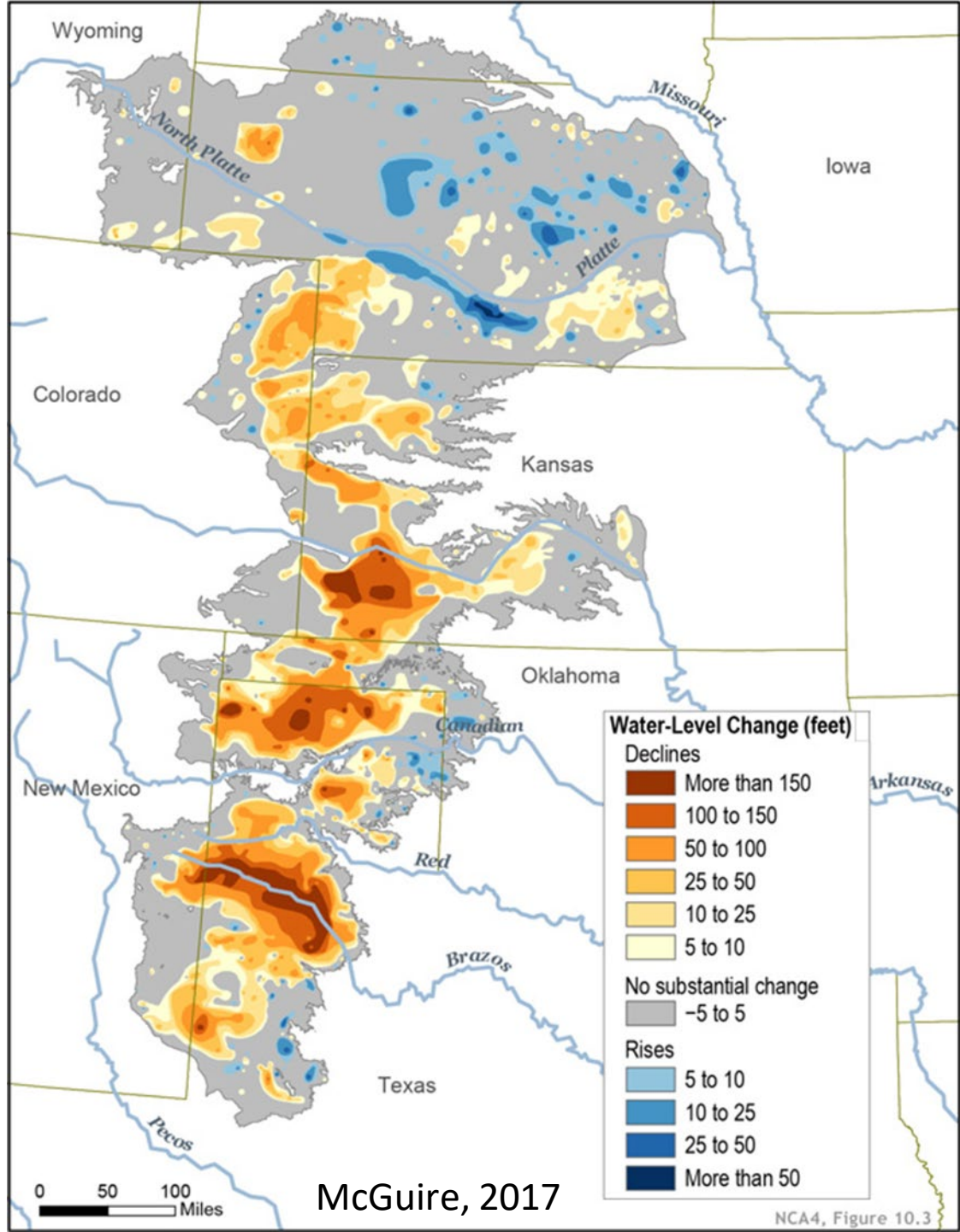
Improving Water Productivity and New Water Management Technologies to Sustain Rural Economies

In response to water resource problems related to a declining aquifer and climate change

Ogallala Aquifer Program

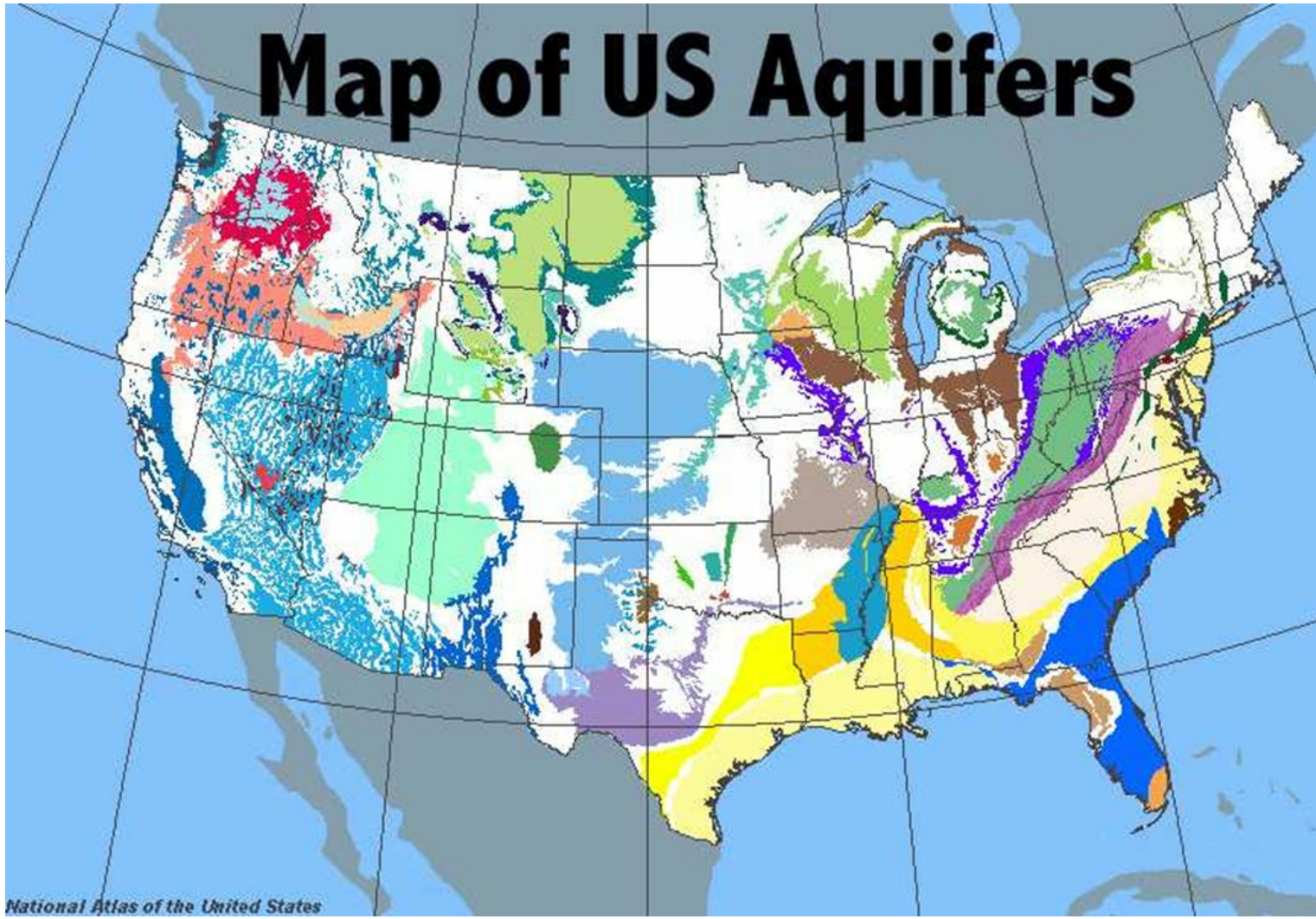
USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

