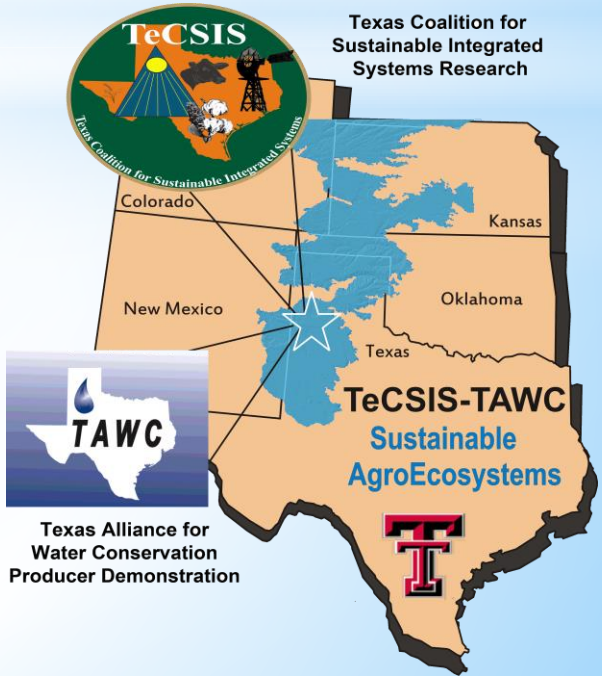
Water Footprint in High Plains Agriculture

