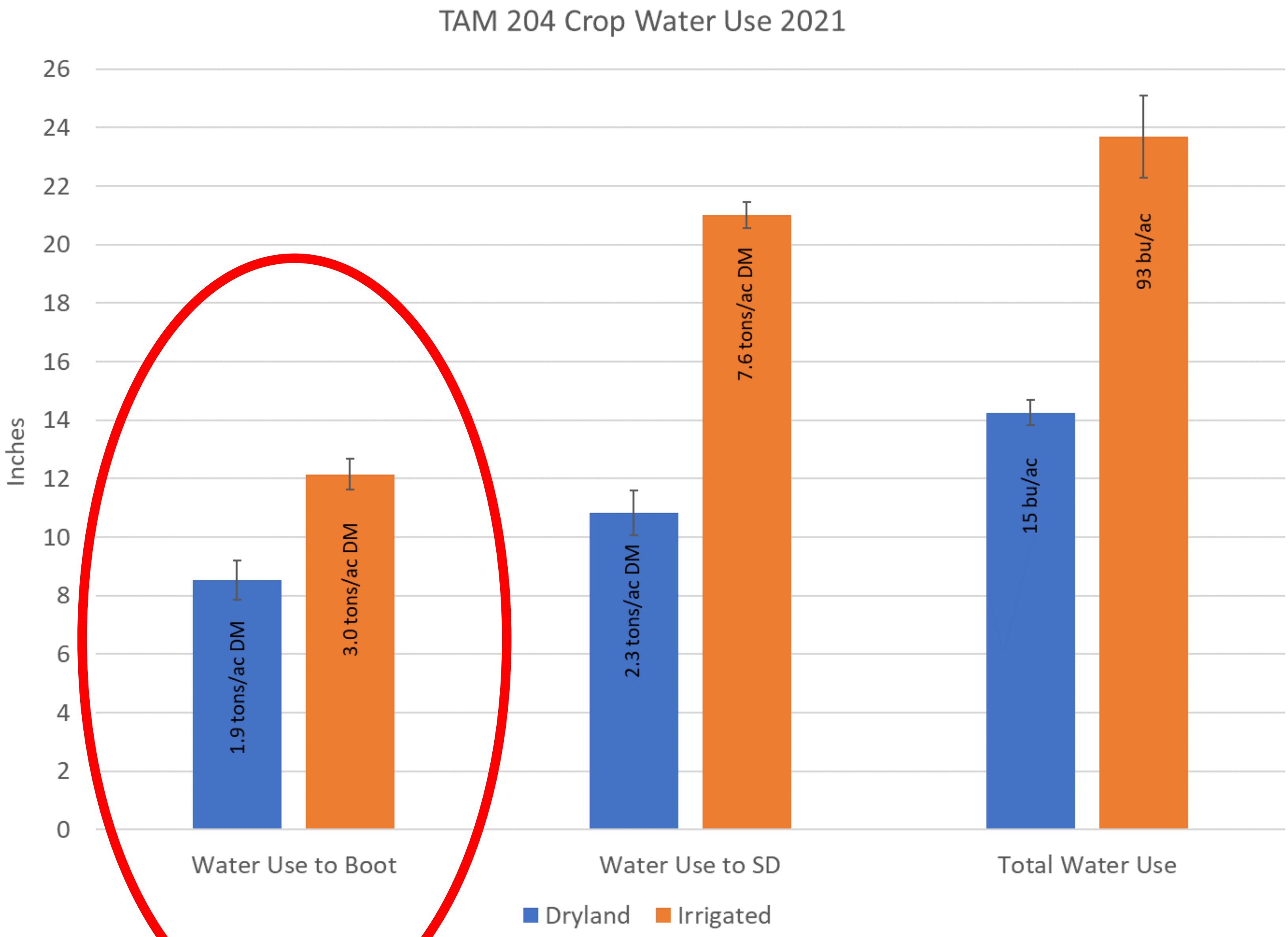


2023 AgriLife Forage Sorghum Trial at Bushland
Yield (tons/ac); DM Basis
12
11
10
9
8
7
6
5
4
3
2
1
0
P4205
SS405
S72
33F70
ADV F7424
F429
FX23001
Silo-Max 100
S470
X22077DT
ADV F8322
Pearl
Super Sile 30
X23013DT
P8616
S473
X23012DT
X52242
X22201DT
Dynagraze II BMR
F24
F71FS72 BMR
SP2606 BMR
PSS587
X5061038
Dynagraze II
S425
ADV XF171
NK300
DKC70-64
84G62
F72FS25 BMR
F382
AF7102
DK37-07

Winter Small Grain Silages

Filling the High Plains' "Silage Gap" (M. Marsalis, NMSU)

- Wheat (Wheatlage)
- Rye
- Barley
- Triticale



Irrigated: 8.3 inches irrigation + 6.8 inches precip. + 4.1 soil water
Dryland: 5.8 inches precipitation + 8.5 inches soil water

More recent water use data:

- Variety yield potentials have increased but water use has not changed.
- Wheat at boot uses about 8” water on dryland….but it will use more if you have the water.
    - When are you terminating? Heading?

