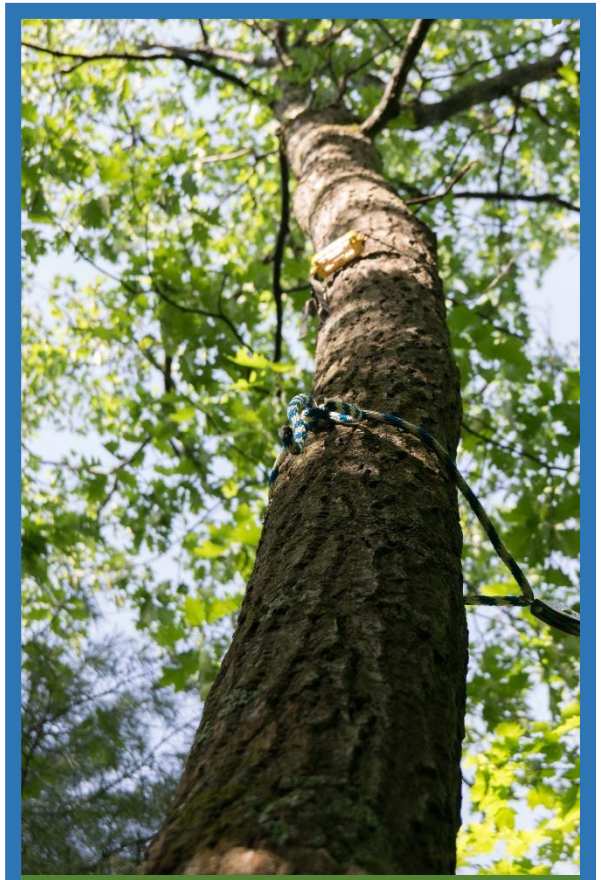
Evaluating tree growth and quantifying groundwater use in sandy Wisconsin forests

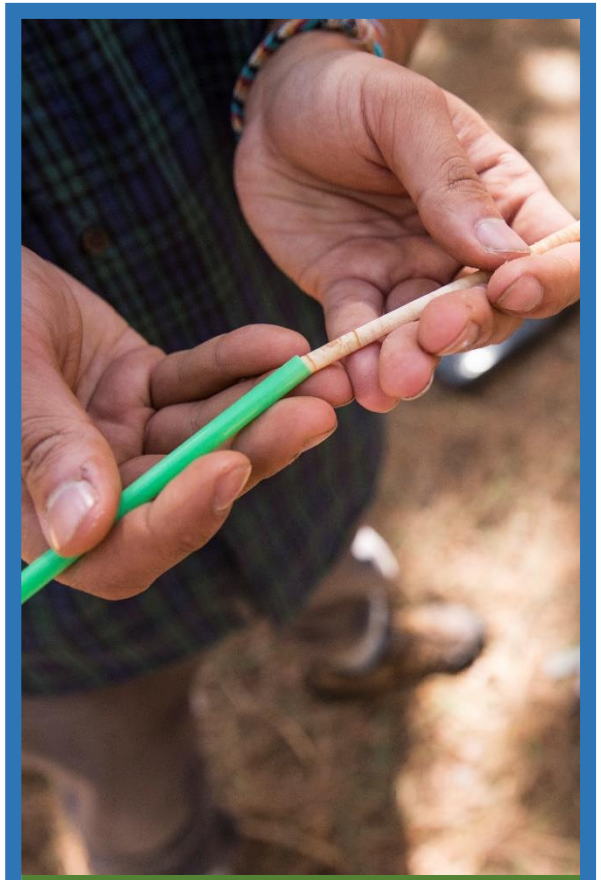
Dom Ciruzzi & Steve Loheide
AWRA – WI Section
March 8, 2018

Photo: Sara Stathas

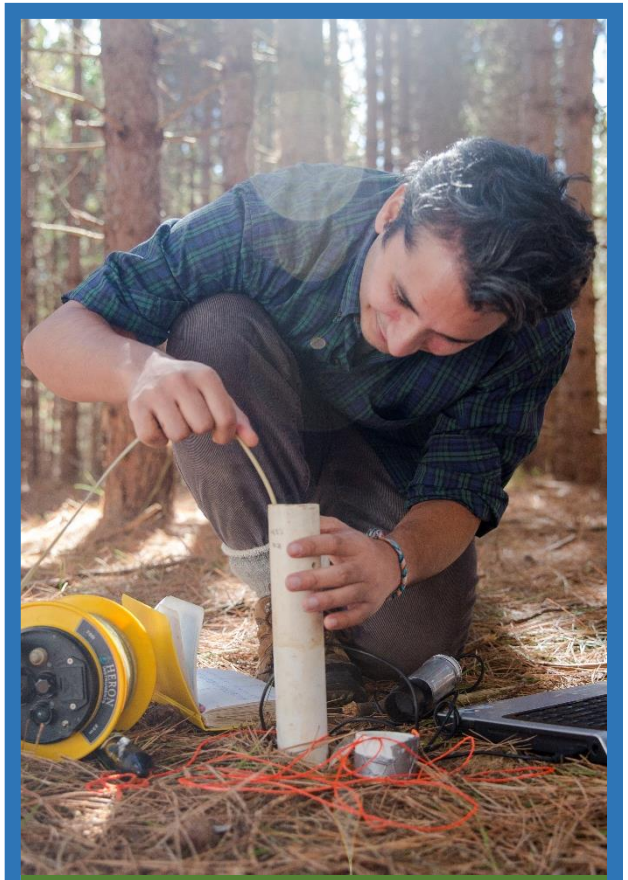
Outline



Motivation



Tree growth along a depth to GW gradient

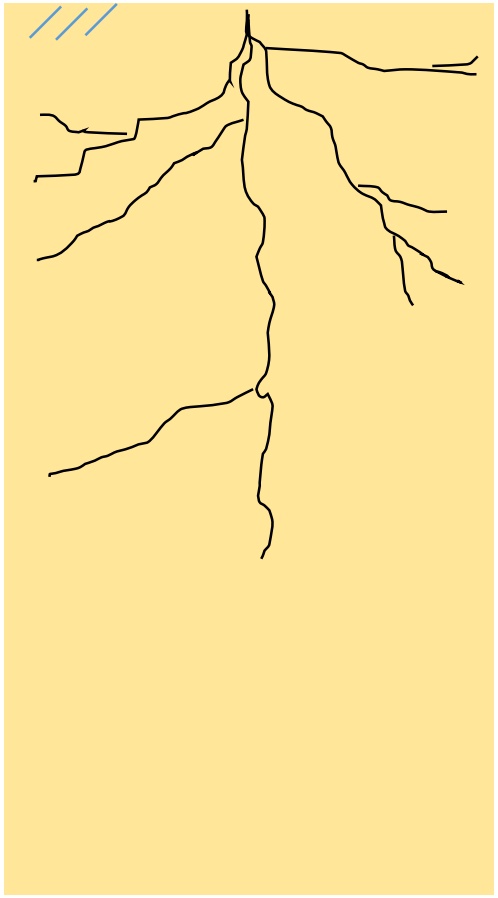


GW use by forests in WI

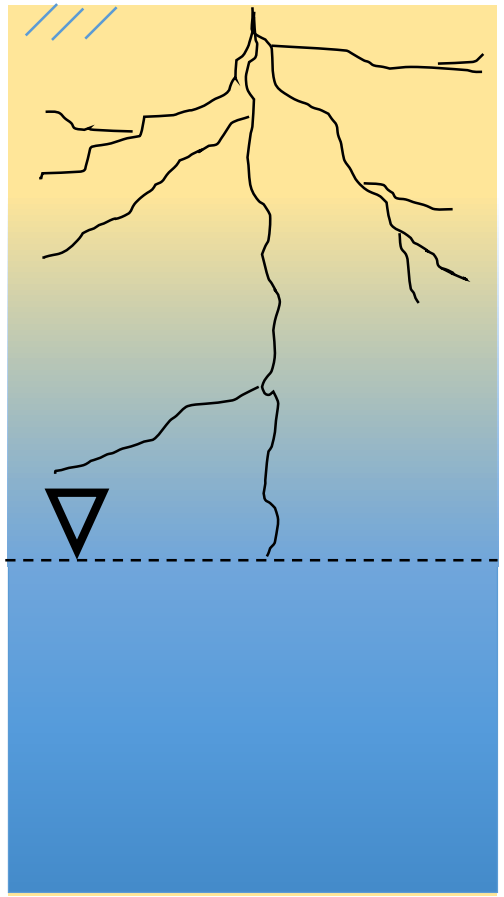
Summary & Implications

Motivation:
Changing water pressures on forests

Motivation: Sandy soils and the role of shallow groundwater in reducing water stress



- Sandy soils drain water quickly
- “Soil droughts”
- Water stress
  - Reduced veg. growth



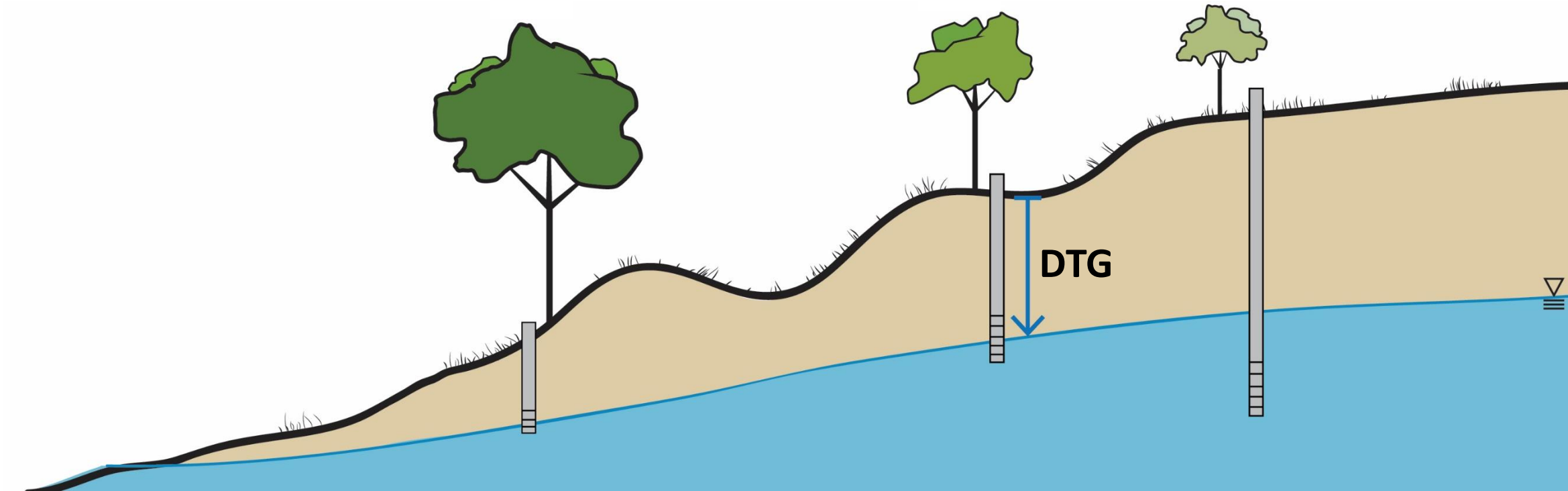
- Available deeper store of water
- Avoid water stress
  - Higher veg. growth
- “Use groundwater”

