

**CONSUMPTIVE USE OF WATER:
IMPACTS OF 2020 AGRICULTURAL PRACTICES
CNPPID/NPPD**

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June 2024



TODAYS TOPICS (what to discuss?):

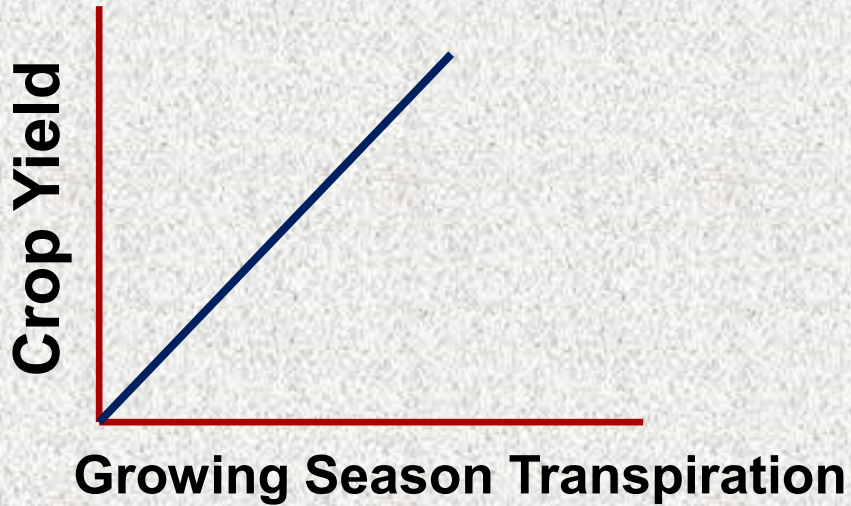
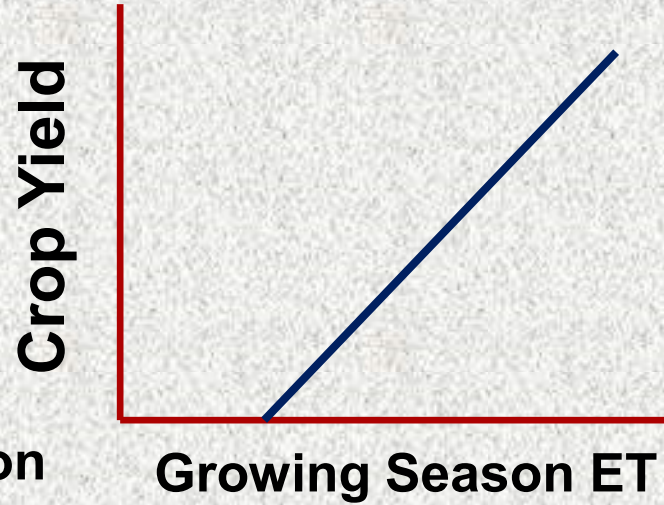
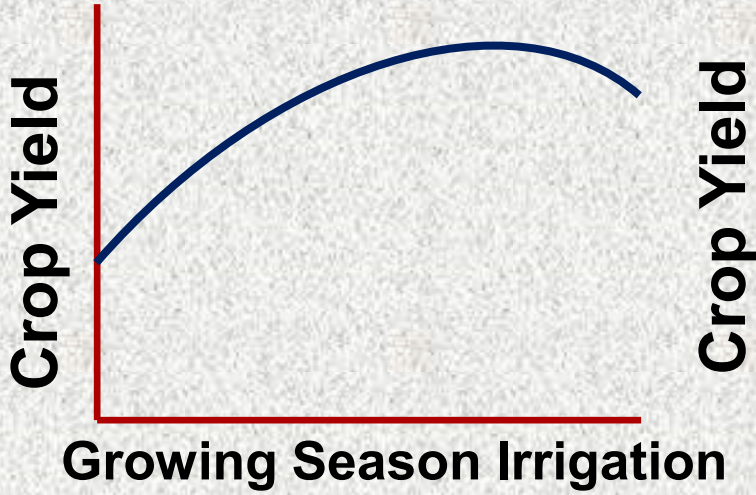
- *Crop yield and Evapotranspiration (ET)*
 - *Efficiency of modern irrigation systems*
 - *Cover crop impacts on ET*
 - *No-till impacts on ET*
 - *Impacts on Net Recharge and Runoff*
 - *Future??*
-

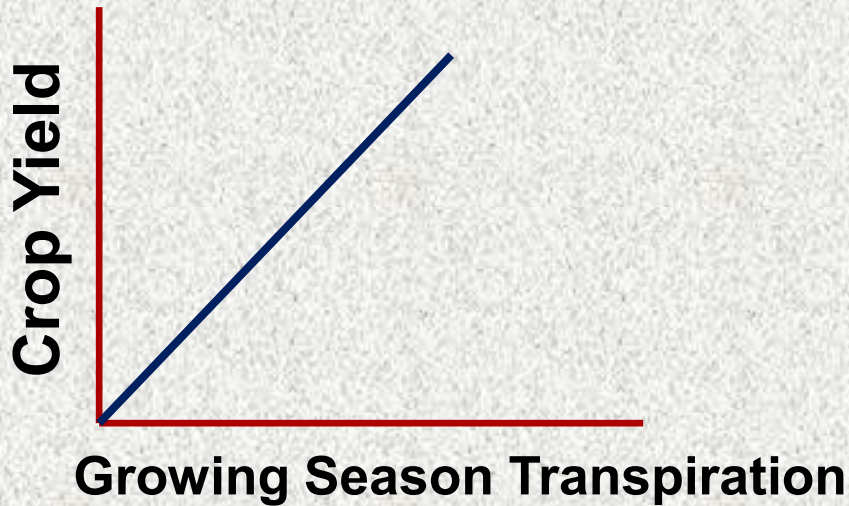
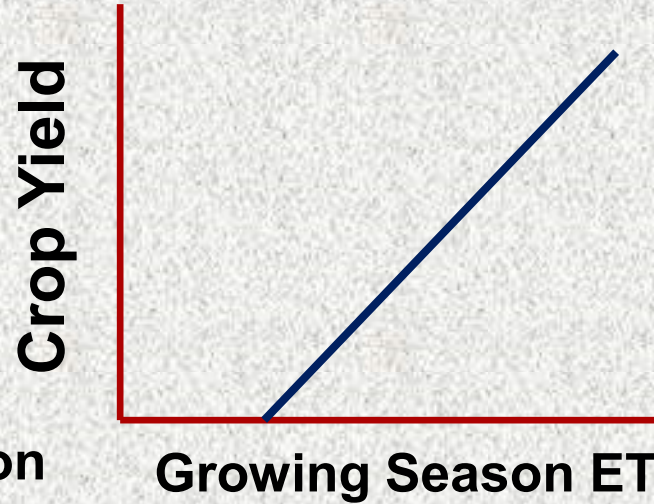
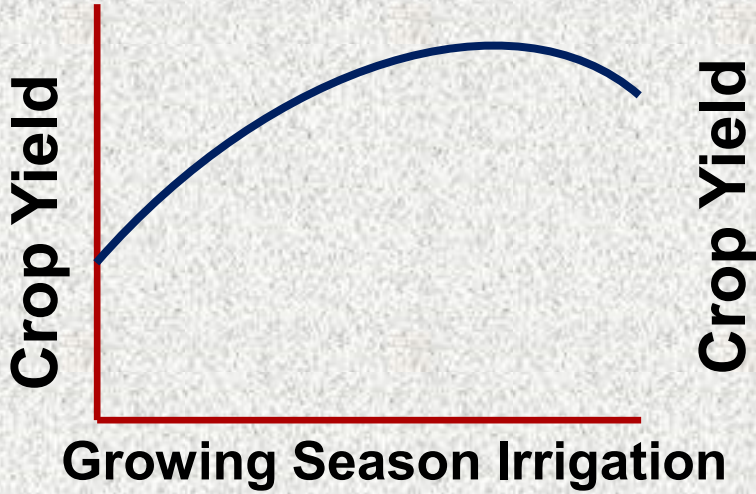


***GOAL: DISCUSS METHODS FOR
REDUCING EVAPORATIVE
“LOSSES” OF LIQUID WATER***



CROP YIELDS AND ET

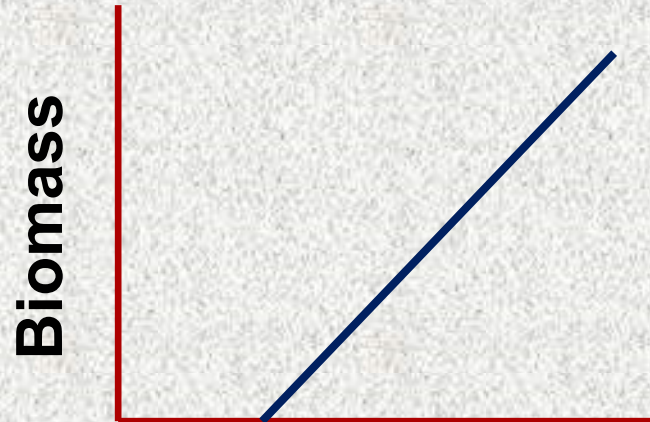




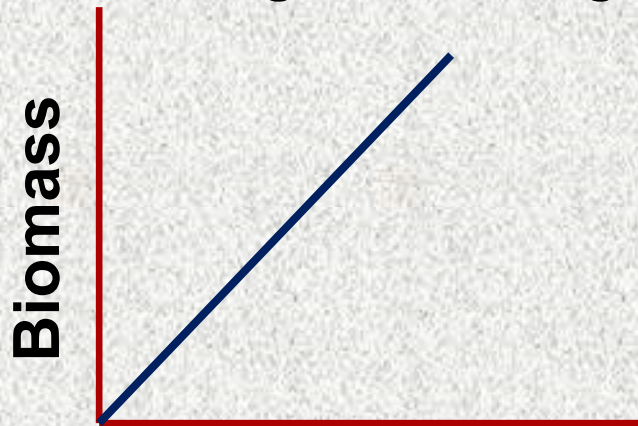
**Actually this
wasn't the
whole story**



Growing Season Irrigation



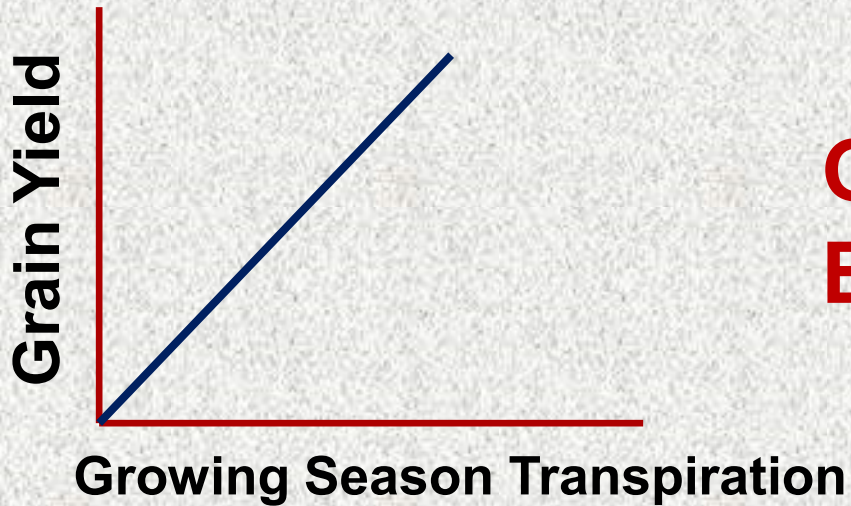
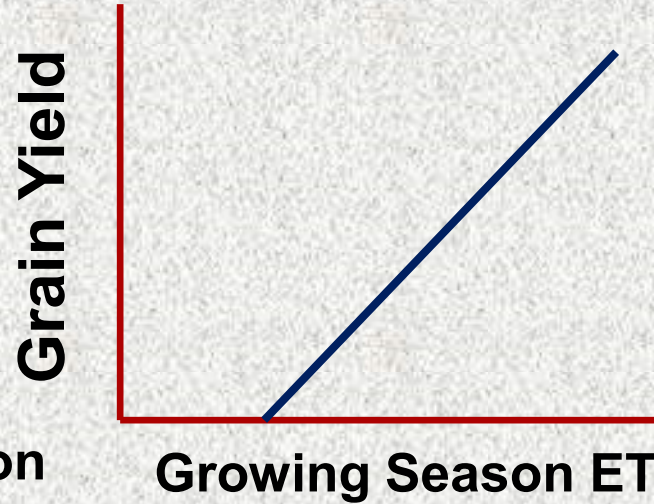
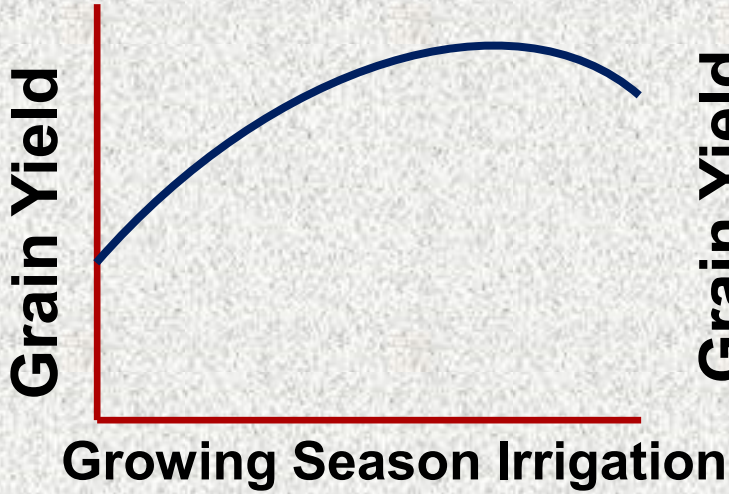
Growing Season ET