Science by the Glass, Climate Science Center – May 9, 2017

Chuck West
CASNR Water Center
Plant & Soil Science Department



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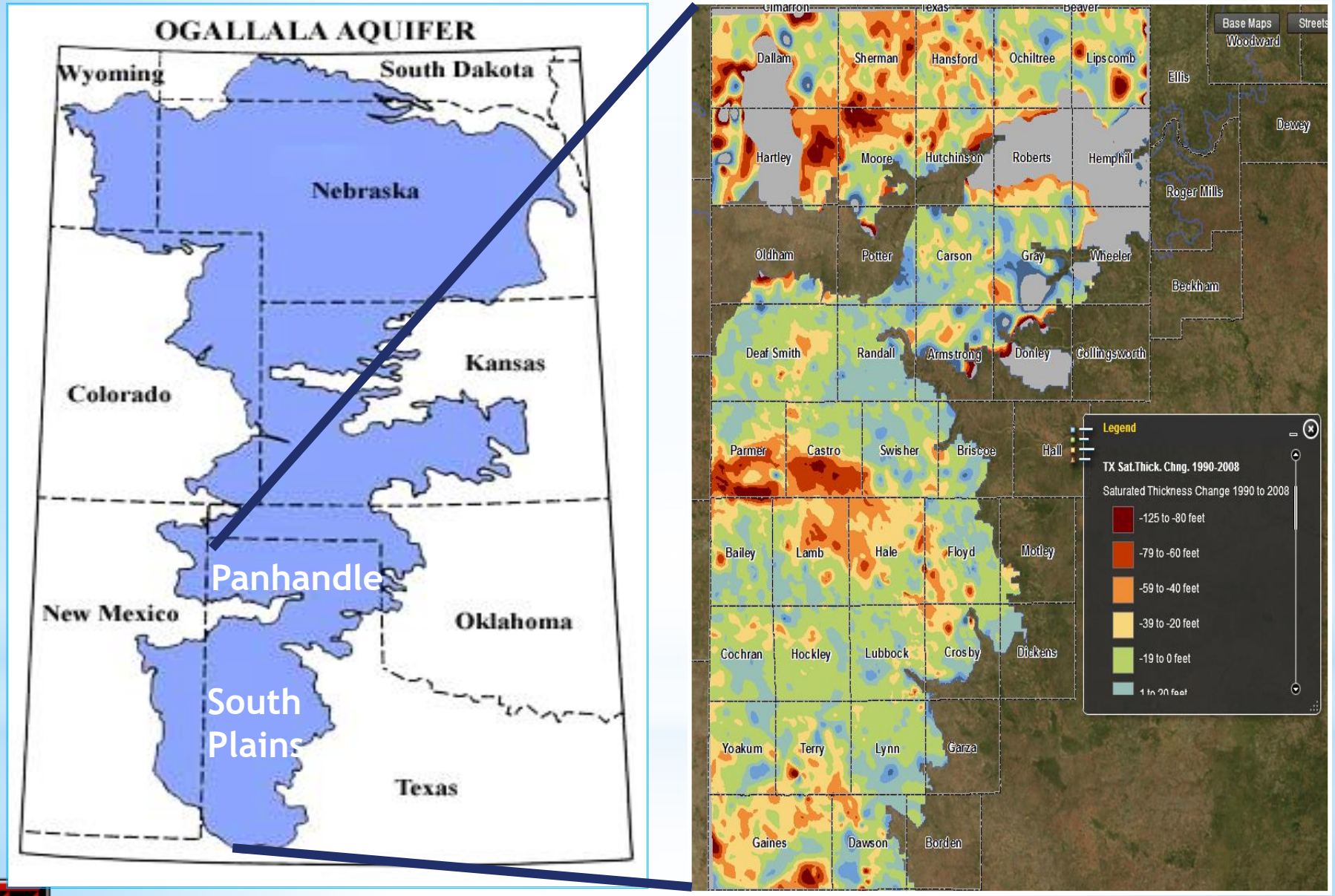
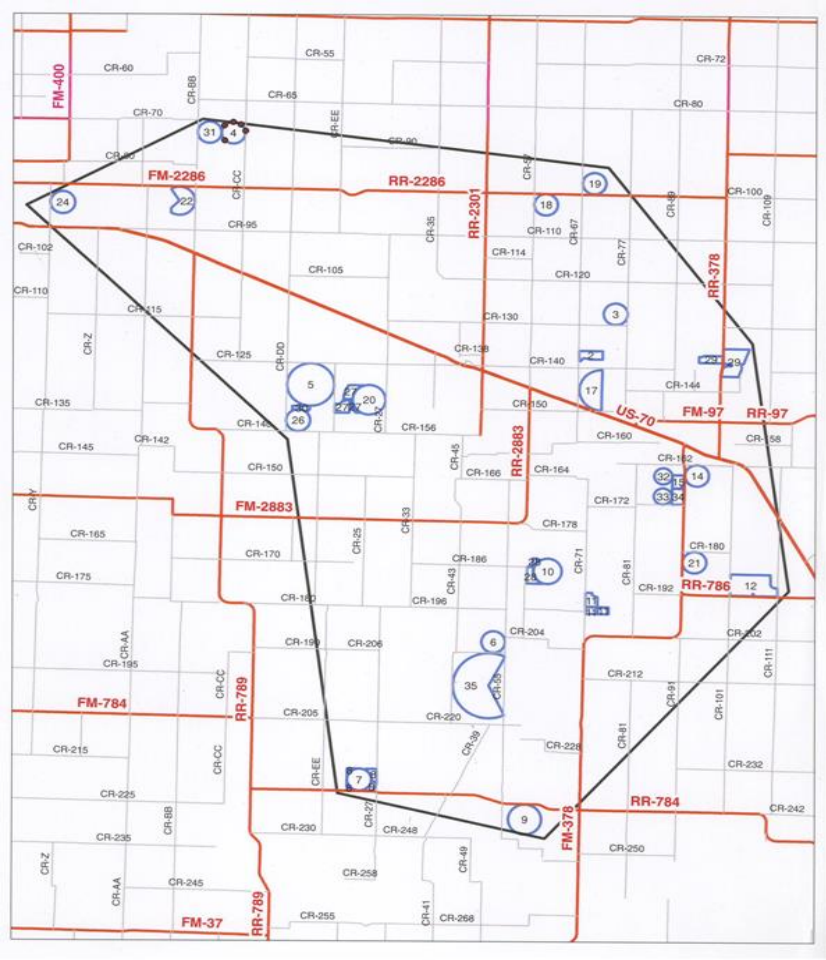
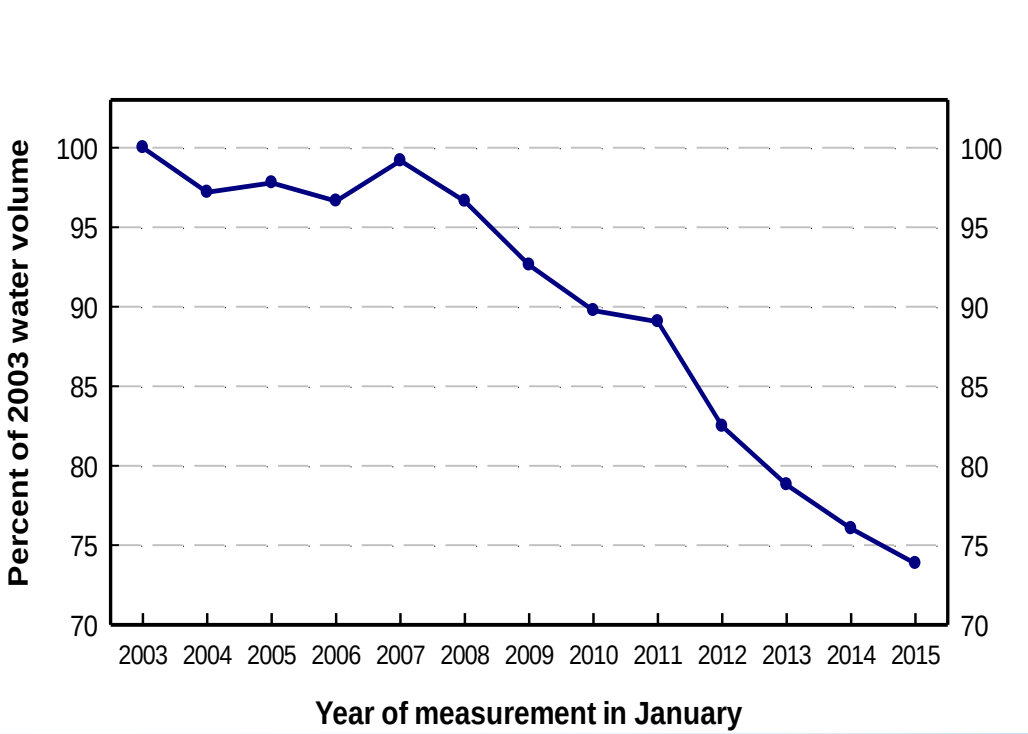

OGALLALA AQUIFER
Wyoming
South Dakota
Nebraska
Kansas
Colorado
Panhandle
New Mexico
Oklahoma
South Plains
Texas
Base Maps
Streets
Woodward
Dallam
Sherman
Hansford
Ochiltree
Lipscomb
Ellis
Dewey
Hartley
Moore
Hutchinson
Roberts
Hemphill
Roger Mills
Oldham
Potter
Carson
Gray
Wheeler
Beckham
Deaf Smith
Randall
Armstrong
Donley
Collingsworth
Parmer
Castro
Swisher
Briscoe
Hall
Legend
TX Sat.Thick. Chng. 1990-2008
Saturated Thickness Change 1990 to 2008
-125 to -80 feet
-79 to -60 feet
-59 to -40 feet
-39 to -20 feet
-19 to 0 feet
Bailey
Lamb
Hale
Floyd
Motley
Cochran
Hockley
Lubbock
Crosby
Dickens
Yoakum
Terry
Lynn
Garza
Gaines
Dawson
Borden

Texas Alliance for Water Conservation

Water use data from 30 farms, 12 years





Annual decline of 3%-points, or ~50 cm.