Research Questions

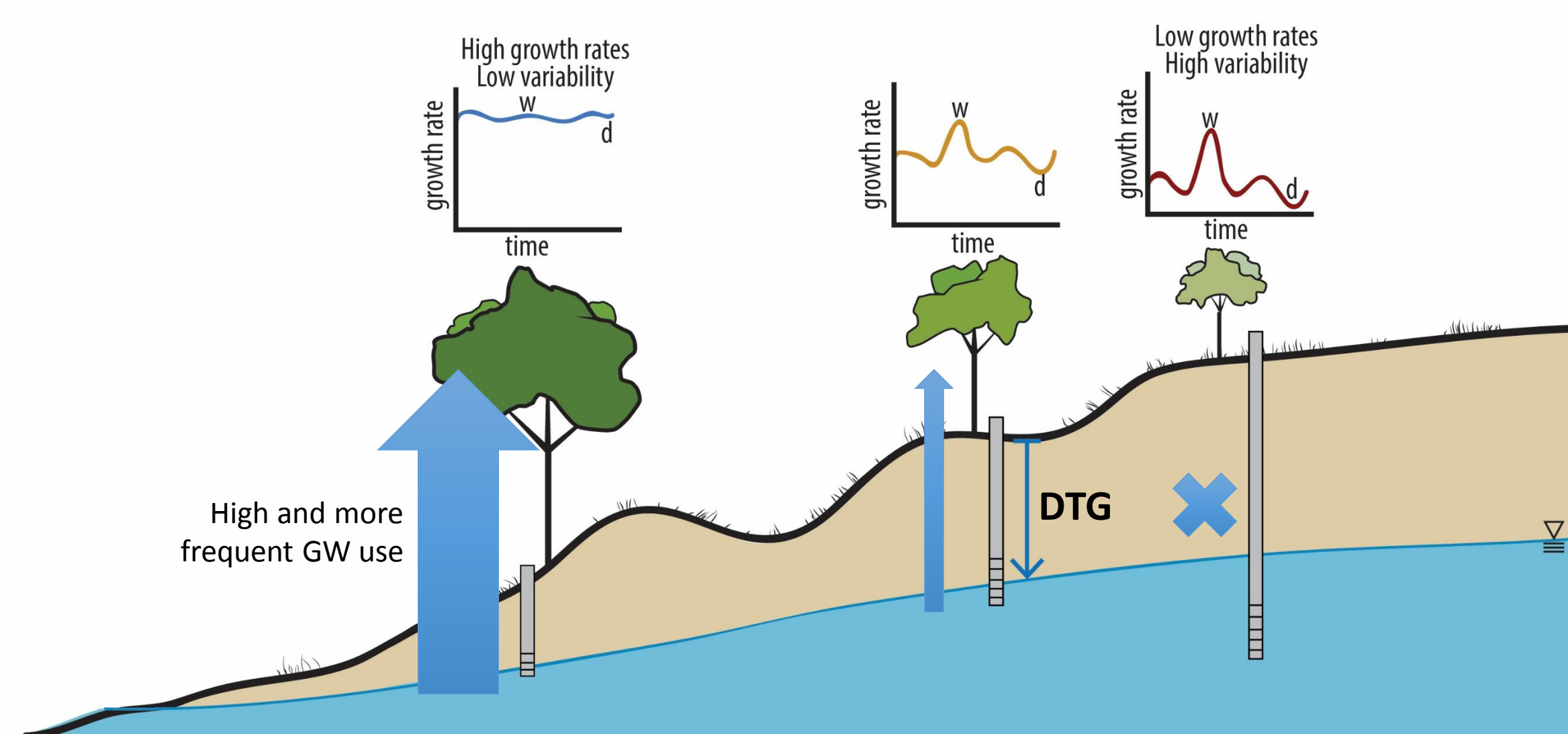
To what extent does shallow groundwater influence tree growth?

How much groundwater do trees use?

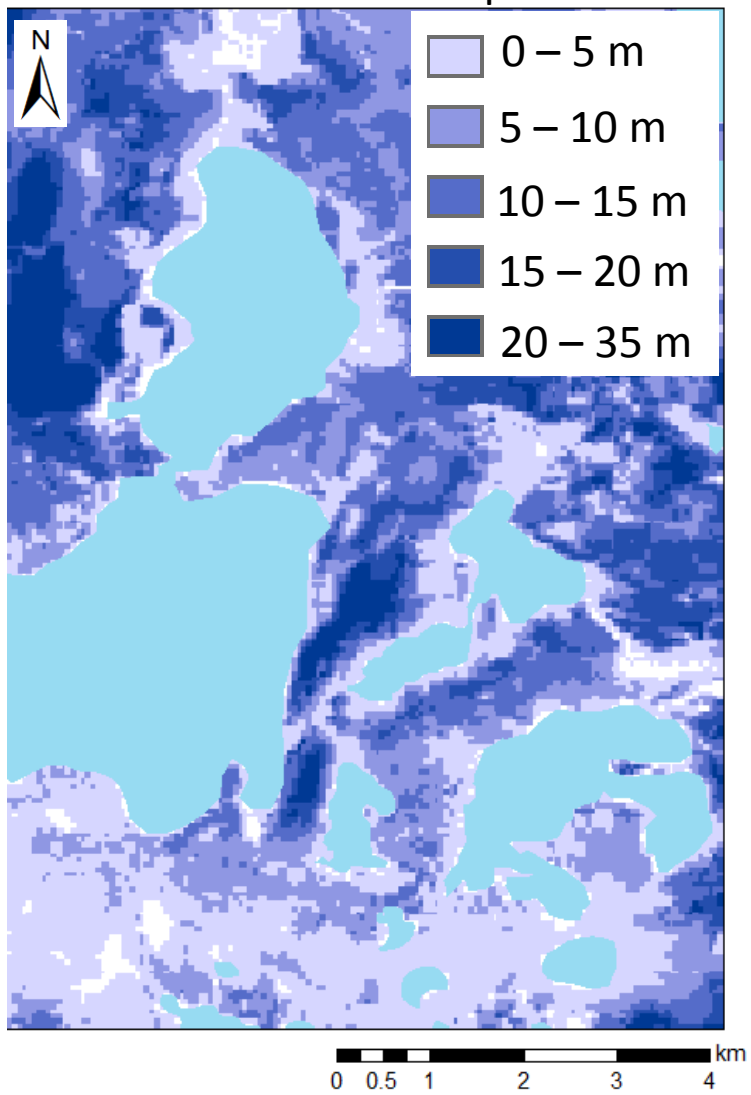
Conceptual Model & Hypotheses



Conceptual Model & Hypotheses



Northern Wisconsin

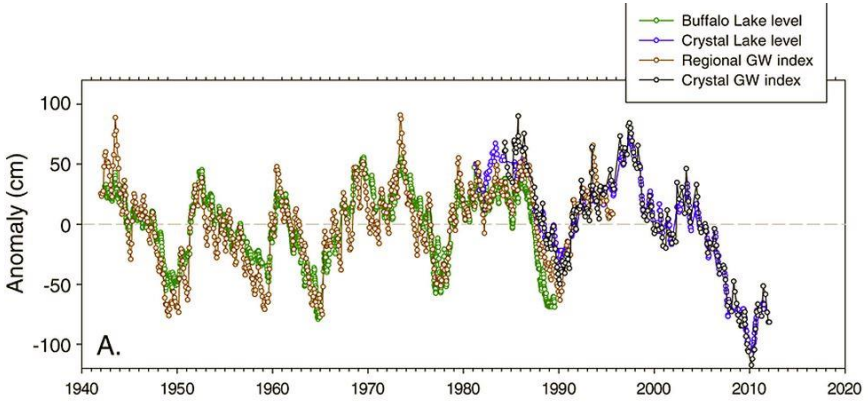


Northern Wisconsin in deep drought

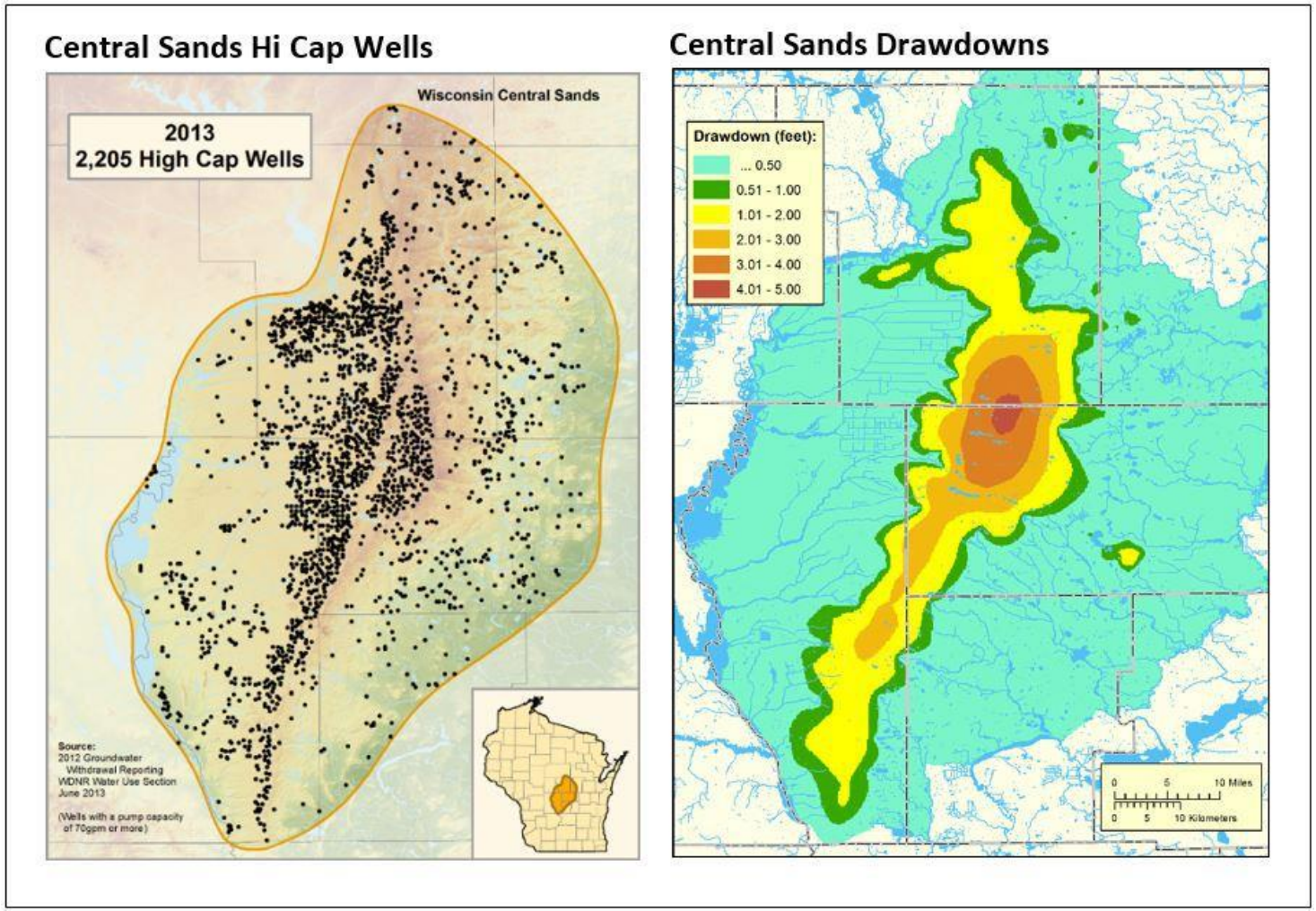
By Meg Jones of the Journal Sentinel
Published on: 5/25/2010