Growing Season Transpiration

**Biomass is
above ground
only**

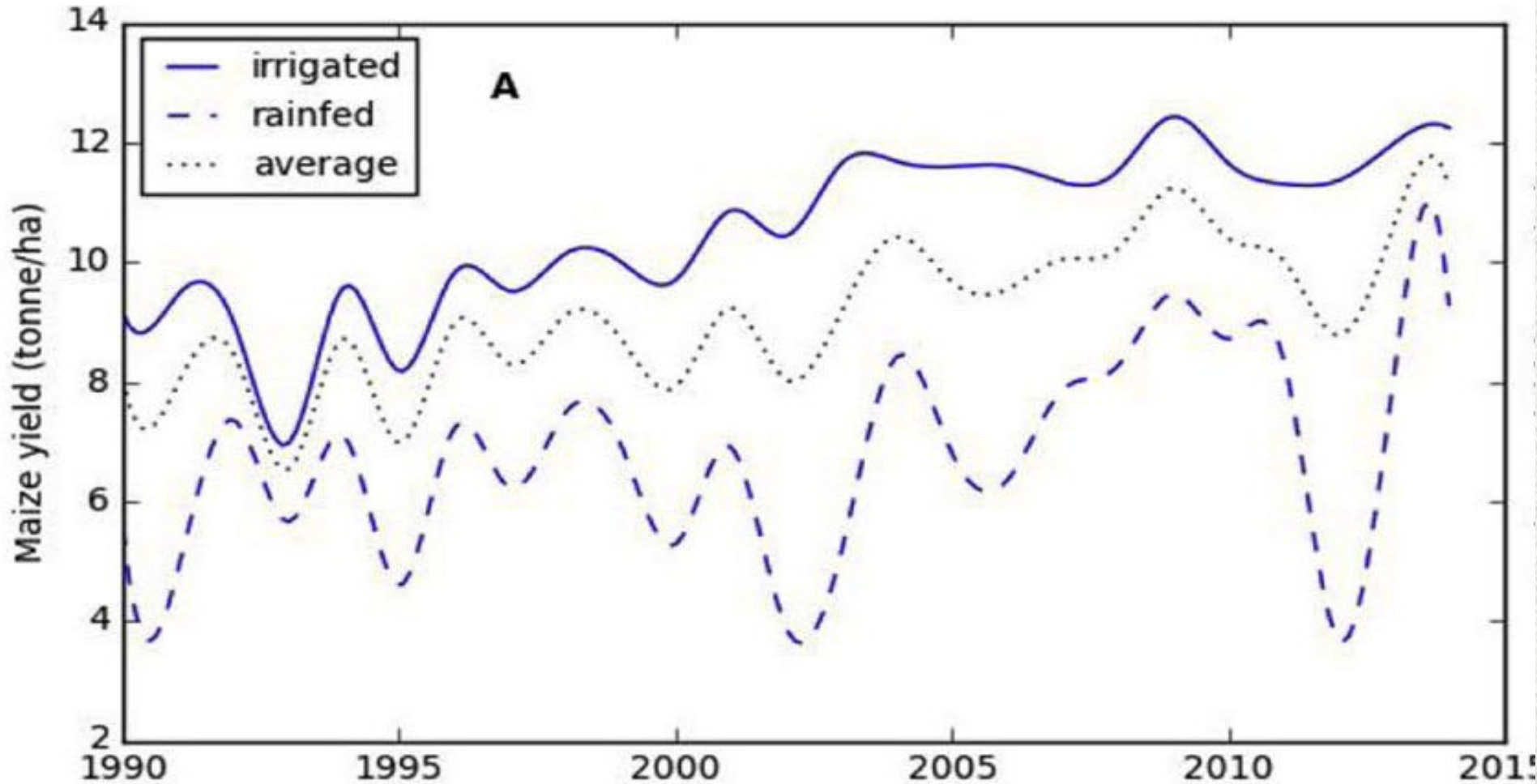
Grain Yield = Biomass × Harvest Index



$$\text{Grain Yield} = \text{Biomass} \times \text{HI}$$

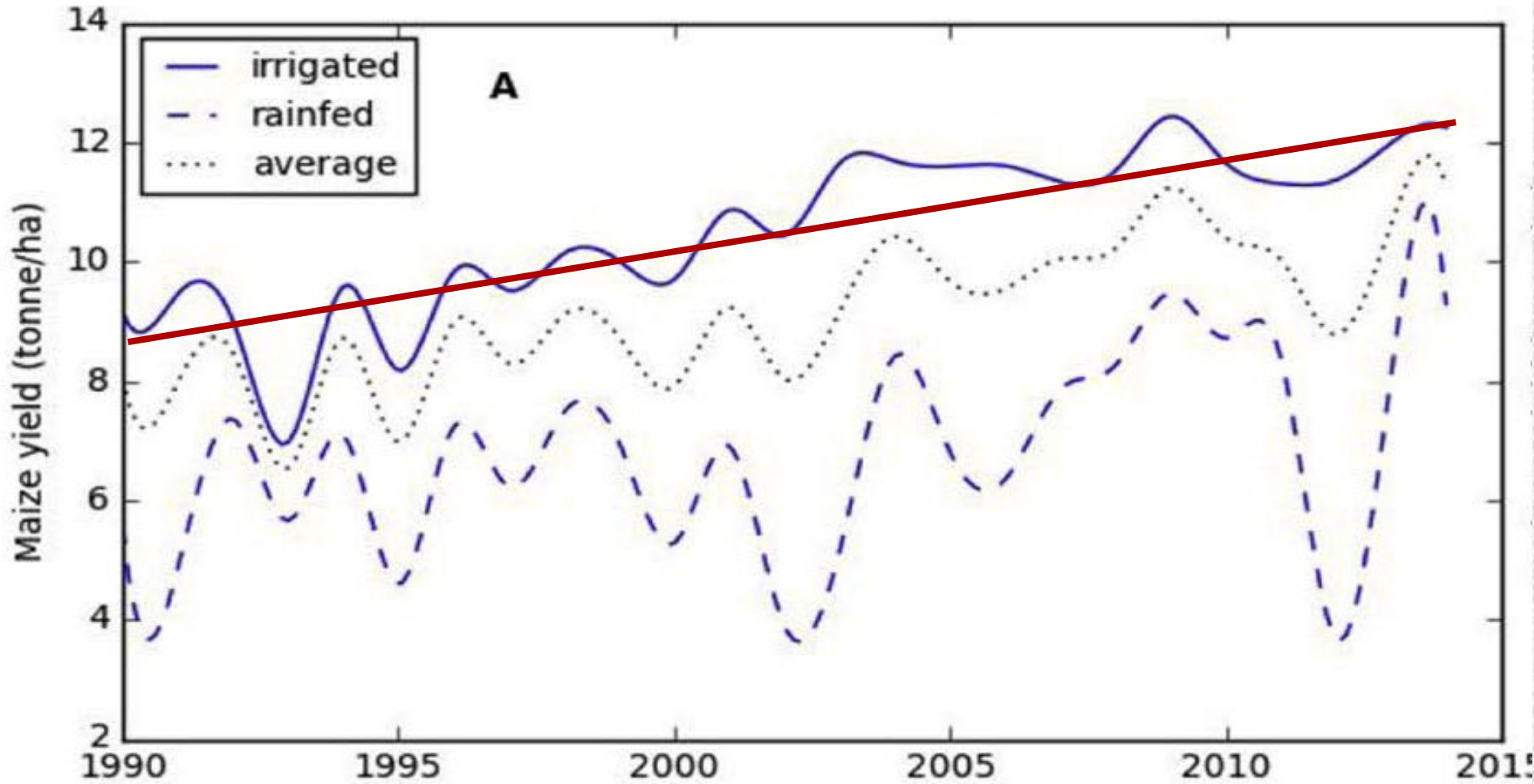
Corn Yields 1990-2014

Nebraska Water Productivity Report
by the Water for Food Institute (DWFI)



Corn Yields 1990-2014

Water for Food Institute (DWFI) Nebraska Water Productivity Report

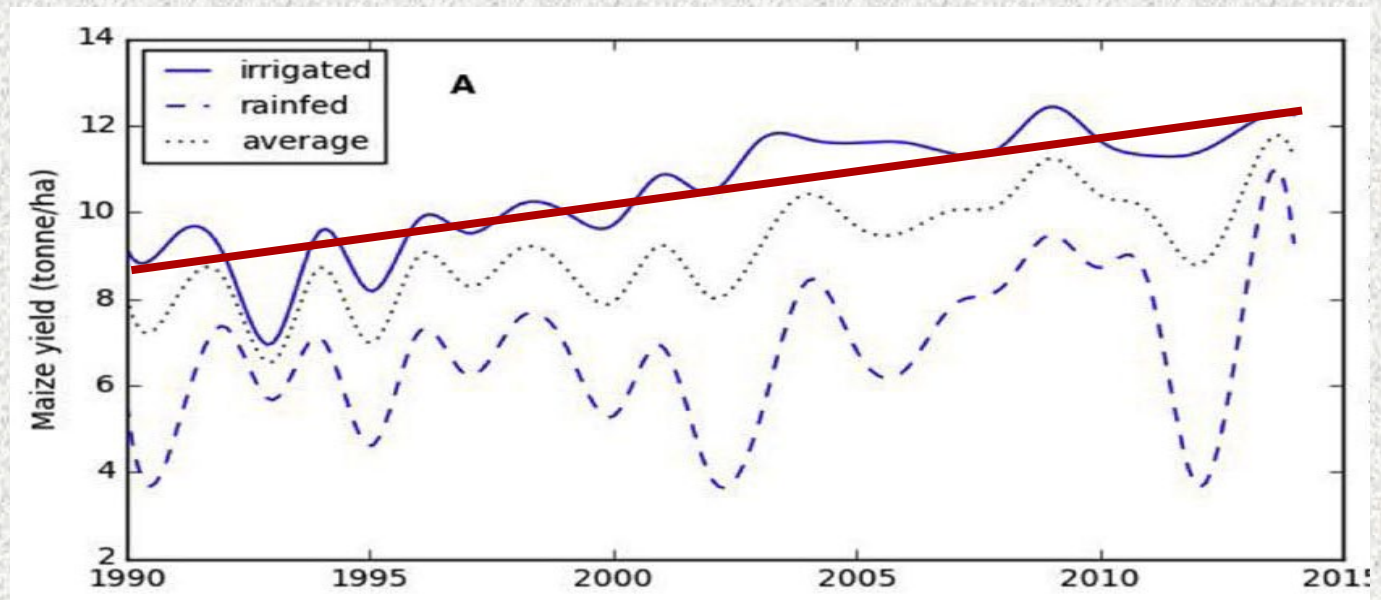



Average yields of irrigated corn

1990-1994 139 bu/ac


2010-2014 186 bu/ac

34% increase in yields during this 25 year period
– **did ET increase?**






“This (yield increase) was achieved through enhanced crop genetics and better management of soil, nutrients, and water.”