Ogallala water-level change through 2015 →



USDA Agricultural Research Service

- Addresses water resource problems across American aquifers
- Focuses on:
- **Watershed Management**
- **Water Availability**
- **Crop Improvement and production**



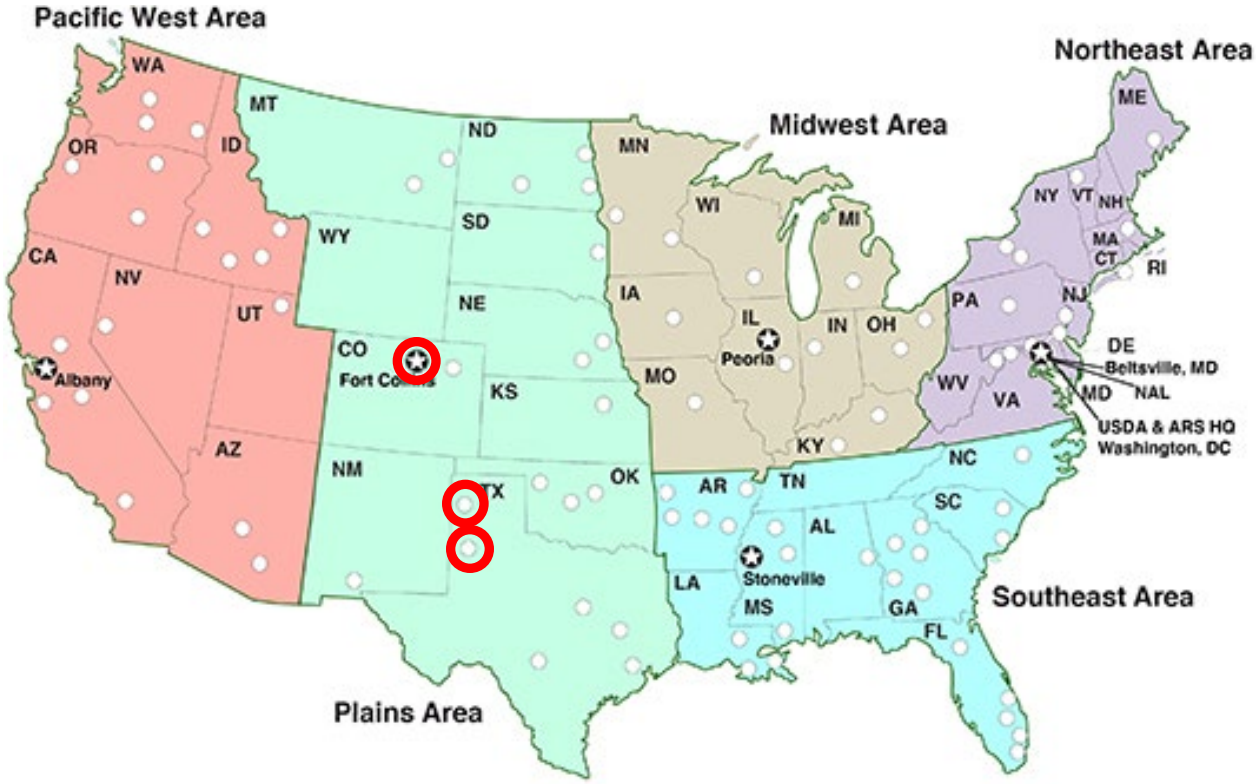
USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

USDA ARS Natural Resources and Sustainable Agricultural Systems – NRSAS

- National Programs in NRSAS
  - Water Availability and Watershed Management (NP #211)
  - Soil and Air (NP #212)
  - Grass, Forage, and Rangeland Agroecosystems (NP #215)
  - Sustainable Agricultural Systems Research (NP #216)
- Allied National Programs
  - Plant Genetic Resources, Genomics and Genetic Improvement (NP #301)
  - Crop Production (NP #305)
  - Food Animal Production (NP #101)

ARS Laboratories on the Ogallala Aquifer

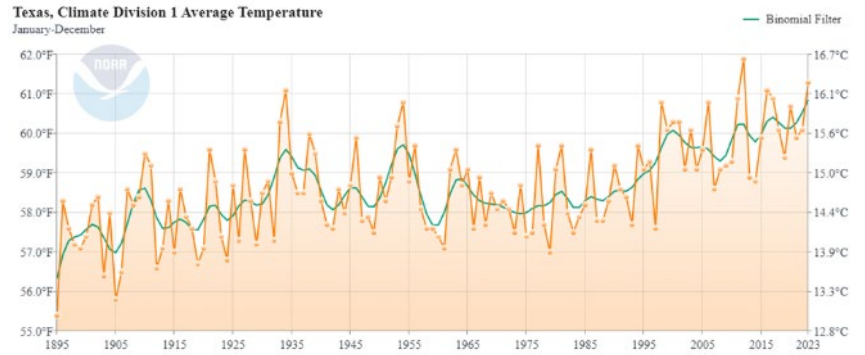
Bushland, TX (NP 211, NP 212, NP 216)
Lubbock, TX (NP 211, NP 212, NP 216, NP 301)
Fort Collins, CO (NP 211, NP 212, NP 216, NP 301)