Drought of 2012 draws comparison to devastating 1988 dry spell

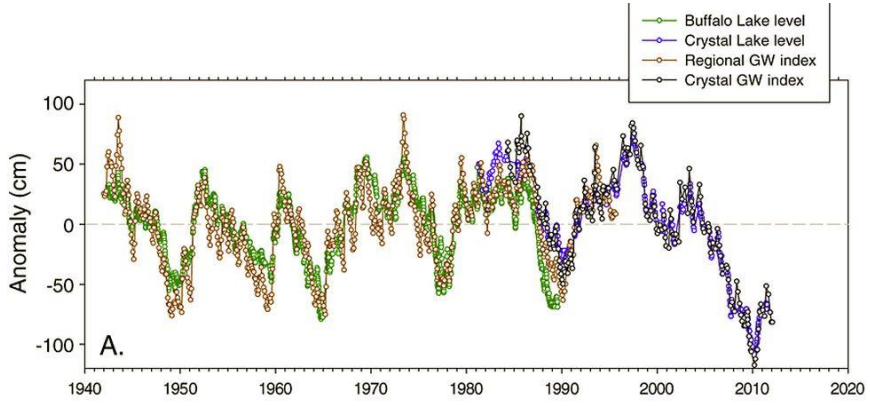
STEVEN VERBURG | Wisconsin State Journal | sverburg@madison.com | 608-252-6118 Jul 29, 2012



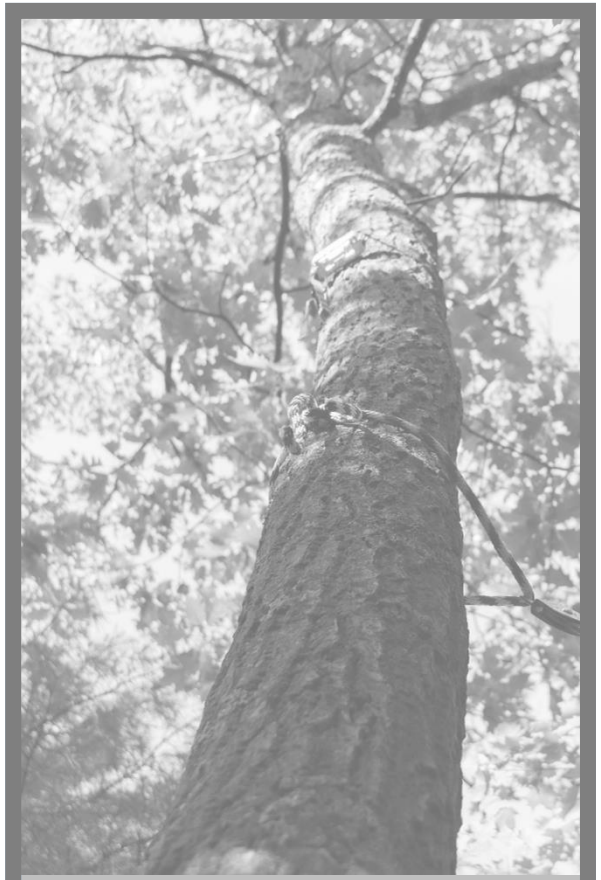
Central Sands, Wisconsin



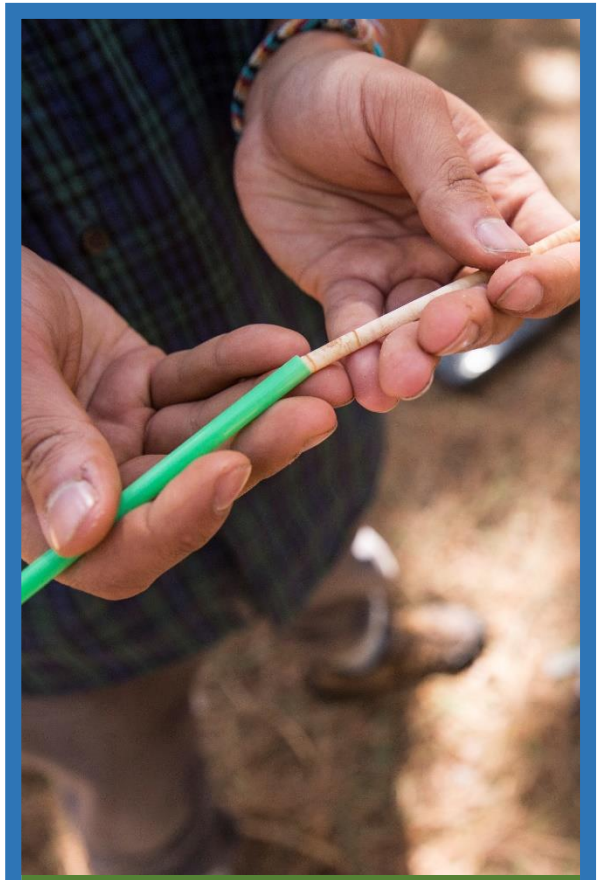
Groundwater resources are shaped by both climate variability and pumping



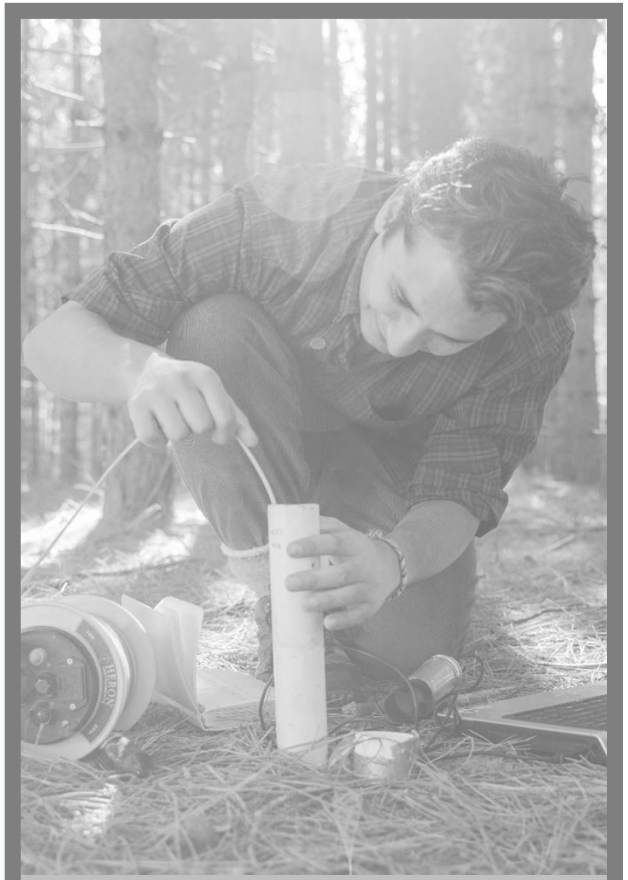
Outline



Motivation



Tree growth along a depth to GW gradient



GW use by forests in WI

Summary & Implications

To what extent does shallow groundwater influence tree growth?

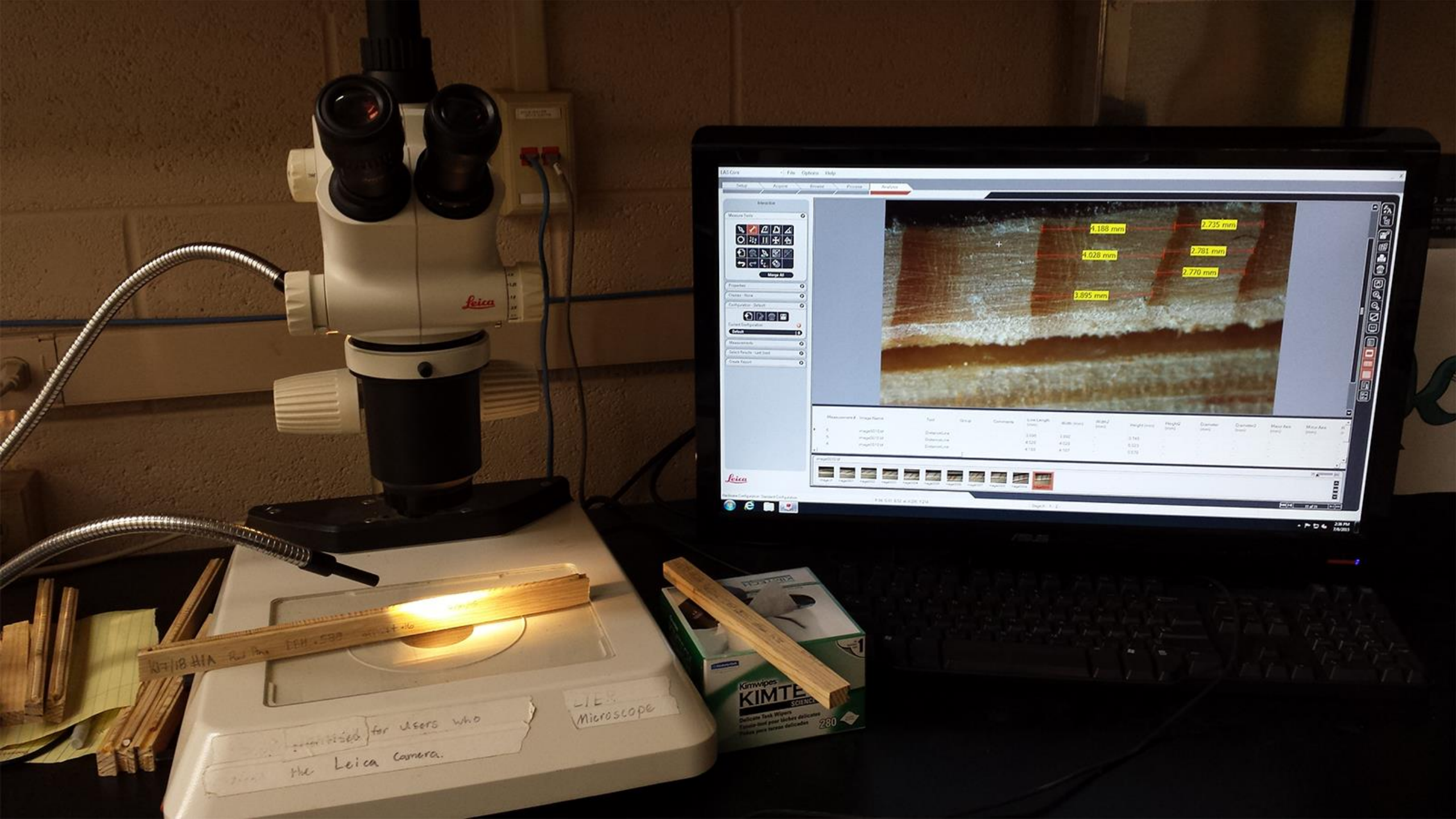
How does tree growth change along a depth to groundwater gradient?

