

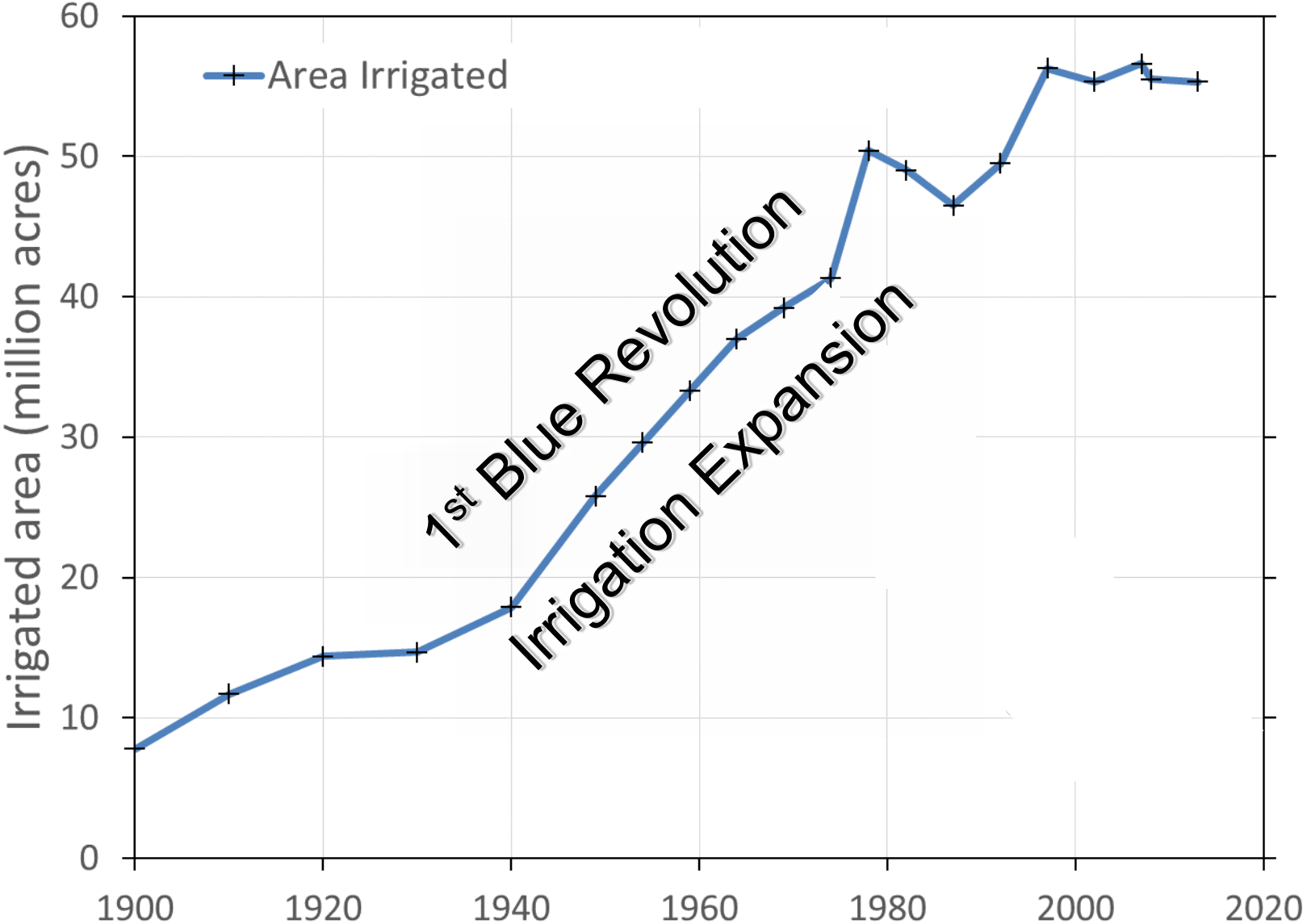
# Emerging Technologies for Water Management and Conservation: Precision Irrigation

