



# Trees as Hydrologic Sensors: Evaluating Tree Rings to Reconstruct Historic Groundwater Levels in Central and Northern Wisconsin

 @DomCiruzzi  
 ciruzzi@wisc.edu

Dom Ciruzzi (PhD Candidate, UW-Madison) & Dr. Steve Loheide • 43<sup>rd</sup> Annual Meeting AWRA Wisconsin Section • February 28, 2019



# What Will Wisconsin's Climate Look Like In The Future?

Models Offer Insight On How Climate Change Will Affect The State

By Noah Ovshinsky

Published: Saturday, December 16, 2017, 6:00am



## Northern Wisconsin in deep drought

*By Meg Jones of the Journal Sentinel*

Published on: 5/25/2010

## Impacts on Forests

### Drought is killing trees across the Midwest

Judy Keen, USA TODAY Published 9:00 a.m. ET Jan. 27, 2013

WISCONSIN NEWS

### State's Christmas tree growers feel impact of drought

*By Meg Jones of the Journal Sentinel*

## Impacts on Water Resources

### Drought causes water level drops in Minnesota and Wisconsin lakes

By Rachael Gleason | November 27, 2009

### Droughts drain northern lakes

*By Lee Bergquist of the Journal Sentinel*

Published on: 5/23/2009



LAKE LEVELS

## High-capacity wells possibly lowering some lake levels

KATE PRENGAMAN | Wisconsin Center for Investigative Journalism Jul 22, 2013

## War over water in the land of plenty

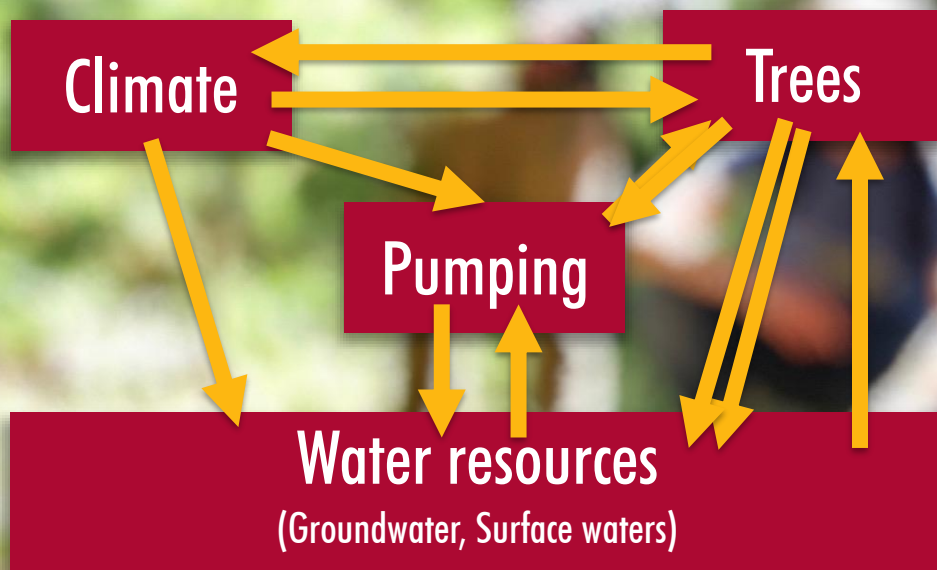
CROPS CLASH WITH LAKES AND STREAMS IN CENTRAL WISCONSIN

Lee Bergquist, *Milwaukee Journal Sentinel*

Published 8:08 p.m. CT Sept. 3, 2016 | Updated 10:49 a.m. CT Sept. 8, 2016

“...the thirst of a growing tree population in central Wisconsin has been overlooked as a source in depleting groundwater.”







**1**



Background on  
Tree Growth

**2**



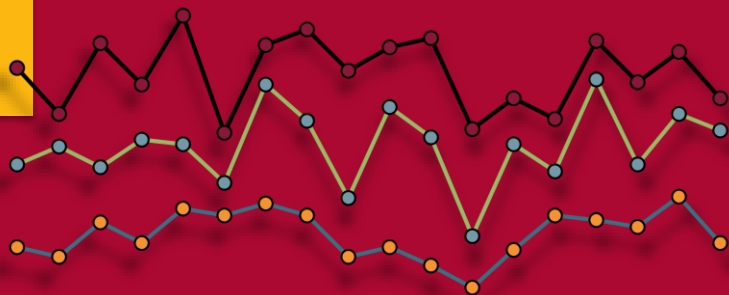
Groundwater-Tree  
Interactions in Wisconsin

**3**



Methods:  
Tree Ring Analysis

**4**



Groundwater Level  
Reconstruction Since the 1930s

**5**



Trees as an  
Alternative Hydrologic Sensor

# WHAT INFLUENCES TREE GROWTH?



Nutrient Availability



Water Availability



Available Energy



Climate



Competition



Insect Infestations



Fires



+ Many more ...

# TREE RINGS RECORD ENVIRONMENTAL VARIABILITY

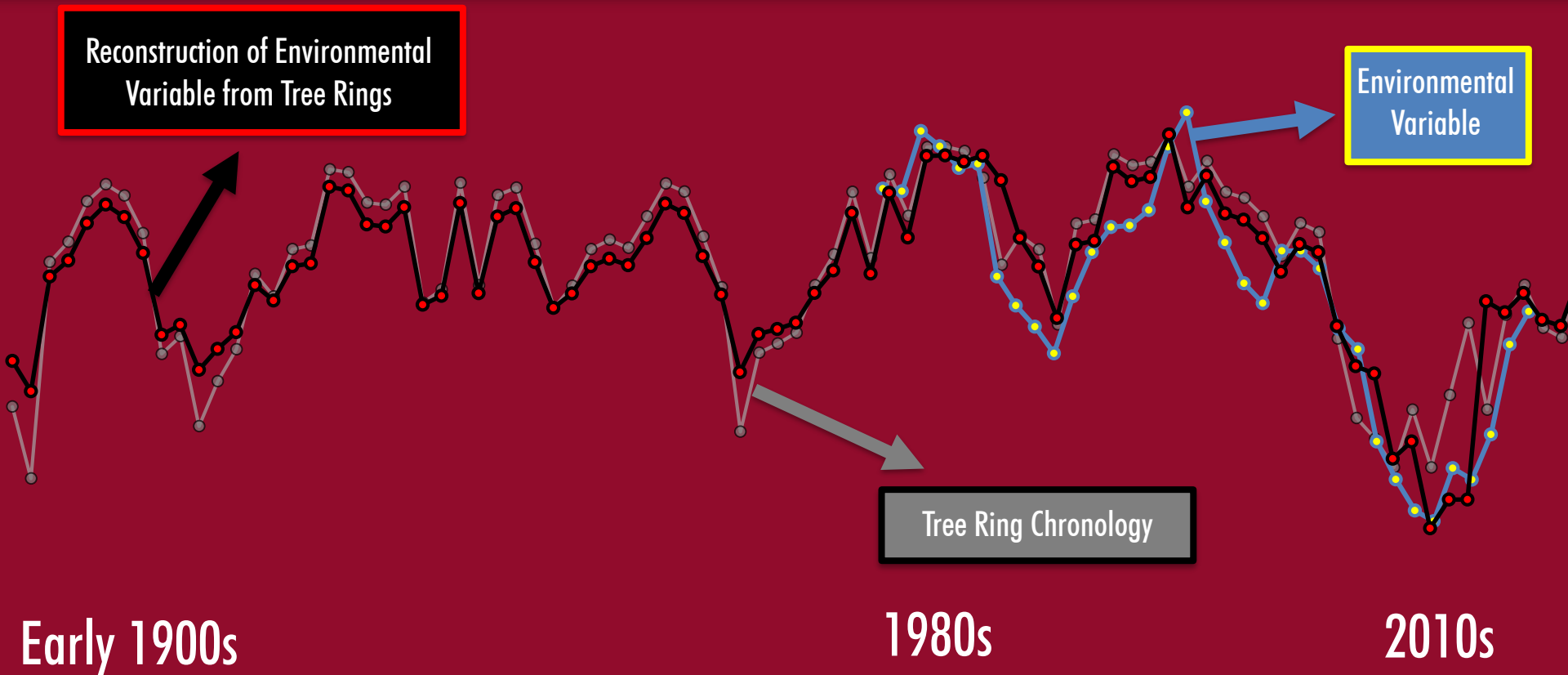
Trees grow in “rings” — records annual environmental signals