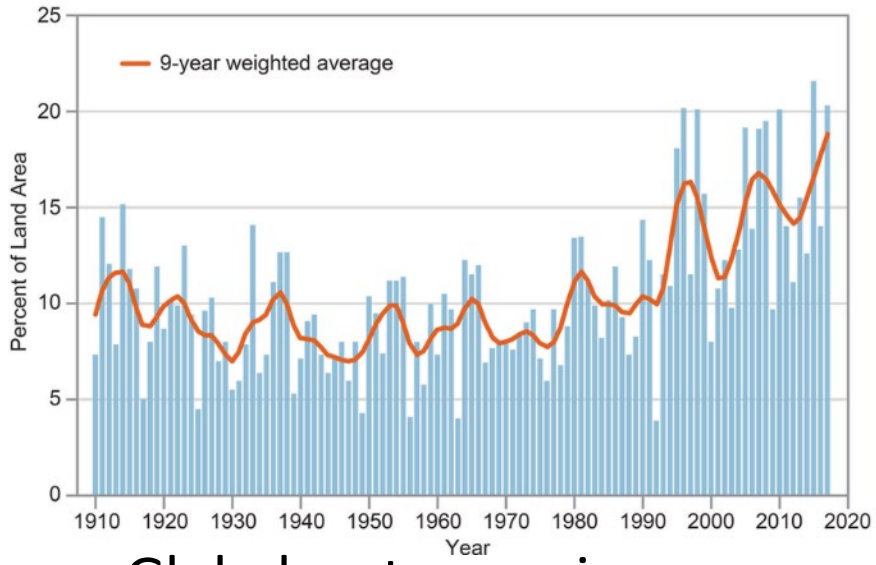
The Problem Set

- Ogallala aquifer declines restrict present and future irrigation
  - Particularly in the central and southern high plains
- Precipitation and temperature changes make dryland agriculture less viable
  - Precipitation becoming more variable – larger, less frequent storms make rainfall less effective
  - Temperature is increasing – 2 degrees F since 1990 – causing crop water use to increase (up to 70 mm/yr) while effective rainfall decreases

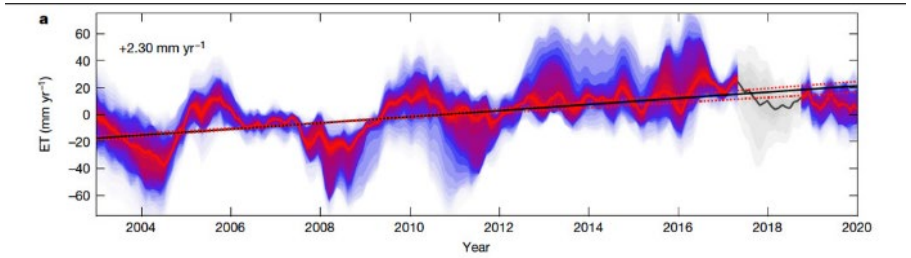
Temperature increase



Extreme event increase



Global water use increase



The Ogallala Aquifer Program – OAP

Established by Congress in 2003 as a consortium of four universities in Kansas and Texas and USDA ARS with a mission to improve the sustainability of agricultural industries and rural communities in these and adjoining states through innovative scientific research and technology transfer while conserving the natural resources upon which human activities depend (https://ogallala.tamu.edu/). The OAP's current objectives are:

- Develop and evaluate water management strategies and technologies, including dryland cropping systems, that could **reduce water withdrawals** for irrigation while maintaining/enhancing agricultural industry economic viability and the vitality of the Southern Ogallala Aquifer Region.
- Develop/evaluate management strategies and technologies to increase productivity and profitability of **forage or other short-season** cropping systems to reduce/eliminate water withdrawals.
- Improve the **understanding of hydrological and climatic factors** that affect water use and economic profitability, and provide estimates of the climatic, hydrologic, cropping, and profitability conditions that are likely to occur on the southern High Plains over the next 50 years.
- Determine the impacts of **alternative water withdrawal/use policies** on the economic viability of the agriculture industry and the vitality of the Southern Ogallala Aquifer Region.
- Develop best management practices for **alternative crops that increase the sustainability** of dryland farming or high value crops that maintain farm income with decreased pumping from the aquifer.

Texas A&M AgriLife Research | Extension · Kansas State University · West Texas A&M University · Texas Tech University · USDA United States Department of Agriculture Agricultural Research Service

Premises – Keys to unlocking conservation

- A key to reducing irrigation withdrawals while remaining economically viable is to increase crop water productivity (CWP - the economic yield per unit of water used) and nutrient use efficiency.
- Irrigation technology, cropping systems management, and crop varietal improvements serve this premise – allowing farming to remain profitable while using less water.
- Complementary keys include:
  - Public policy must provide the framework within which CWP increases result in decreased water withdrawals
  - Technology and knowledge transfer to farmers must be effective and germane to their economic problems

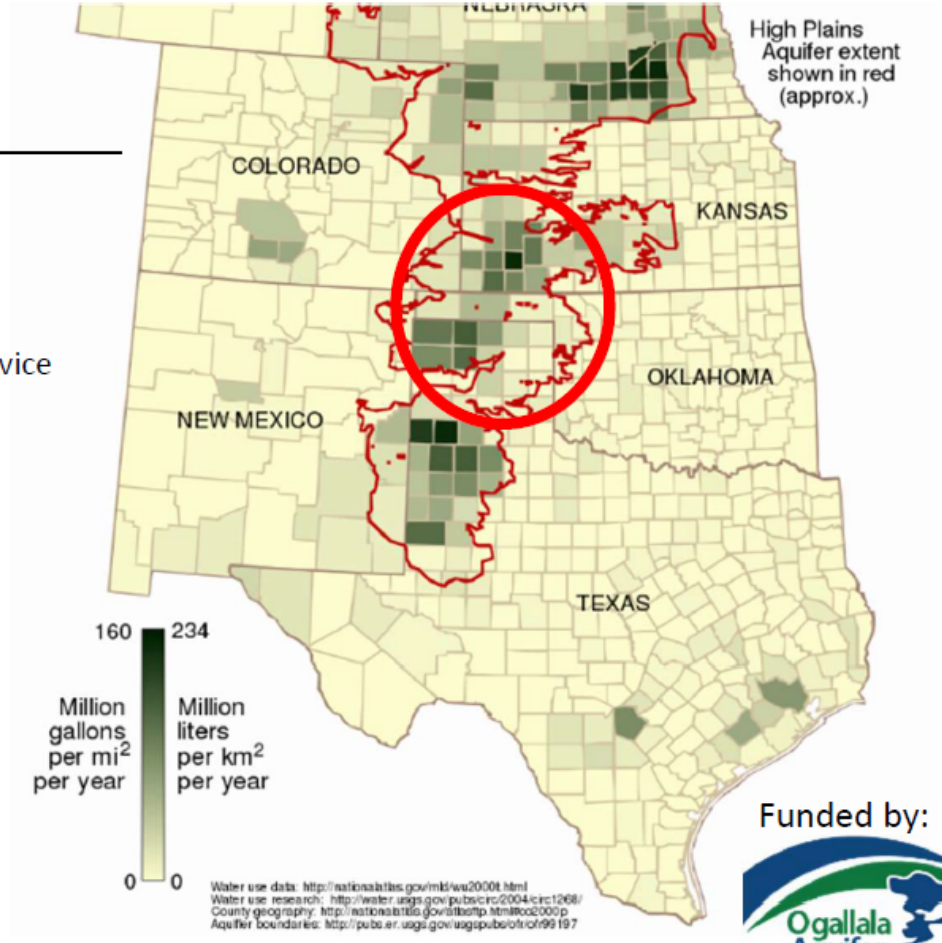
Cotton Production in “Thermally” Limited Environments – An OAP irrigation reduction project