To match modeled yields with reported USDA yields some key model inputs that were increased with time were:

- Harvest index
 - Plant population
-


$$\mathbf{Water\ Productivity} = \frac{\mathbf{Grain\ Yield}}{\mathbf{Growing\ Season\ ET}}$$



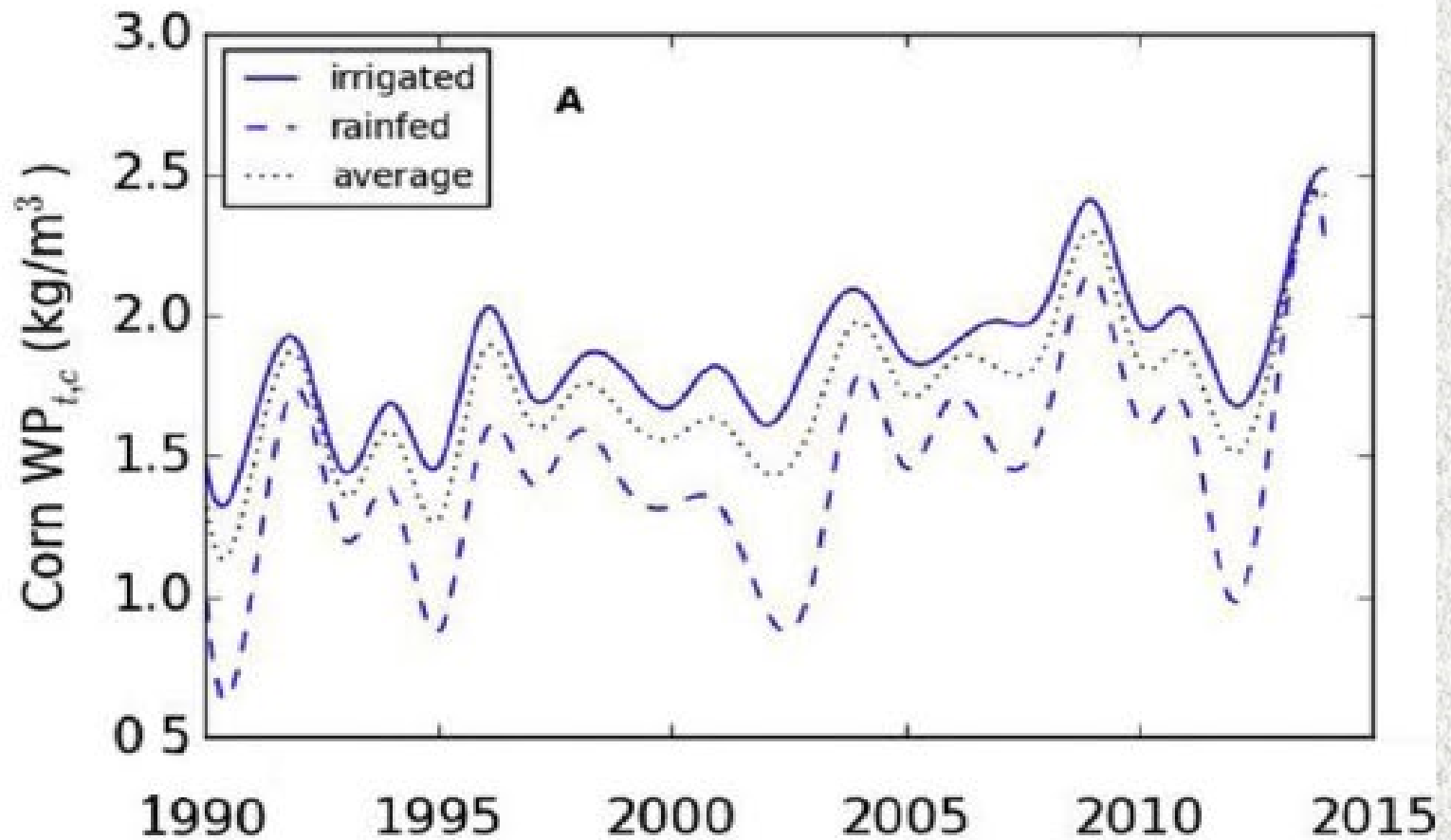
Water Productivity Answers the Question:

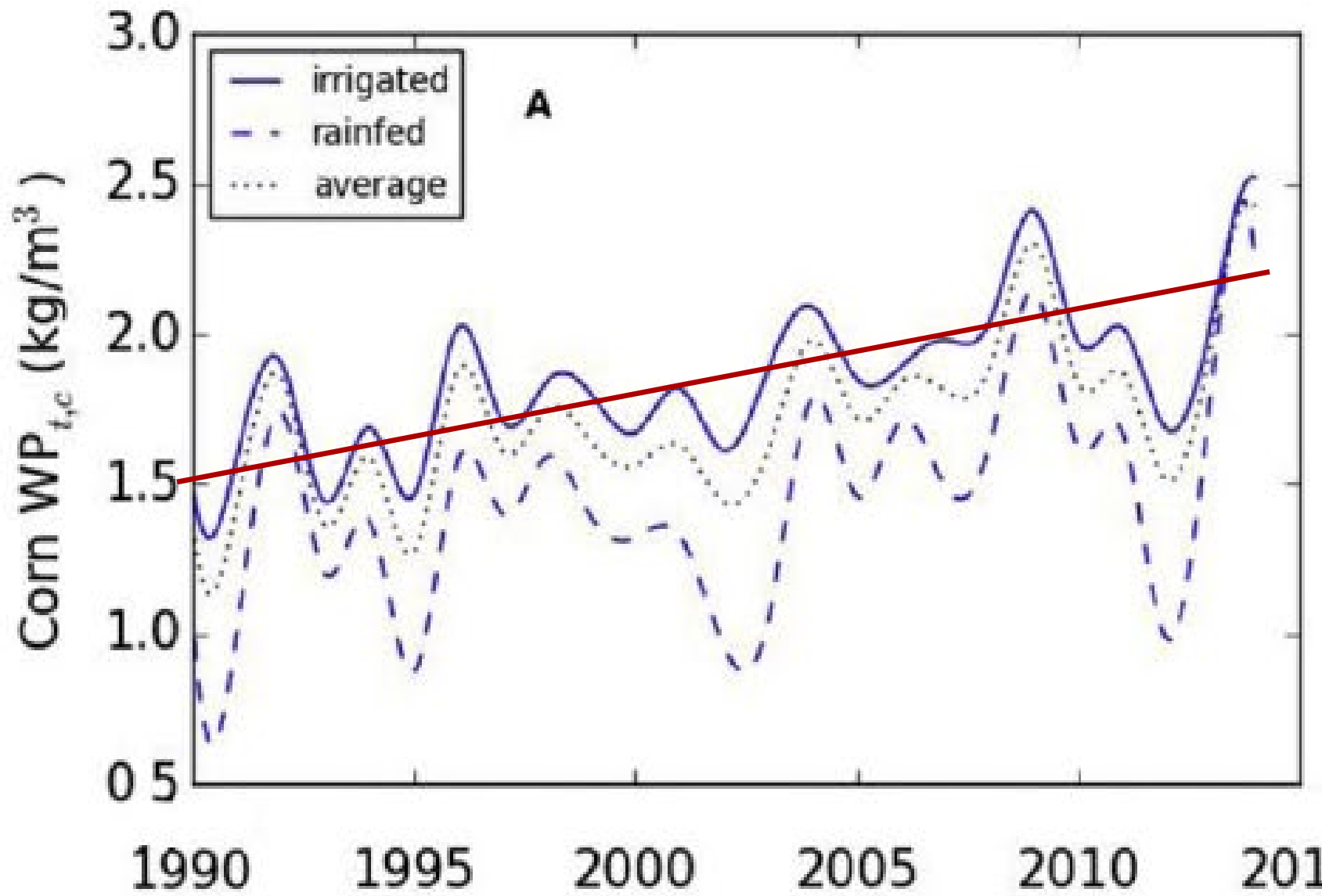
How Many Bushels per Acre-Inch of ET?

Water Productivity

Corn 1990-2014

Nebraska Water Productivity Report
by the Water for Food Institute (DWFI)





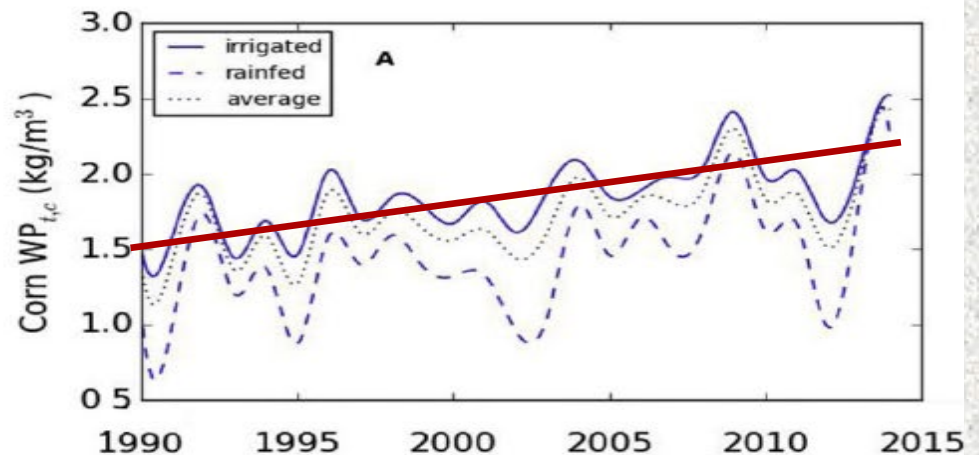
Average water productivity of irrigated corn