## Key Point:

If an environmental variable sufficiently influences tree growth, tree rings are essentially untapped data records over decades/centuries



# TREE RINGS CAN SUPPLEMENT SPARSE DATA



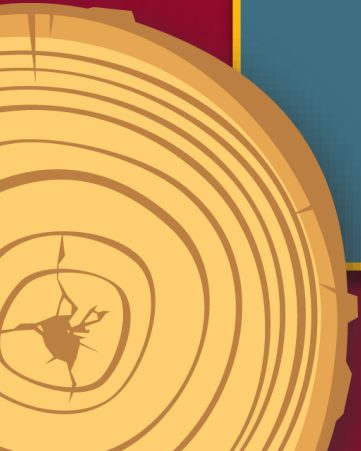


# TREES AS HYDROLOGIC SENSORS?

## Research Questions:

To what extent and under what conditions does groundwater influence tree growth?

Can records of tree growth be evaluated to reconstruct historic groundwater levels?



# SITE DESCRIPTION: NORTHERN WISCONSIN



Forests near Trout Lake Research Station



Long-term Ecological Research Site



35 Years of Groundwater Levels



Groundwater resources are shaped by  
climate variability (droughts)

# SITE DESCRIPTION: CENTRAL WISCONSIN

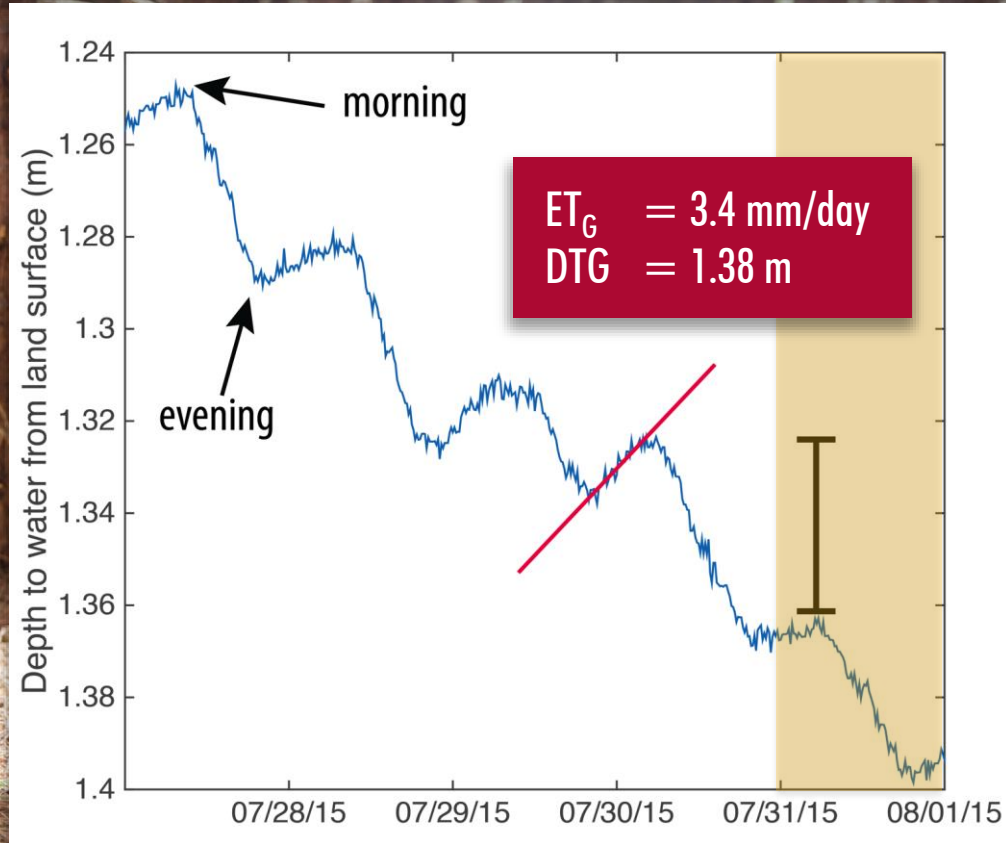


Forests in Central Sands, WI

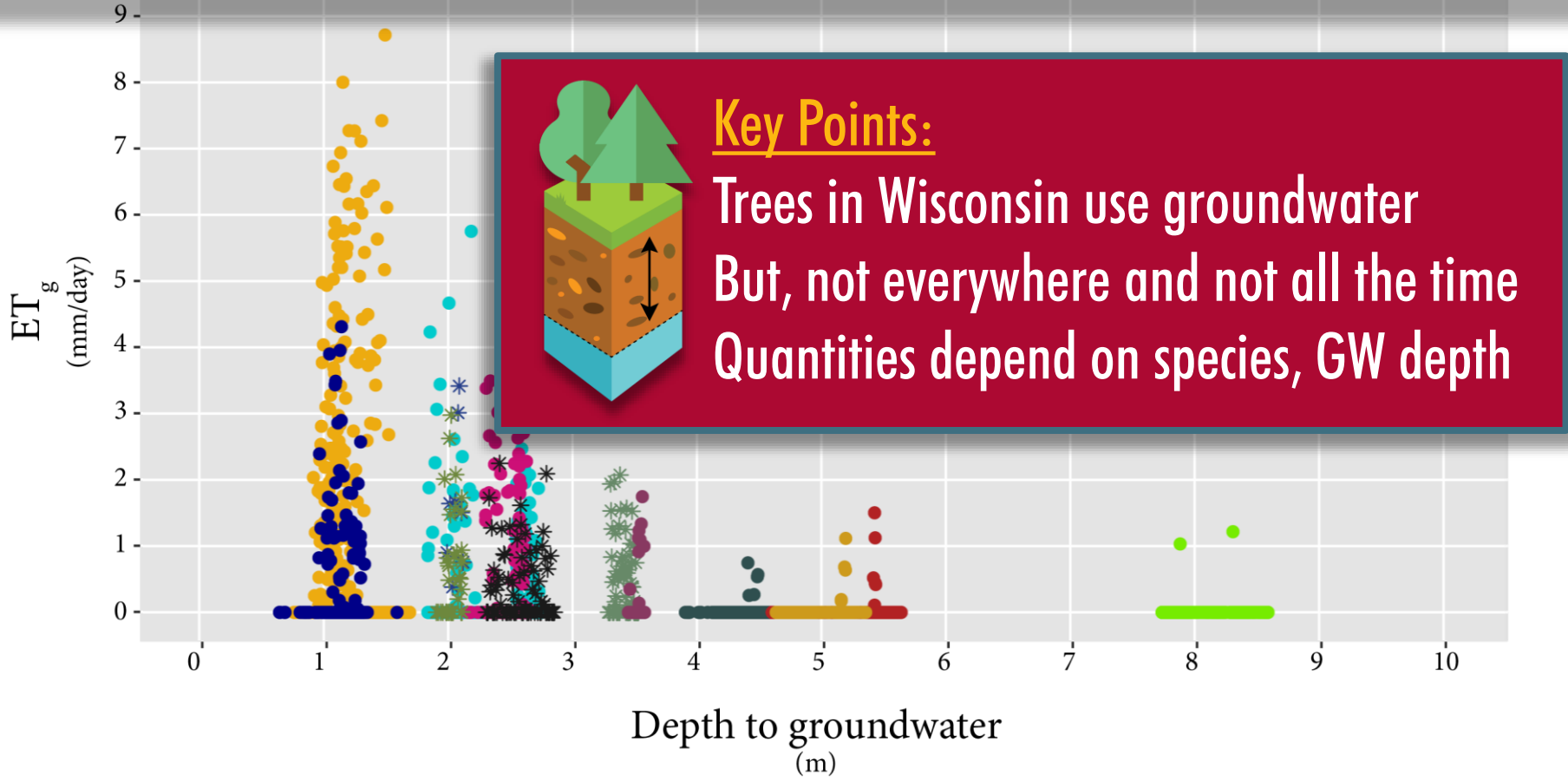
Groundwater resources are shaped by both climate variability and pumping