Irrigation methods

Sprinkler

Sub-surface Drip

Furrow

Dryland

Comments about Water Use Efficiency vs. Water Footprint

WUE = is yield/water input

ROI or 'Bang for the Buck'

WF = is 1/WUE water use/yield

Impact of using a nonrenewable resource for producing a low-value product because the economy depends on stretching the water supply.

Point: WUE of rain < that from irrigation.

Eddie Teeter Farm
Corn with subsurface drip

- **Yield = 15 t/ha** (240 bu/acre)
- **Water supply = 760 mm** (30 in.)
  - **Rain: 330 mm** (13 in.)
  - **Irrigation: 430 mm** (17 in.)
- **WUE = 2 kg/m^3**
- **WF = 0.5 m^3/kg**

Technology comparison and demonstration

Spray

PMDI

LEPA

Comparison of LEPA vs. LESA - 3 years

	SPRAY	LEPA
Cotton lint yield kg/ha	1046	1200
Total costs $/ha	2314	2366
Net returns $/ha	141	447
Water applied mm	495	495
WUE kg/m^3	0.21	0.24
Water footprint m^3/kg	4.7	4.1

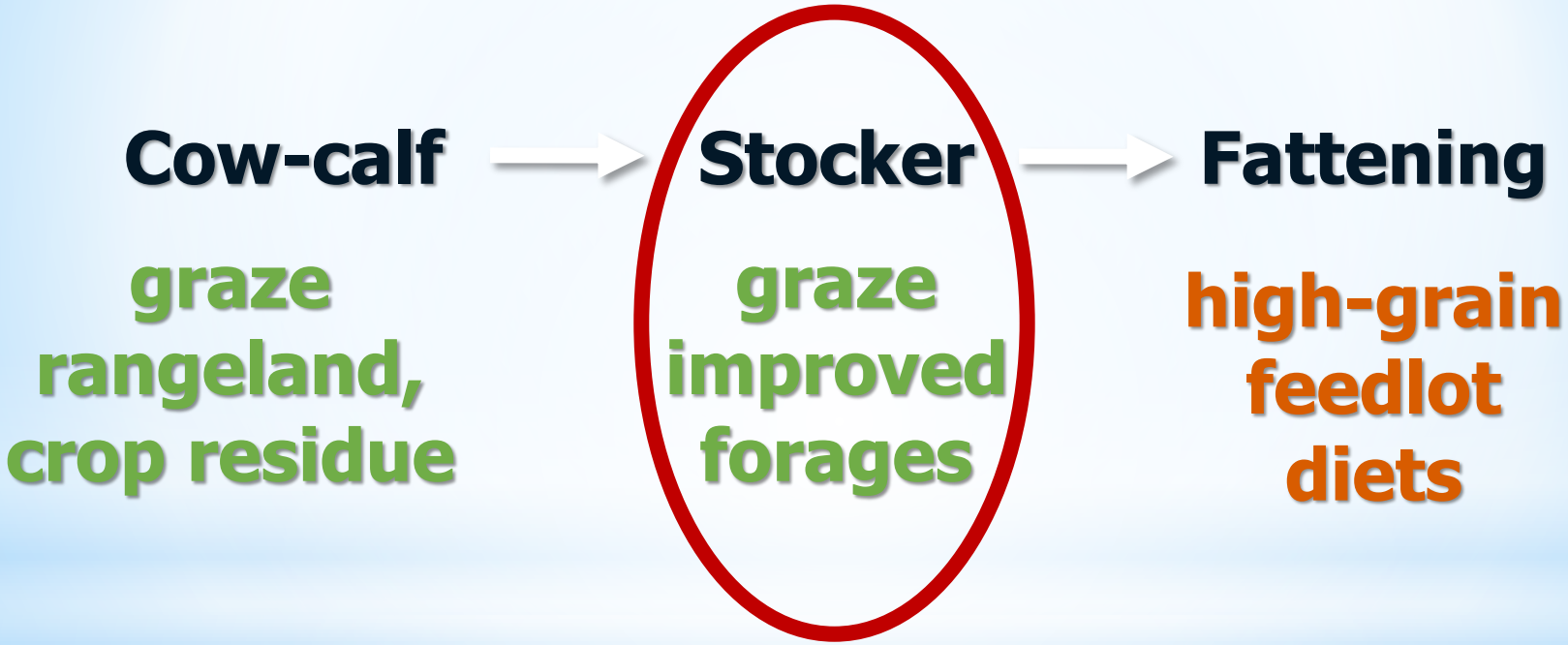
Yates & Pate. 2014. Cotton Beltwide

Why forages and cattle?

- Native ecosystem is grassland.
- Perennials provide year-round ground cover, wildlife habitat, C sequestration, diversity.
- Beef cattle and hay are high-value commodities.
- Require modest water inputs.

<u>Hypothesis</u>: Forages/livestock production provides profitable means of transitioning to low water-input and dryland agriculture in the Texas High Plains.

Beef Production Chain



Is it possible to strategically integrate high-quality legumes *without* increasing the water footprint?