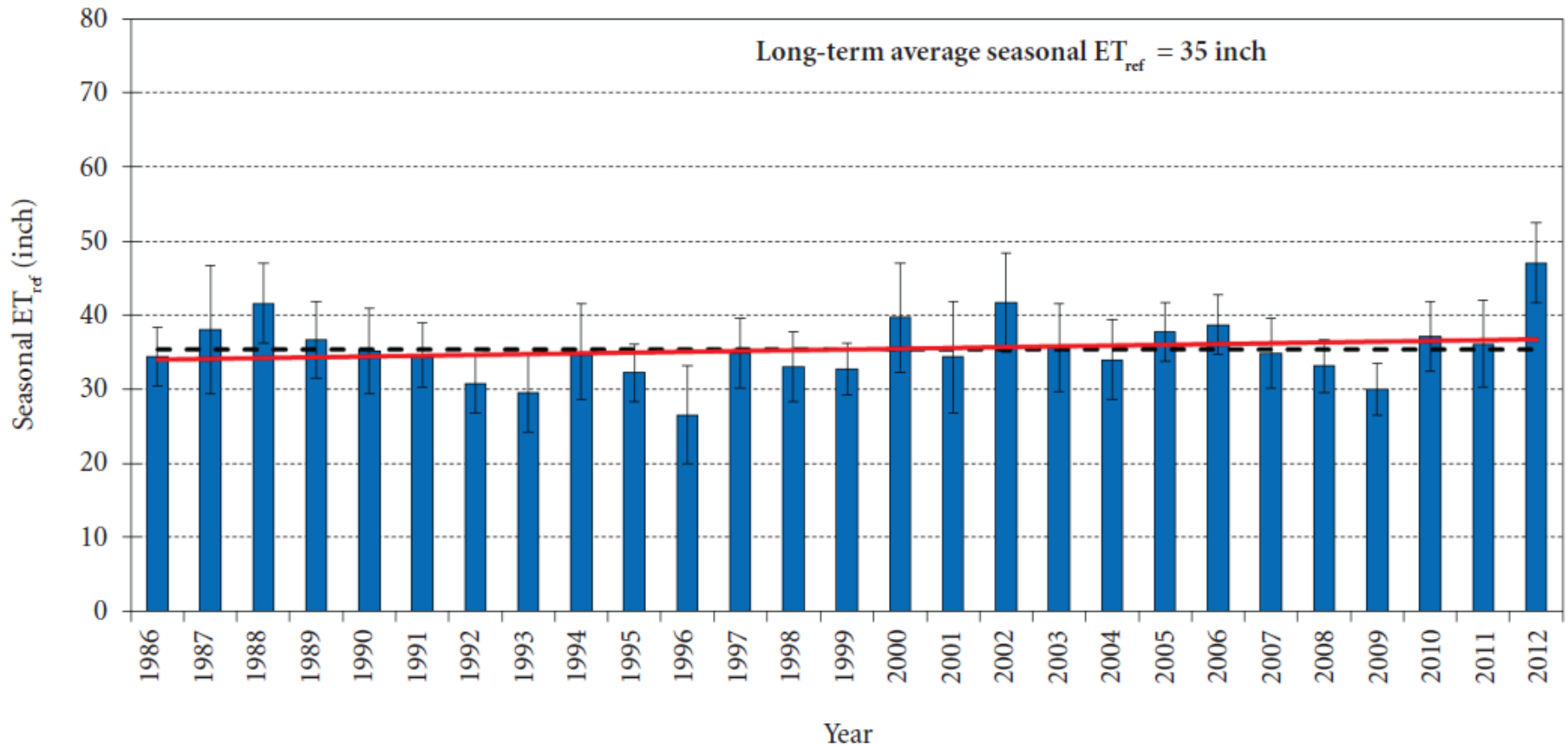
1990-1994 6.46 bu/ac-in

2010-2014 8.24 bu/ac-in

28% Increase in water productivity during this 25 year period

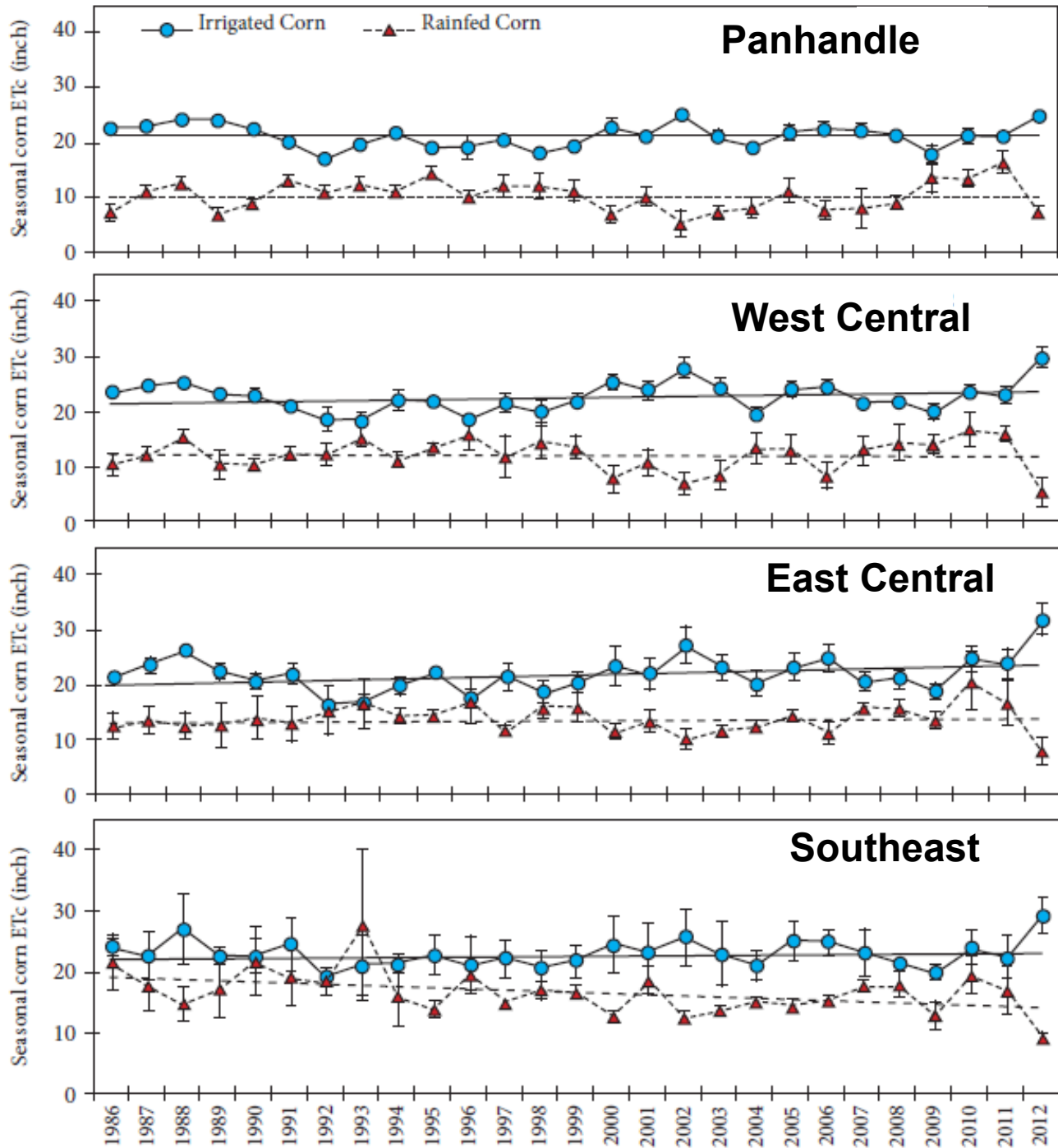
- **did ET increase?**
- **yes, based on these yield and WP increases, ET increased by about 5%**





ET_{ref} = Reference Crop ET (based only on 4 weather factors: temperature, solar radiation, wind, and relative humidity)

Trend shows about a 2 in. increase in 27 years, **about 6 %**



From Sharma and Irmak (2015)

Average irrigated Corn ET in Nebraska = 22.4 in

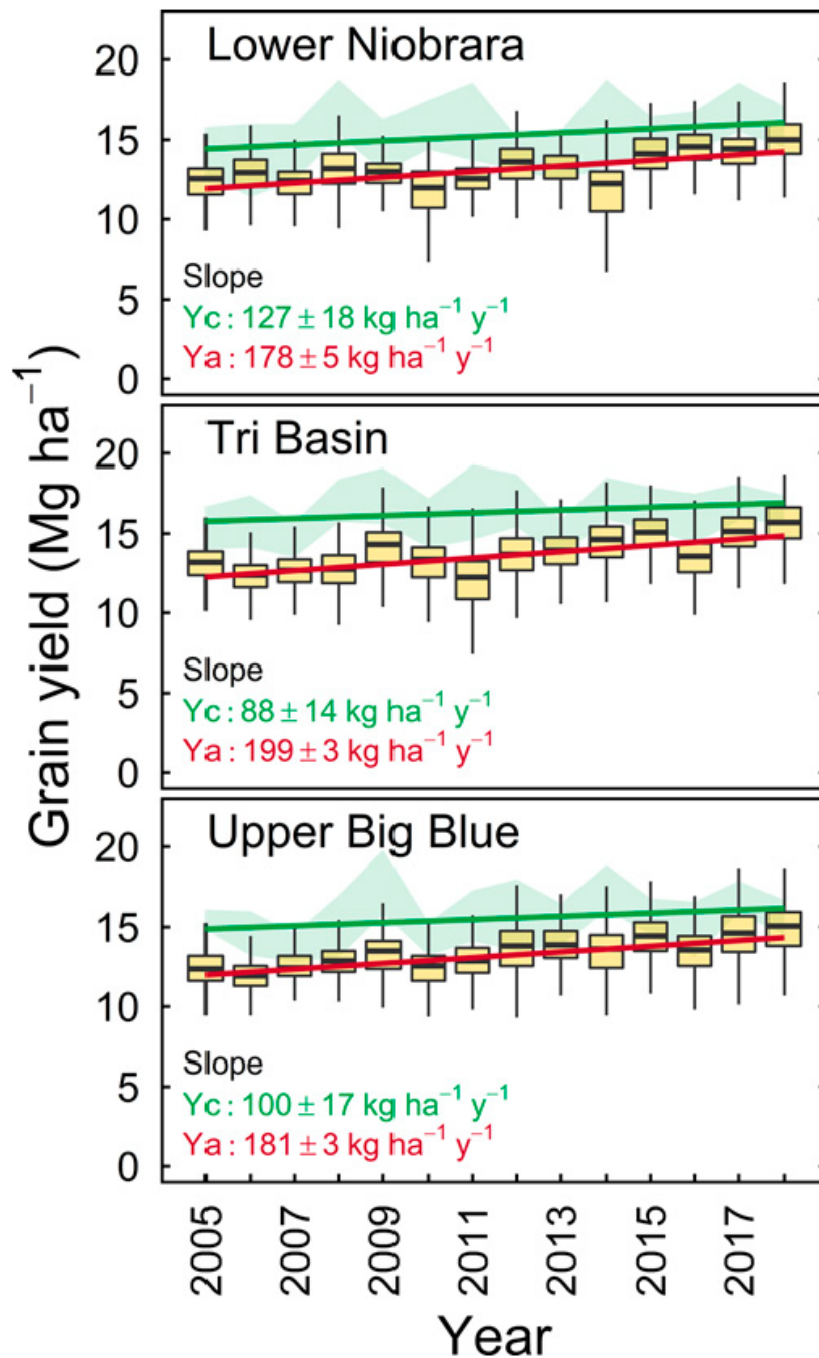
Average increase in 27 years is 1.2 in, **about 5% increase**

Recent Paper by
Rizzo, ..., Cassman, and Grassini
(2022)

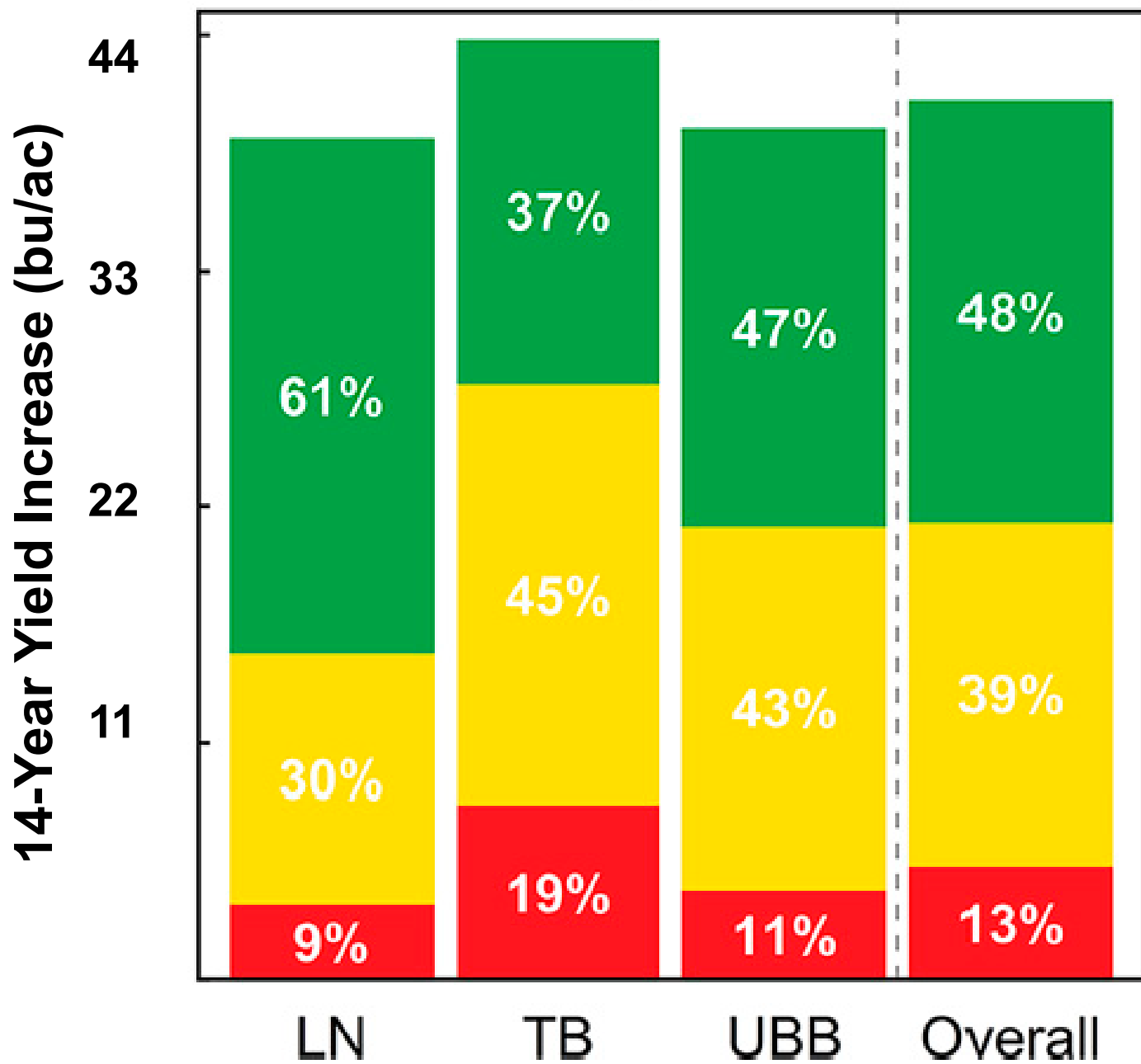
*“Climate and agronomy,
not genetics, underpin
recent maize yield gains in
favorable environments”*


About 48 % of yield gain was
due to climate

(3% due to CO₂ rise)



■ Climate ■ Agronomic ■ Genetic





“We found an upward trend in cumulative solar radiation during grain-filling over the study period from 2005 to 2018 ($P < 0.01$), which largely explained the climate-driven yield gain for irrigated maize”