Wheatlage and the "Forage Gap"

- **Planned** – no longer an "opportunity crop"
- Insufficient summer silage produced to meet regional livestock needs
- Wheatlage: lower yielding than summer silages but a high-quality option
- Forages provide farmers an alternative market
- Forages generally use less water than grain crop because of earlier harvest stage – **opportunity for farmers with low well capacities**

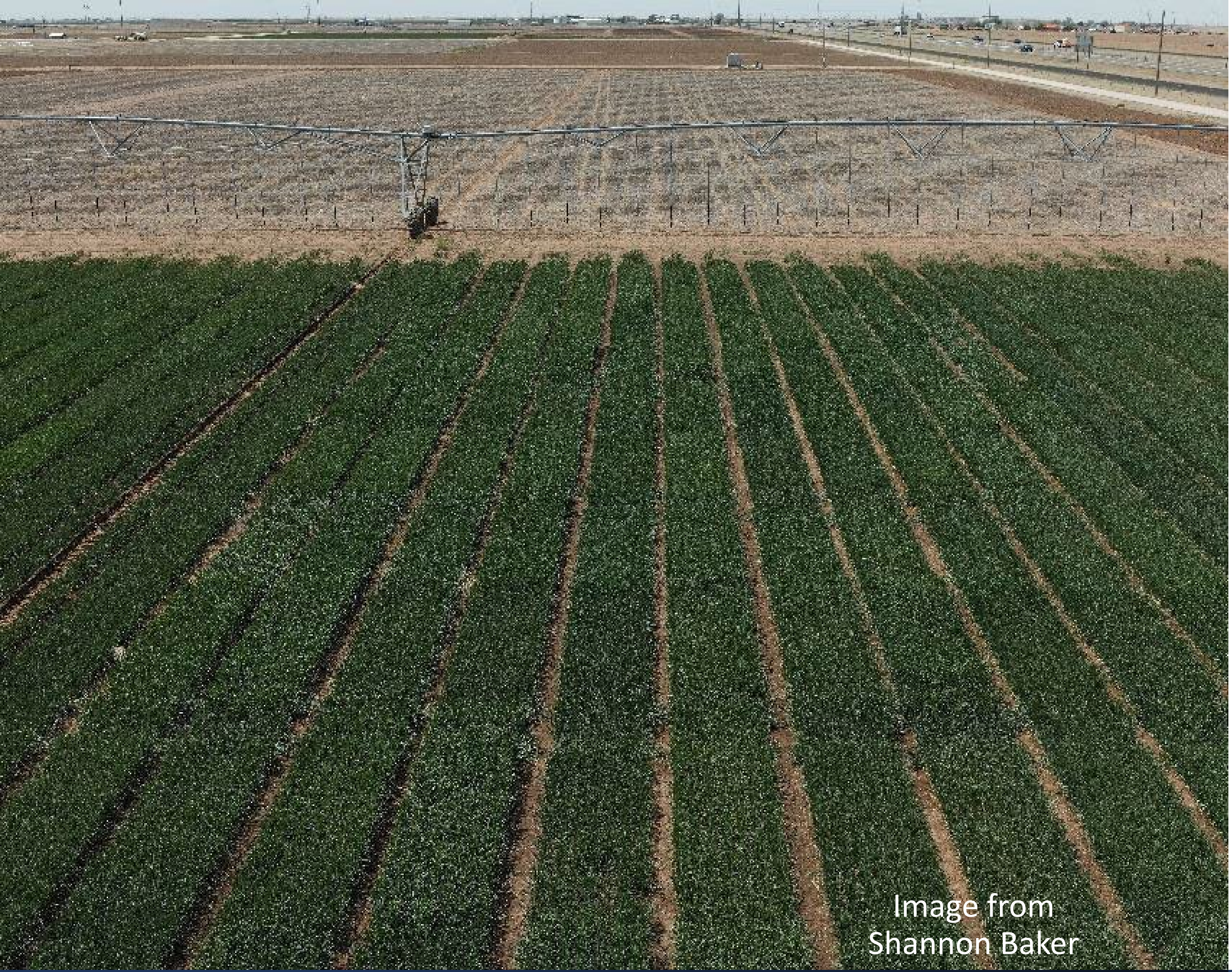
Average historical yield

	Average Yield tons/ac	
	DM	65% Moist.
Corn Silage	~~9.5~~	~~27 (22-30)~~
Sorghum Silage	8.0	23 (20-28)
Wheatlage	5.3	15 (11-22)
		(Range)