Species comparison for water footprint

m^3 water used / kg biomass

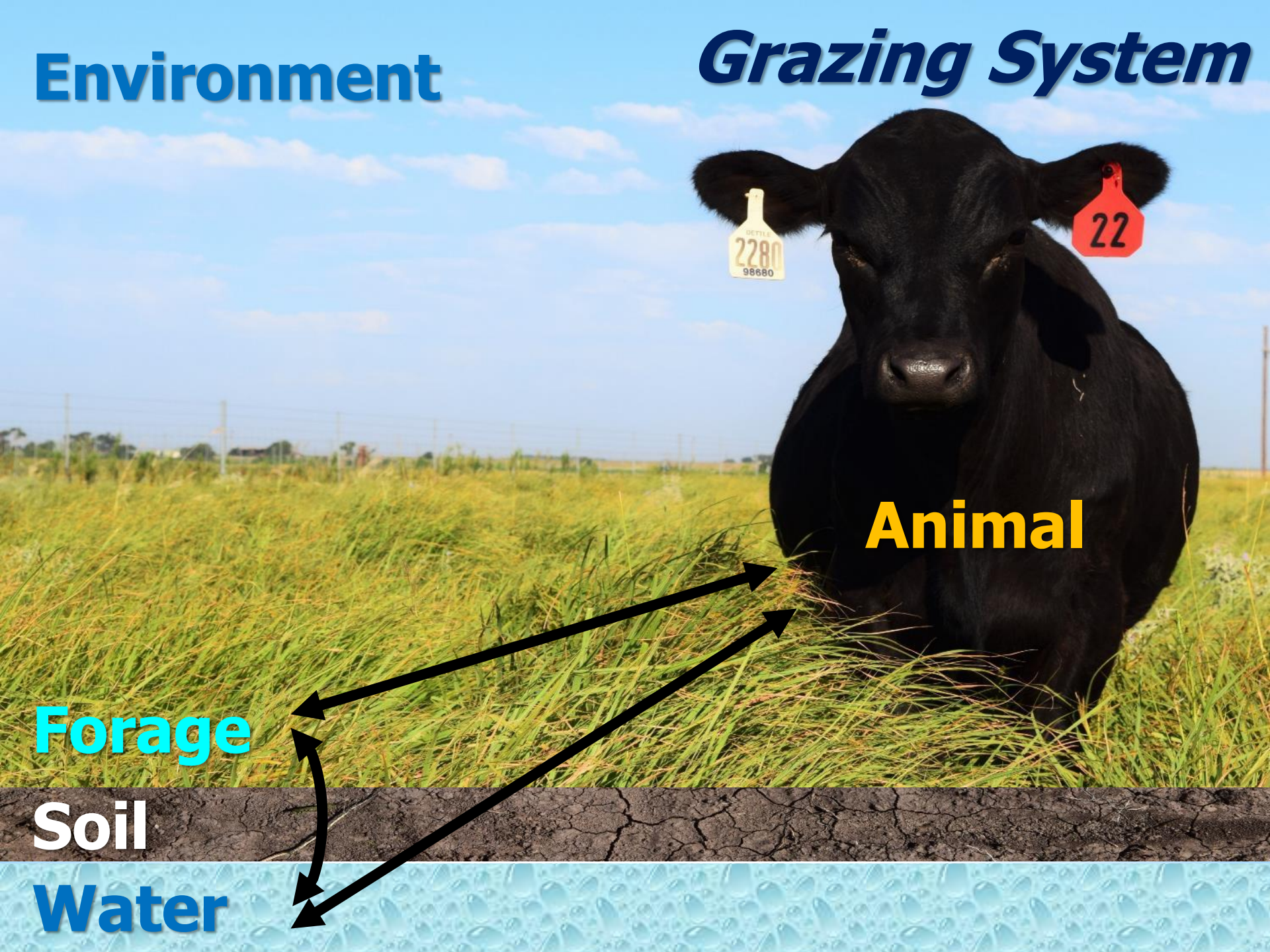
kg transpiration / kg biomass yield

Forage species	Water footprint
	kg transpired/kg biomass
Corn	370
Wheat	500
Bermudagrass	265
Alfalfa	770

Beef Stocker Treatments

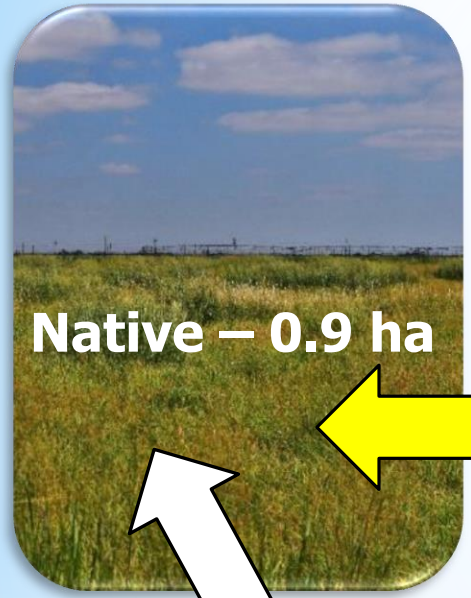
Forage system	N fertilizer	Avg irrigation
	kg/ha	mm/yr
Grass only	67	207
Grass-alfalfa	0	223