Key Agronomic Practice Changes

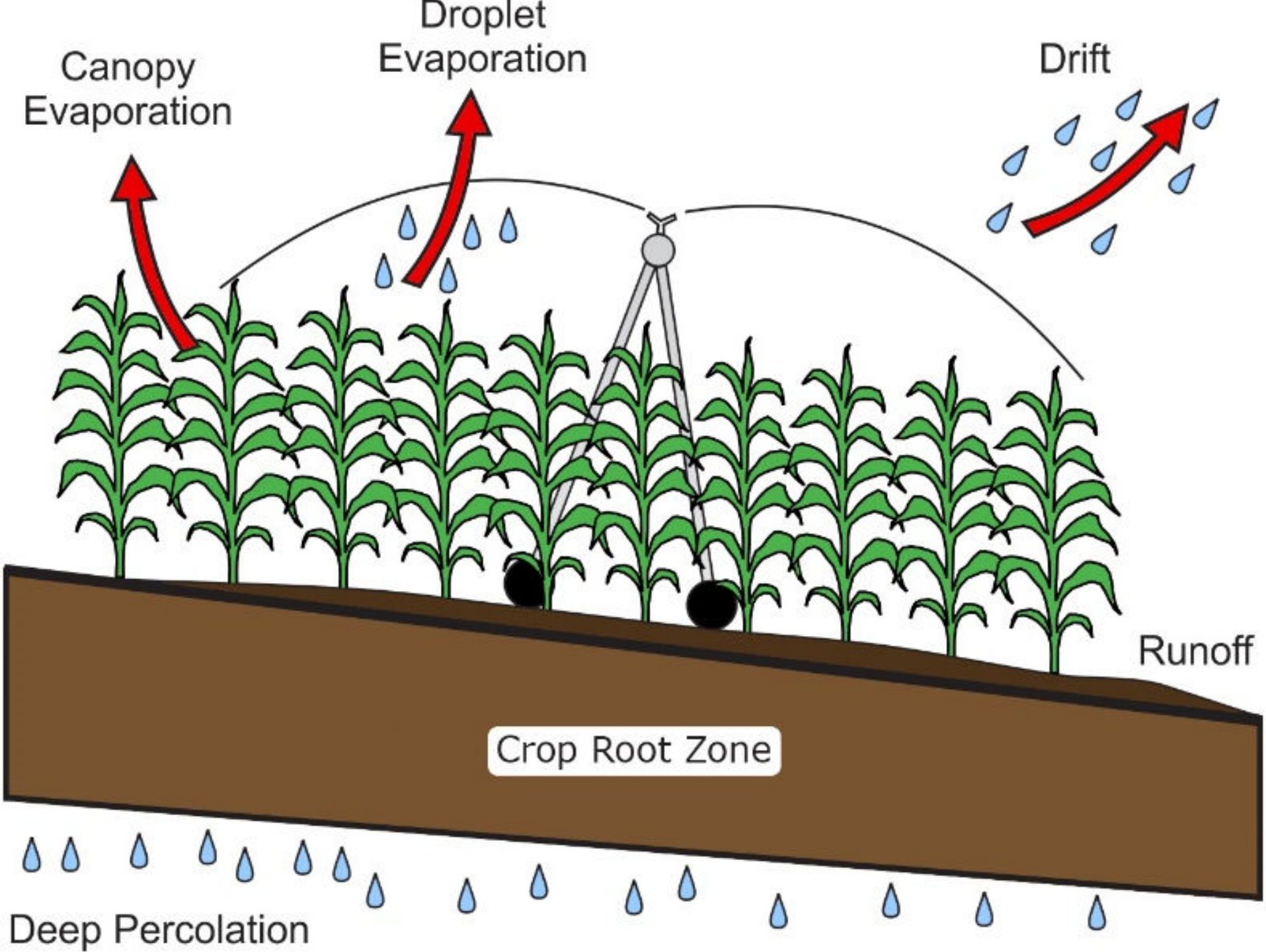
Practice	Change	14-year Yield Increase (bu/ac)
Planting rate (Plants/ac)	30,000 to 32,400	6
Folier fungicide/ insecticide (% of acres)	27 to 61	2
Nitrogen Application (lb/ac)	167 to 196	11

Discussion





***EFFICIENCY OF MODERN
IRRIGATION SYSTEMS***



What Have You Seen?


- Runoff ?
 - Evaporation ?
 - Drift ?
 - Deep Percolation ?
-











This base flow is the result of deep percolation

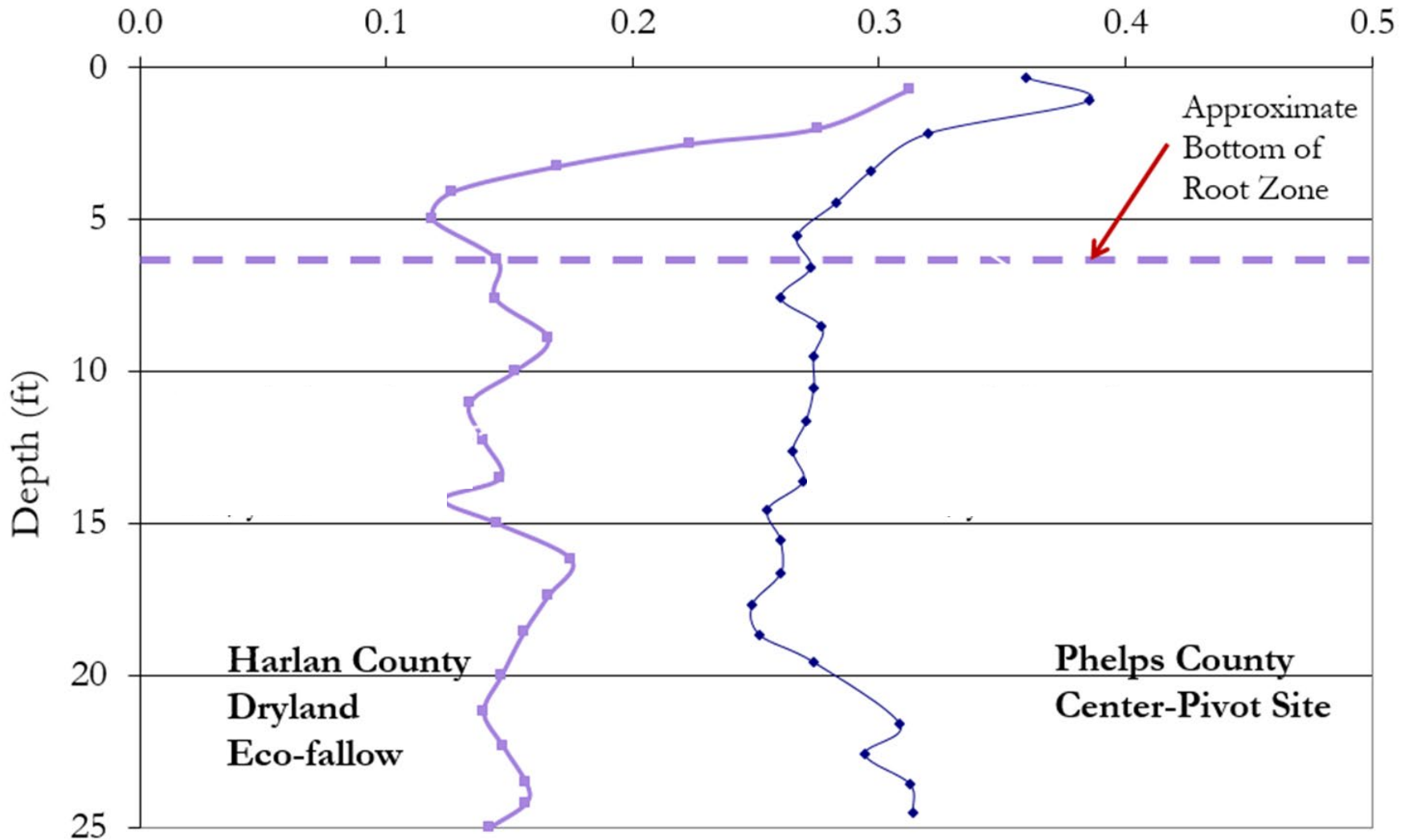
This subsurface tile drainage is the result of deep percolation







Soil Water Content



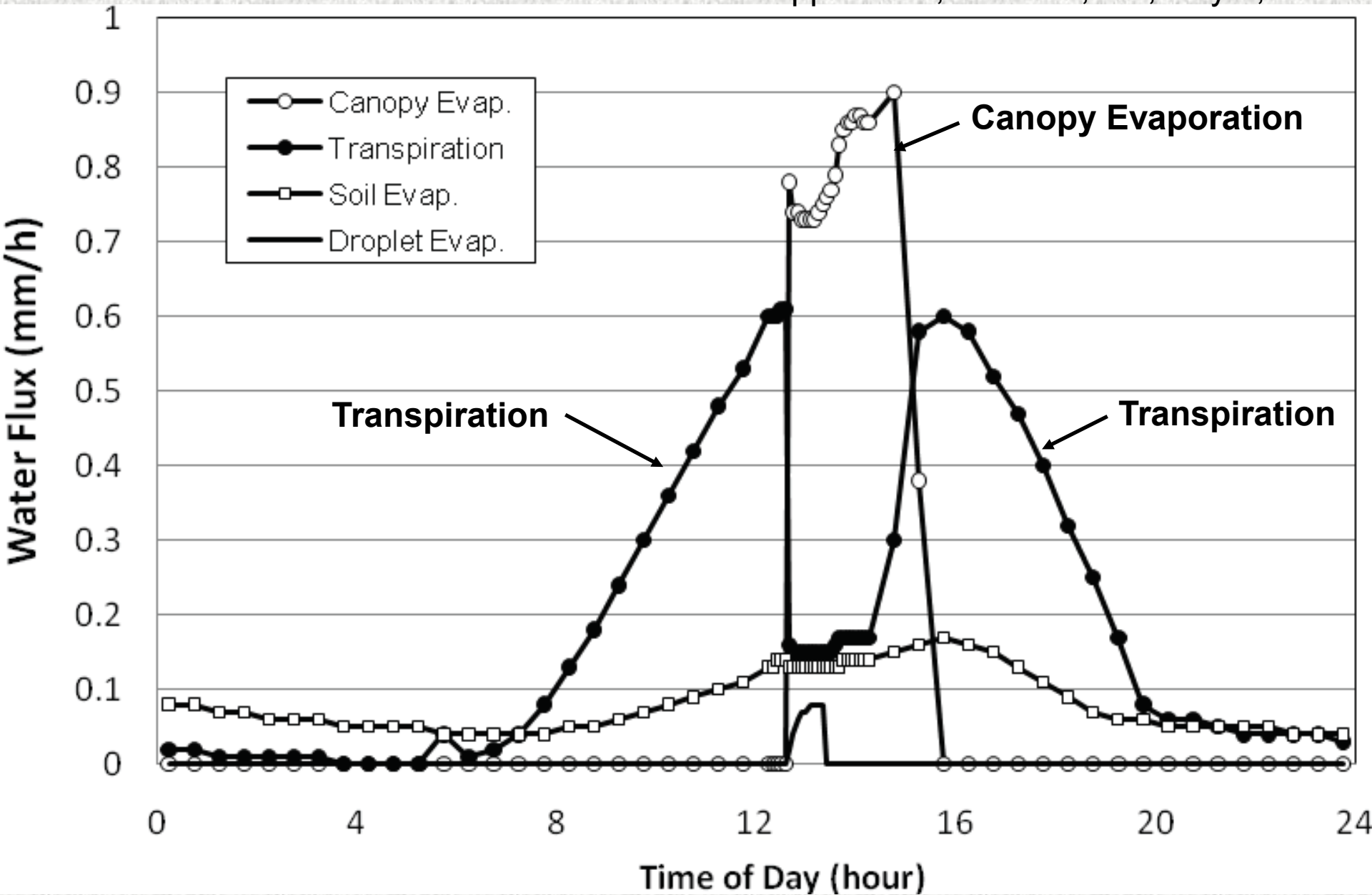
This soil water below the root zone is the result of deep percolation

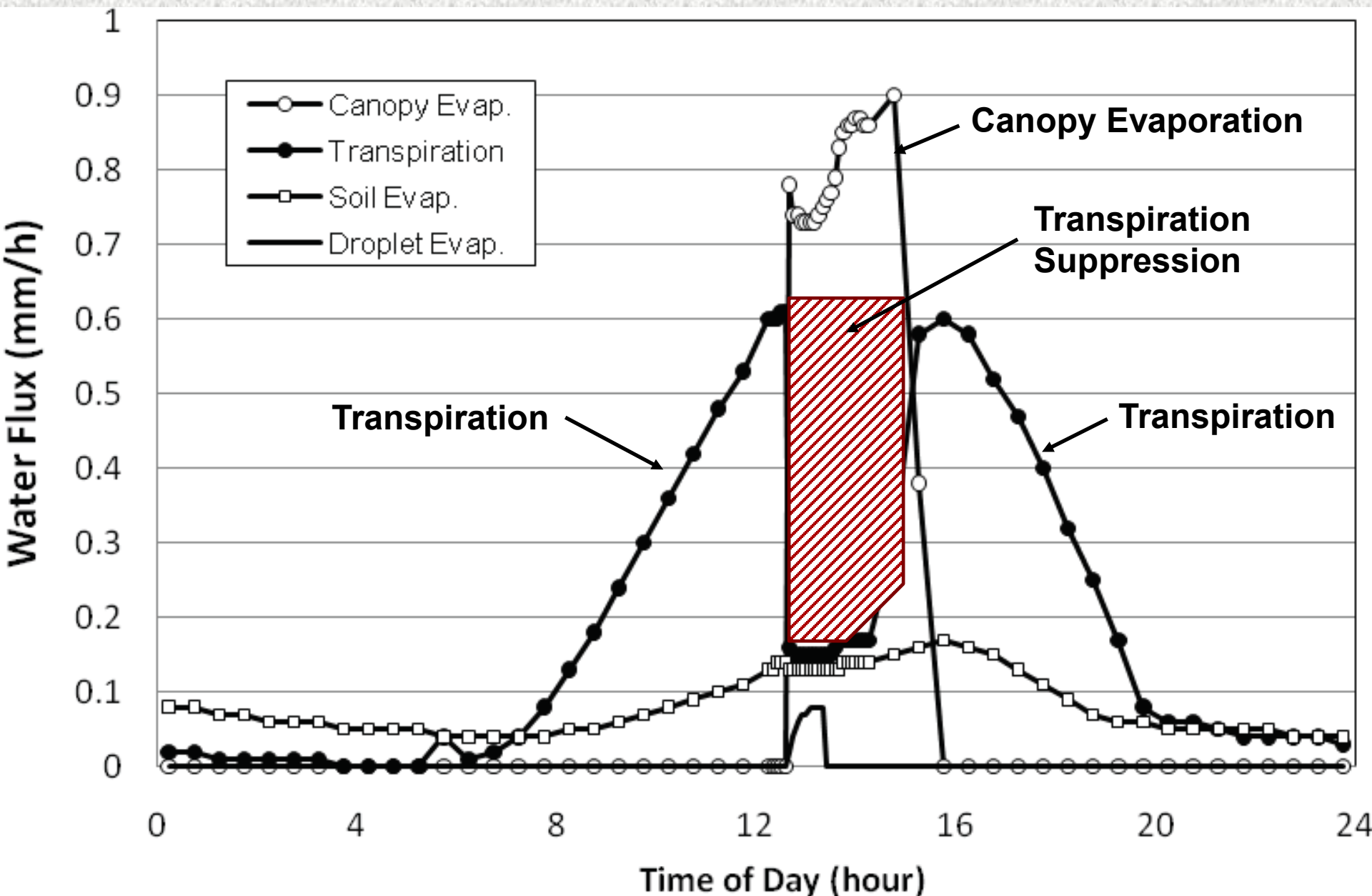


How much loss?