**Steve Evett**  
**USDA ARS**



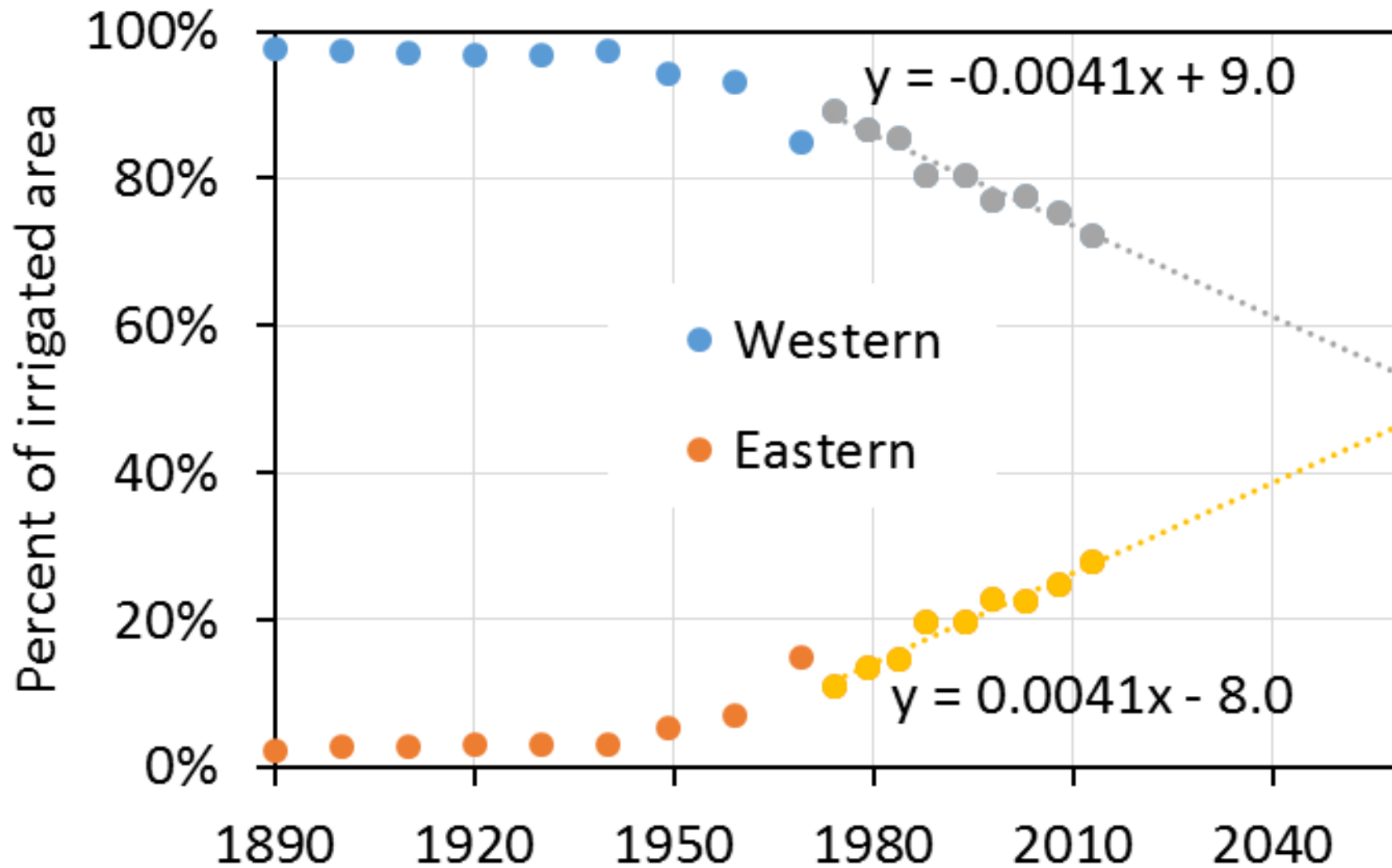
**Josette Lewis**  
**EDF**

# U.S. Irrigation – 1<sup>st</sup> Blue Revolution

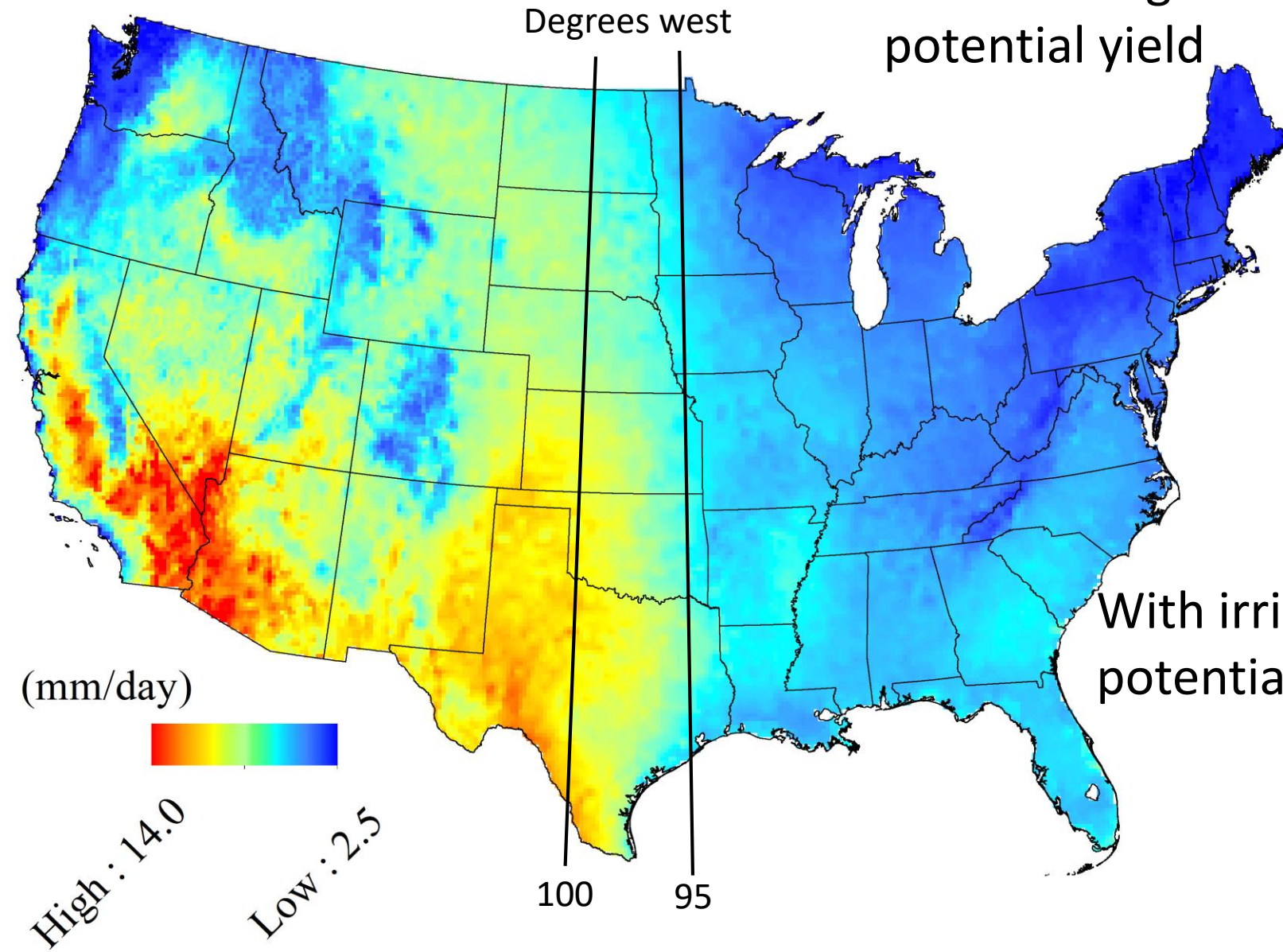


Source: ERS 2002, 2013