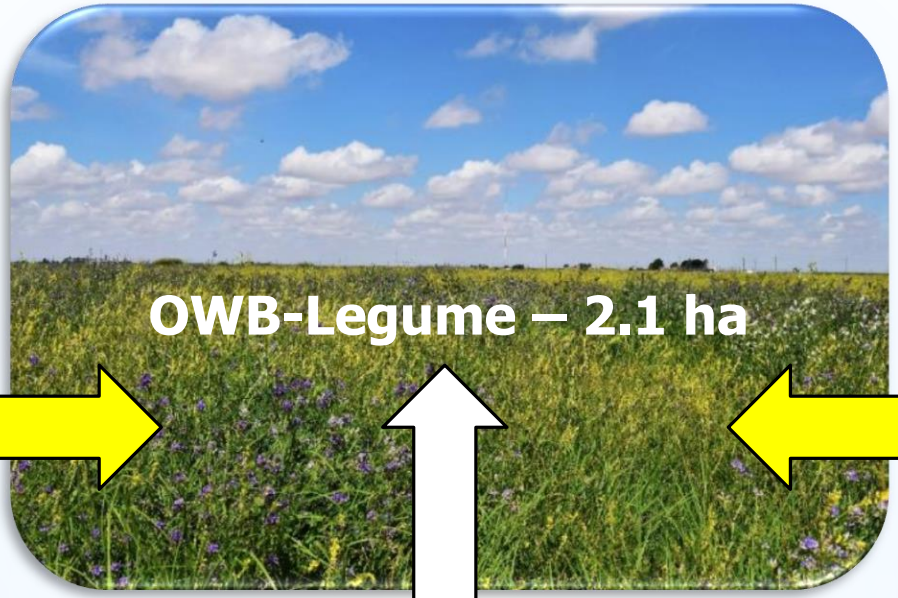
Lisa Baxter, PhD student

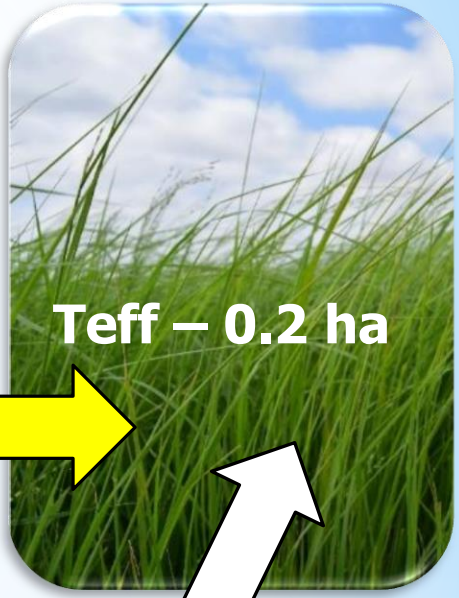

Environment
Grazing System
22
Animal
Forage
Soil
Water

Grass-only grazing rotation (12 head on 8.3 ha)

GL grazing rotation (8 head on 4.1 ha)








82


82

Literature values of WF for beef (m^3/kg)

1. Life cycle in CA: 3.7
2. Life cycle in Southern Plains: 3.1
3. Global average: 15
4. Pasture-fed beef (U.S.): 22
5. Western feedlot: 4

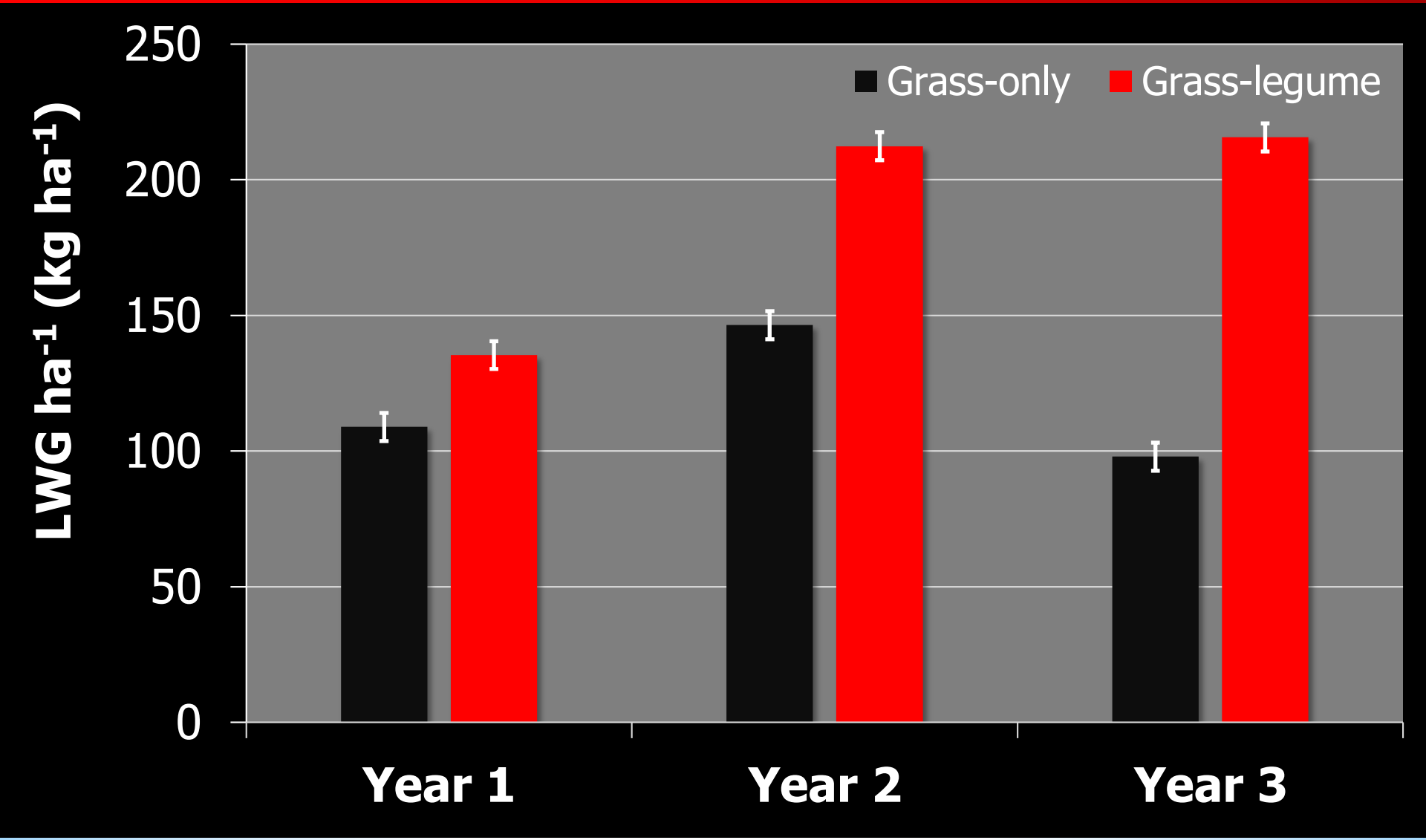
Water Footprint Calculations

- Water footprint = **m^3** water delivery / **kg** LWG
  - (Effective rainfall + *corrected* irrigation) / *observed* LWG
  - (Effective rainfall + *total* irrigation) / *total* LWG

    This included gain predicted from feeding back the harvested hay.
  - *Total* irrigation + drinking water / *total* LWG

Trials #1 and 2:

Comparison of Observed LWG per ha



Bars represent SE mean.

n = 3; $P < 0.001$

Water footprint in m^3/kg beef gain

Water inputs	Grass-only	Grass + legume	Δ %
Effective rain + irrig + drinking	33	22	-34 %
			
Irrigation + drinking	3.3	2.4	-27 %
			

Why? Legume presence required slightly more irrigation, but it increased animal gain 60% over grass alone. Twice the protein content, more digestible energy.