*Average Yields for the Texas High Plains Production Region

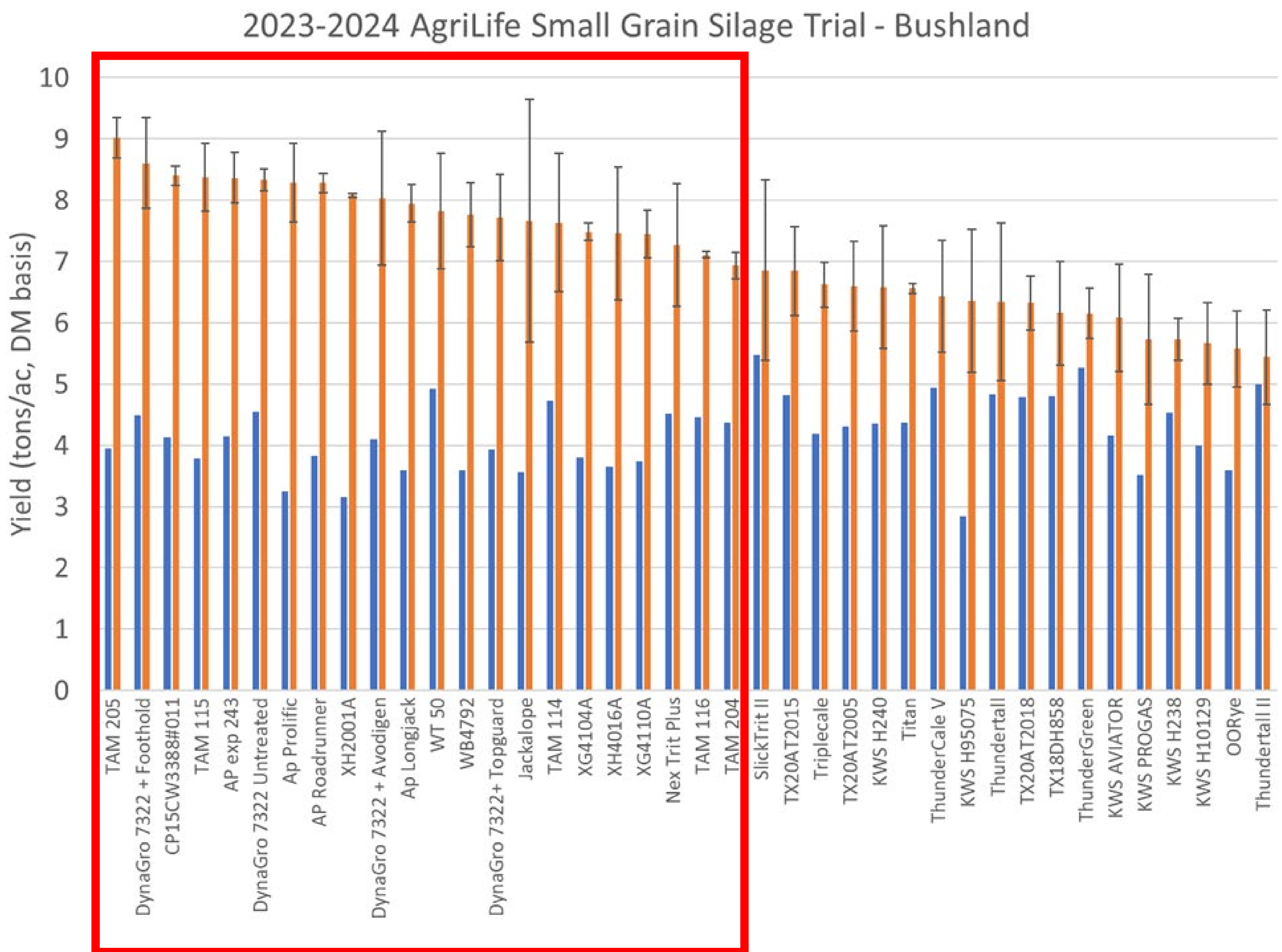
Boot Harvest Stage - Green Chop

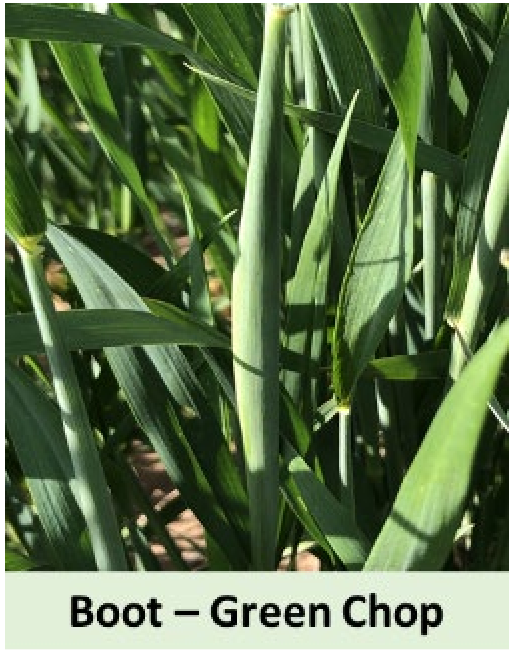
- Directly fed or wilted prior to ensiling
- Optimize forage quality
- Less yield but less water