Evaluating tree growth along DTG gradient

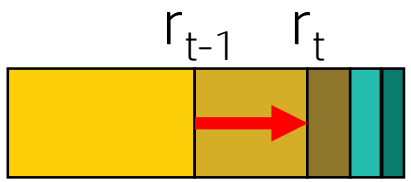
Collect cores along DTG gradient in northern and central WI

…Processing…

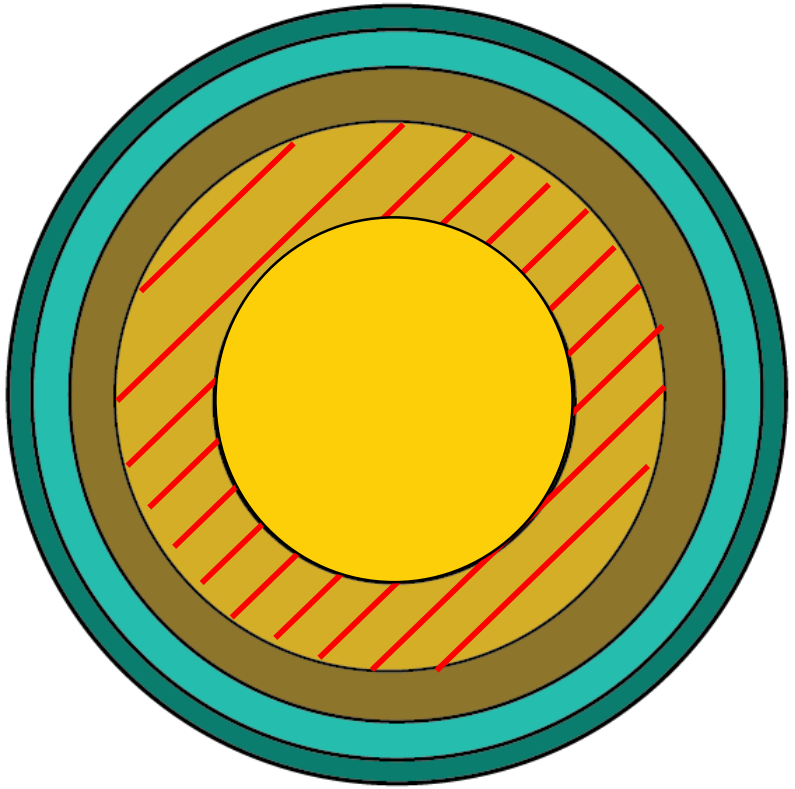
Perform analyses on Growth Index


Leica
4.188 mm
2.735 mm
4.028 mm
2.781 mm
2.770 mm
3.895 mm
for users who
the Leica camera.
Microscope
Kimwipes
KIMTE
280

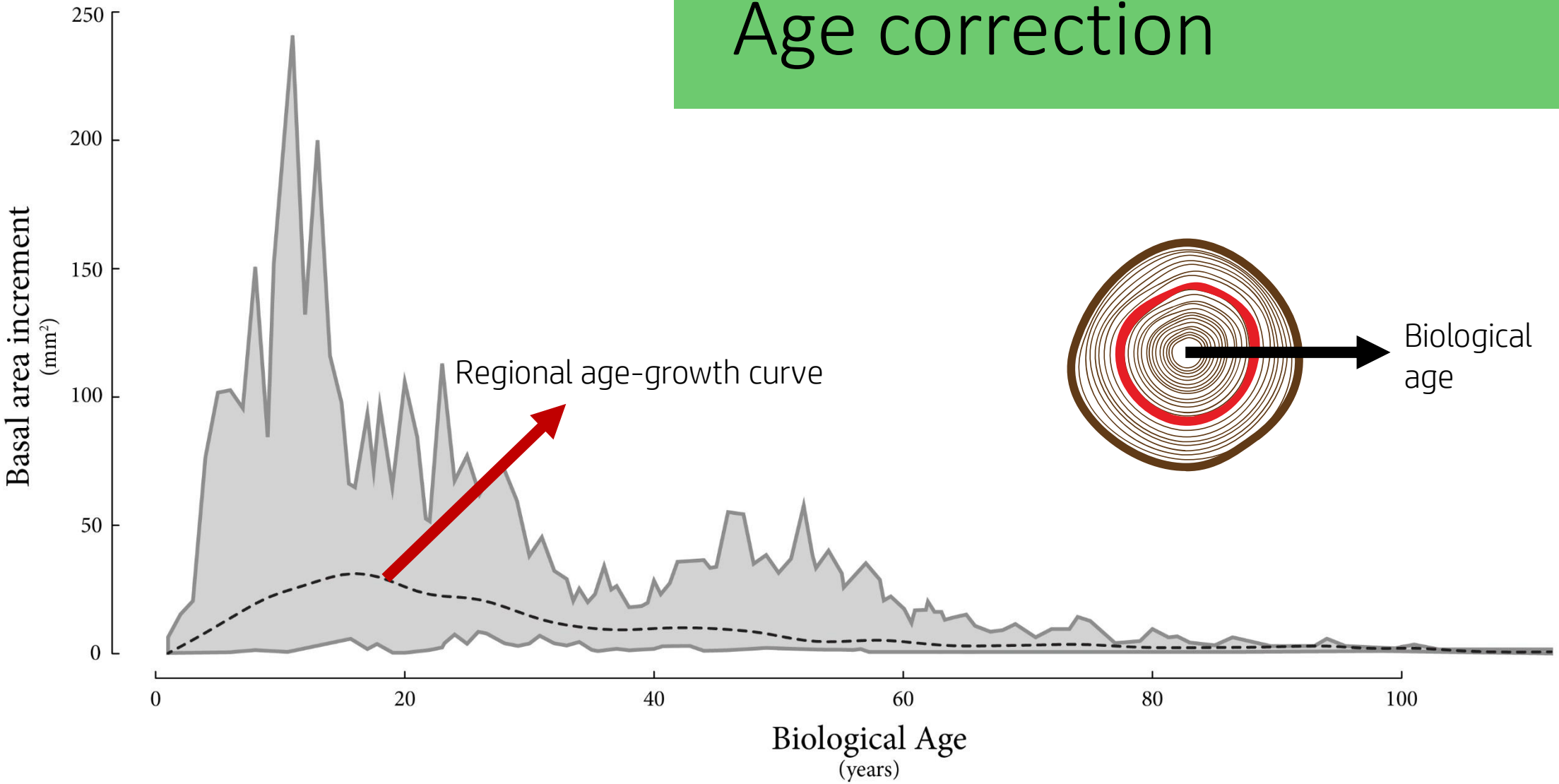
Basal area increments



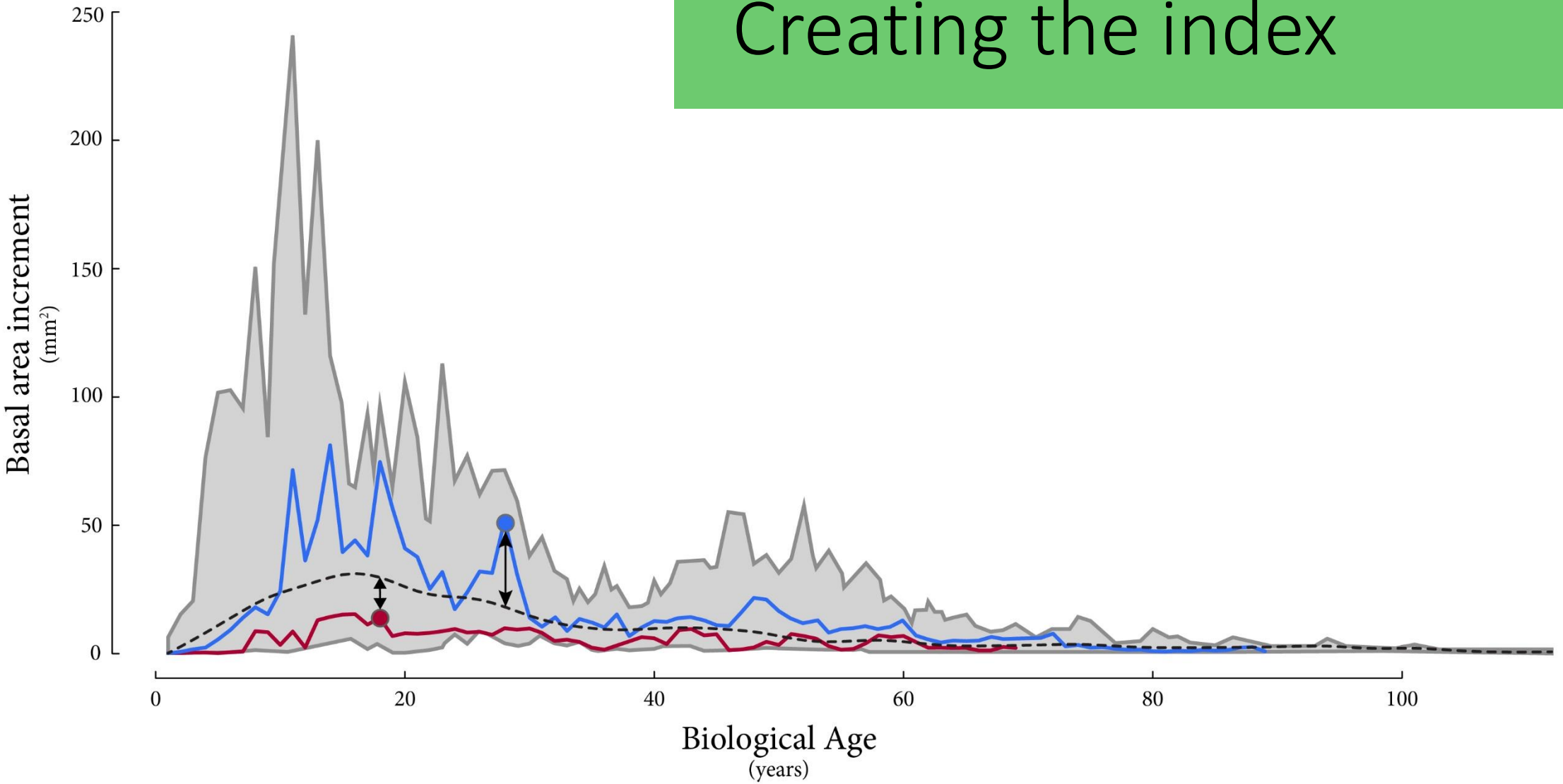
$[mm^2/yr]$ **BAI =** $\pi(r_t{}^2 - r_{t-1}{}^2)$



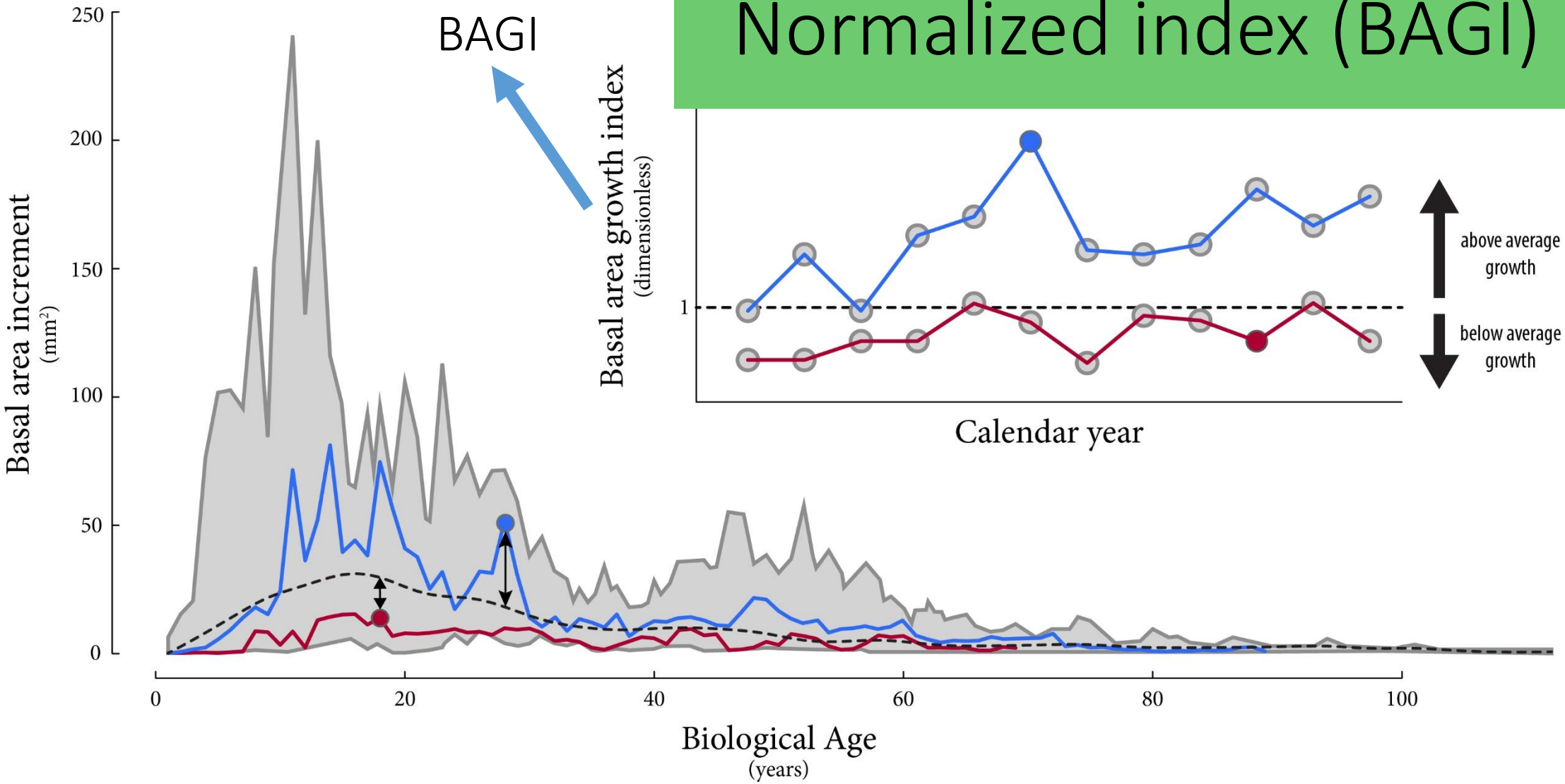
Age correction



Creating the index



Normalized index (BAGI)