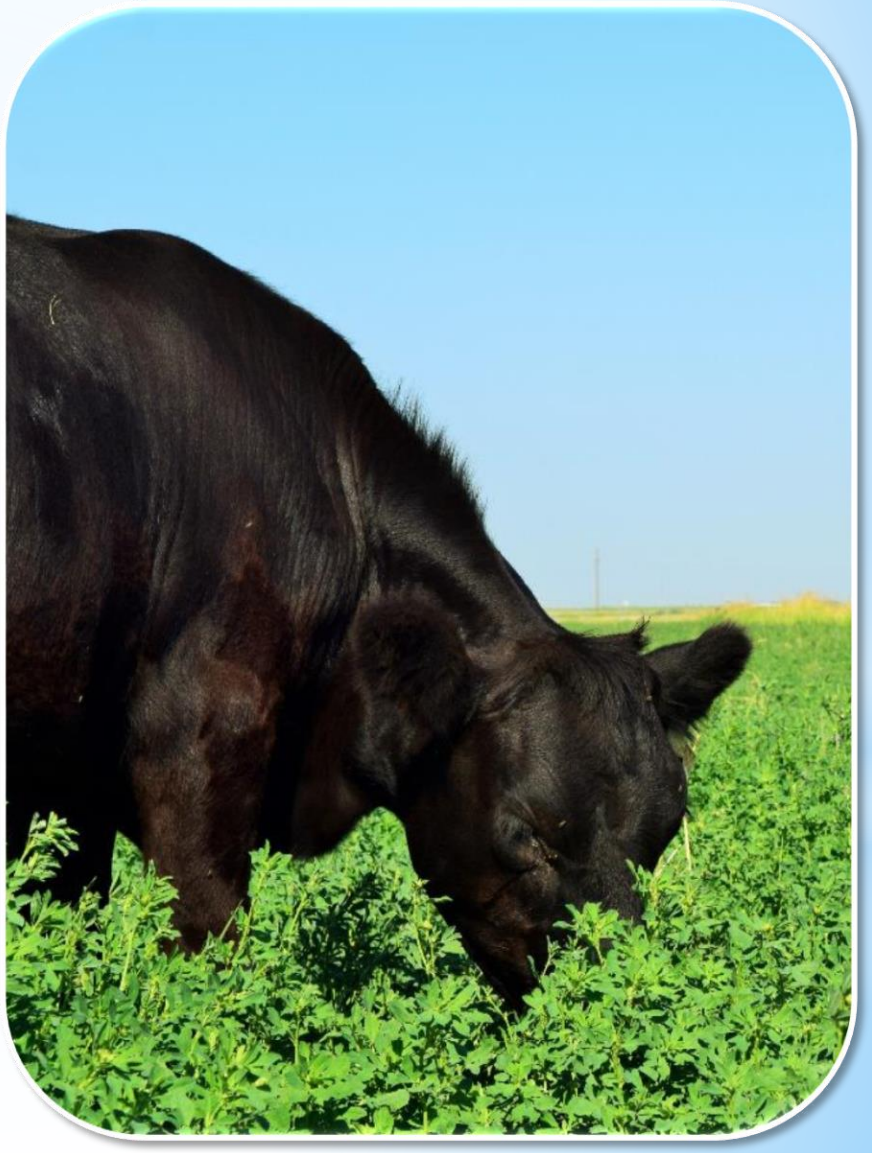
Alfalfa uses more water per kg of forage, but leverages two major attributes:

1. Much higher nutritive quality
2. Fixes N via symbiosis, so C and GHG footprints are also lower.

Trials #1 and 2:
Conclusions

- Inclusion of legumes increased beef stocker gain per ha
- Grass-Legume system did not require more water

➔ **Legumes reduced water footprint of system with respect to observed & total LWG**