- Shorter season varieties use less water
- Early planting is more productive
- Courtesy of Dr. Jourdan Bell, Texas A&M AgriLife Research and Extension

Project Team

Investigators:

- Jonathan Aguilar, Kansas State University
- Louis Baumhardt, USDA ARS-CPRL
- Jourdan Bell, Texas A&M AgriLife Research and Extension Service
- Craig Bednarz, West Texas A&M University and Texas A&M AgriLife
- Andrew Wright, Texas A&M AgriLife Extension Service
- Bill Golden, Kansas State University
- Bridget Guerrero, West Texas A&M University
- Lucas Haag, Kansas State University
- Gary Marek, USDA-ARS-CPRL
- Thomas Marek, Texas A&M AgriLife Research
- Donna McCallister, Texas Tech University
- Dana Porter, Texas A&M AgriLife Extension Service
- Aleksey Sheshukov, Kansas State University



Funded by:

Ogallala Aquifer Program

Texas A&M AgriLife Research | Extension

Kansas State University

West Texas A&M University

Texas Tech University

USDA United States Department of Agriculture Agricultural Research Service

Reducing evaporative loss/increasing CWP with SDI

Subsurface drip irrigation (SDI)
versus
Center pivot sprinklers

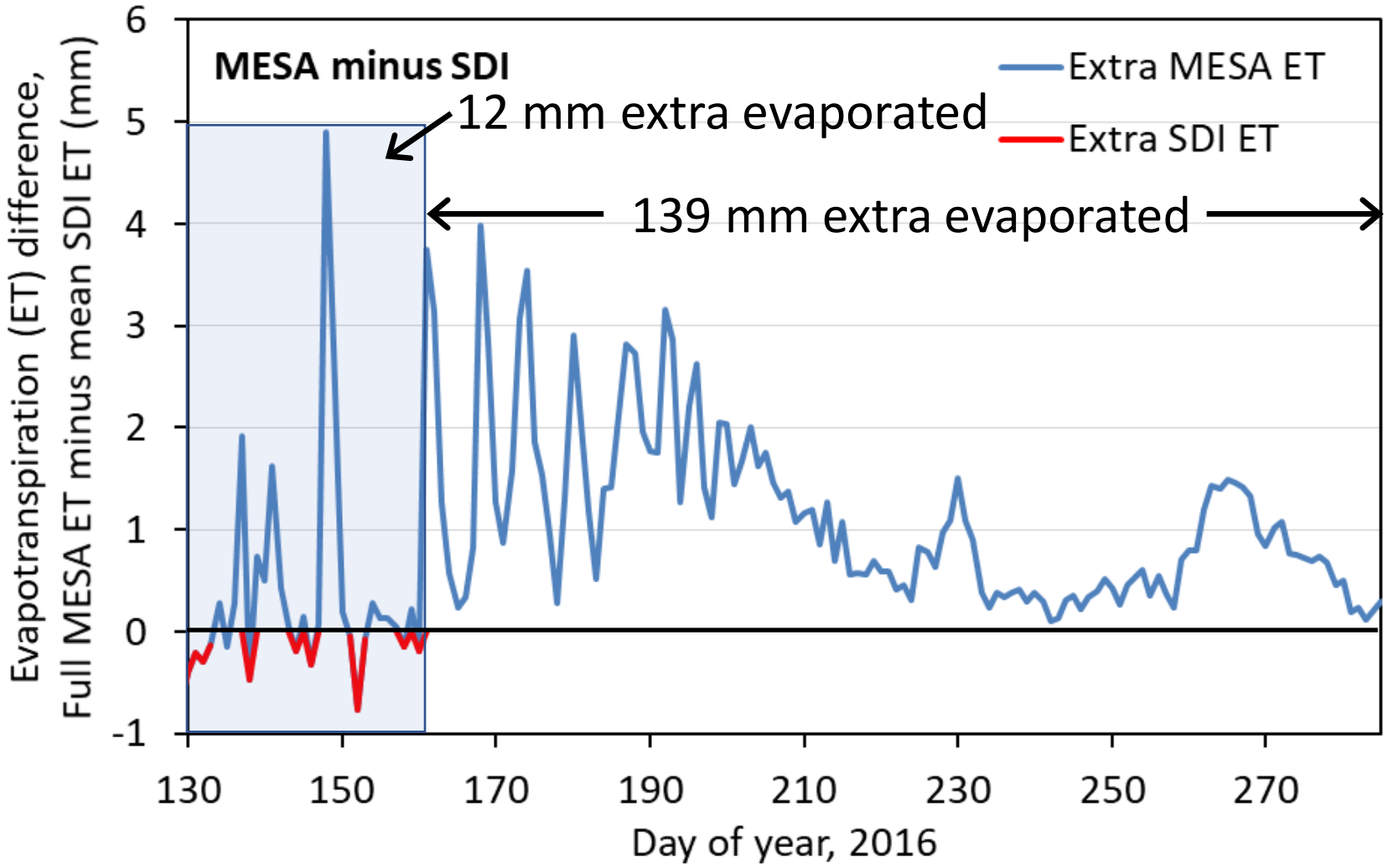
An OAP SDI and Center Pivot Crop Water Productivity (CWP) Demonstration Project

Application method affects Corn water use (ET) & CWP

SDI reduced overall maize water use by 17 to 18% while increasing yield by 0 to 20% and CWP by 18 to 46%.