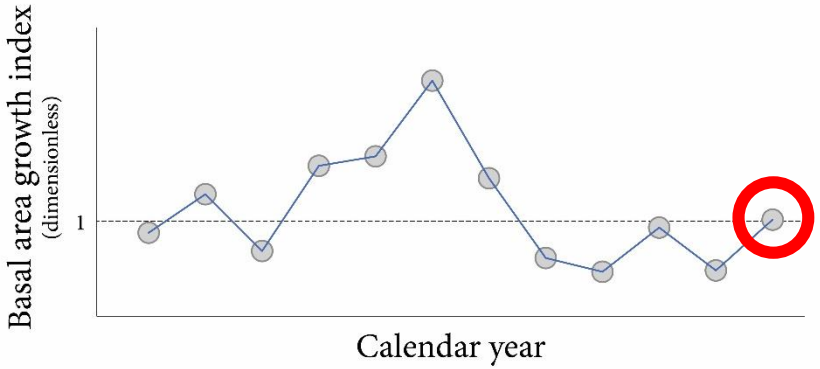


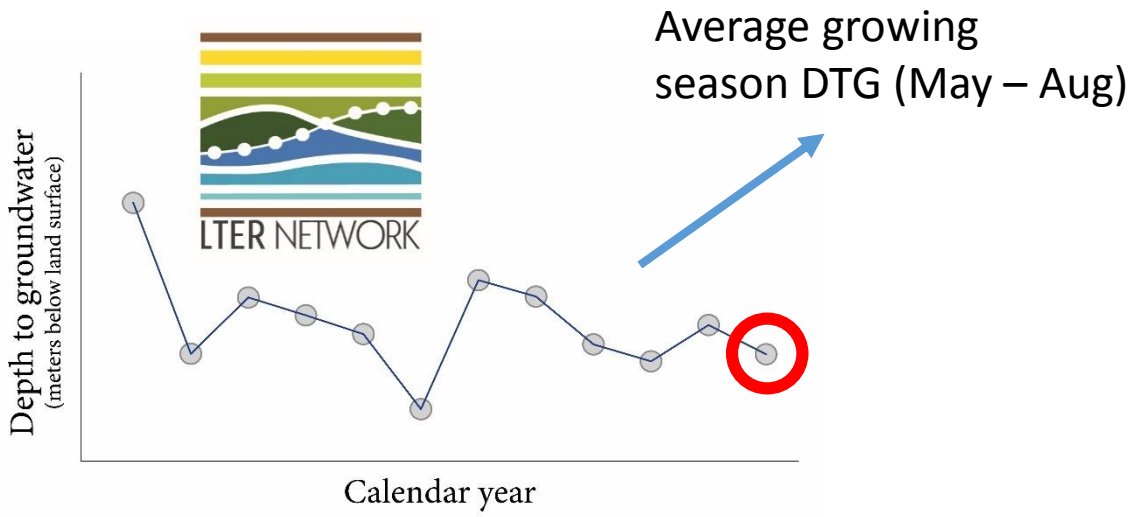
Tree growth response along a depth to groundwater gradient

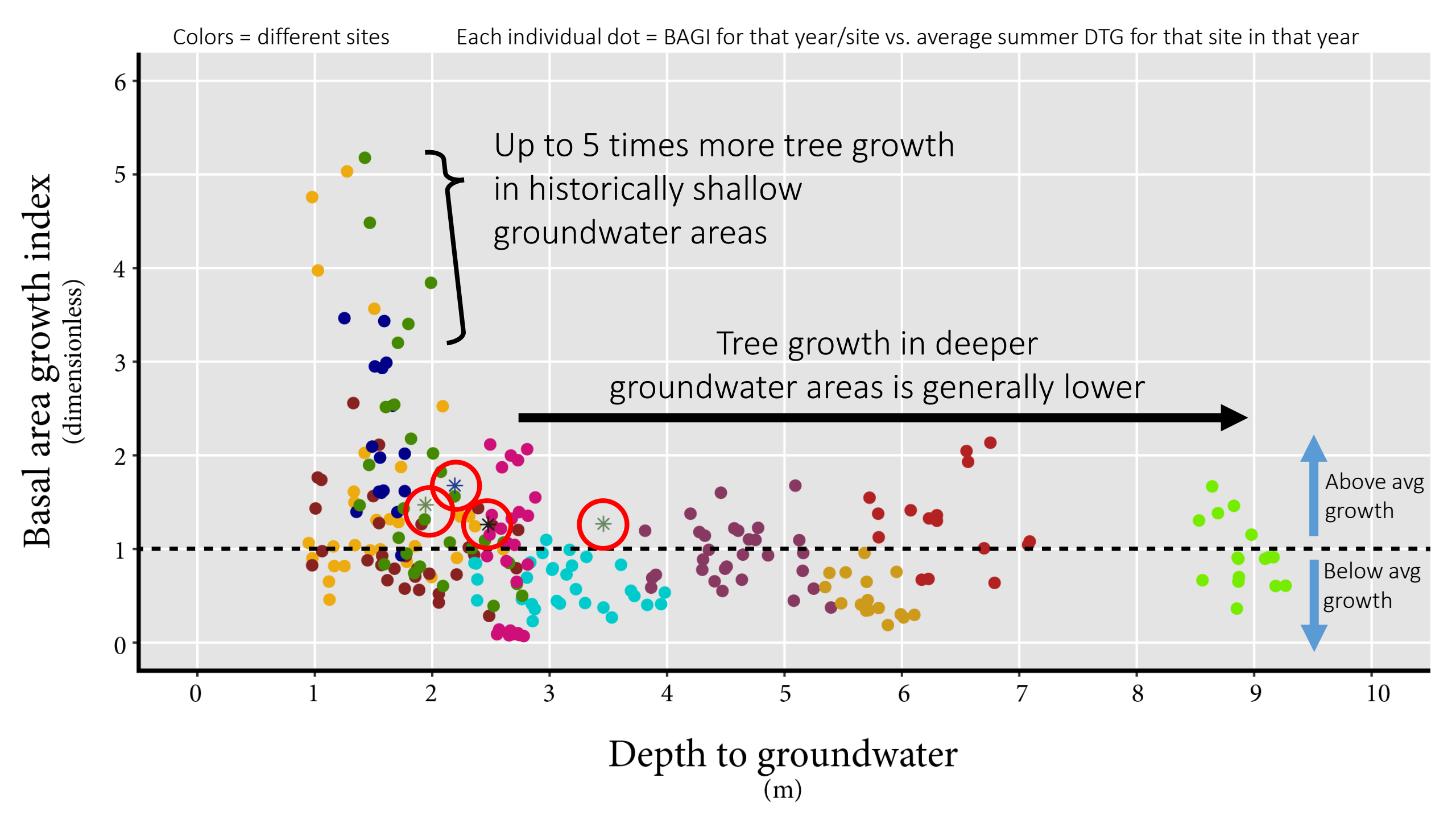
Time series:
BAGI for each tree

Time series:
Average BAGI for each site

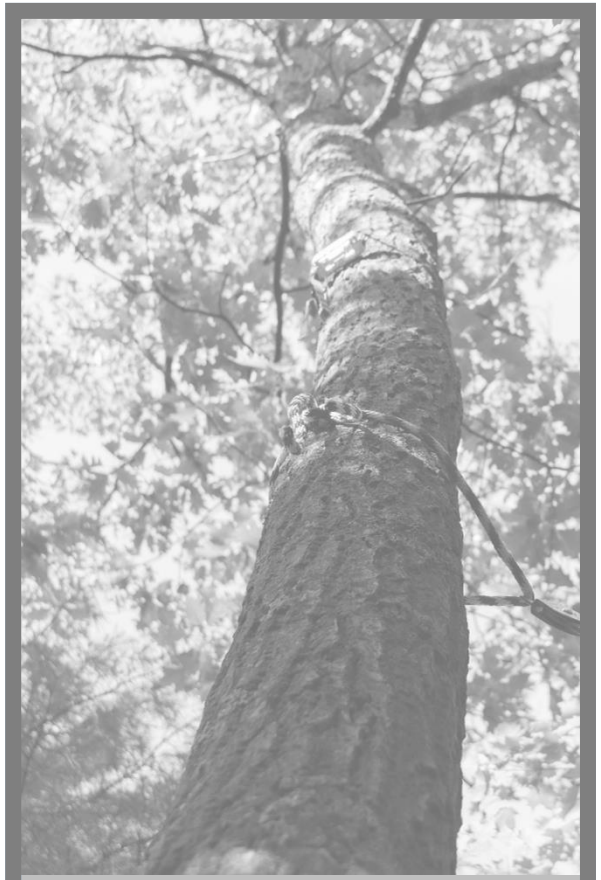
Match BAGI in a year to that site's DTG in that year





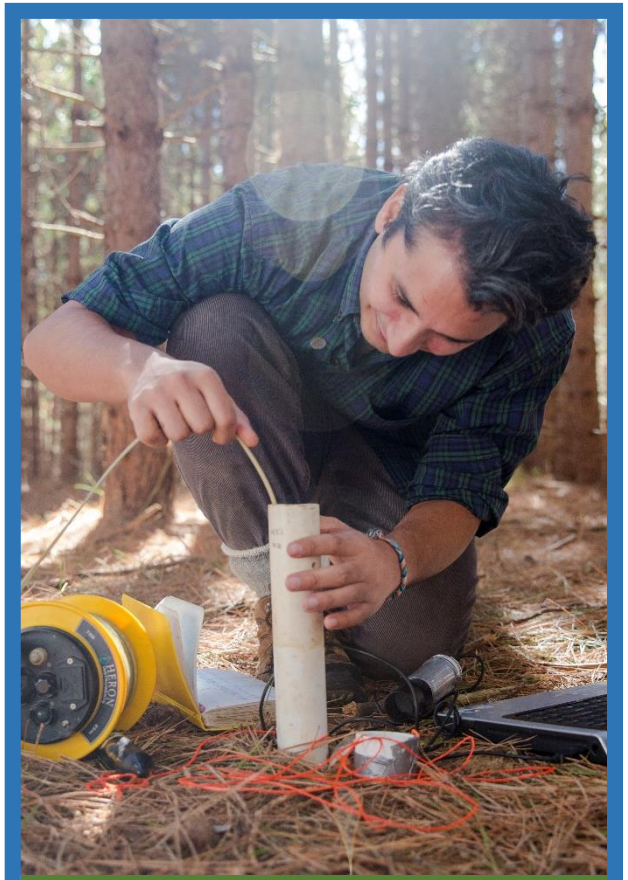

Colors = different sites
Each individual dot = BAGI for that year/site vs. average summer DTG for that site in that year
Basal area growth index
(dimensionless)
Up to 5 times more tree growth
in historically shallow
groundwater areas
Tree growth in deeper
groundwater areas is generally lower
Above avg
growth
Below avg
growth
Depth to groundwater
(m)
0
1
2
3
4
5
6
7
8
9
10