www.fieldtomarket.org

Field to Market®

The Alliance for Sustainable Agriculture

From Bill Robertson. 2014. Nat. Cotton Council

Program Goals

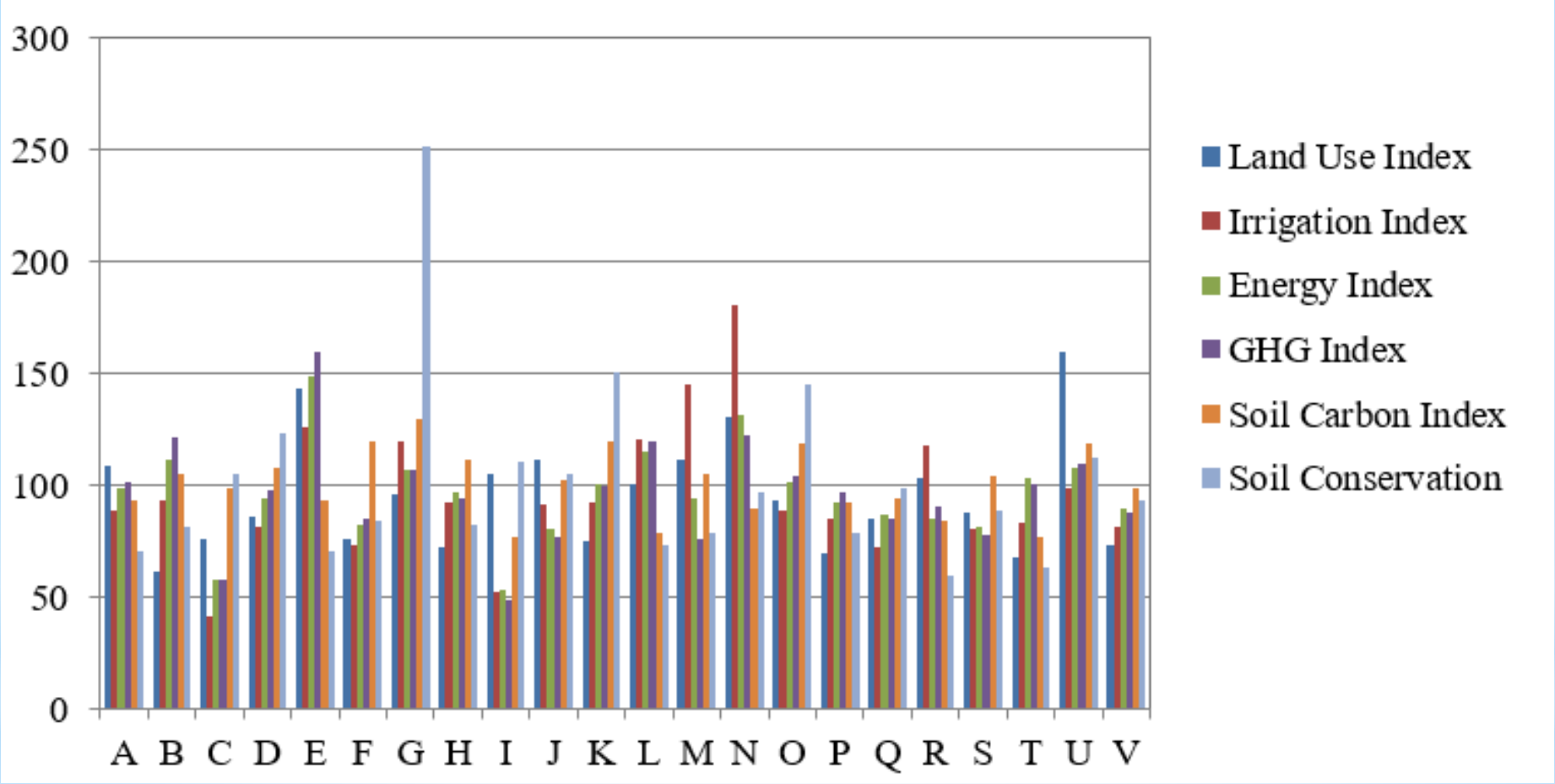
- Field to Market seeks to engage 50 million acres in its supply chain program by 2020 in order to:
  - Improve land use efficiency
  - Improve water quality
  - * Improve irrigation water use efficiency
  - Improve energy use efficiency
  - Reduce GHG emissions per unit of output
  - Reduce soil erosion

Field to Market

From Bill Robertson. 2014. Nat. Cotton Council

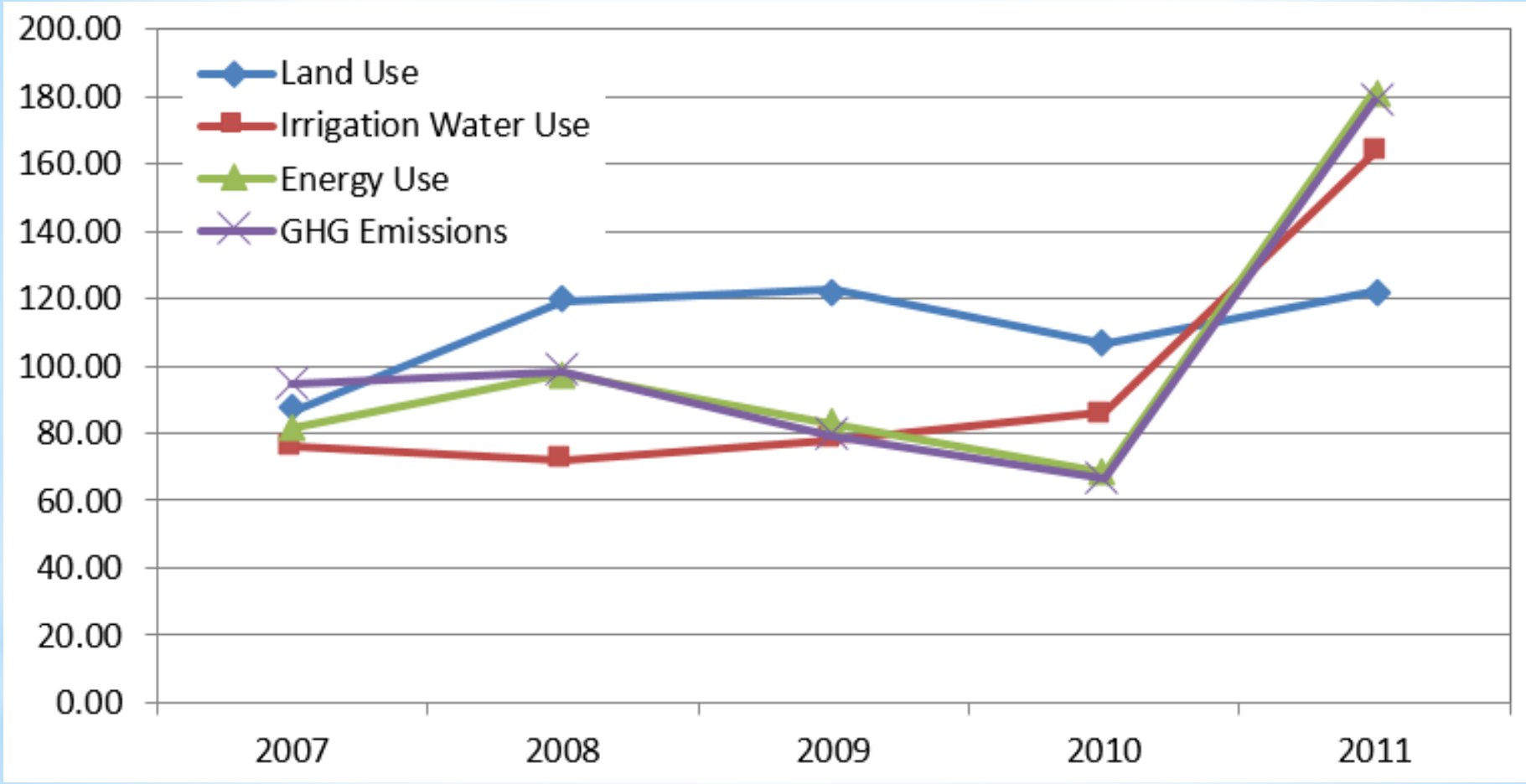
From Bill Robertson. 2014. Nat. Cotton Council