- In air (evap & drift)
- From wet canopy

From Derrel Martin et al (2012)
1-inch application, McCook, NE, July 6, 1995





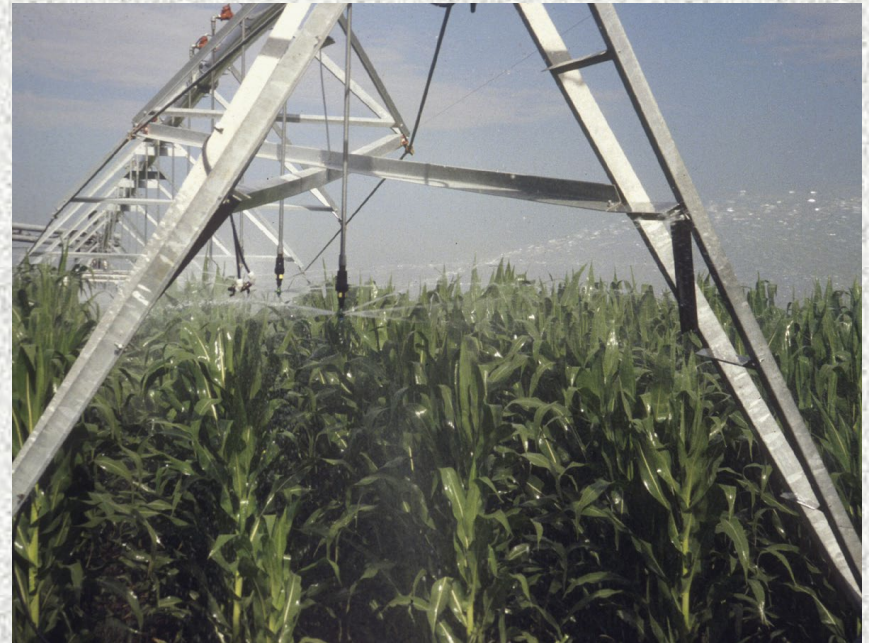
Impact Sprinklers

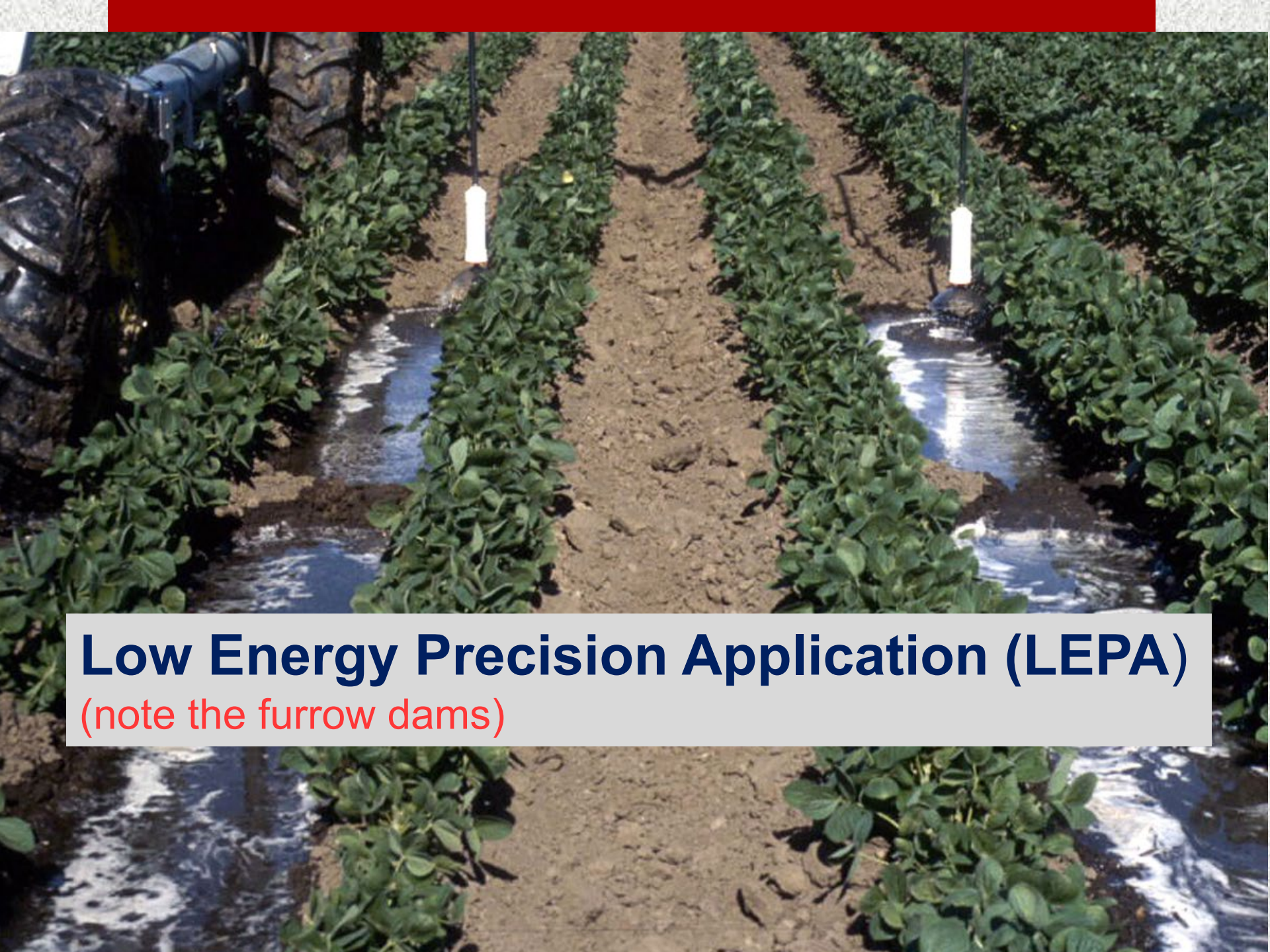


Spray w/o Drops



Spray w/drops

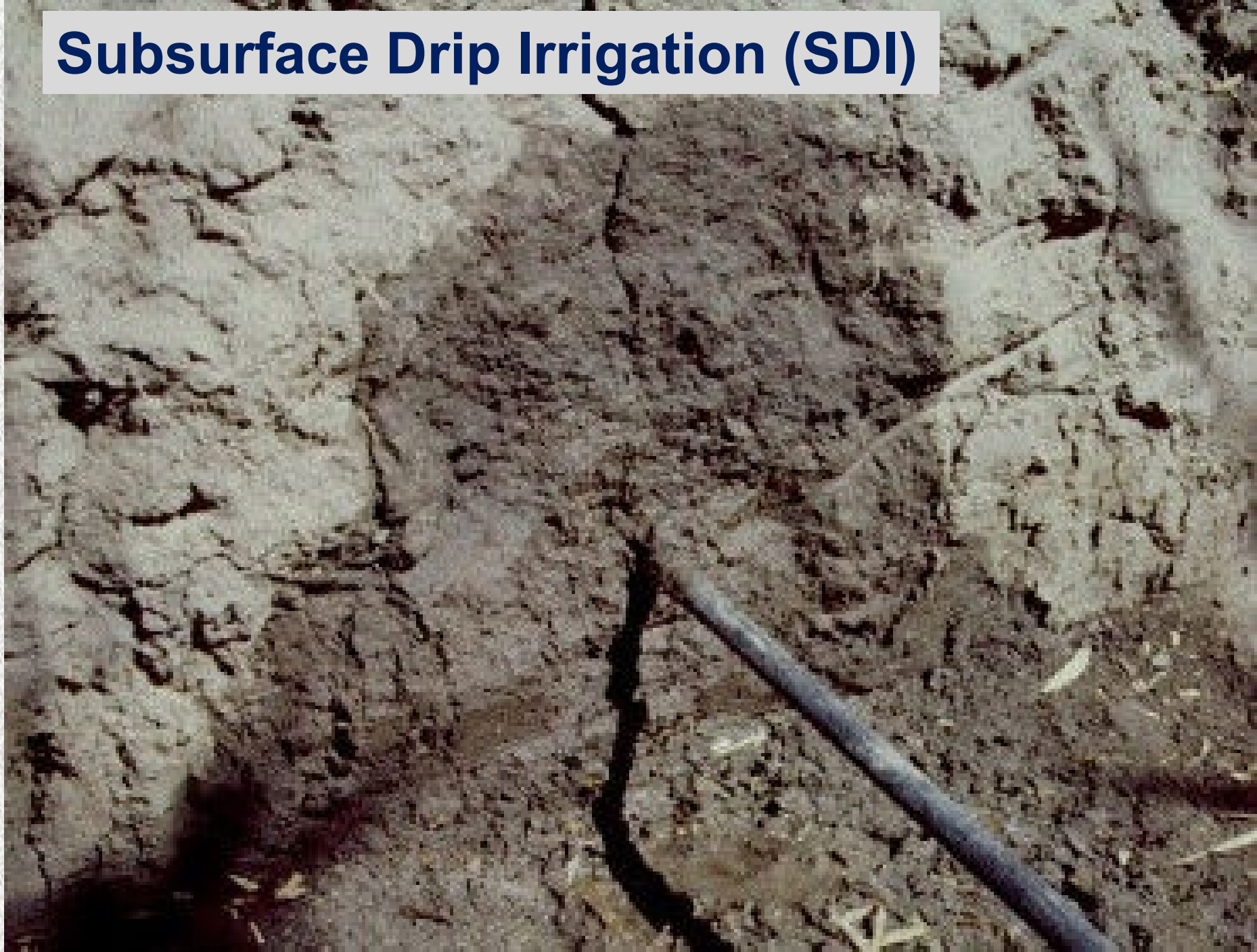




Low Energy Precision Application (LEPA)

(note the furrow dams)

Subsurface Drip Irrigation (SDI)



Surface Irrigation



Irrigation Water Losses and Efficiency (%)*

	Air Losses Evap. + Drift	Net Canopy Evaporation	Total Evap. Losses	Deep Perc. & Runoff	Efficien cy
Impact	3	7	10	5	85
Spray, w/o drops	2	5	7	5	88
Spray, w/drops	1	4	5	5	90
LEPA	0	0	2	4	94
SDI	0	0	0	4	96
Furrow w/o Reuse	0	0	0	50 (30 + 20)	50
Furrow w/ Reuse	3	0	3	30	67

*Data for well designed, well managed, and well maintained systems and with no runoff except surface irrigation



Data for well designed, well managed, and well maintained systems and with no runoff



Discussion



COVER CROP IMPACTS ON ET



Cover Crop Impacts

- Increase soil organic carbon/improve soil quality
 - Reduce soil erosion
 - Weed suppression
 - Increase infiltration/reduce runoff
 - Reduce nitrate leaching
 - Reduce drainage (deep percolation/recharge)
 - Increase ET?
-