# Eastward migration of U.S. irrigation



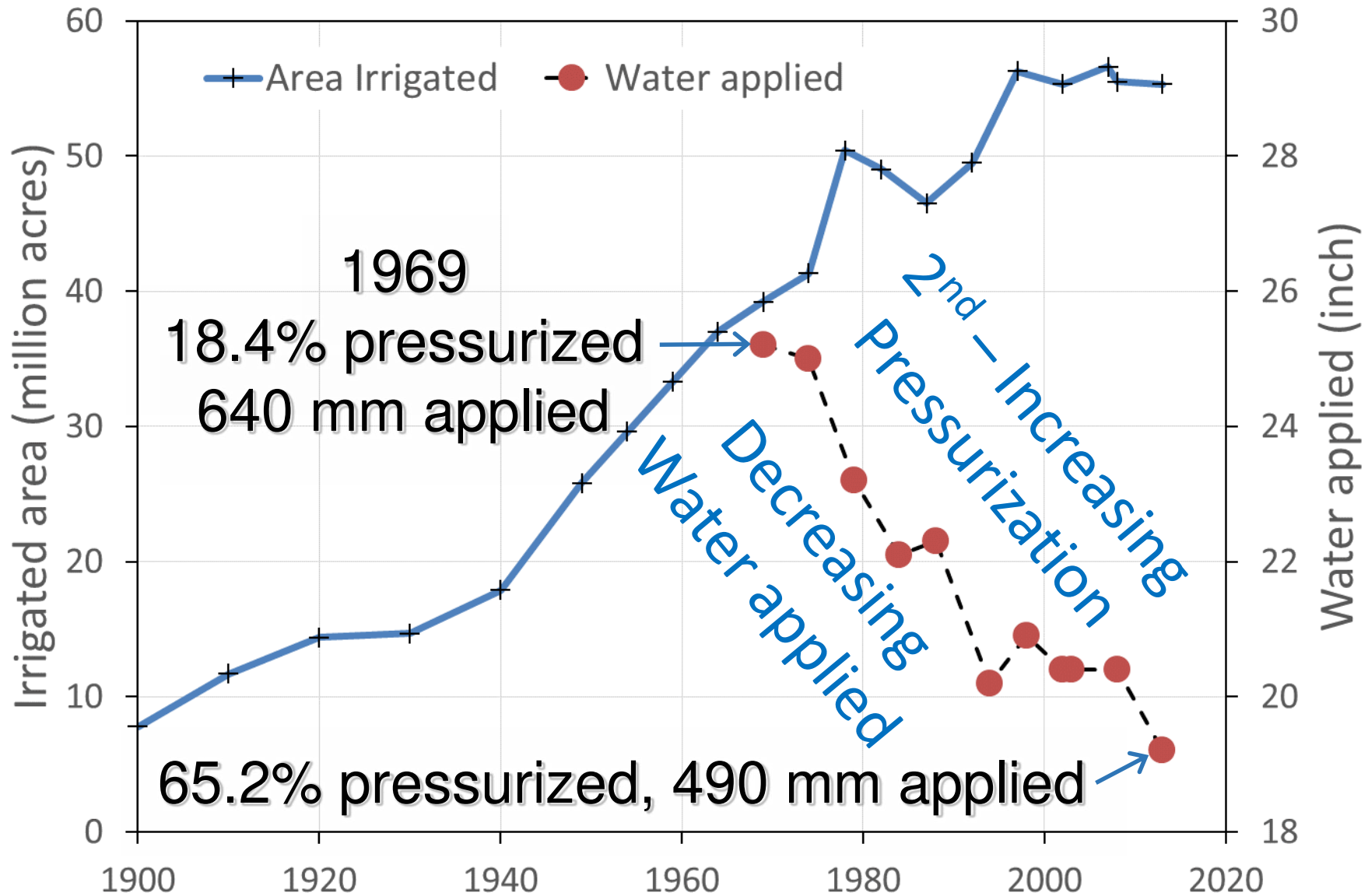
# Reference evapotranspiration



Without irrigation: 50% of potential yield

With irrigation: 80% of potential yield

# U.S. Irrigation – 2<sup>nd</sup> Blue Revolution



Source: ERS 2002, 2013