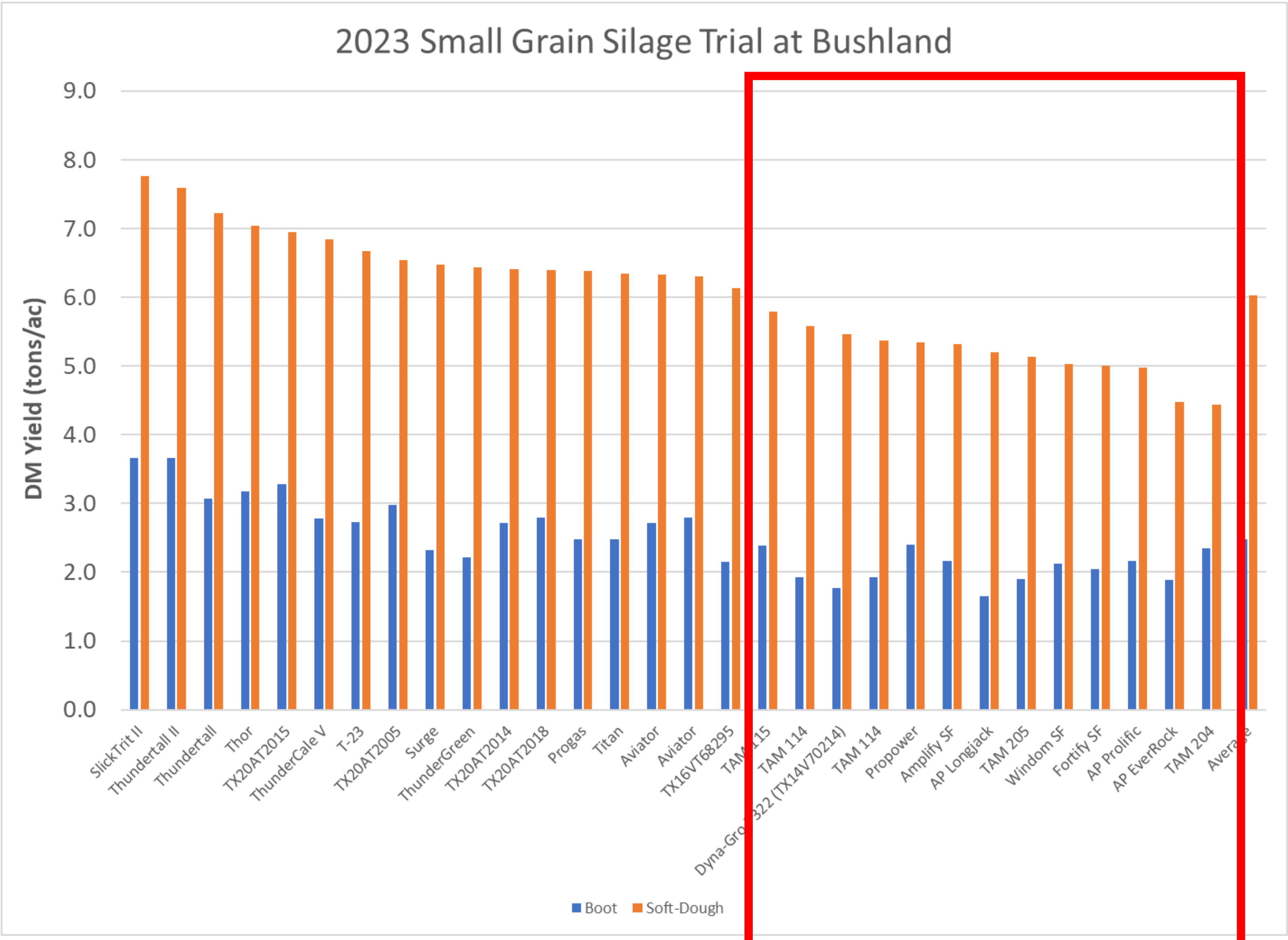
2022-2023 Small Grain Silage Trial at Bushland