Fieldprint Calculator SI for TAWC sites



Stokes et al. 2014. Proc. Cotton Beltwide.

Fieldprint Calculator SI for TAWC sites

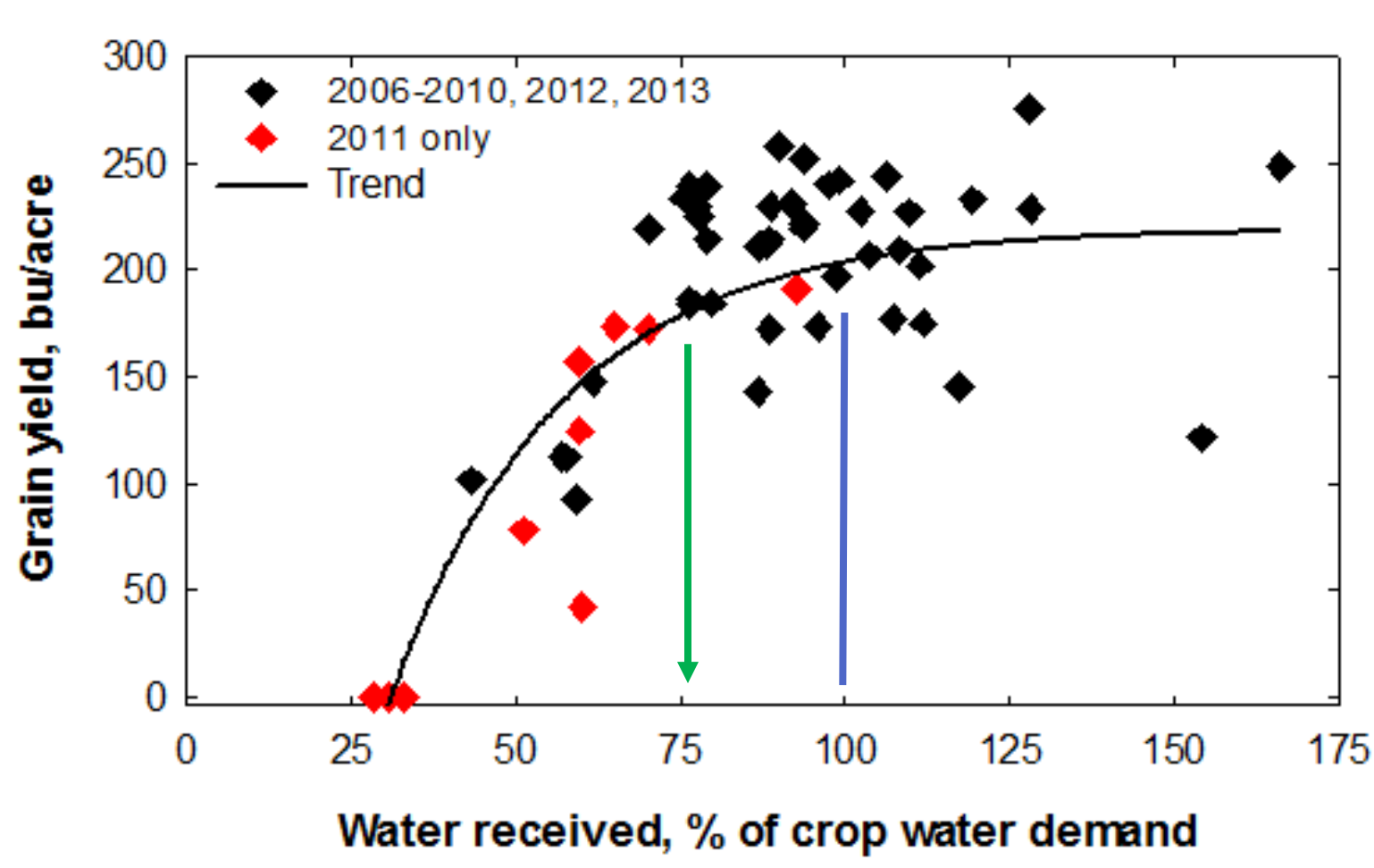


Stokes et al. 2014. Proc. Cotton Beltwide.

Practices that Reduce WF in the Field

- Manage soil for high infiltration rate
- Irrigation type (drip)
- Irrigate <PET by monitoring and scheduling
- Variable rate irrigation by soil condition
- New varieties with higher WUE
- High quality forages
- Diversify farming system with dryland, low, and moderately irrigated crops

Yield response to total water



$y = -505 + 724(1-e^{-.0385x})$ $R^2=0.92$ $SE_{est}=18$

QUESTIONS ?

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Data contributed by P. Brown, R. Kellison, P. Johnson, J. Pate, L. Baxter, K. Stokes.
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