# More crop per drop

1967-2007

Water applied ↓ 14%

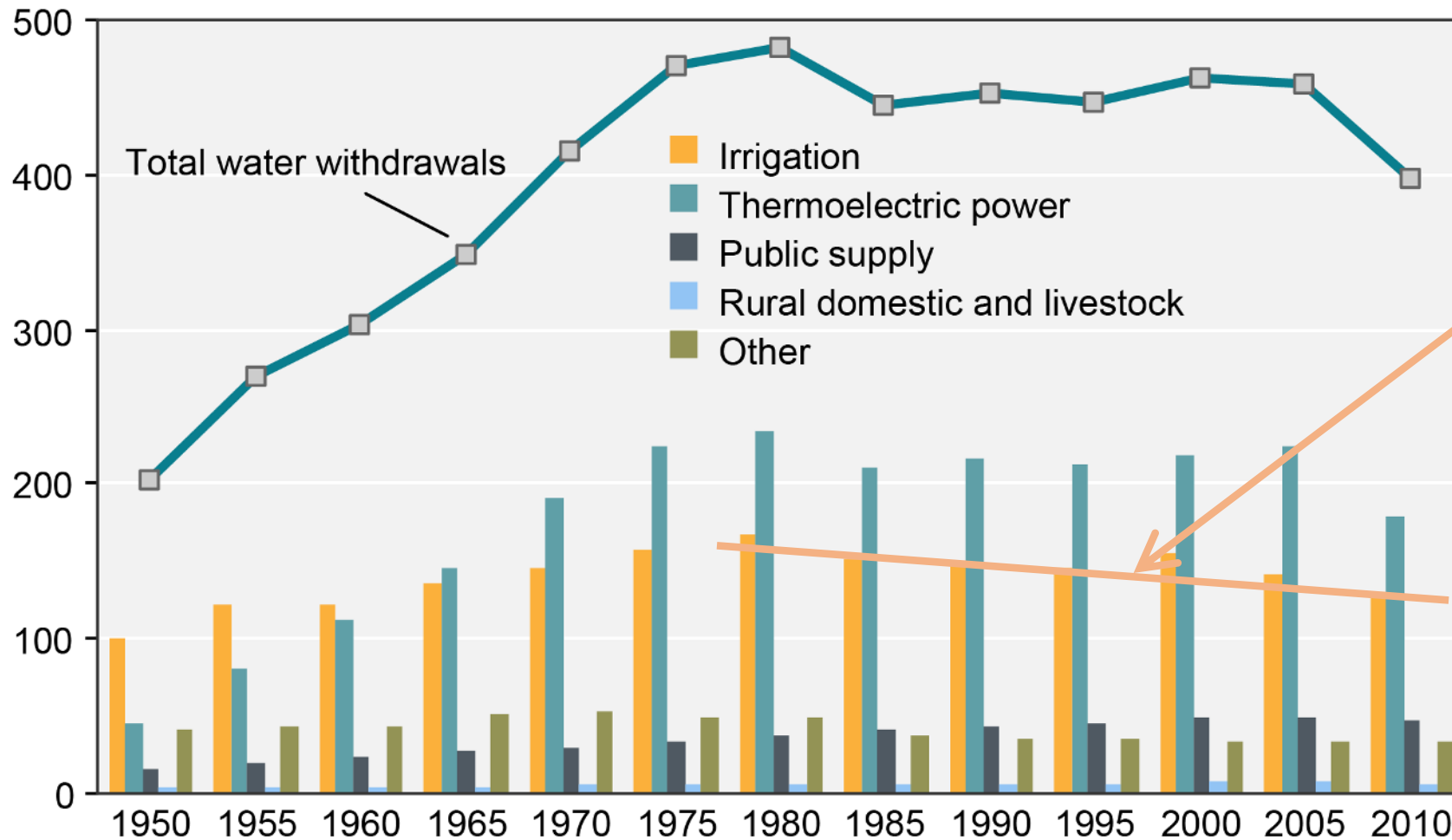
Crop ↑ 85%

'67: \$420 in crops per unit of water

'07: \$700 in crops

# Declining irrigation water demand

Withdrawals (million acre-feet per year)