SDI reduced evaporative (E) losses by 138, 151 & 129 mm in 2013, 2016 and 2018, respectively.

Similar results for cotton and sorghum.

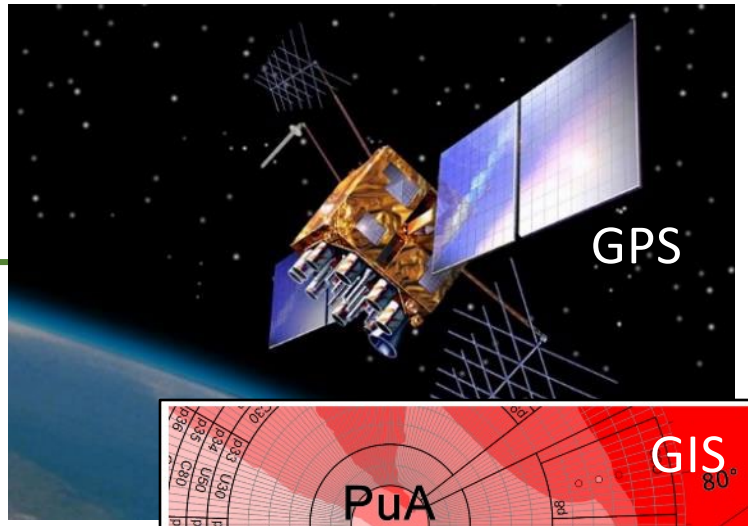


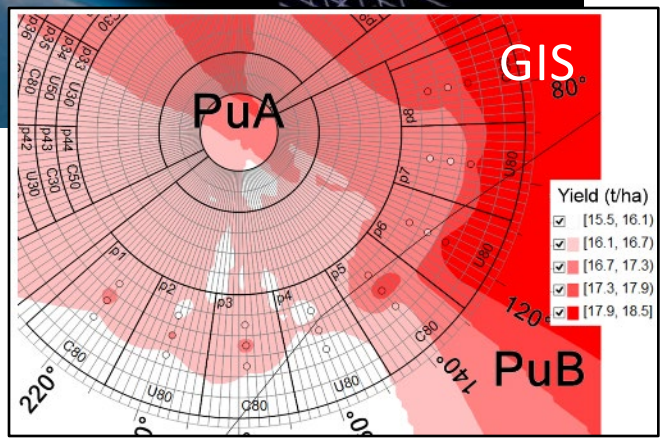
Evett, S.R., D.K. Brauer, P.D. Colaizzi, J.A. Tolk, G.W. Marek and S.A. O'Shaughnessy. 2019. Corn and sorghum ET, E, Yield and CWP as affected by irrigation application method: SDI versus mid-elevation spray irrigation. Trans. ASABE 62(5):1377-1393. https://doi.org/10.13031/trans.13314

Evett, S.R., G.W. Marek, P.D. Colaizzi, D.K. Brauer, and T.A. Howell, Sr. 2020. Are crop coefficients for SDI different from those for sprinkler irrigation application? Trans. ASABE. 63(5):1233-1242. https://doi.org/10.13031/trans.13920

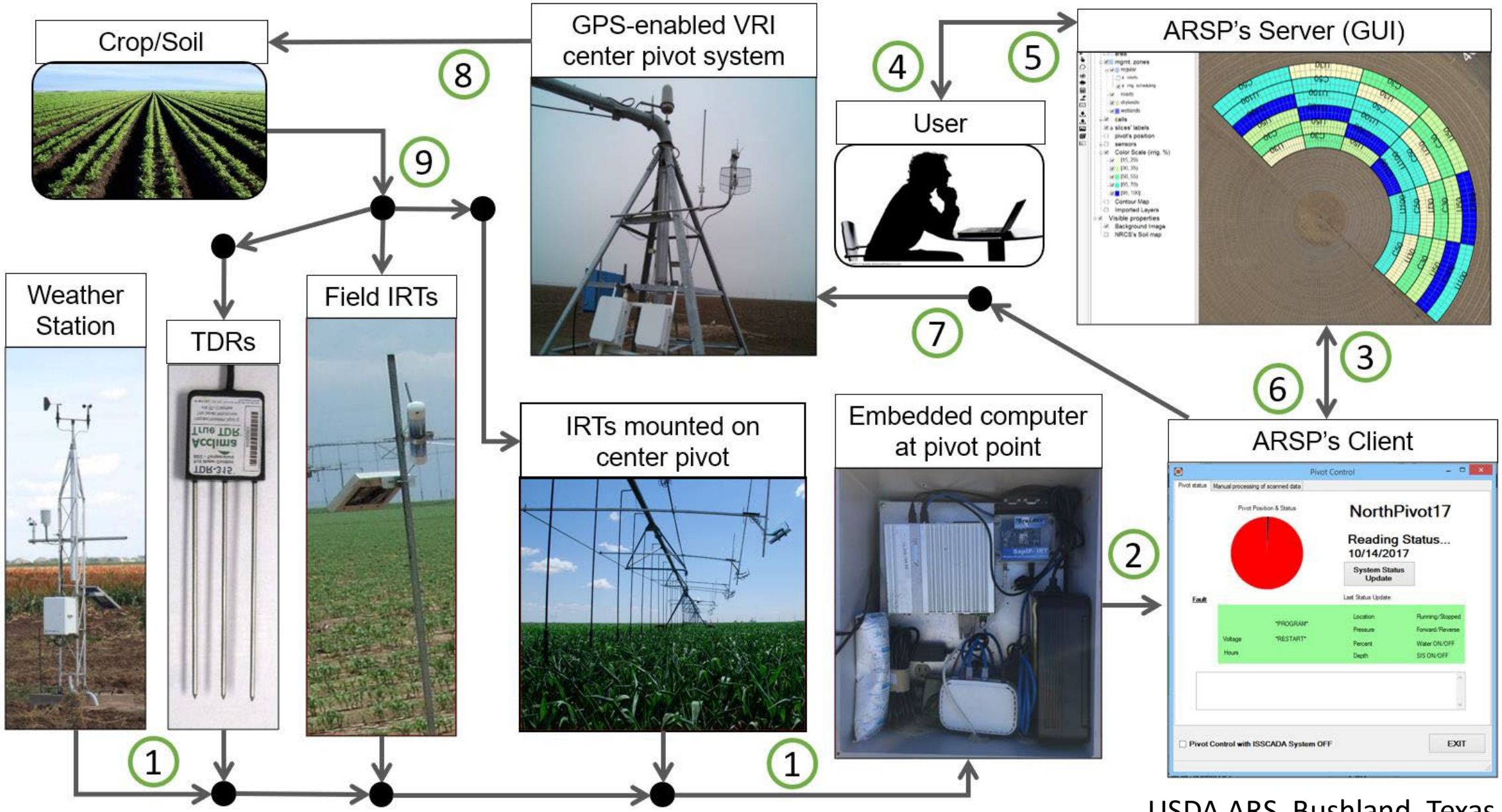
VRI Enabling Technologies – Support 3rd Blue Revolution