Outline



Motivation

Tree growth along a depth to GW gradient



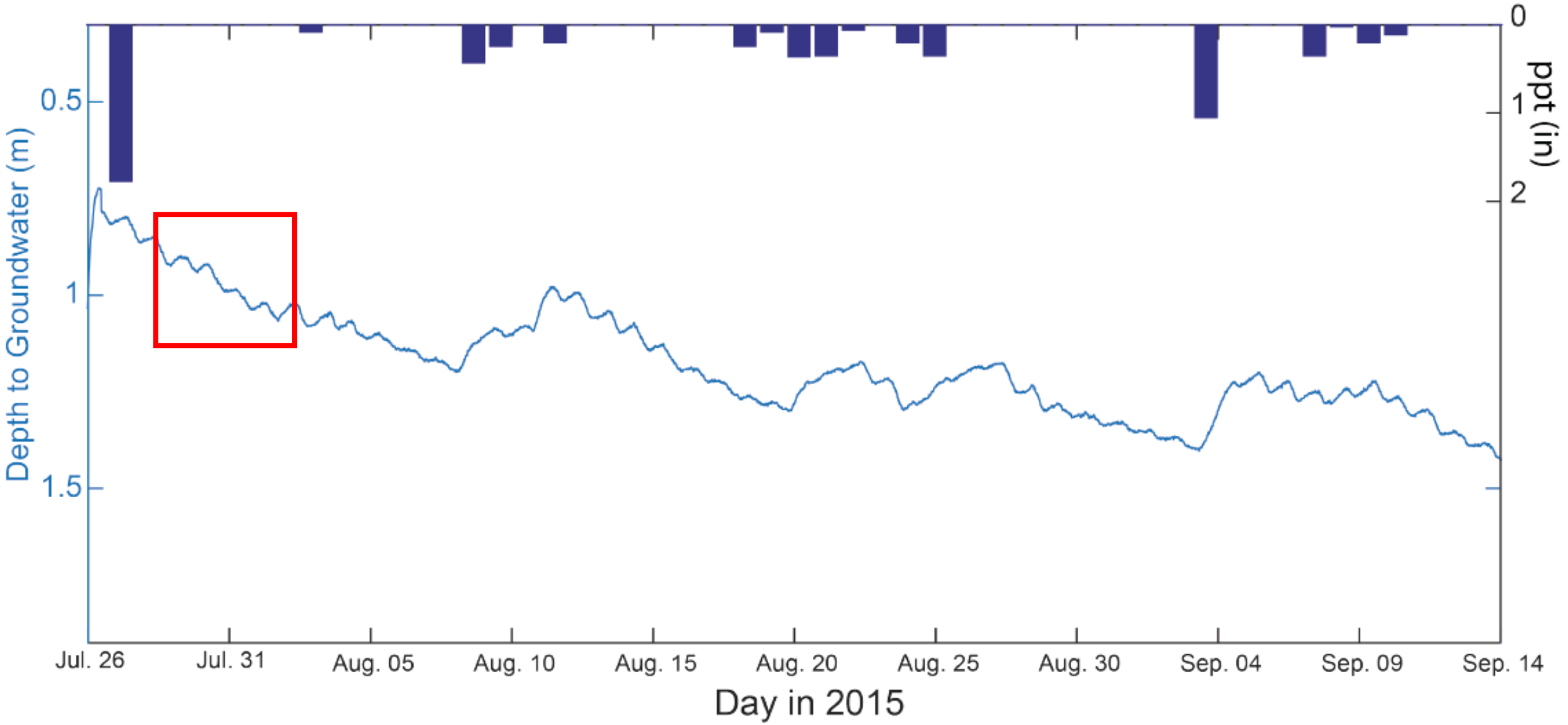
GW use by forests in WI

Summary & Implications

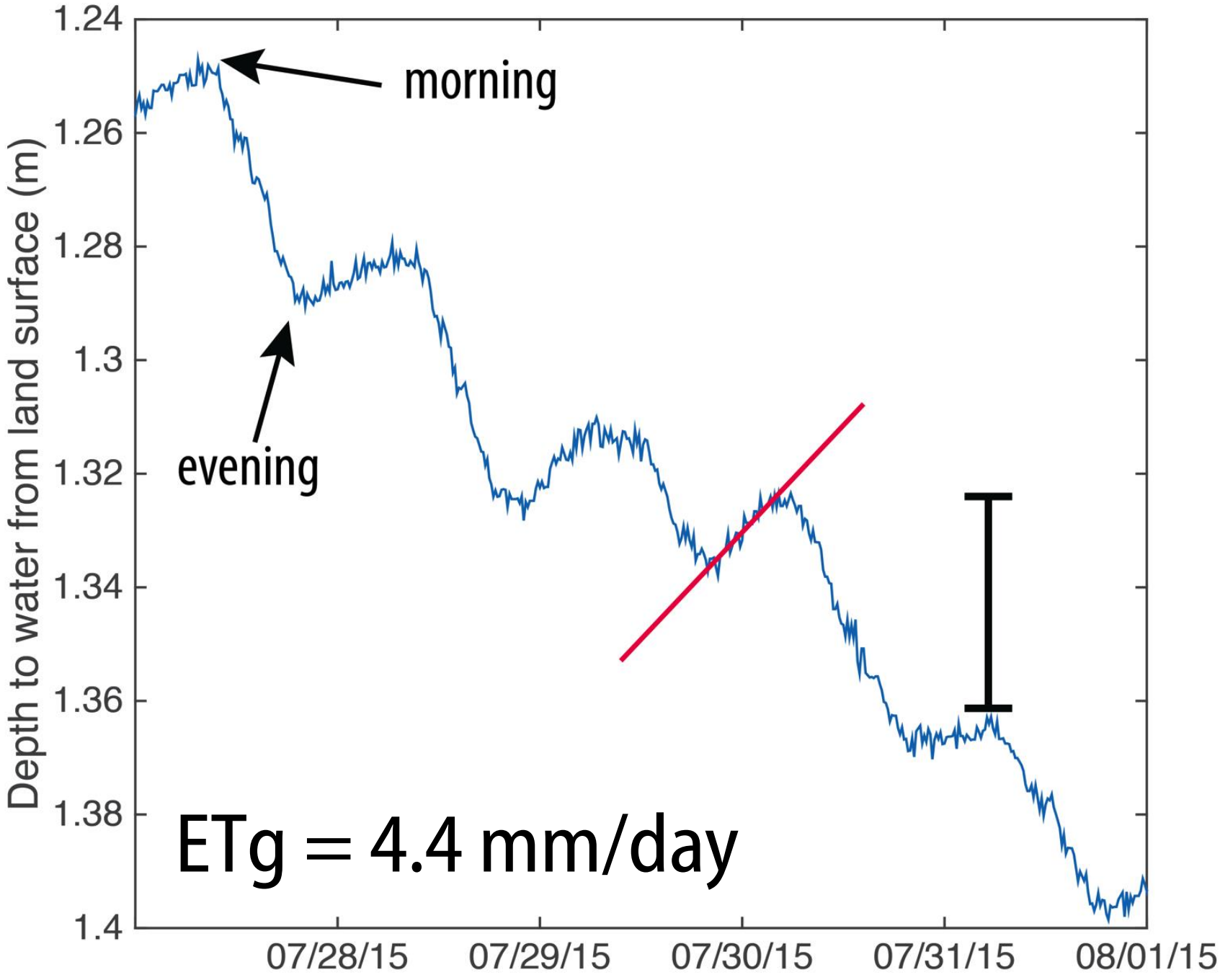
How much groundwater do trees use?

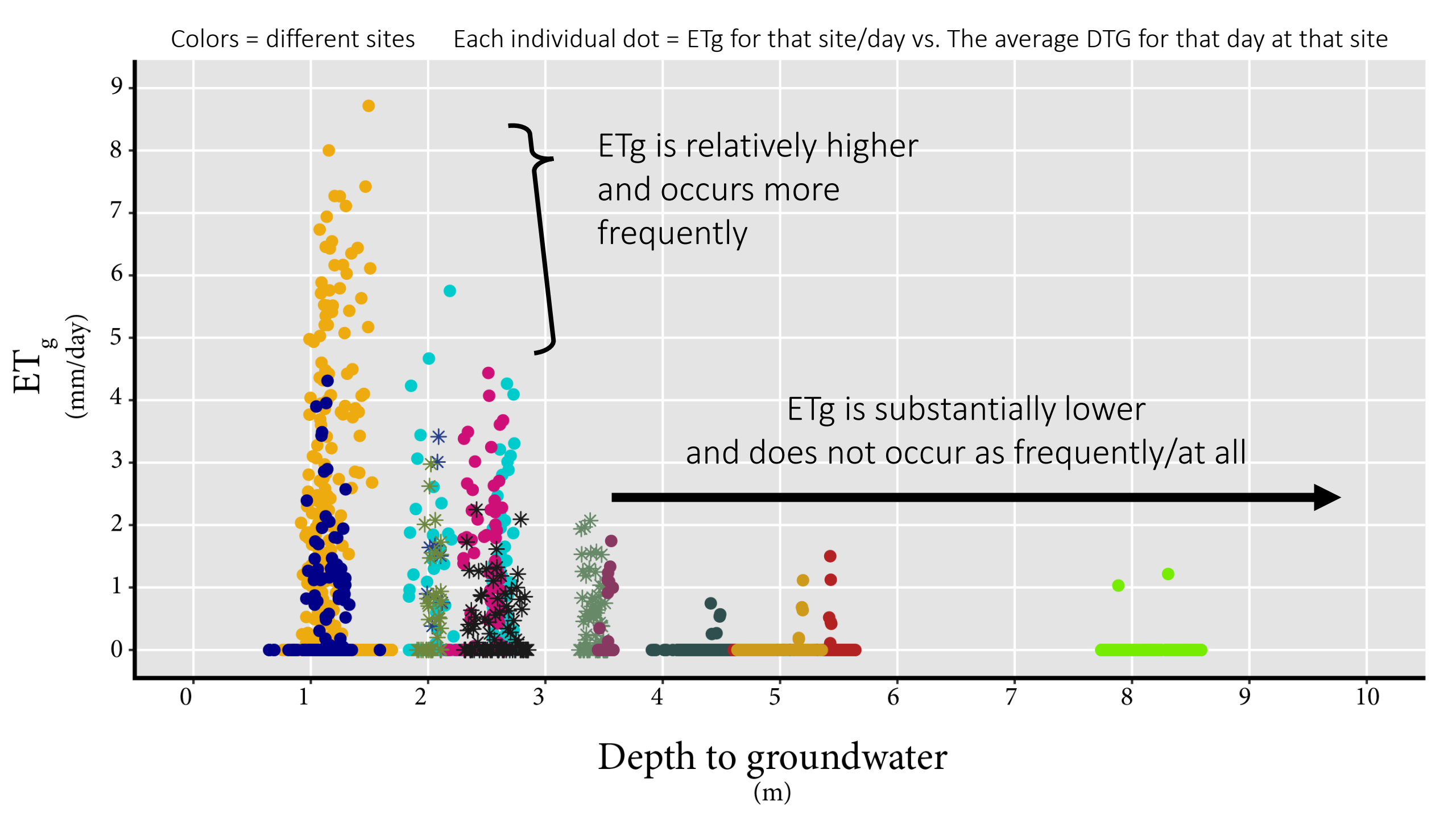
Do these amounts change along a depth to groundwater gradient?