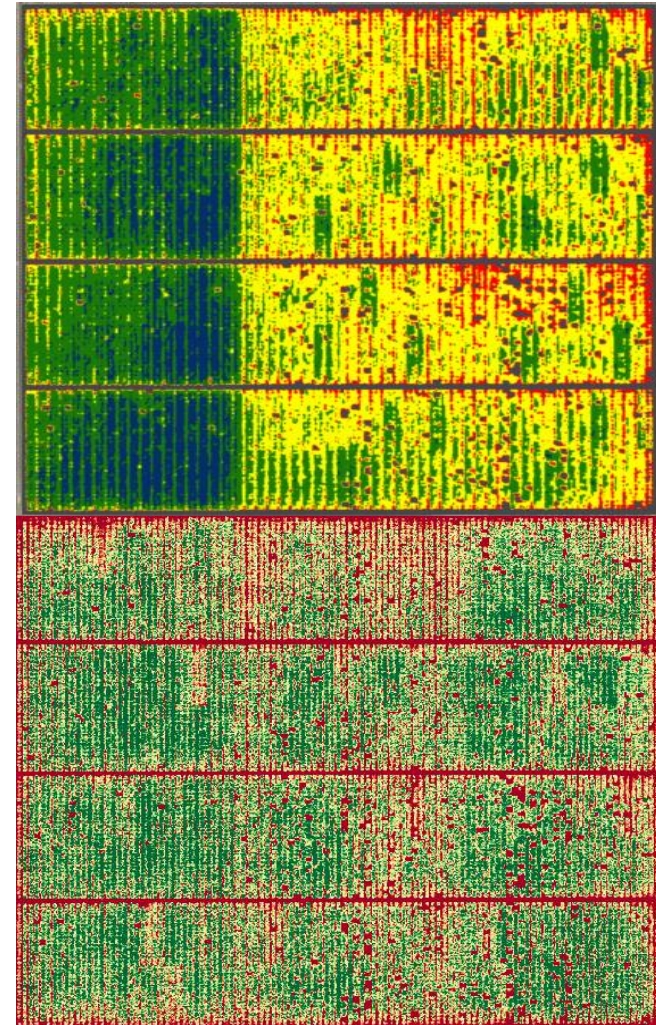
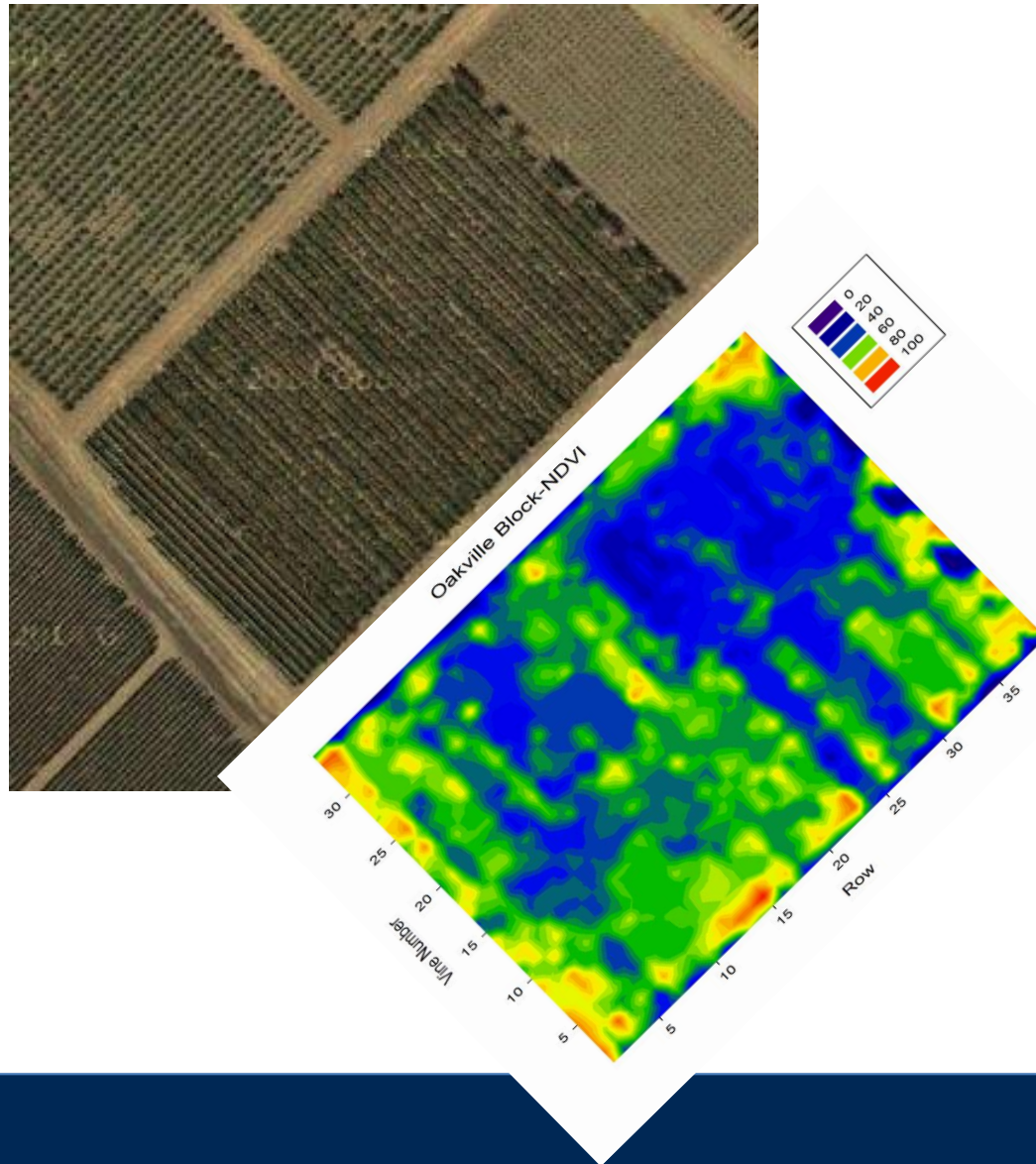
Source: ERS 2002, 2013

# 3<sup>rd</sup> Blue Revolution

**From uniformity to precision**



# Fields are not uniform



# Enabling Technologies – 3<sup>rd</sup> Blue Revolution

- GPS
- Miniaturized computing power
- Internet-of-Things: wireless, low-power, low-cost, distributed sensor systems
- Cloud based computing
- Open Source Hardware
- Open Source Software