- Geographical Positioning Systems (**GPS**)
- Geographical Information Systems (**GIS**)
- Miniaturized computing power
- Data in the **Cloud**
  - Soil maps, satellite images, ET maps, weather, plant and soil water status, etc.
- **Cellular networks** allowing data almost anywhere
- Internet-of-Things (**IOT**) - Wireless, low-power, low-cost, distributed **sensor systems**
- **Open Source** Hardware & Software
- **Pressurized Irrigation → VRI**





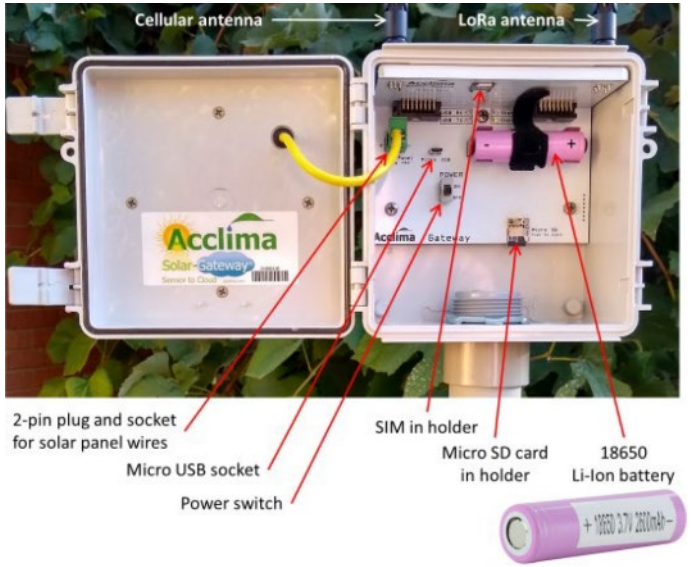
ISSCADA – A hardware/software decision support system



USDA ARS, Bushland, Texas

The Bushland system: Sensors, DSS & VRI Systems

- **Georeferenced sensor systems**
- Soil water sensors
  - Positioned in key areas of field
  - Used in hybrid algorithms combining plant and soil water status data
- Wireless canopy temperature sensors
  - Main indicator of crop water stress
  - Integrated crop water stress index (iCWSI) calculated
  - iCWSI used alone or in hybrid mode (humid locations)
- Wireless node and gateway systems - IOT
  - Position nodes where needed – Data goes to cloud

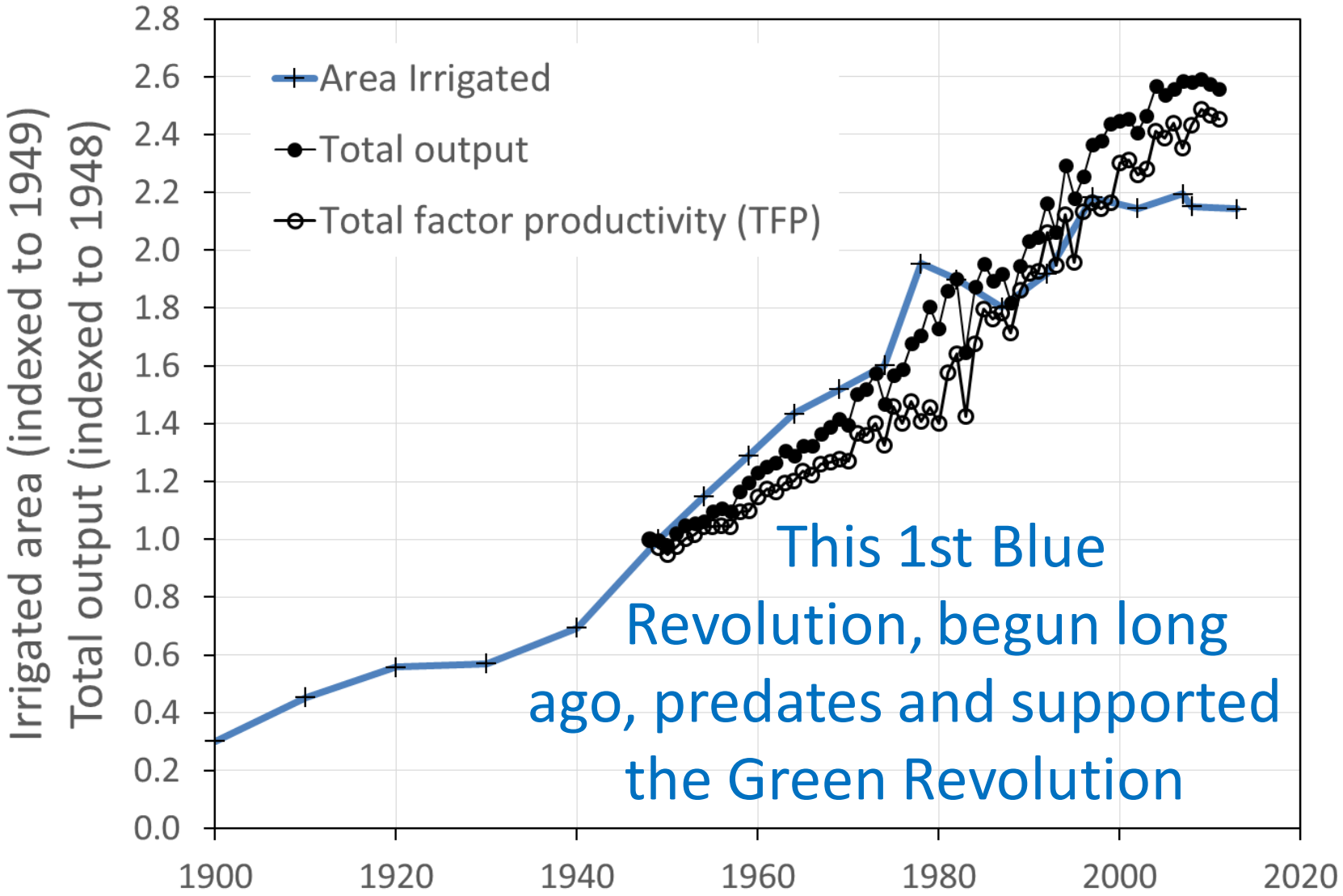


A national perspective – Irrigation in the USA
Plus notes on the irrigation efficiency "paradox"