# PREVIOUS RESEARCH: GROUNDWATER USE BY TREES



# PREVIOUS RESEARCH



# Groundwater-Forest Interactions

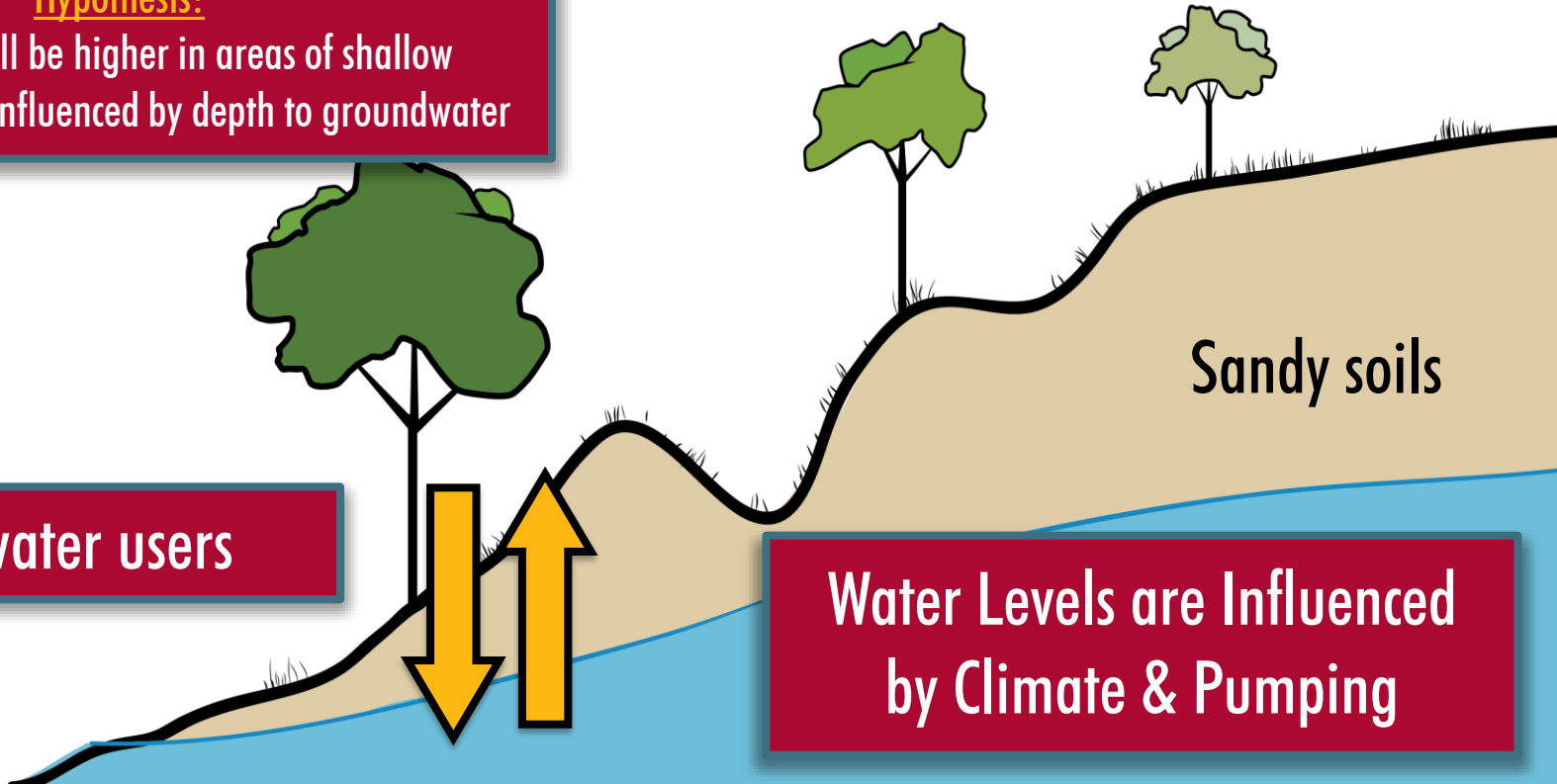
## Hypothesis:

Tree growth will be higher in areas of shallow groundwater and influenced by depth to groundwater