Diurnal water table fluctuations

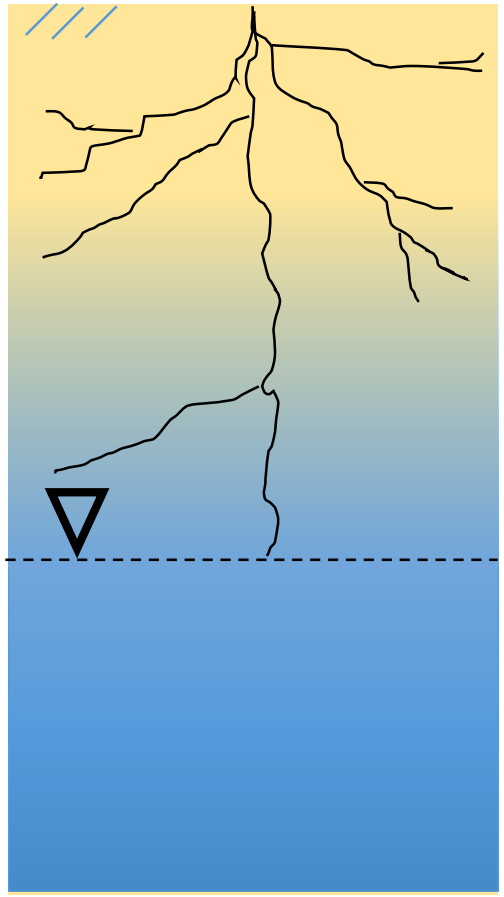


Estimating consumption of groundwater by forests for ET




Colors = different sites
Each individual dot = ETg for that site/day vs. The average DTG for that day at that site
ETg is relatively higher and occurs more frequently
ETg is substantially lower and does not occur as frequently/at all
ETg (mm/day)
Depth to groundwater (m)
0
1
2
3
4
5
6
7
8
9
10

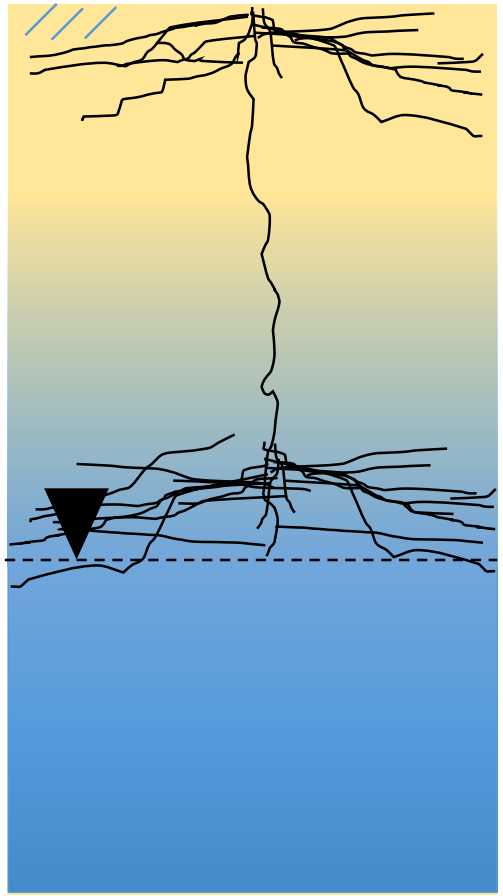
Observations from the field



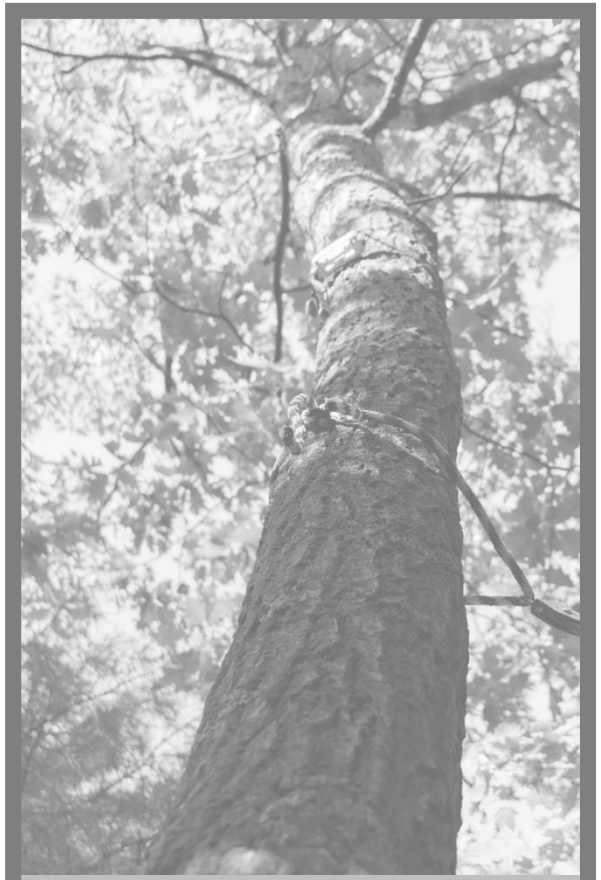
Pine plantation in Portage County, WI

Rooting depth (qualitative) profile

- Lots of roots in first 20 cm
- Not many roots 20-180 cm
- Lots of live roots 180-200 cm
- Water table at 200 cm

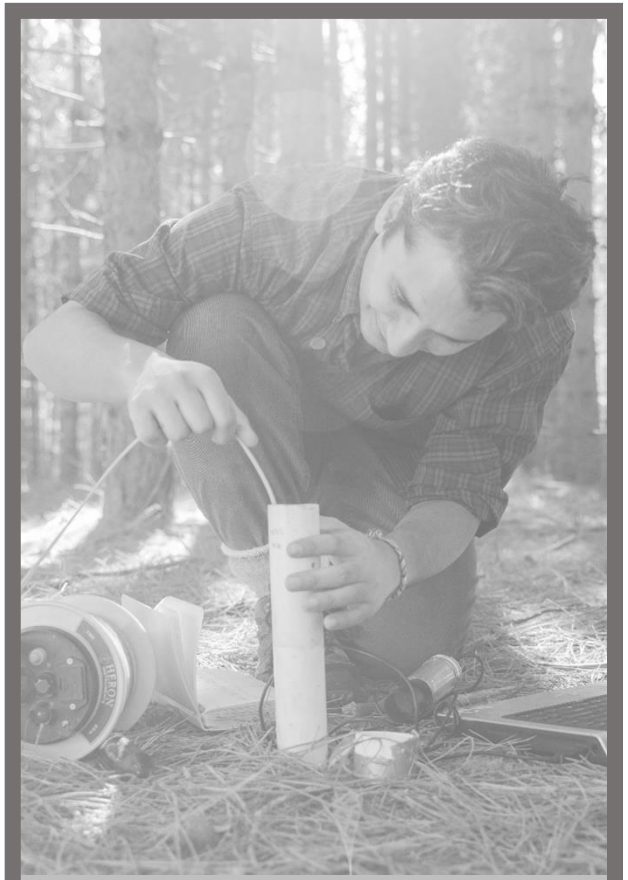


Outline



Motivation

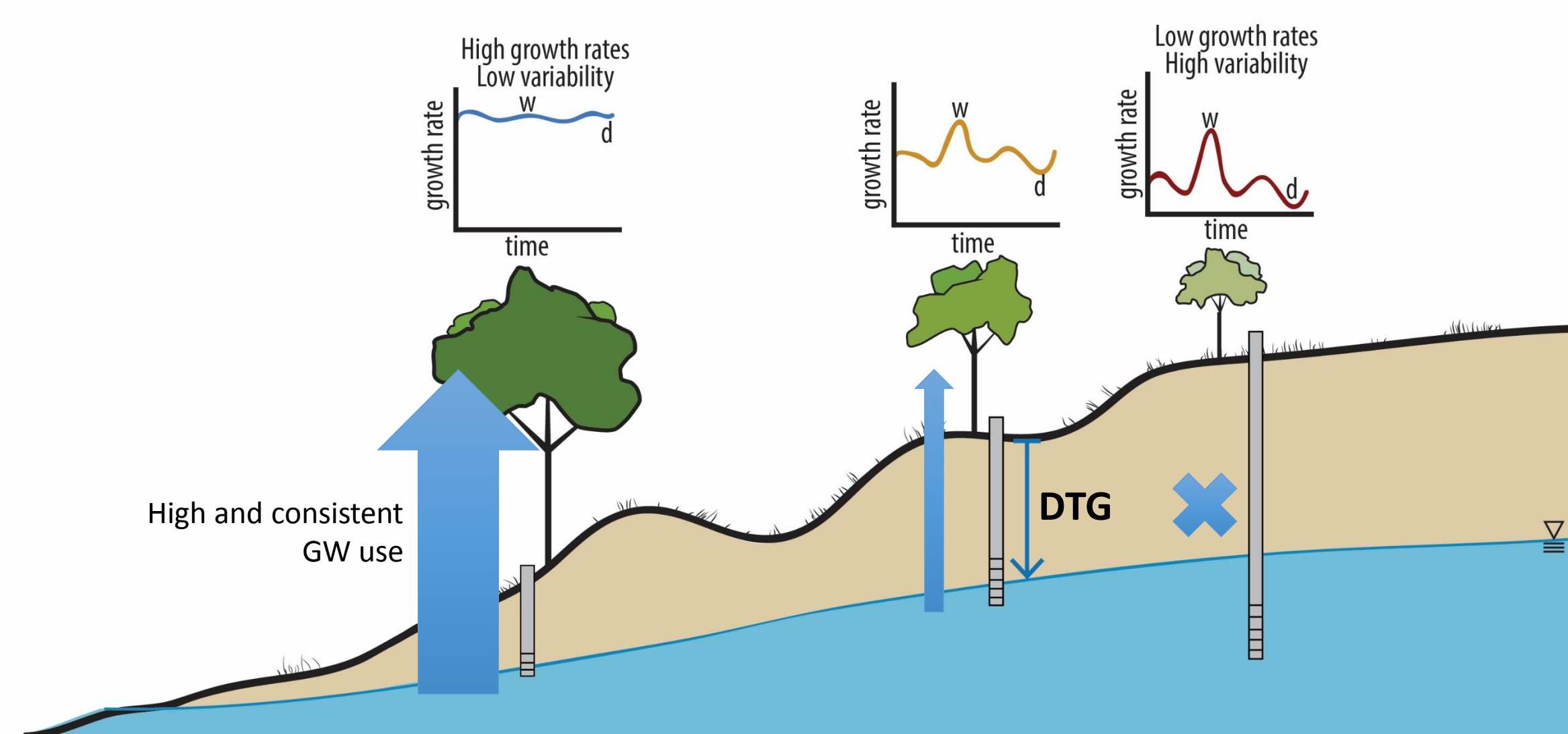
Tree growth along a depth to GW gradient