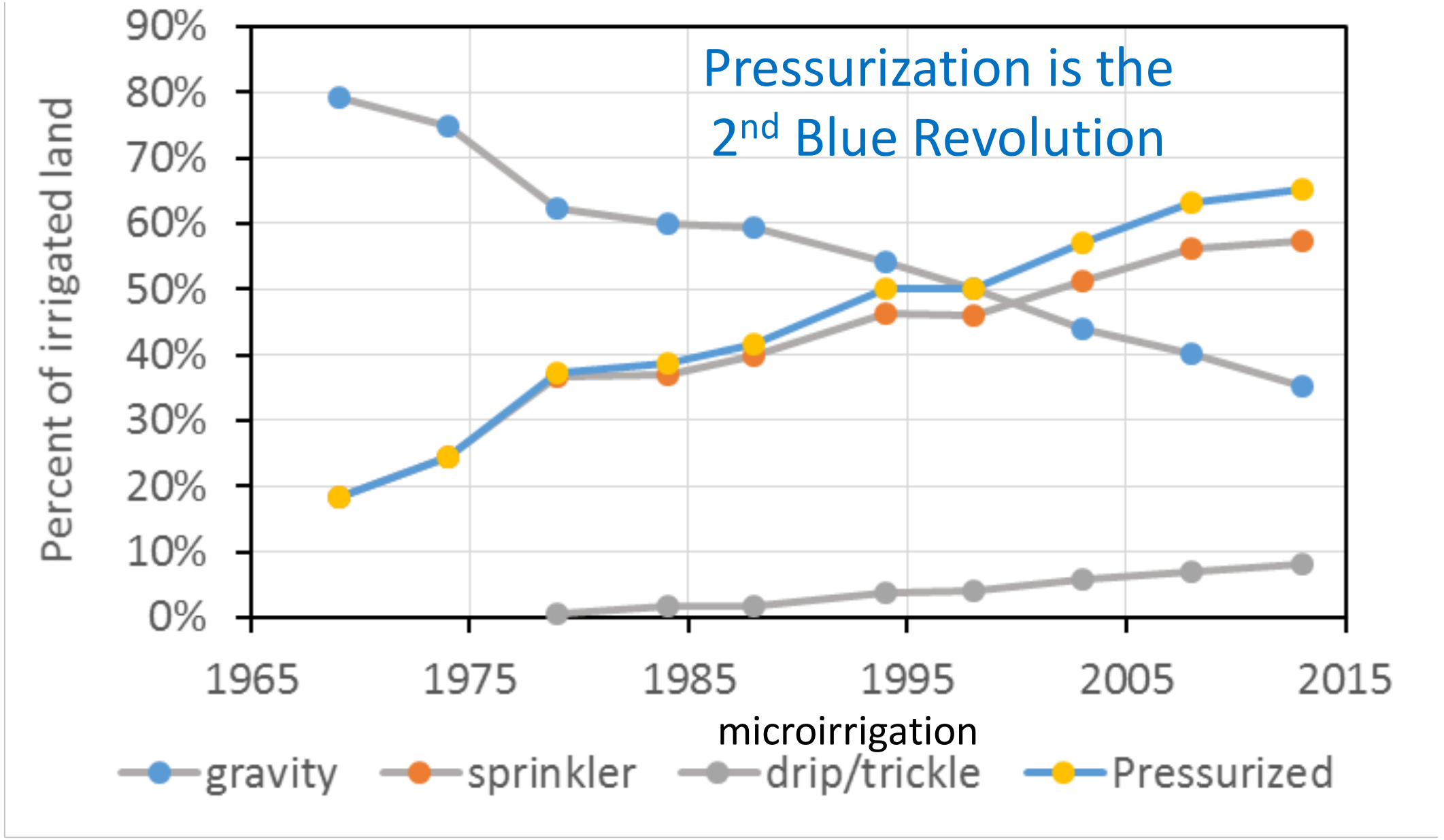
Science- & Water-Driven Productivity Increase