# **Silicon Valley ⇌ Farm**

**Wireless field & plant sensors**

**Remote sensing**

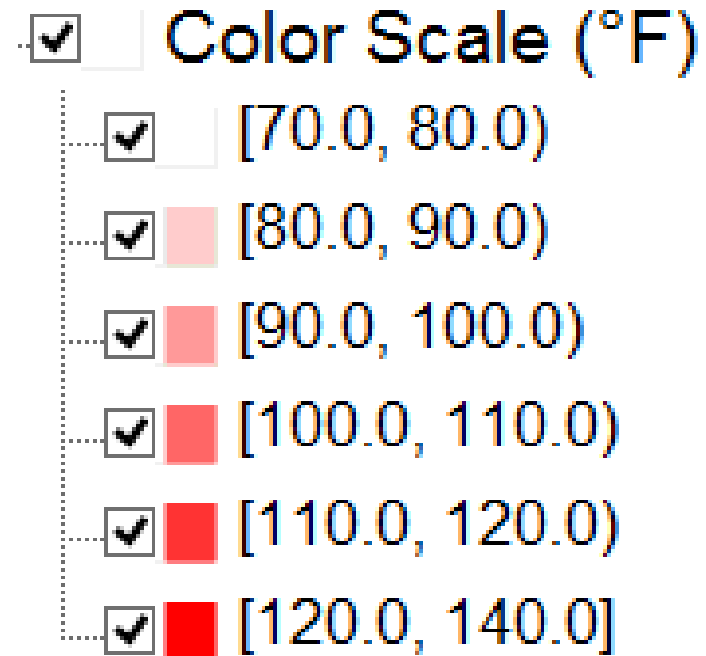
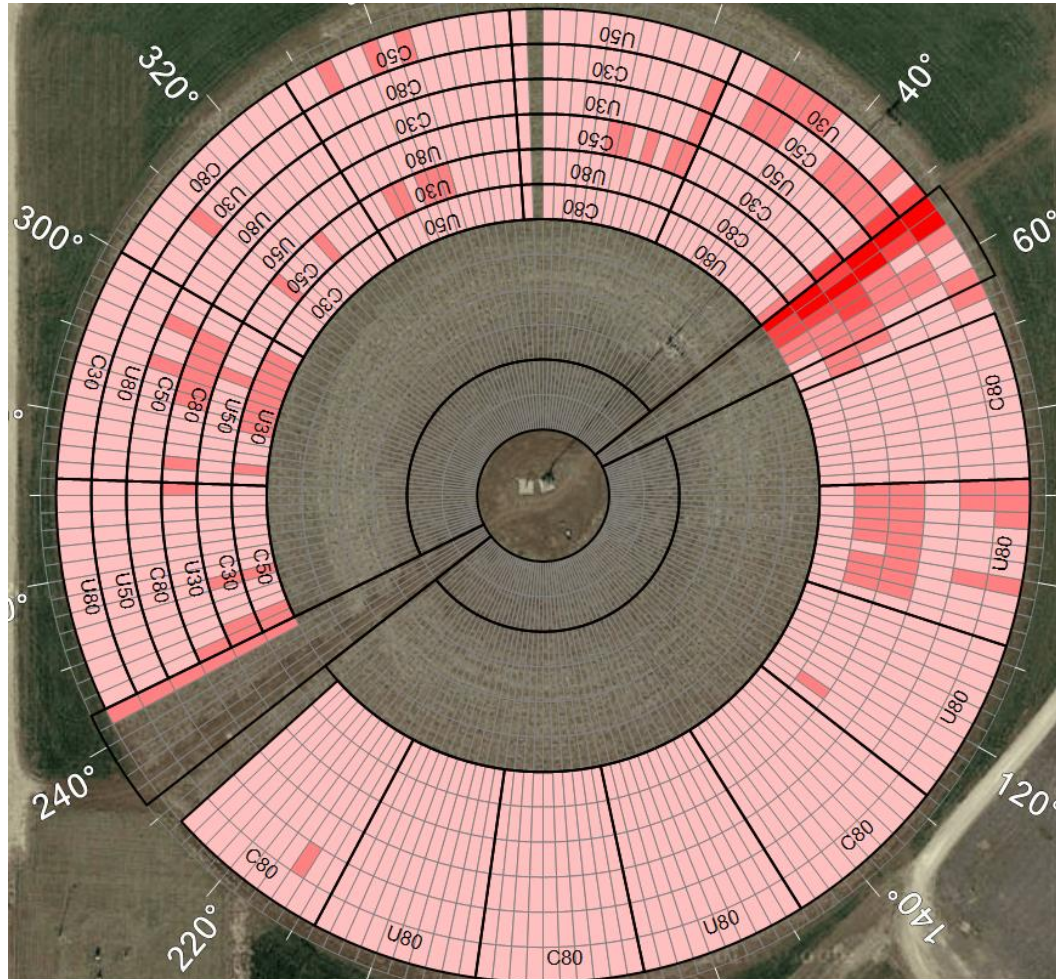
**Data analytics**