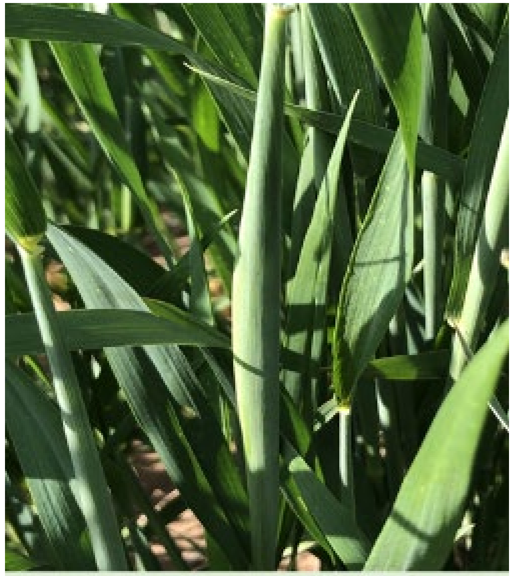
	Boot	Soft-Dough
Triticale	2.9	6.8
Rye	2.5	6.1
Wheat	2.1	5.1
Average	2.5	6.0


2023-2024 AgriLife Small Grain Silage Trial - Bushland
Yield (tons/ac, DM basis)
0
1
2
3
4
5
6
7
8
9
10
TAM 205
DynaGro 7322 + Foothold
CP15CW3388#011
TAM 115
AP exp 243
DynaGro 7322 Untreated
Ap Prolific
AP Roadrunner
XH2001A
DynaGro 7322 + Avodigen
Ap Longjack
WT 50
WB4792
DynaGro 7322+ Topguard
Jackalope
TAM 114
XG4104A
XH4016A
XG4110A
Nex Trit Plus
TAM 116
TAM 204
SlickTrit II
TX20AT2015
Triplecale
TX20AT2005
KWS H240
Titan
ThunderCale V
KWS H95075
Thundertall
TX20AT2018
TX18DH858
ThunderGreen
KWS AVIATOR
KWS PROGAS
KWS H238
KWS H10129
OORye
Thundertall II