Decoupled from irrigated acreage increase

Irrigation is an adaptation to climate change

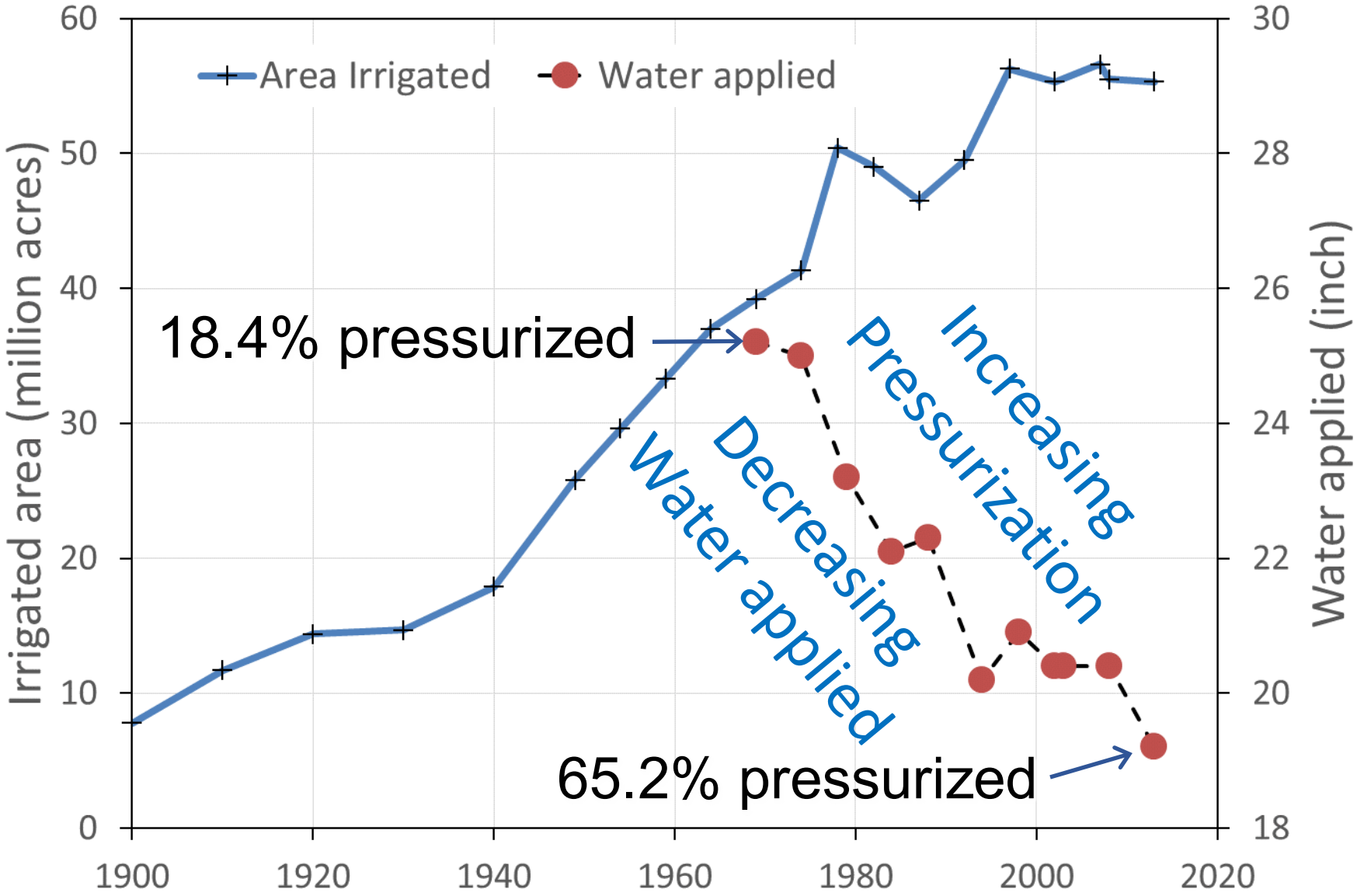


Conversion to Pressurized Systems



U.S. Irrigation – Pressurization: The 2nd Blue Revolution

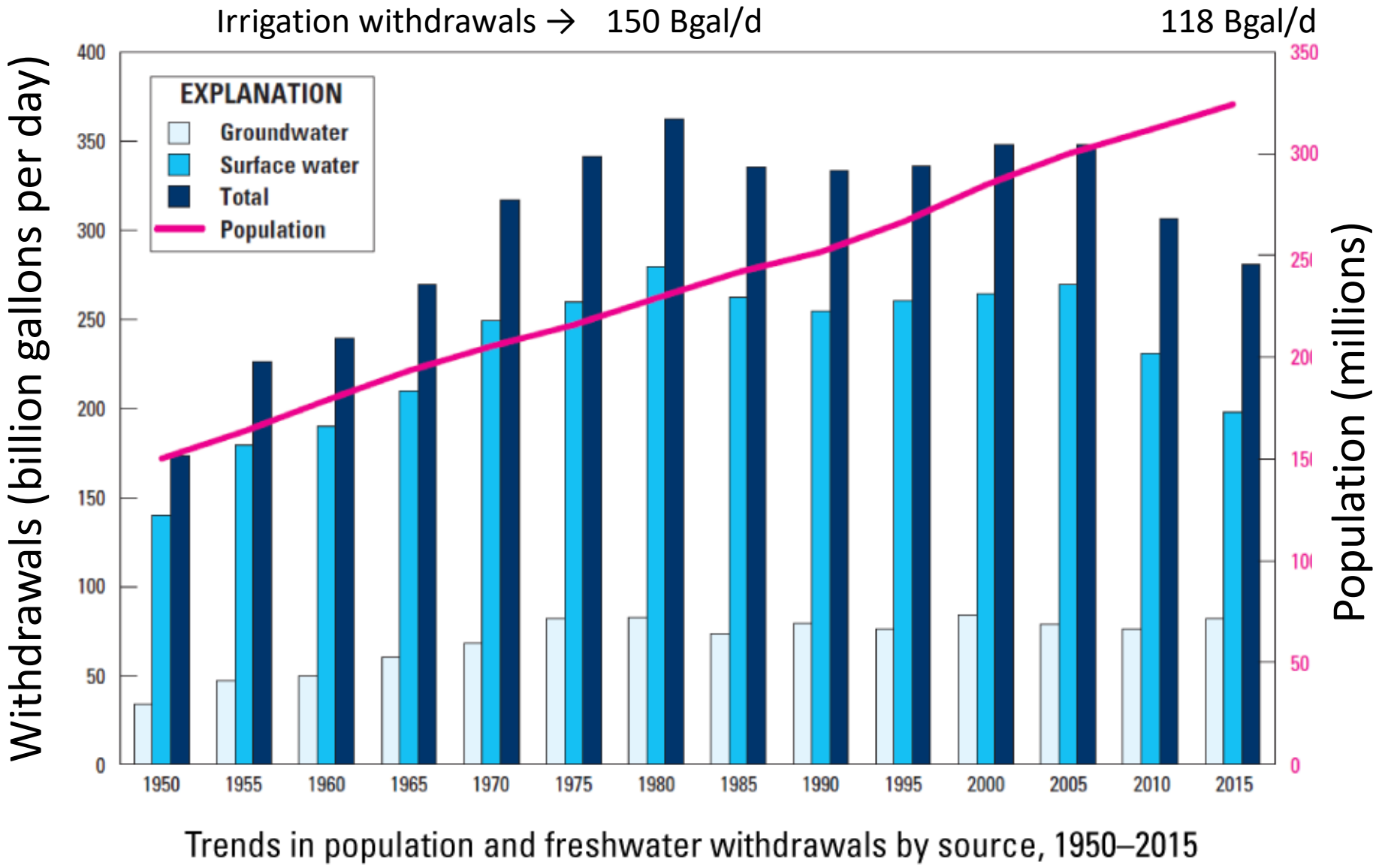
24% decrease in water applied per unit area as pressurized irrigation increased from 18.4% to 65.2%, 1974 - 2013



Source: ERS 2002, 2013

Trends in population and water withdrawals, 1950-2015

21% decrease in irrigation water withdrawals, 1980 - 2015



Trends in population and freshwater withdrawals by source, 1950–2015

Summary

- USDA ARS supports and collaborates with university partners and stakeholders across the Ogallala aquifer region to address water resource and societal concerns
- Modern irrigation technology adoption in the U.S. has corresponded with substantial decreases in irrigation water withdrawals – contrary to the “irrigation efficiency paradox”
- Shifts to forages and other short-season, reduced irrigation, crops are a focus of ARS and OAP research and development
- The OAP multi-disciplinary, multi-institutional approach yields substantial progress