Groundwater users

Sandy soils

Water Levels are Influenced  
by Climate & Pumping





# METHODS: TREE CORES



# ANALYZING TREE GROWTH

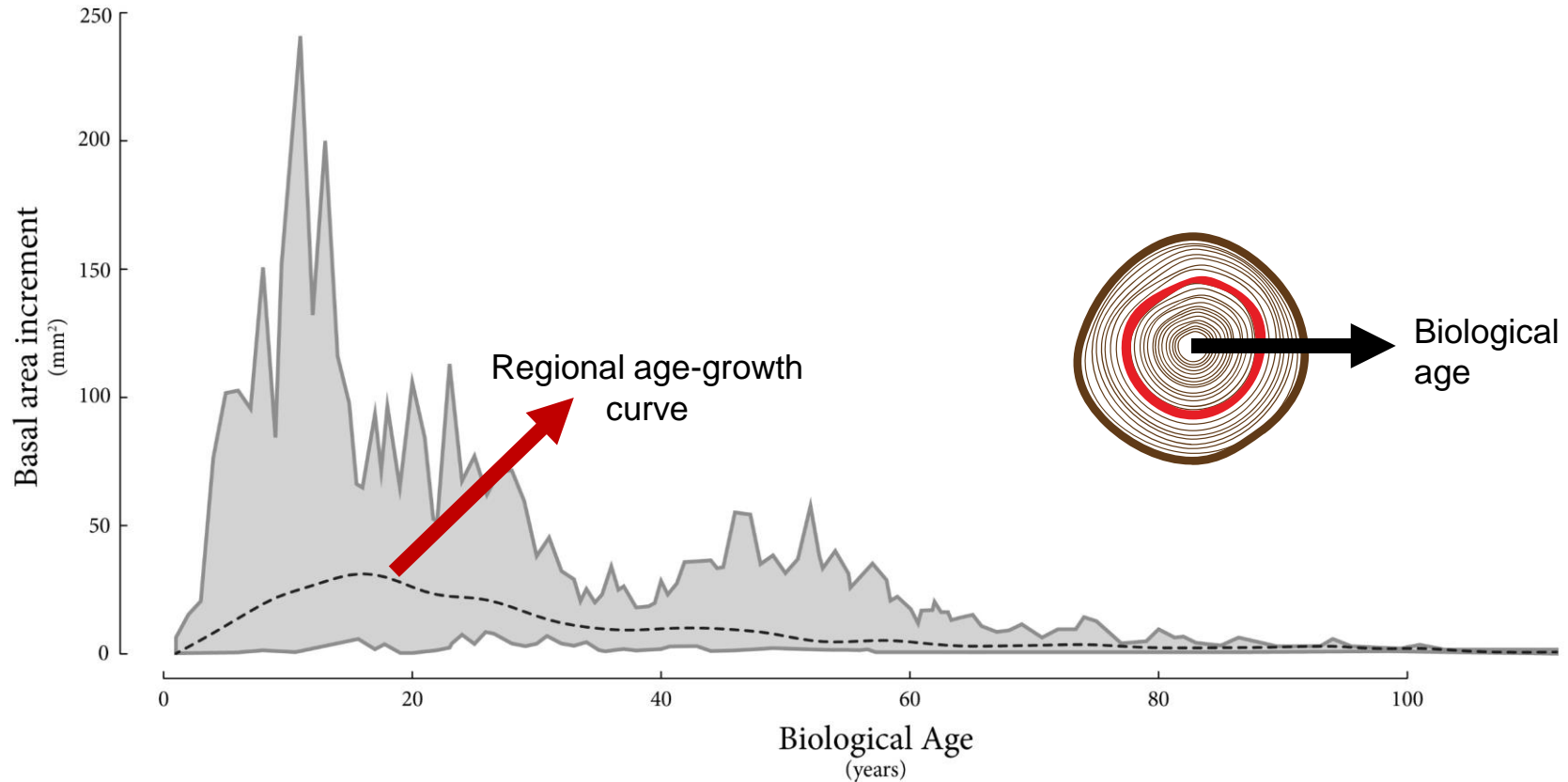


$r_{t-1}$   $r_t$   
→

$$[mm^2/yr] \quad \mathbf{BAI} = \pi(r_t^2 - r_{t-1}^2)$$

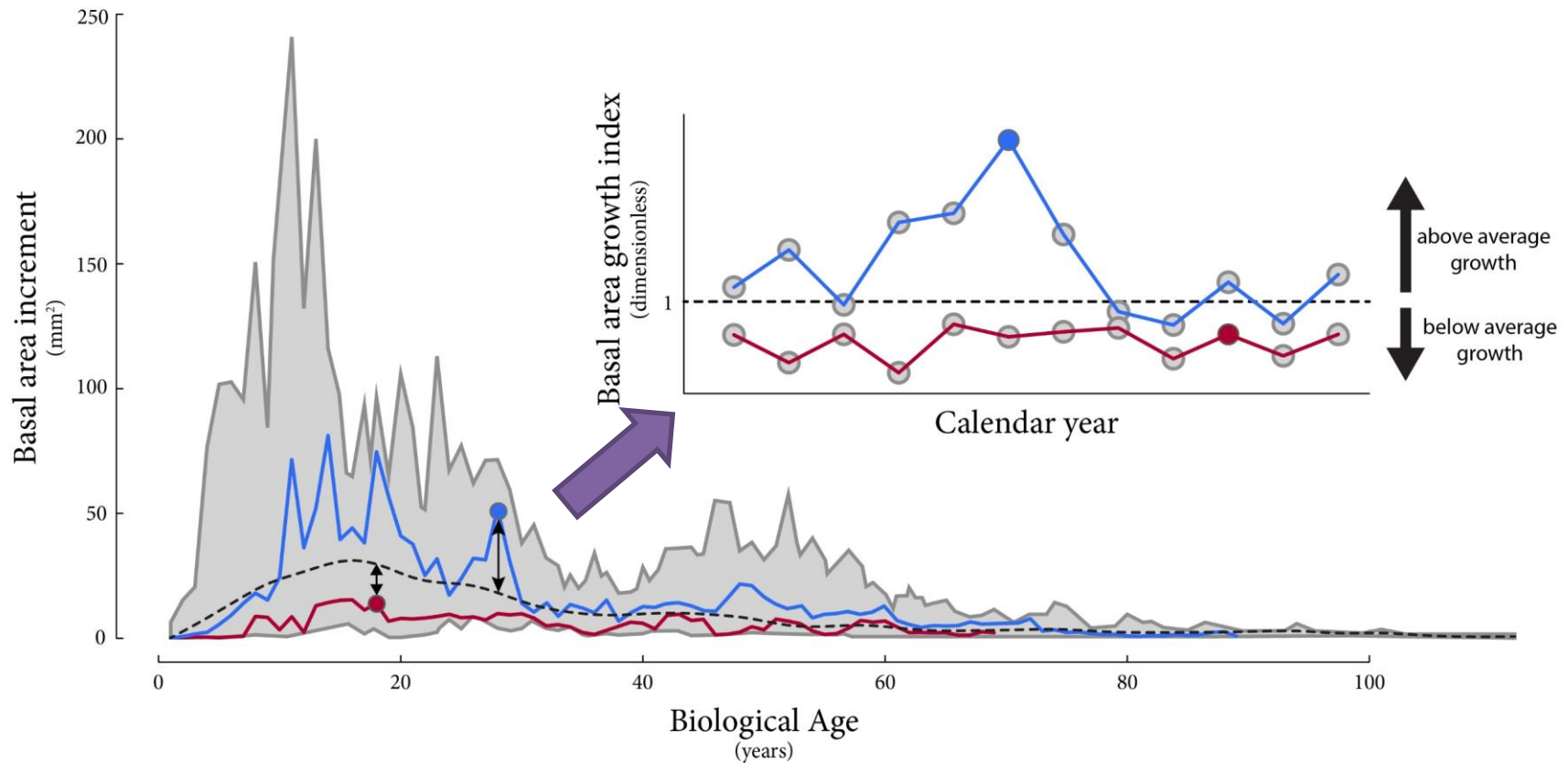