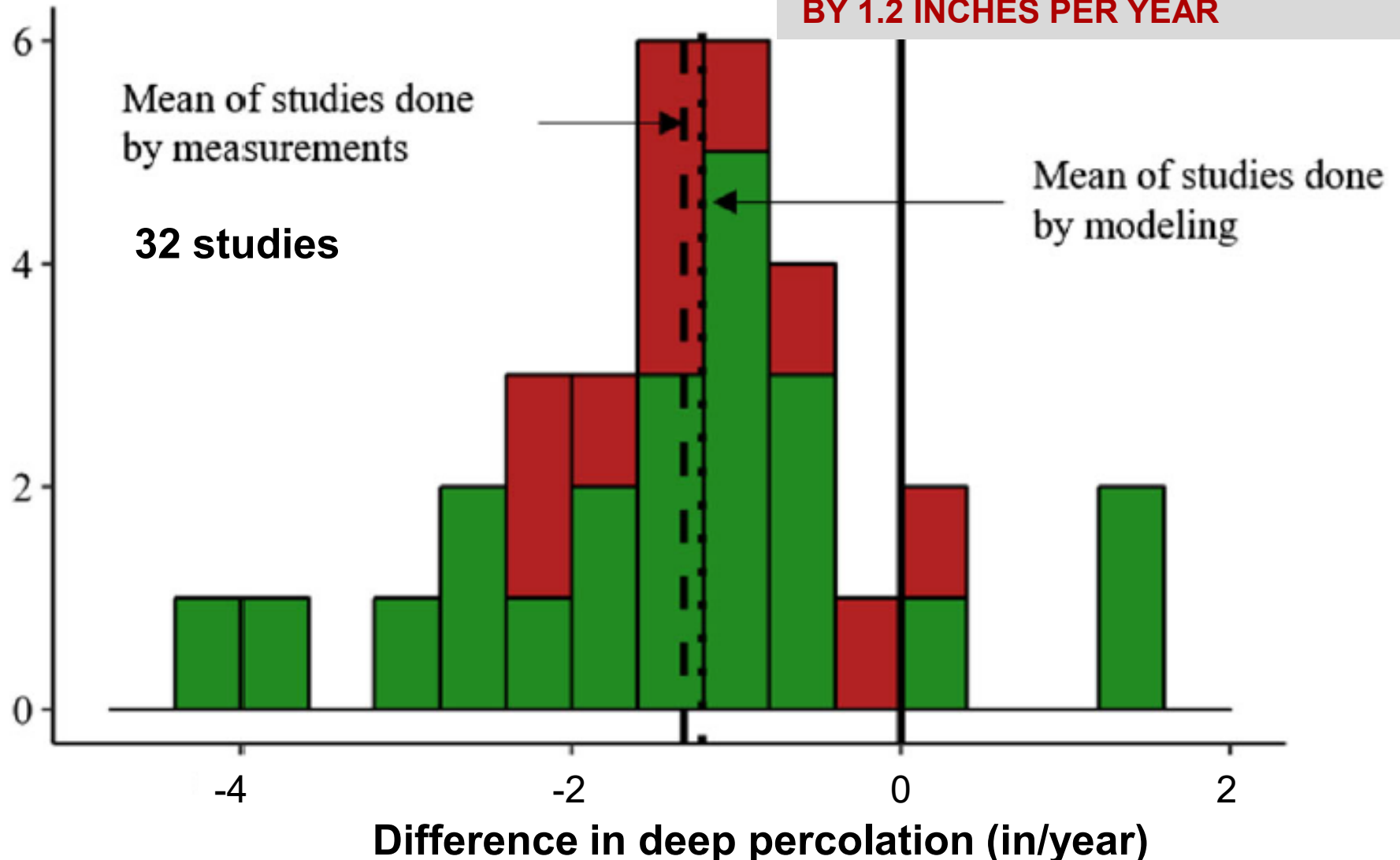
Cover Crop Impacts


- Increase soil organic carbon/improve soil quality
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 - Reduce drainage (deep percolation/recharge)
 - Increase ET?
-

Histogram of mean water drainage under cover crops minus that under bare soil

Number of studies

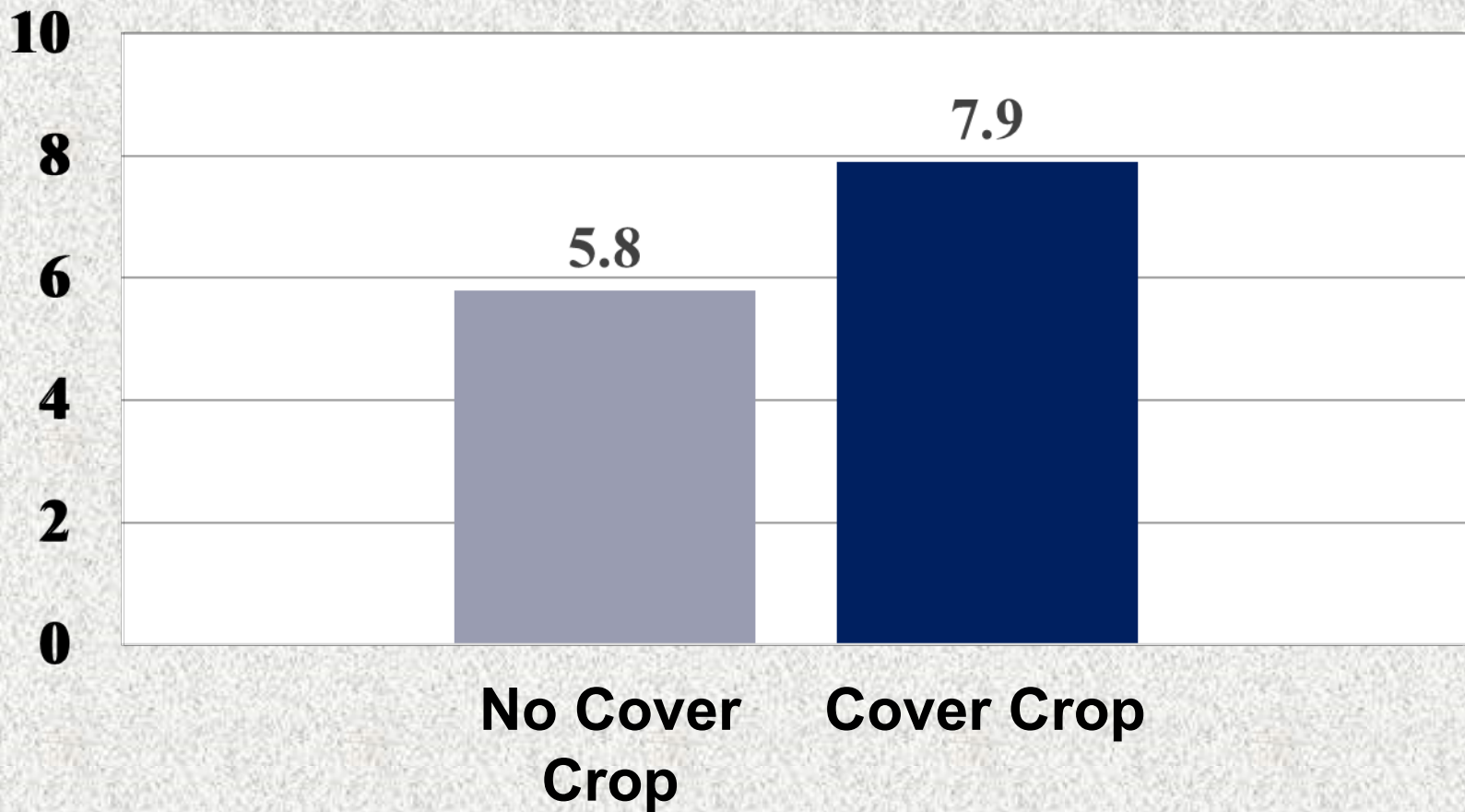
ON AVERAGE COVER CROPS REDUCED PERCOLATION (RECHARGE) BY 1.2 INCHES PER YEAR





**ON AVERAGE COVER CROPS
REDUCED PERCOLATION (RECHARGE)
BY 1.2 INCHES PER YEAR**

ET During Cover Crop Season (in)

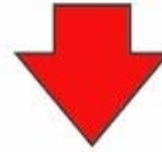


Cover Crops Increased ET by 2.1 in/year
(average of 9 studies)

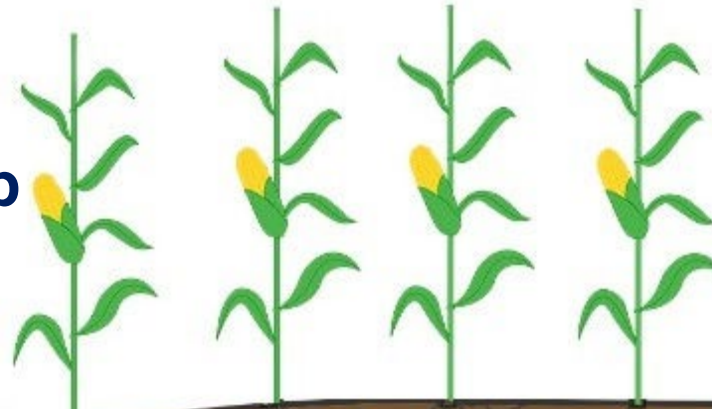
Evapotranspiration

Rainfall

Irrigation



**Imagine this is
your cover crop**



Runoff



Changes in
soil water
storage



Deep
percolation



Bottom of
root zone
of mature plant

Discussion

A scenic view of a fjord with steep, forested mountains on either side and a body of water in the foreground. The sky is filled with dramatic, grey clouds. The word "Discussion" is overlaid in white text on the left side of the image.



NO-TILL & ET

Mulching with Crop Residue will

- Reduce soil water evaporation
- Reduce overland runoff





Some Nebraska Studies

- Boldt et al. (1997), CPNRD, Ridge till vs. disk till
Annual ET reduction = 2.0 in/yr
- Irmak et al. (2019), Center pivot sites near Holdrege
Growing season ET reduction due to no-till = 1.2 in/yr
- Todd et al. (1991) WCREC, North Platte
Growing season ET reduction due to no-till = 1.4 in/yr

The ET reductions are based on a conventional disk and or chisel system that includes **spring and fall tillage**

A photograph of a cornfield with a central path of mulch. The corn plants are green and growing in rows. The mulch path is made of dry corn stalks and is wider than the rows. In the background, there are red flags on poles and a long irrigation system. The sky is overcast.

So what about the off-season?

North Platte


	Tilled Fall and Spring	Tilled Spring Only	No-till
Off-season P (in)	6.8	6.8	6.8
Off-season E (in)	5.6	5.1	3.9
Growing Season ET (in)	24.0	24.0	22.7
Annual ET (in)	29.6	29.1	26.6
Annual Savings w/no-till (in)	3.0	2.5	---



Mulching with Crop Residue will

- Reduce overland runoff

Not much new here. Rawls et al. (1980) and Volkmer (2014) both indicate that Runoff Curve Number for no-till is about 5 points less than for a disk/chisel till system.



**IMPACTS OF CONSERVATION
PRACTICES AND LAND AND
WATER USE PRACTICES ON NET
RECHARGE AND RUNOFF
CONTRIBUTIONS TO AVERAGE
ANNUAL STREAMFLOW**

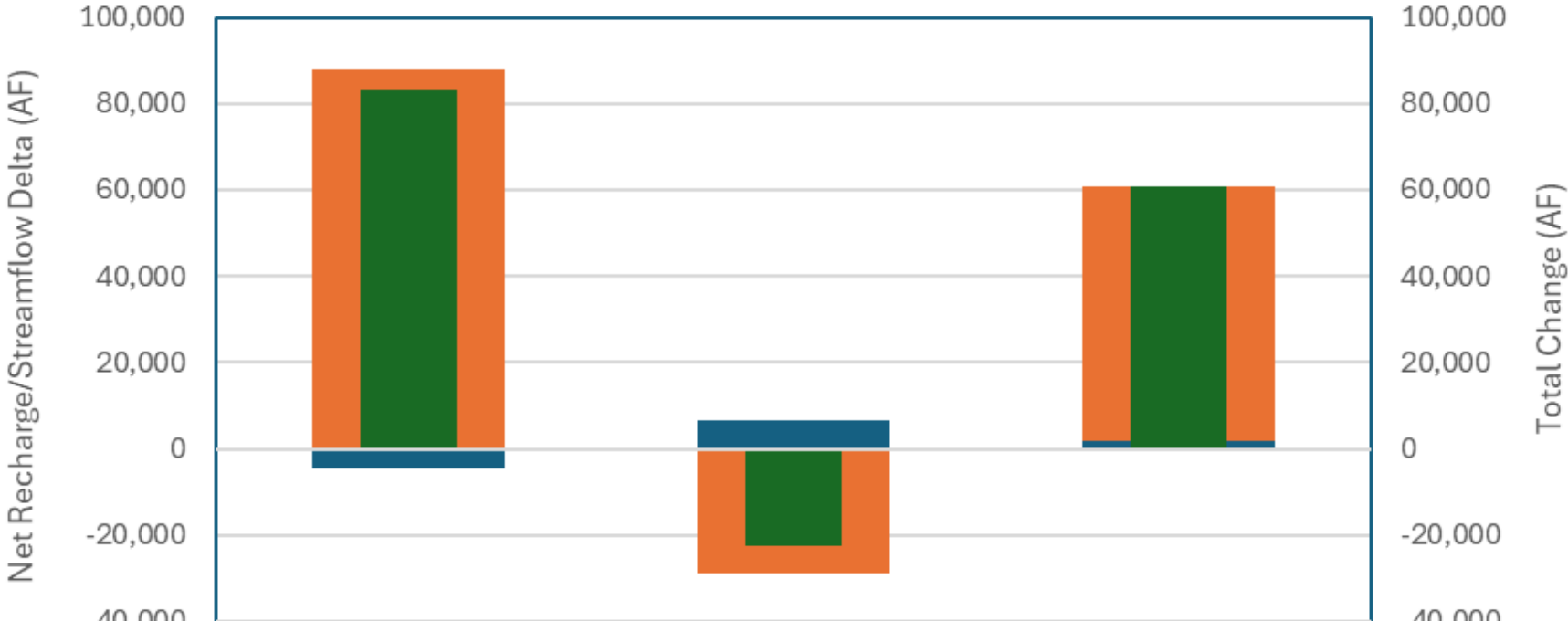
Impact of Production Practice Changes and Water and Land Use Changes on Net Recharge and Runoff Contributions to Annual Streamflow (SF)