Boot – Green Chop


Soft Dough – Wheatlage



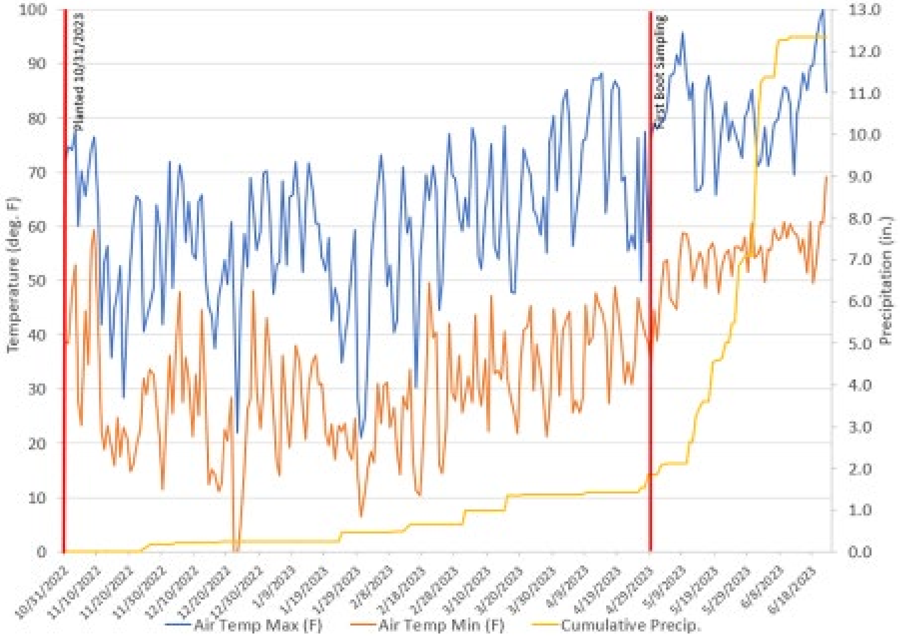


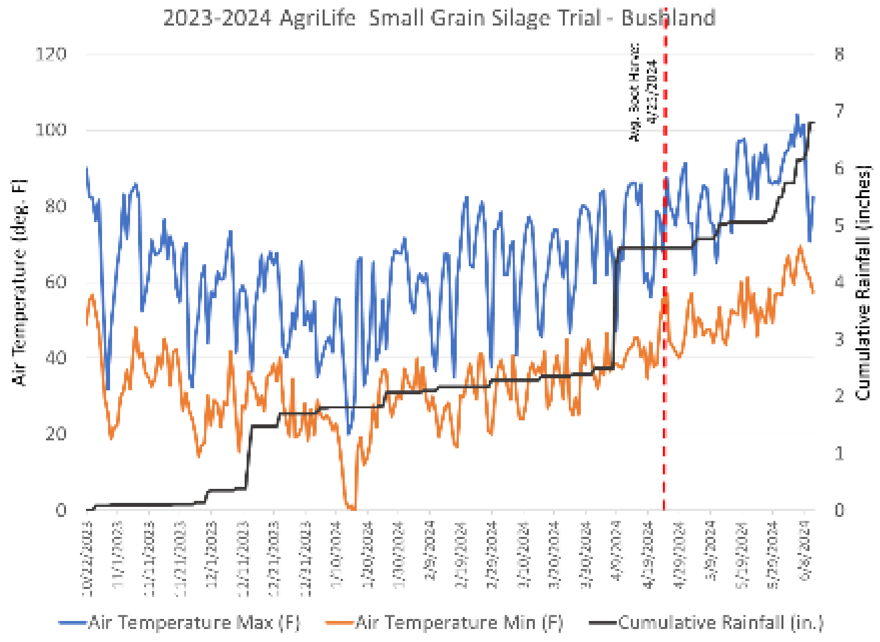
Boot – Green Chop

Soft Dough – Wheatlage

Forage Type Yield Response

- Triticale – later maturity offers yield advantage IF growing late May weather is favorable
  - 2023 70-85 °F after heading and rain
  - 2024 90-100°F after heading and rain too late
- Wheat – earlier maturing
  - 2023 80-90 °F after heading and **dry**
  - 2024 80-90 °F after heading with rain and irrigation
- Need water (irrigation and/or precip) to overcome heat





Perennial Forages Objectives

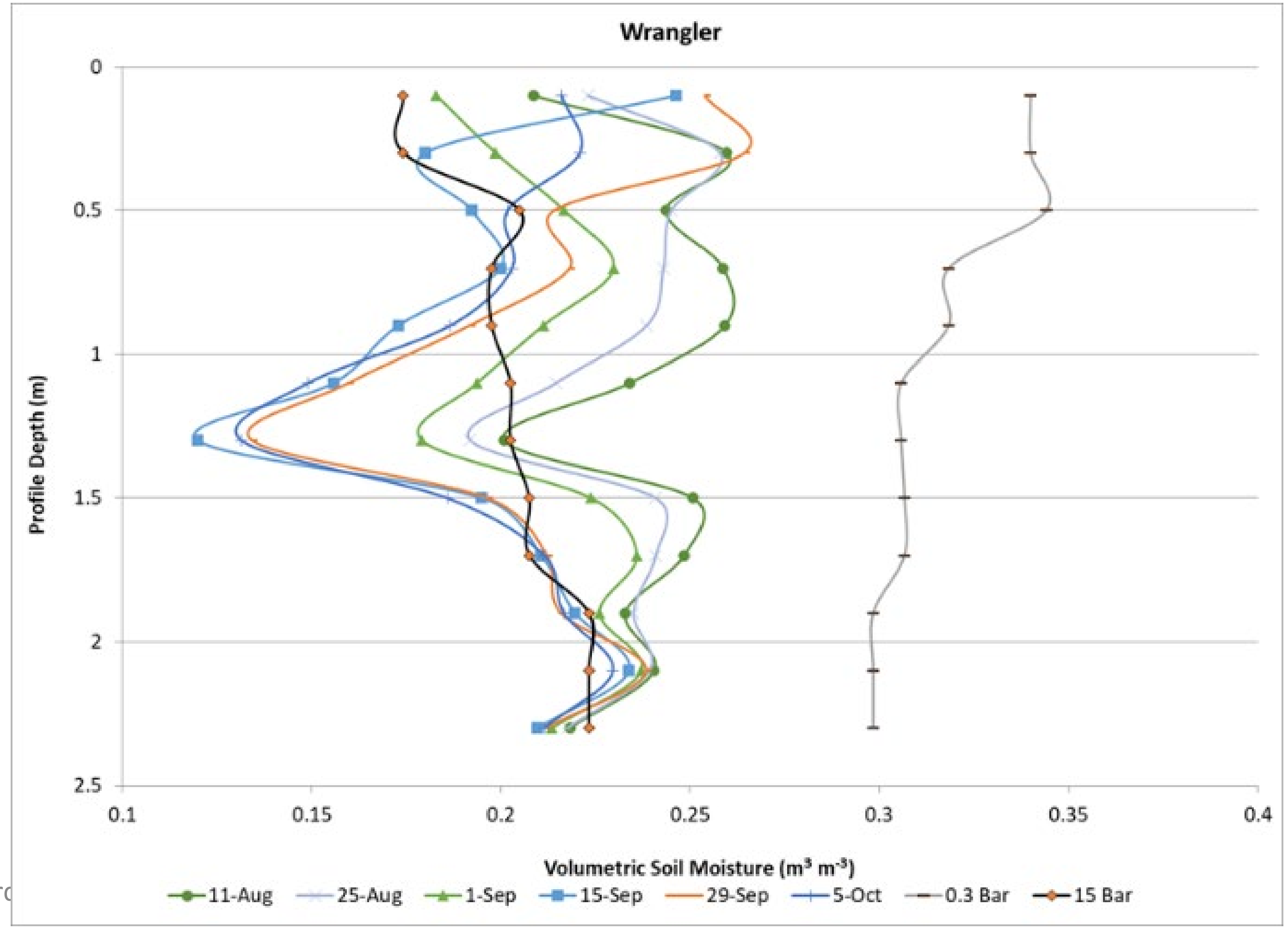
- Alternative option to reduce water withdrawals OR simply optimize the limited irrigation capacity that is available.
- The economic return of native pasture (per acre) is approximately 8% the return on average irrigated croplands (Deines, 2020)
- Improved forages with a higher economic return are essential to sustain the economic viability as crop production declines.