**Control systems**

**Integrated decision support tools**

# Automatic generation of temperature maps

Canopy temp. July 2<sup>nd</sup> 1 pm

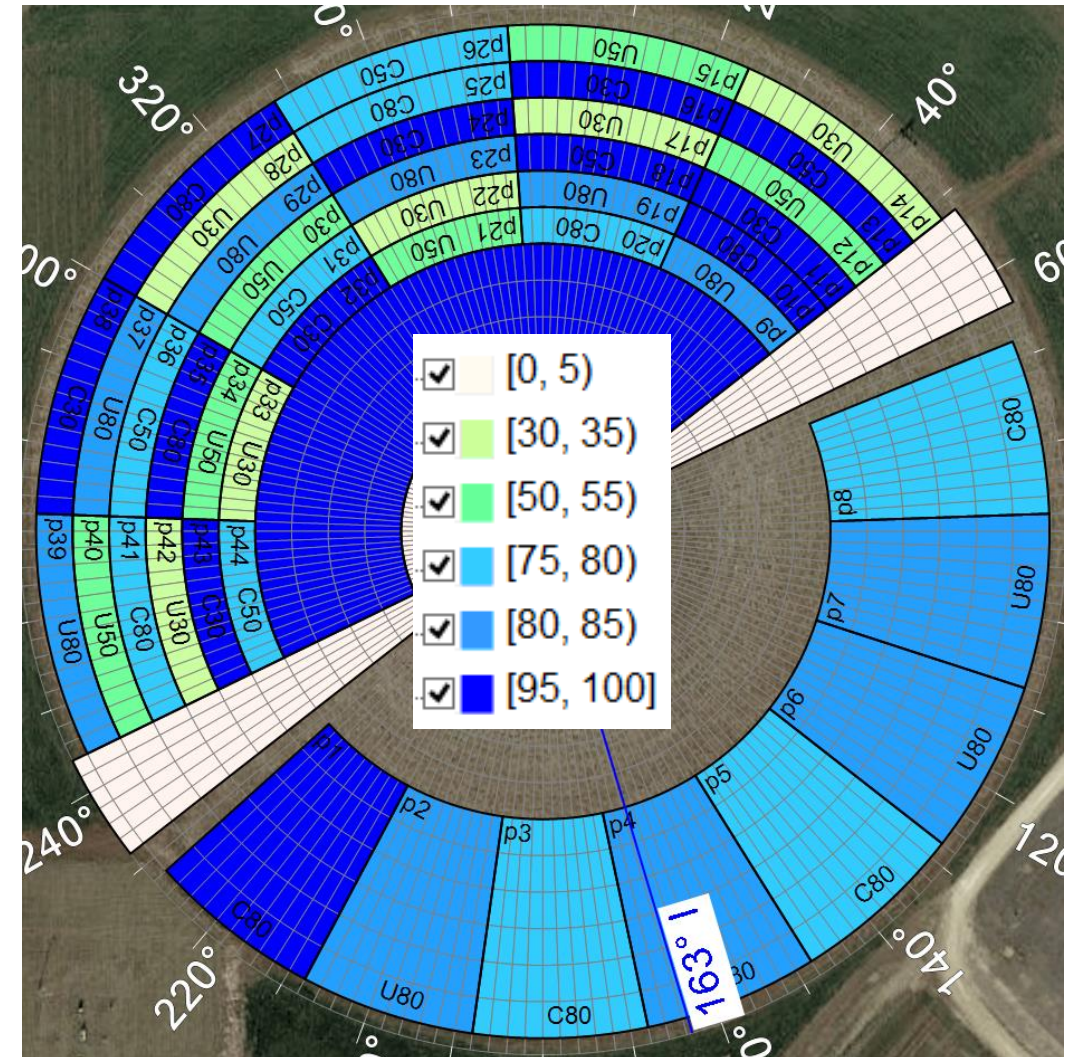
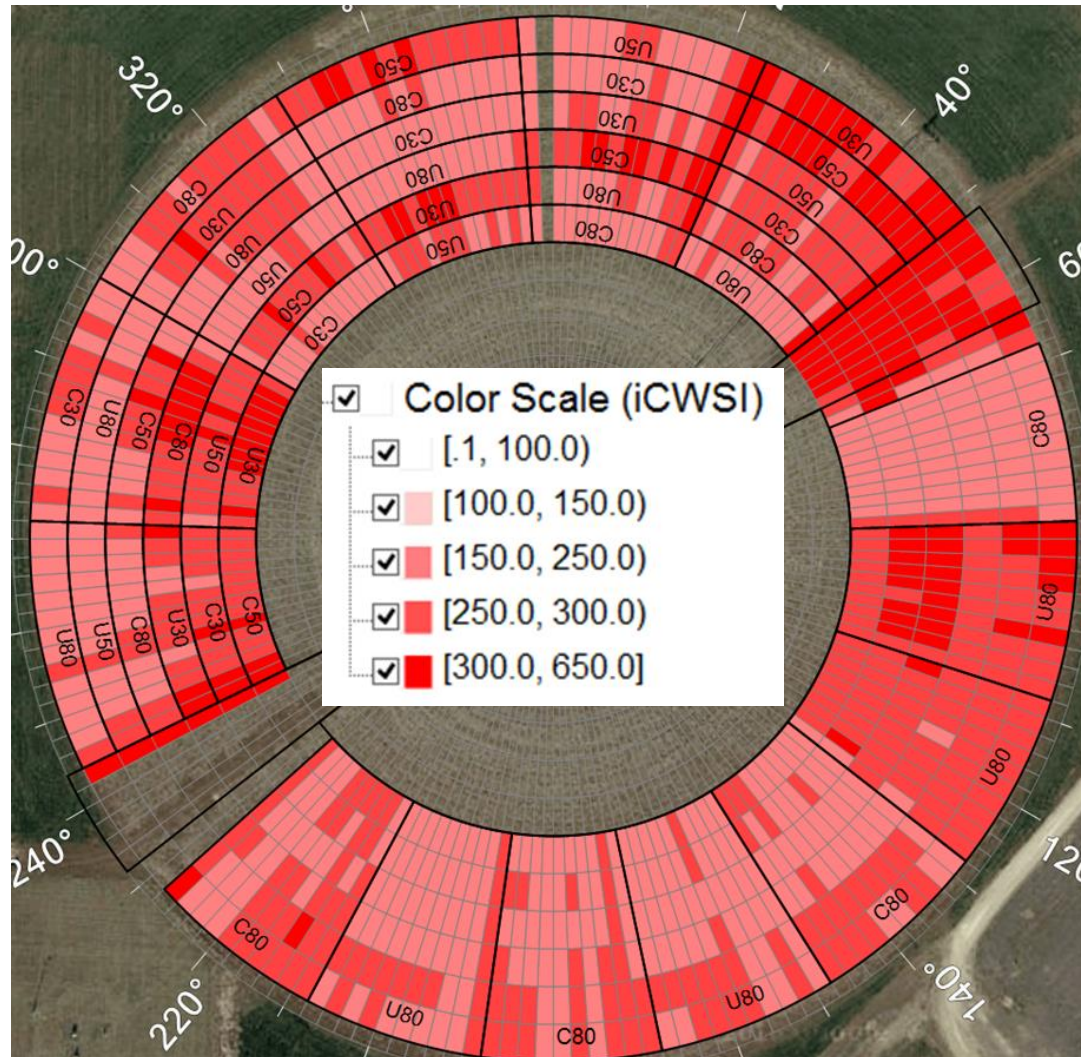