# ANALYZING TREE GROWTH

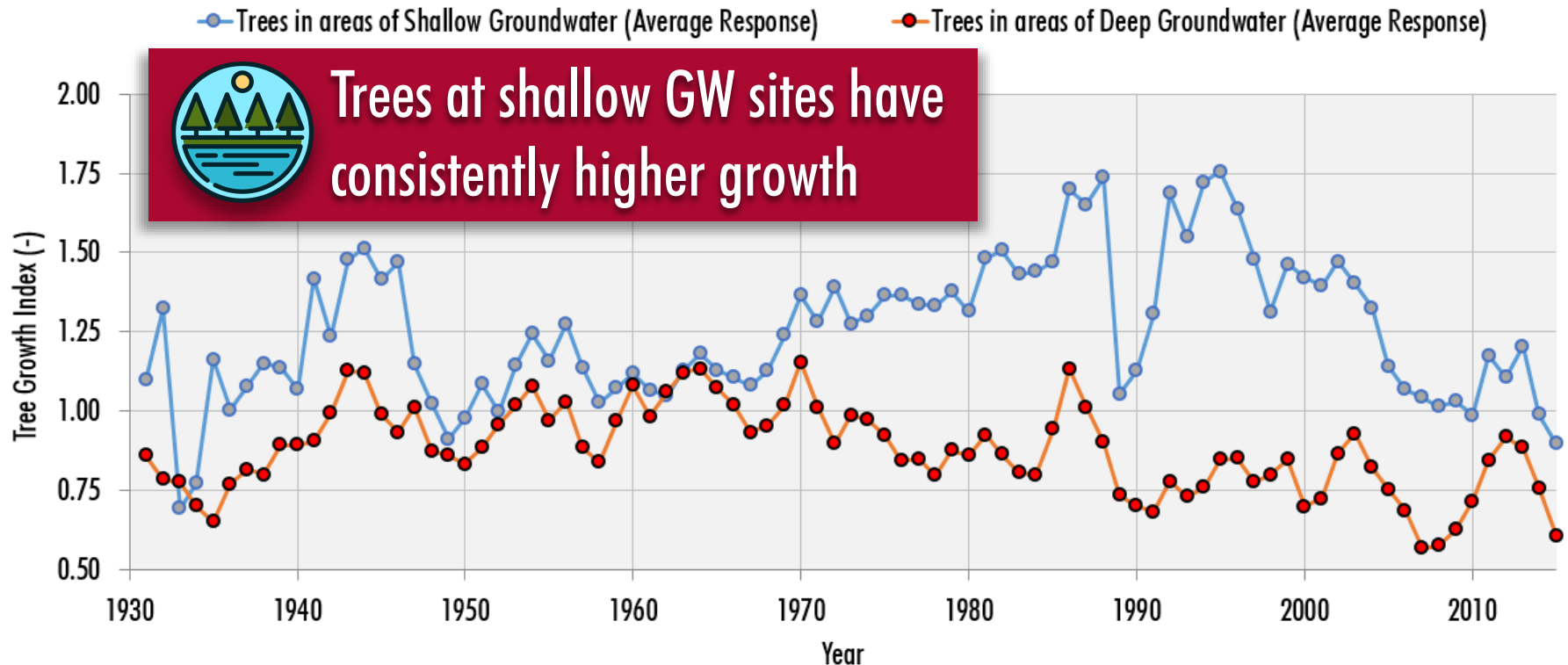




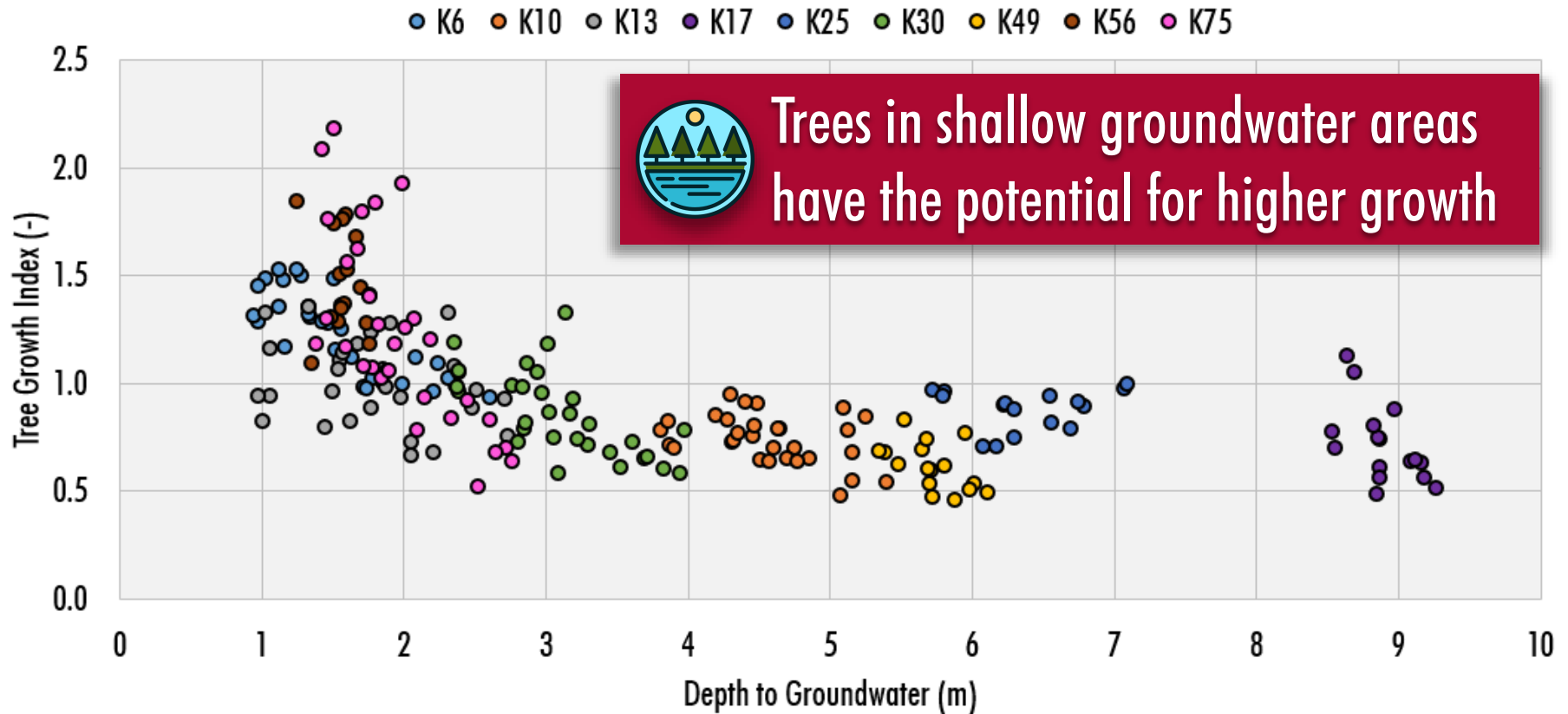
# ANALYZING TREE GROWTH



# TREE GROWTH & GROUNDWATER RELATIONSHIPS



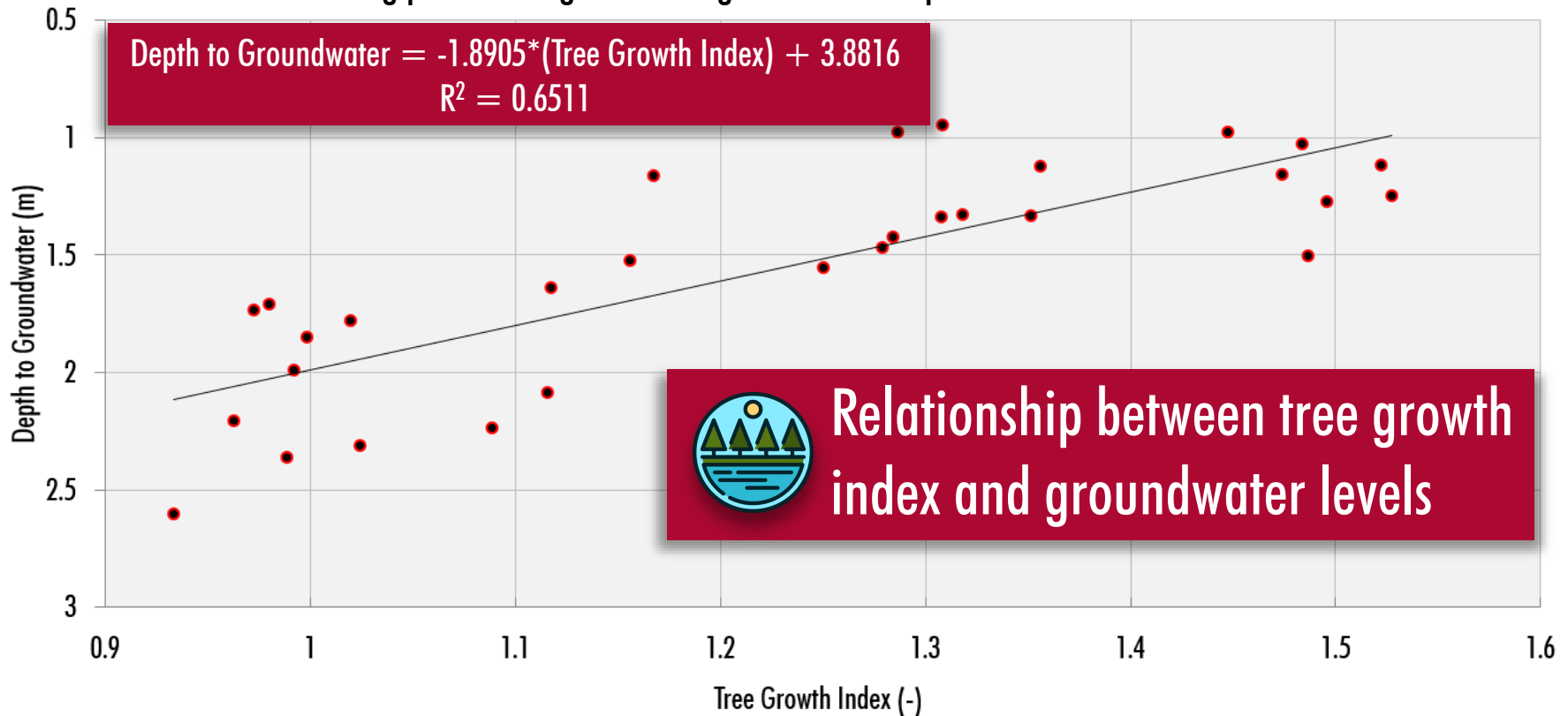
# TREE GROWTH & GROUNDWATER RELATIONSHIPS