OAP Perennial Forage Project at Bushland

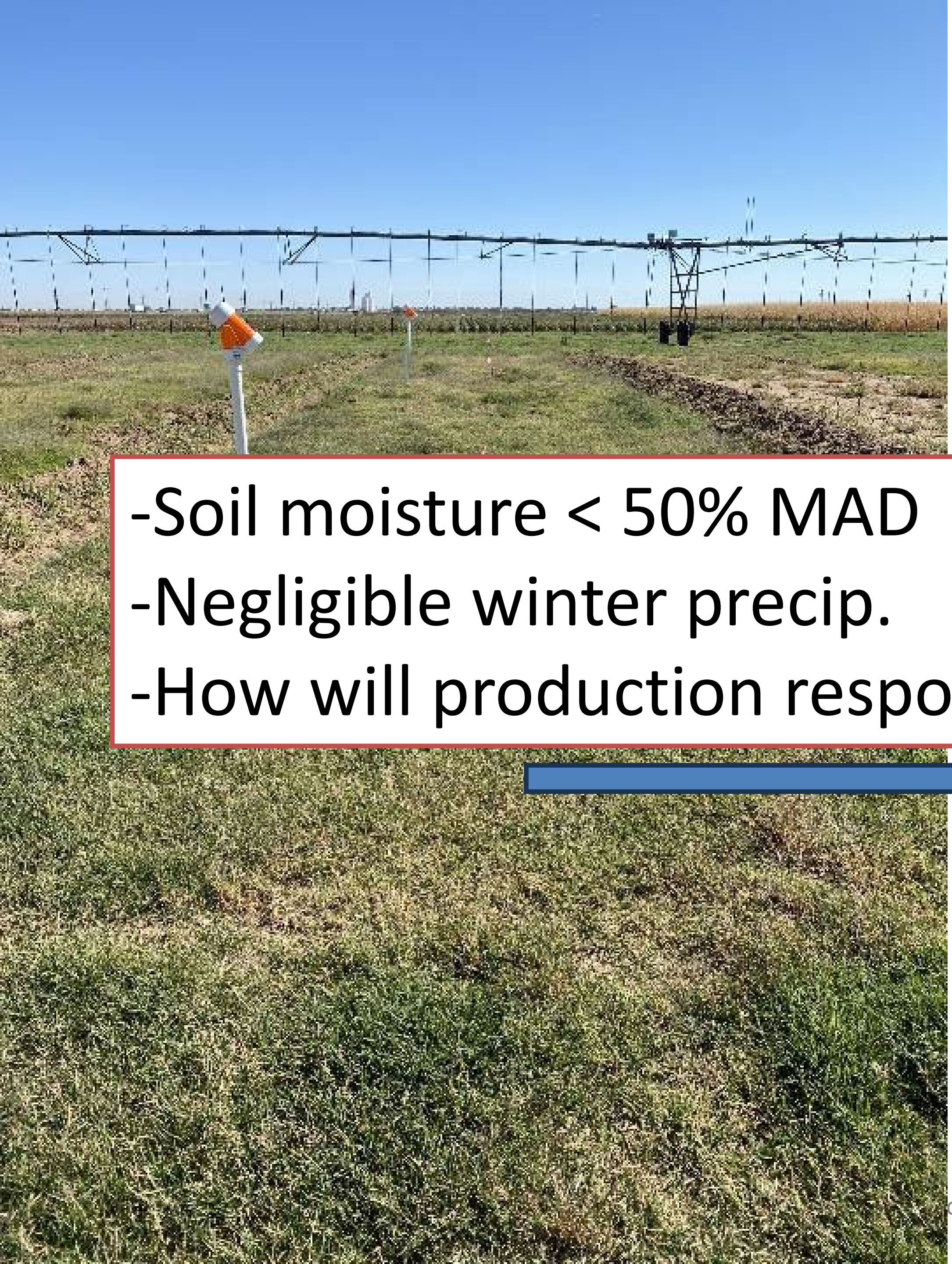
- Reality: perennial forage research is a long-term commitment
- Establishment period: 1-2 years

	Harvest Date			Cumulative Yield
	6/20/2023	8/8/2023	10/18/2023	
Forage	lbs DM/ac			
Wrangler	434 ± 135	933 ± 259	773 ± 441	2140
Wrangler + Alfalfa	794 ± 168			794
Cheyenne		1696 ± 348	1350 ± 452	3047
Sorghum Sudan			944 ± 107	944