	1997 Groundwater Only Irrigated Area (Ac)	Change in Groundwater Only Irrigated Area 1997-2020 (Ac)	1997 Dryland Area (Ac)	Change in Dryland Area 1997-2020 (Ac)	Impact of 2020 Updated Production Practice (AF)		Impact of Land Use Irrigation Status Change (AF)		Net Effect (AF)
					Net Recharge	Runoff contribution to SF	Net Recharge	Runoff contribution to SF	
Twin Platte NRD	207,911	55,350	2,298,224	-59,731	36,950	-1,994	-55,614	6,205	-14,453
Tri Basin NRD	406,660	53,036	450,483	-54,477	87,775	-4,633	-28,924	6,416	60,634
Central Platte NRD	819,474	50,570	1,238,013	-52,638	119,286	-8,442	-34,619	15,660	91,885

Twin Platte NRD

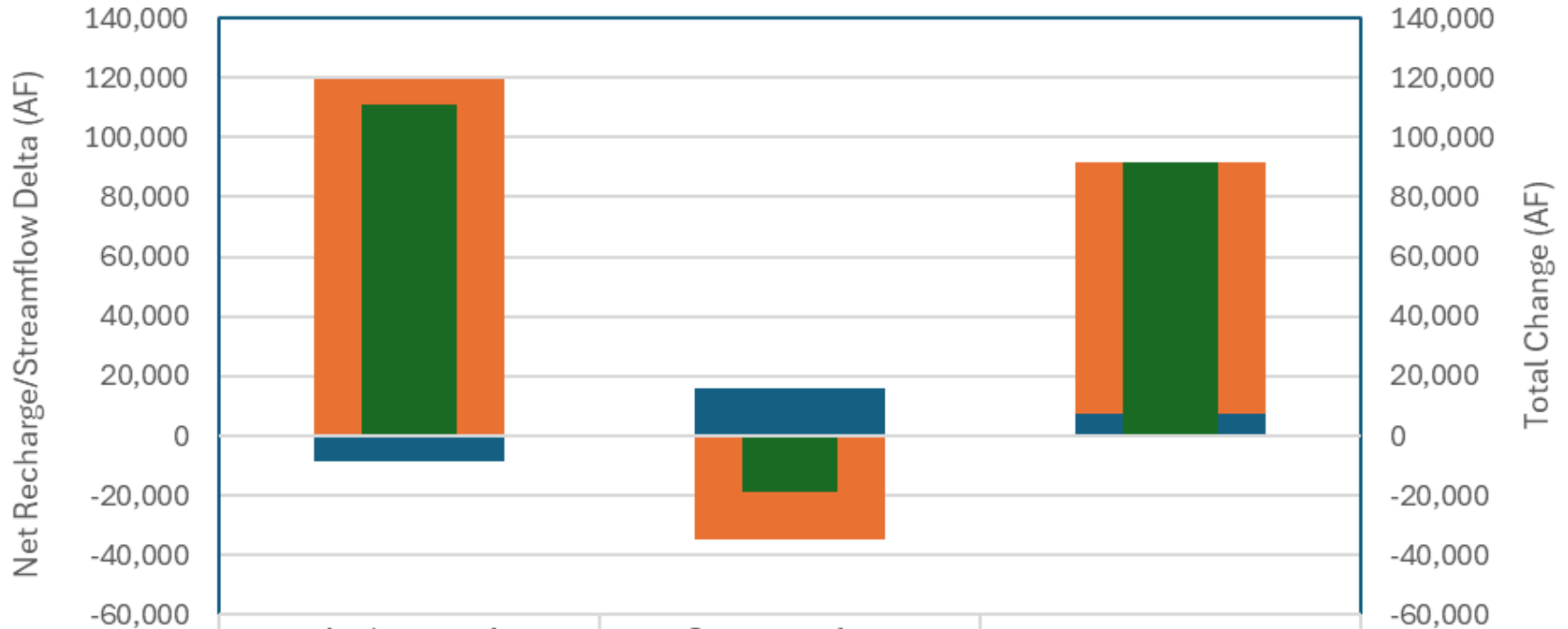


Tri-Basin NRD



	Application of Updated Production Practices	Conversion from Dryland to Irrigated Land Use	Net Effect
Net Recharge Delta	87,775	-28,924	58,851
Runoff to SF Delta	-4,633	6,416	1,783
Total Change	83,142	-22,508	60,634

Central Platte NRD



	Application of Updated Production Practices	Conversion from Dryland to Irrigated Land Use	Net Effect
Net Recharge Delta	119,286	-34,619	84,667
Runoff to SF Delta	-8,442	15,660	7,218
Total Change	110,844	-18,959	91,885



Future?

Double Cropping



Longer Relative Maturity of Hybrids?



Others

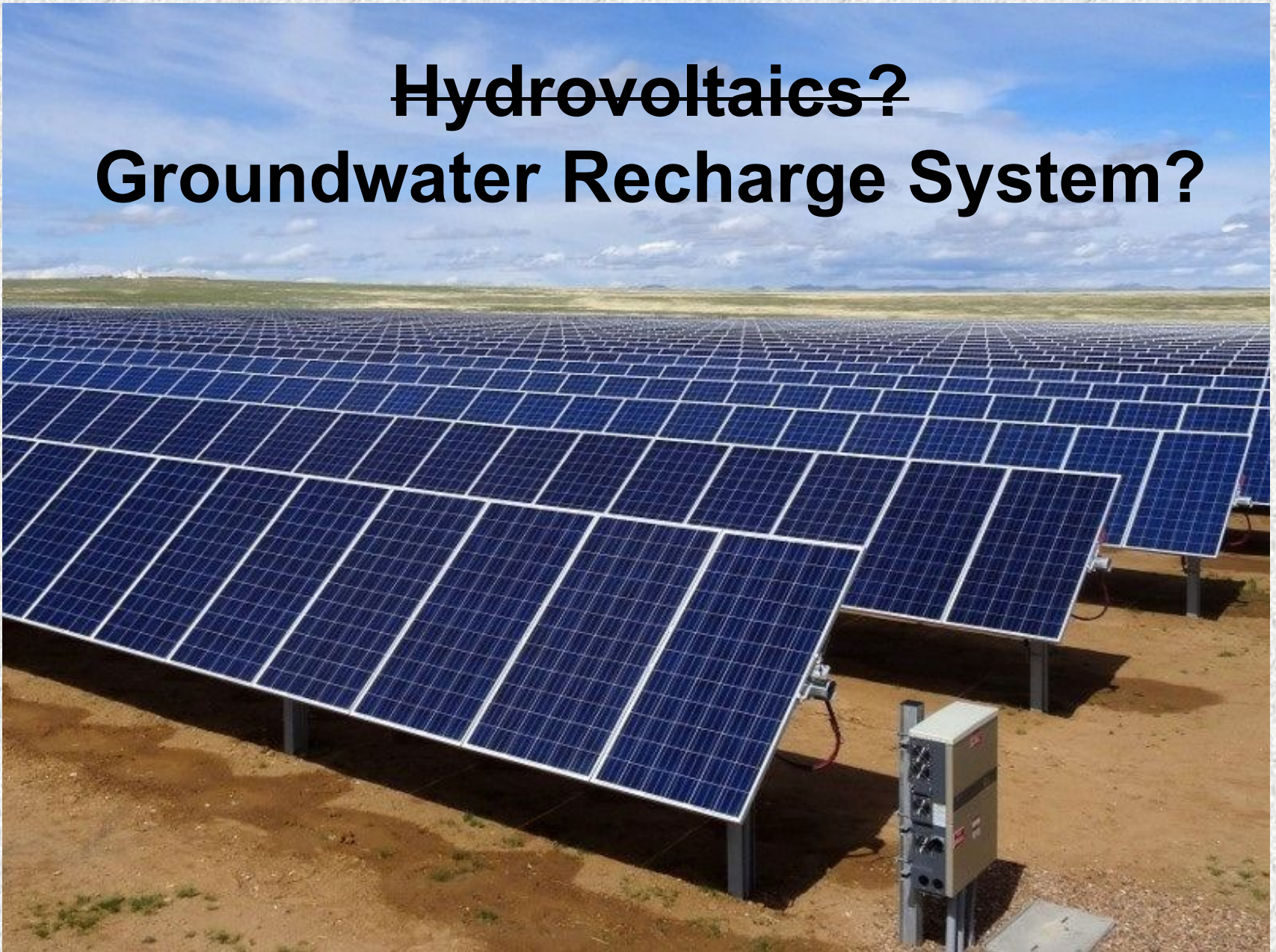
- Regenerative agriculture
 - Perennial cereal crops
-



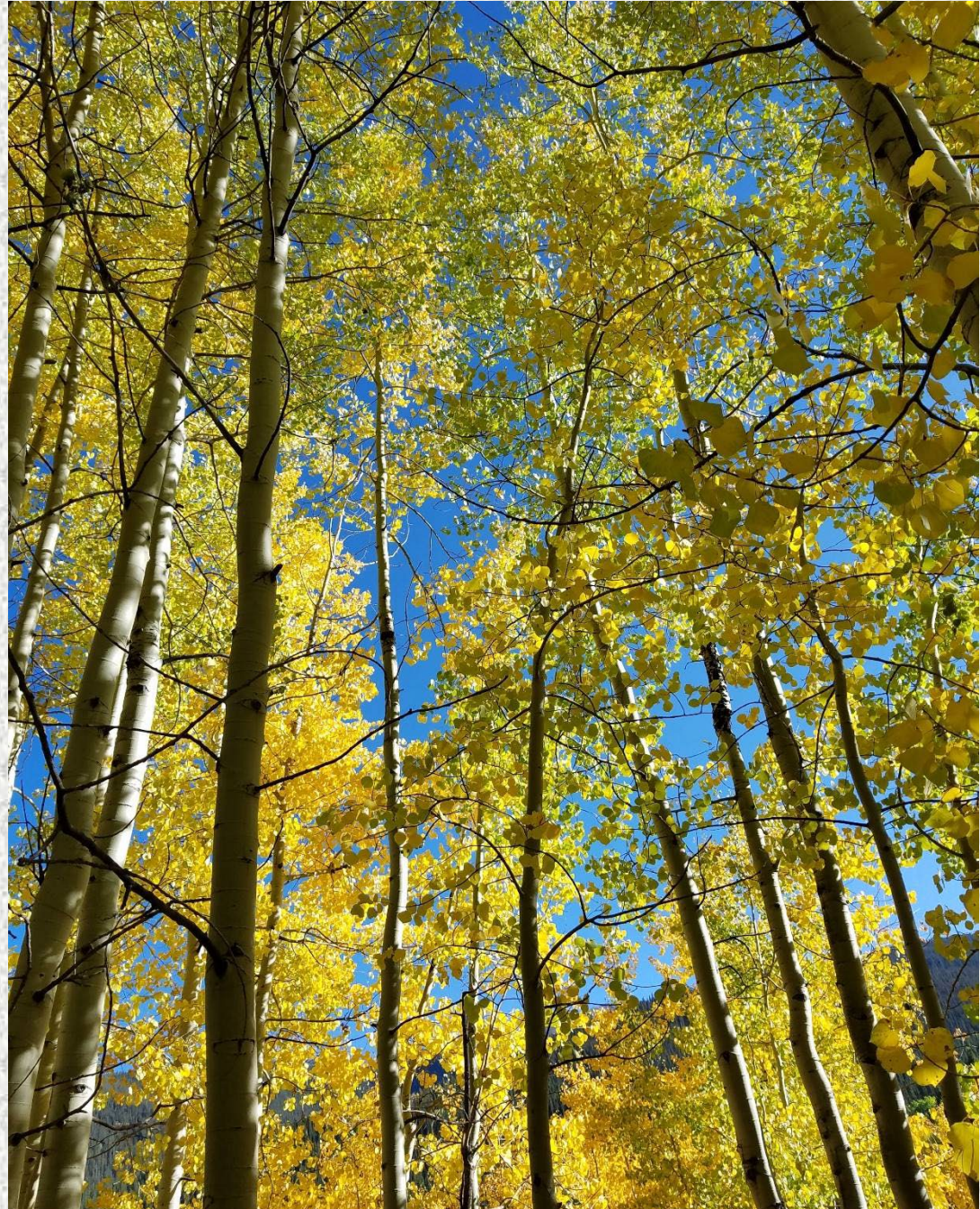
Agrivoltaics?



~~Hydrovoltaics?~~ Groundwater Recharge System?



Discussion



A photograph of a sunset over a large body of water. The sun is a bright orange orb on the horizon, with a shimmering reflection on the water's surface. The sky is filled with dark, dramatic clouds, some of which are illuminated from below by the setting sun, creating a range of colors from deep purple to bright orange. The foreground shows the dark silhouette of a rocky shore and some bushes on the right side. The text "The End" is written in a clean, white, sans-serif font on the left side of the image.

The End