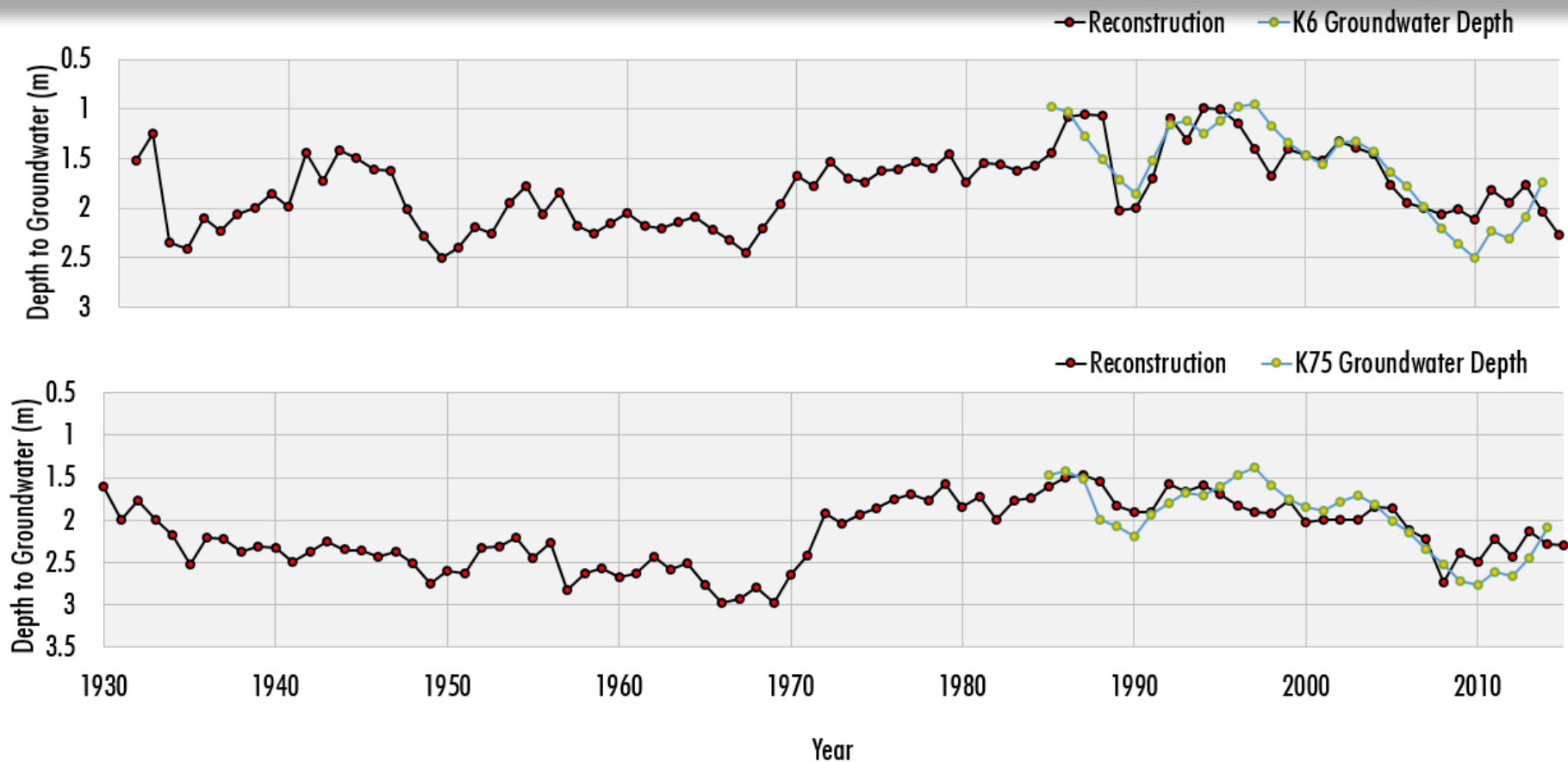


# TREE GROWTH & GROUNDWATER RELATIONSHIPS

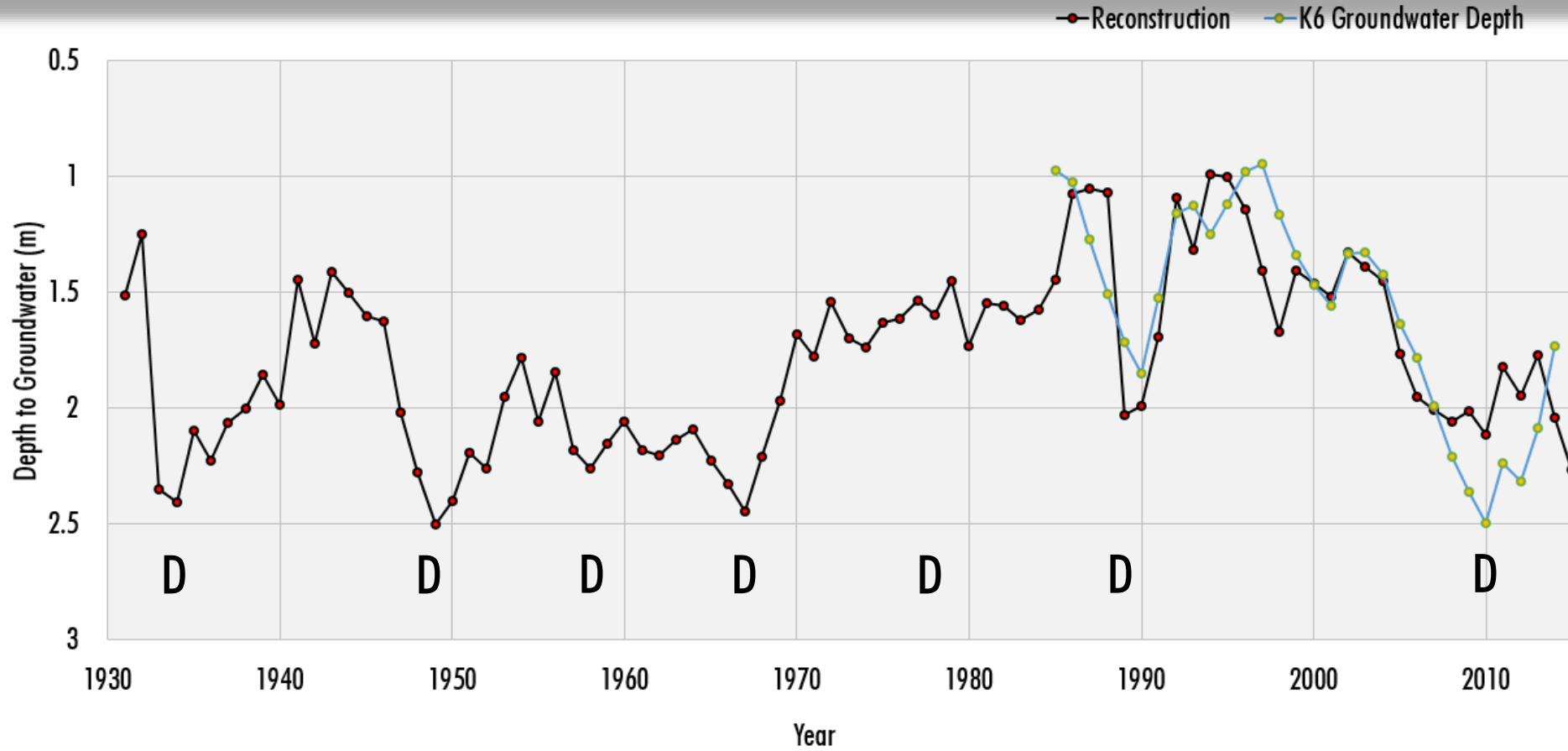
Using paired tree growth and groundwater depth data from 1984-2015