# iCWSI: Crop Water Stress Index

July 2<sup>nd</sup>

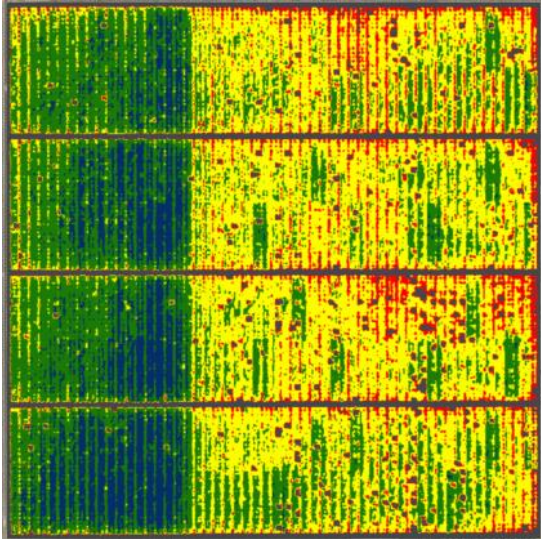
# Prescription Irrigation Map

July 3<sup>rd</sup>

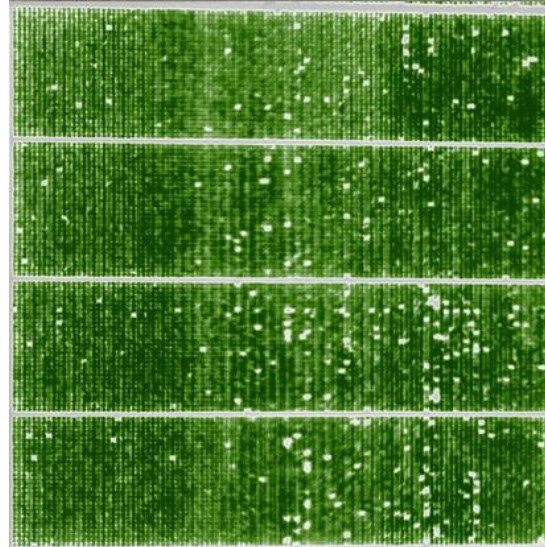


# Arial sensing using thermal infrared cameras

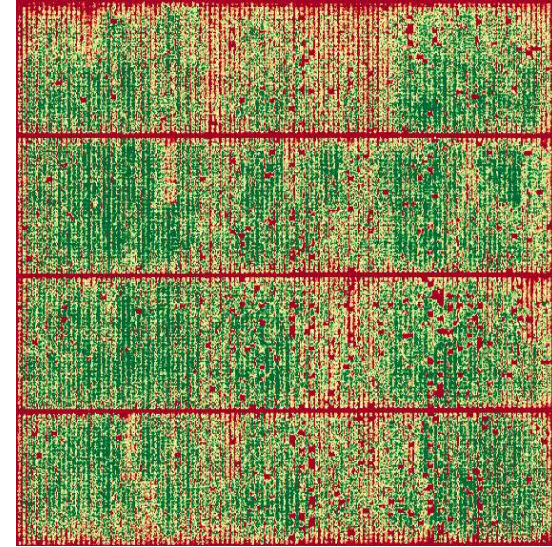
Water stress



Canopy vigor (NDVI)



Chlorophyll content



ceresimaging

# Putting it all together

- Sensors: move from measuring weather to soil to crop water status
- Data + controls: move from uniformity to variability
- More crop per drop