Profile dry down during last cutting growth period



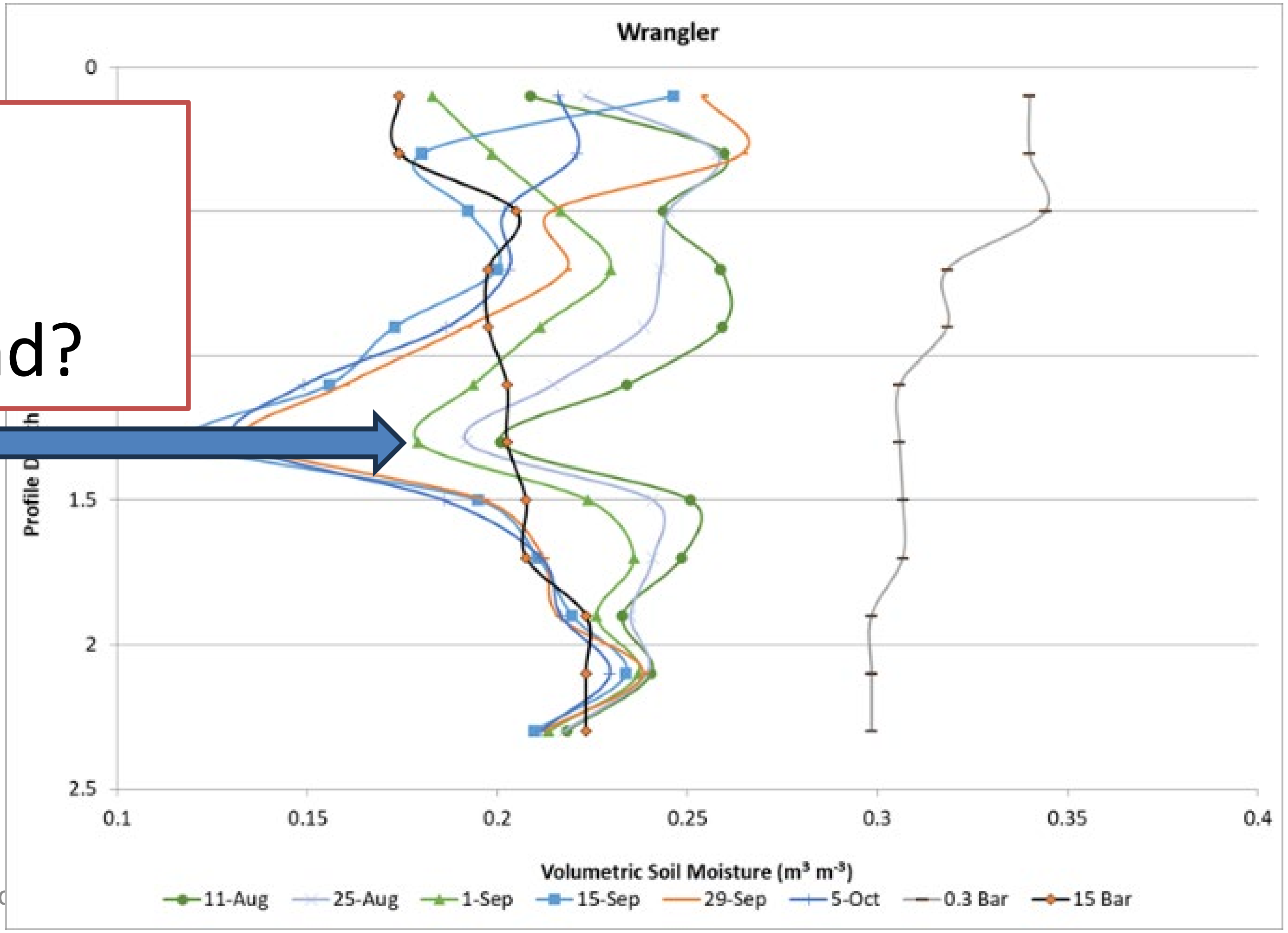
Profile dry down during last cutting growth period



-Soil moisture < 50% MAD

-Negligible winter precip.

-How will production respond?



2024 – No Irrigation

Forage Treatment	5/13/2024	6/27/2024	10/16/2024
	lb DM/ac		
Wrangler	2827	3565	1849
Cheyenne	4014	5160	2831
Wrangler + Alfalfa	2127	3082	1235
Chey + Alfalfa	2193	3577	2040

Summary

- Improved hydrological data for Texas
- As water declines, forages may be the most economical and VIABLE option.
- Research is needed to optimize production with adapted forages under limited irrigation.
- Production functions are needed for LOW water environments.
- A better understanding about the long-term impact of annual forages to soil is needed.

Thanks to:

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Questions?

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