# RECONSTRUCTING GW LEVELS FROM TREE RINGS



# INTERPRETING RECONSTRUCTION FROM TREE RINGS

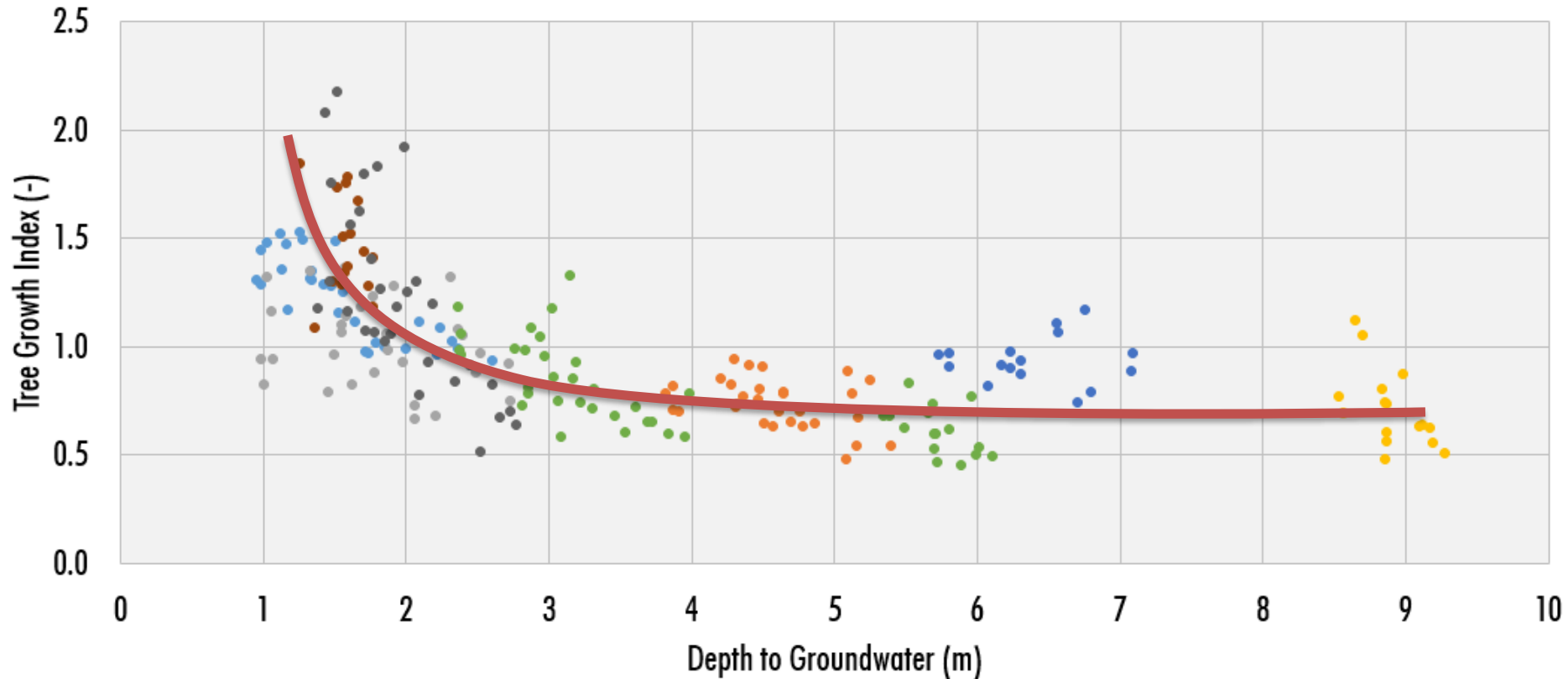




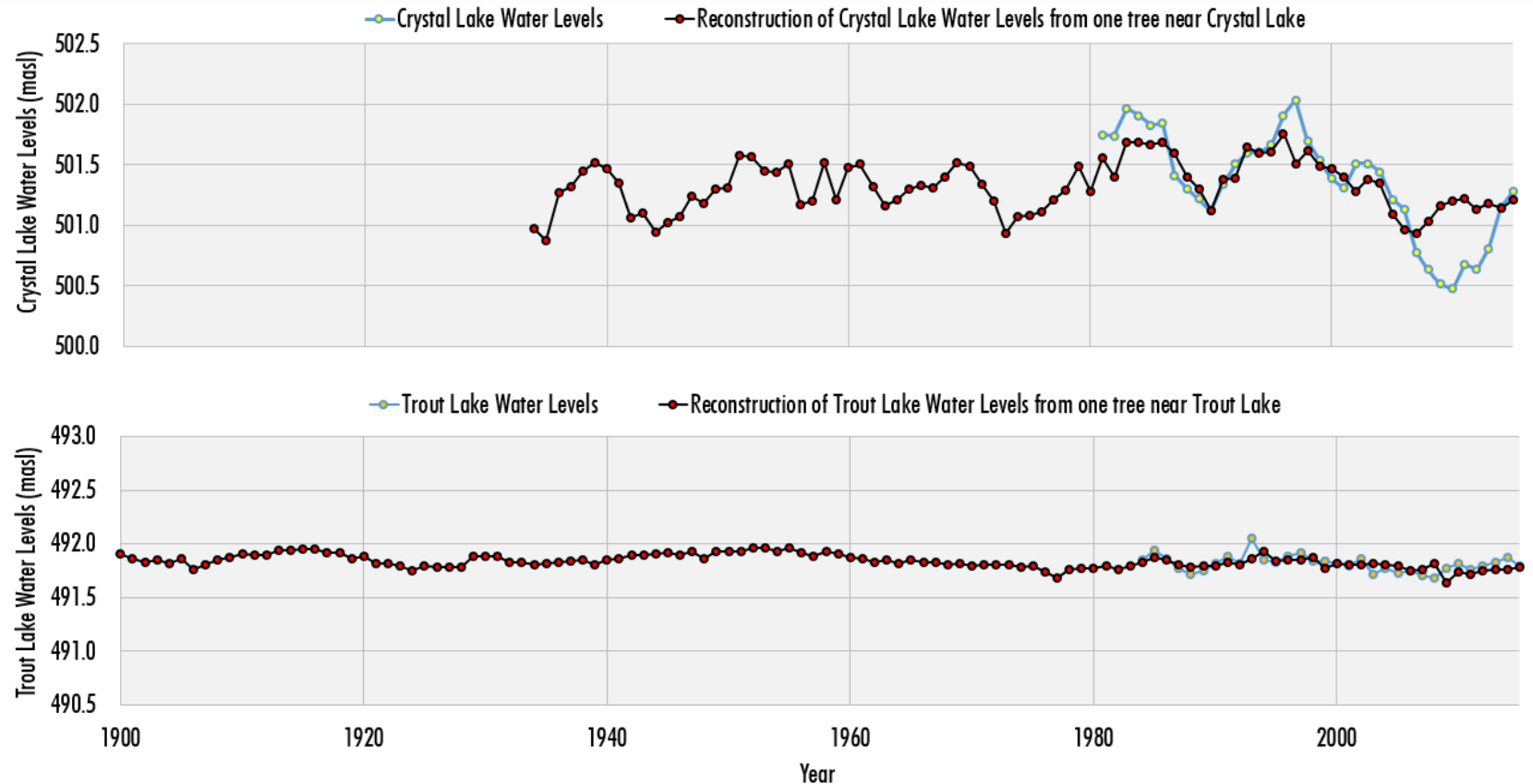




# GENERALIZING TREE GROWTH-GW RELATIONSHIPS

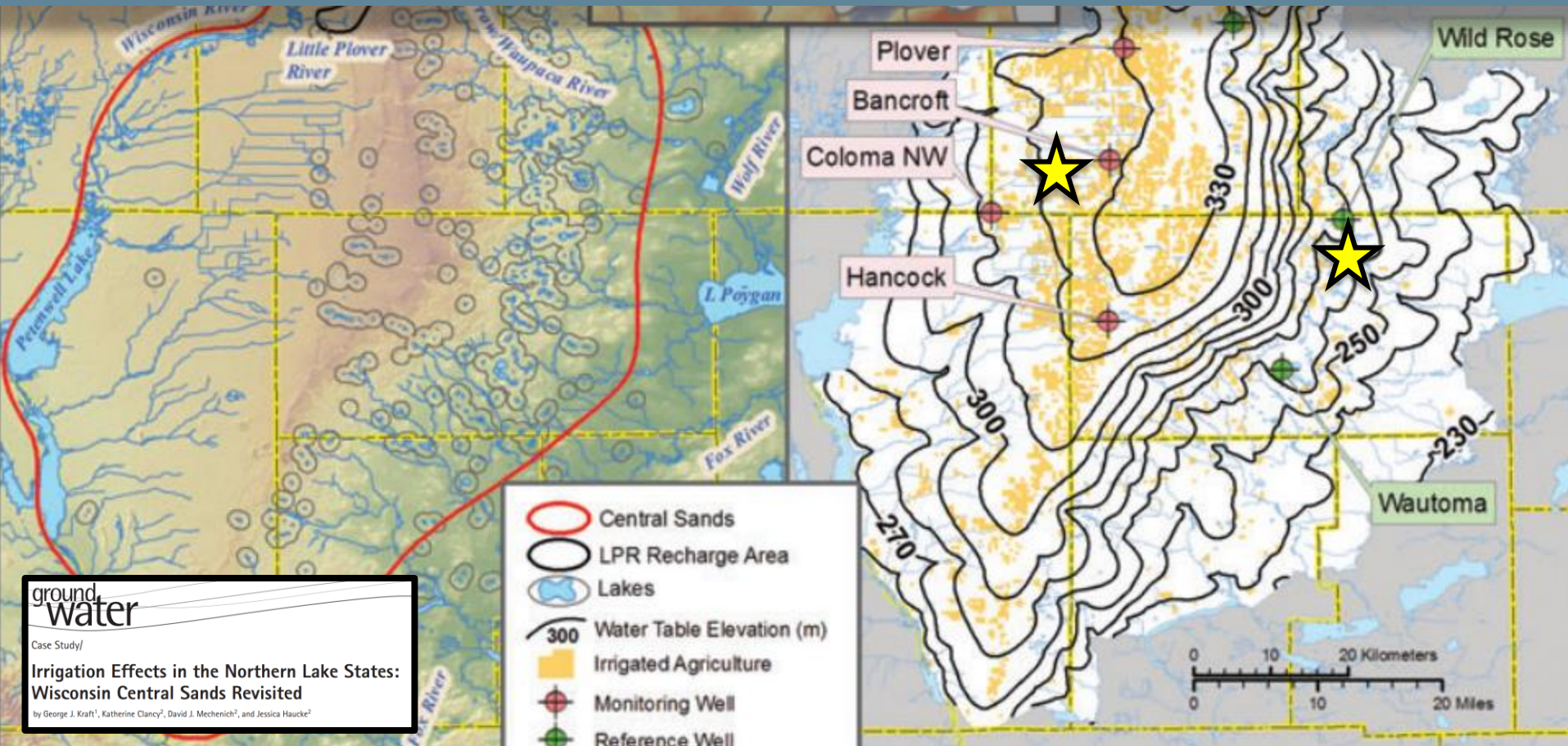


# TREES AS AN ALTERNATIVE HYDROLOGIC SENSOR



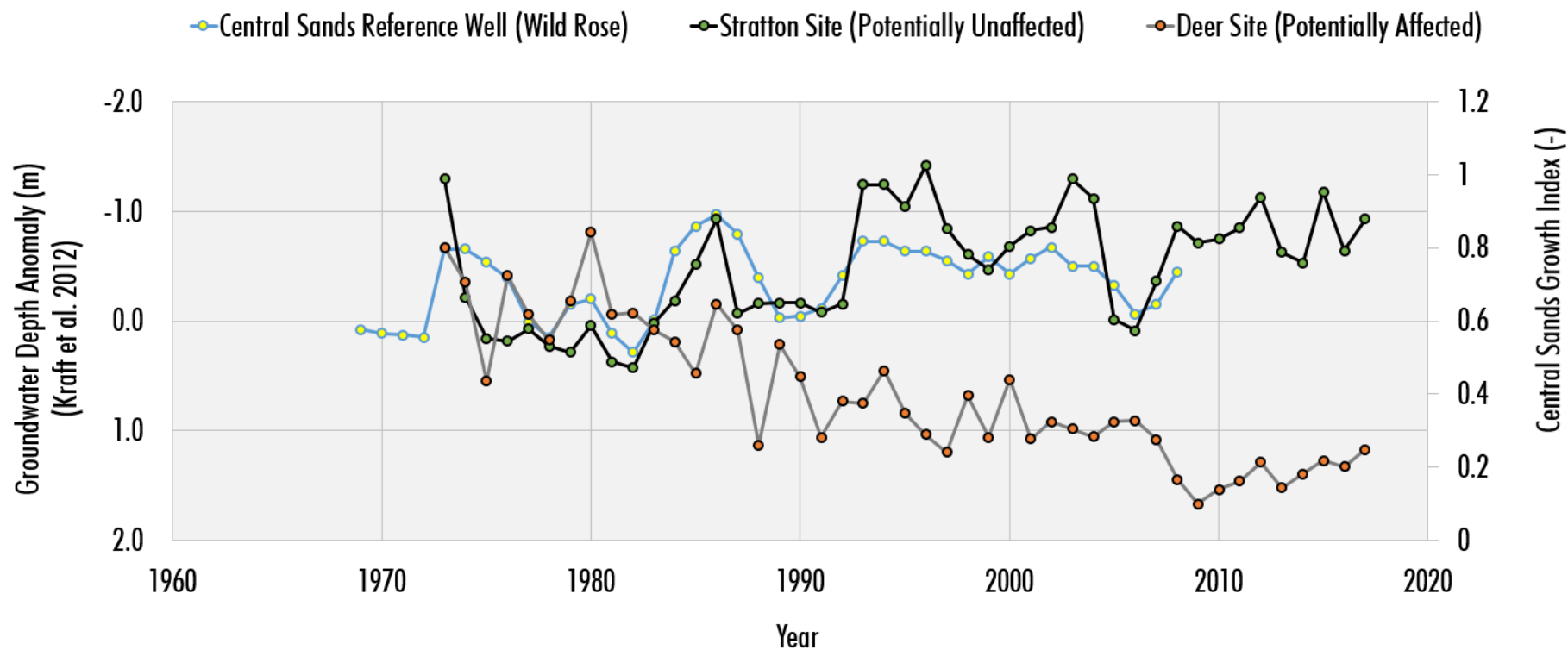


# POTENTIAL EFFECTS OF PUMPING ON TREE GROWTH





# TREE GROWTH IN CENTRAL SANDS



# FUTURE DIRECTIONS



Expand on tree growth-groundwater relationships to Central Sands

What do reconstructions in the Central Sands look like? Do they show signals of climate fluctuations and declines in groundwater levels from pumping?







1



If an environmental variable sufficiently influences tree growth, tree rings are essentially untapped data records over decades/centuries

2



Strong indications of Groundwater-Tree interactions in sandy Wisconsin forests

(Northern & Central Wisconsin)

3



Trees as Hydrologic Sensors:  
Tree rings in these environments can help reconstruct historic water level histories



# ACKNOWLEDGEMENTS

Dr. Steve Loheide

Dr. Monica Turner, Dr. Eric Kruger

UW-Madison Hydroecology Group

NTL-LTER Trout Lake Research Station

## Access to sites

NHAL Forest Personnel

Portage County Parks Department

Wisconsin DNR

Grand Rapids Water & Light Utility

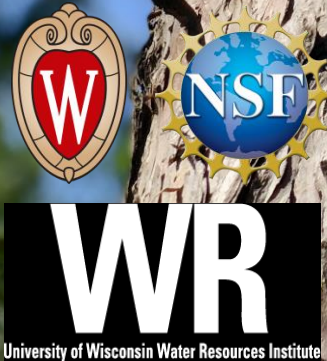
## Funding

UW-Madison Graduate School

Lane Fellowship, UW-Madison Center for Limnology

National Science Foundation (EAR #1700983)

UW Water Resource Institute (WR17R002)





# QUESTIONS?



Photo: Sara Stathas