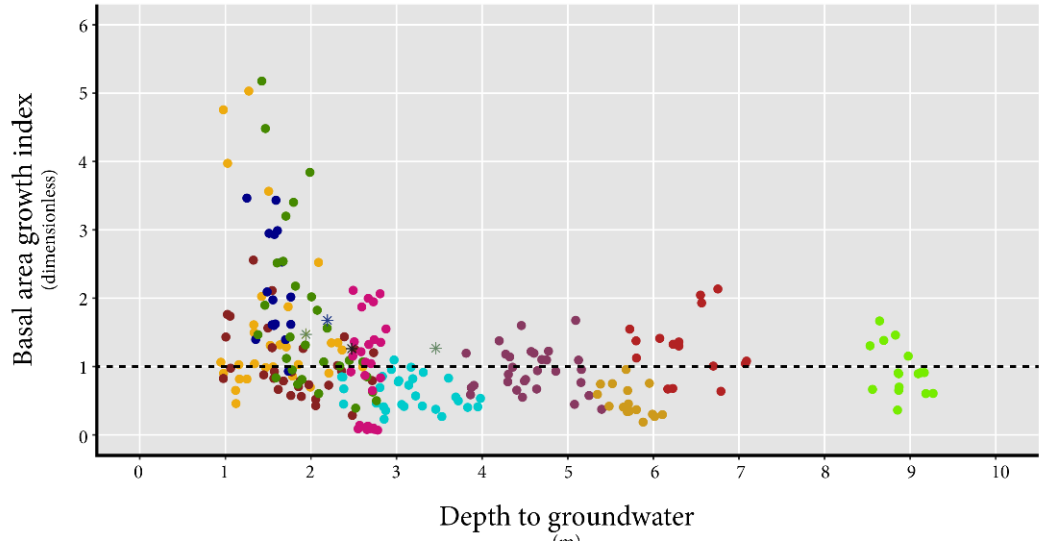
GW use by forests in WI

Summary & Implications

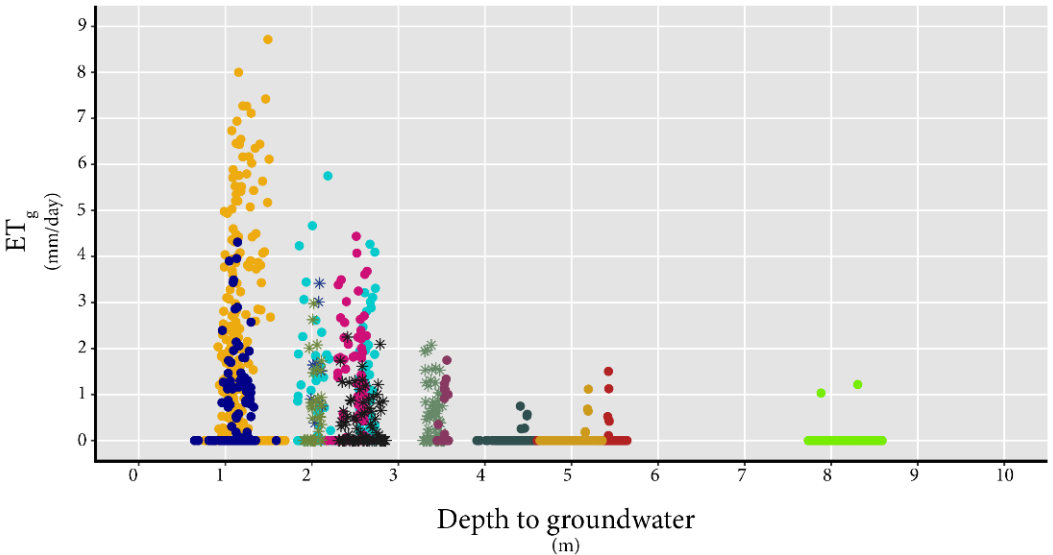
Conceptual model & Hypotheses revisit



Summary of key points



Tree growth is up to 5 times higher in areas of shallow groundwater compared to trees in deeper groundwater sites



ETg is substantially higher and occurs more frequently at shallow groundwater sites compared to deeper groundwater sites

Implications

Tree growth is influenced by water table depth in sandy Wisconsin forests

Potential for understanding where in the landscape drought may have more of an impact on tree growth

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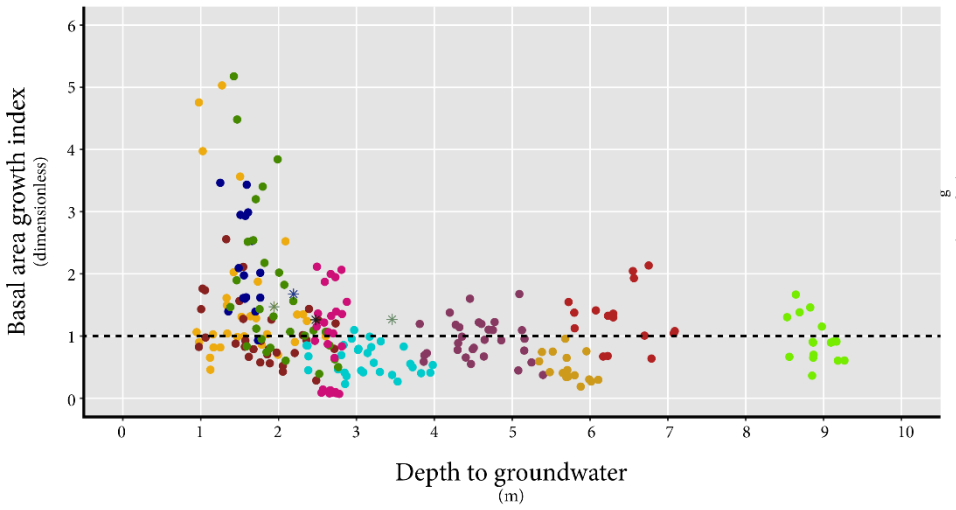
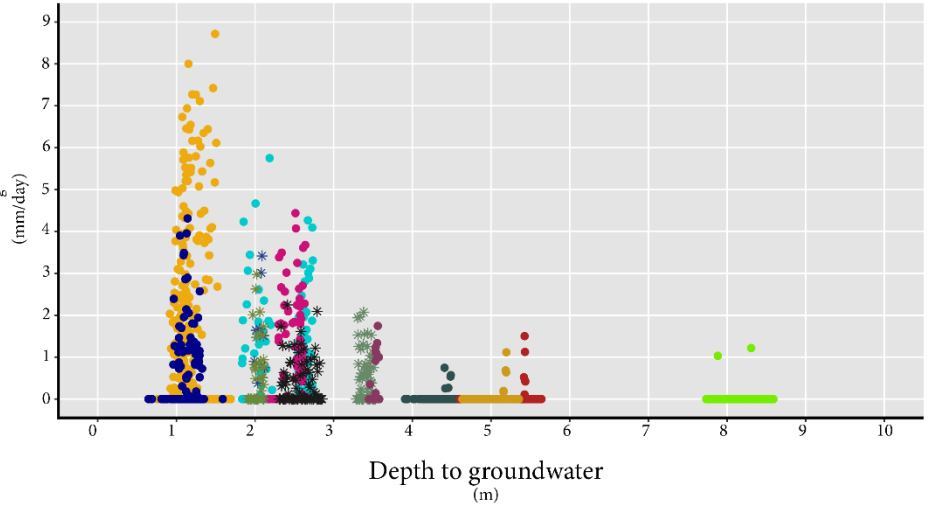
Trees in Wisconsin use groundwater, but not everywhere and not all the time

A step toward improving our understanding of the Wisconsin water budget, particularly evapotranspiration

Future work

- Understanding tree growth as a function of climate + groundwater history (levels, ETg)
- Trees as hydrologic sensors: Extending historic information on groundwater levels, groundwater usage from tree cores
  >> Historic changes in groundwater use due to climate/pumping?





Acknowledgements

Steve Loheide

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

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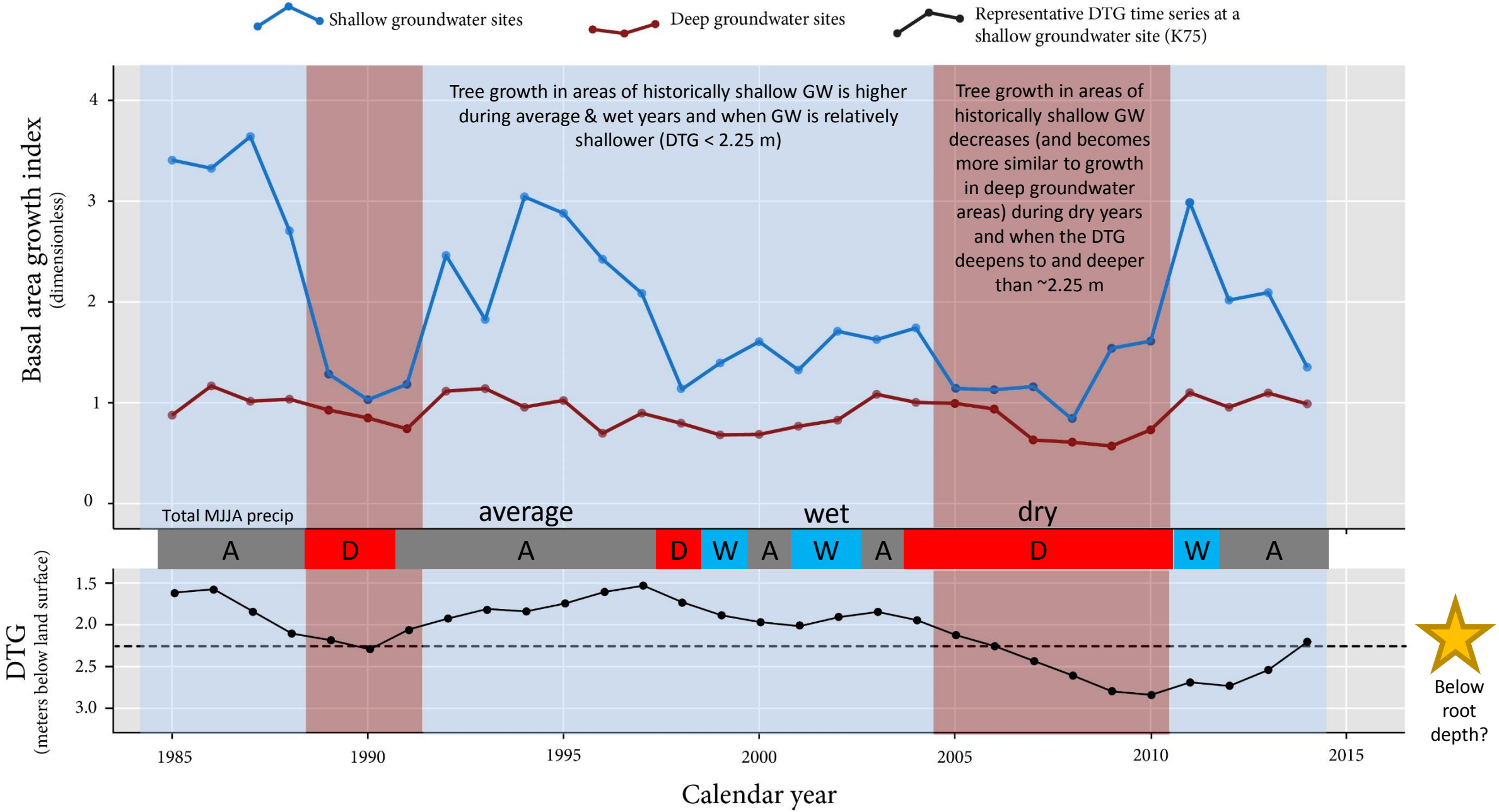
UW Water Resource Institute (WR17R002)


Thanks for listening!
Questions?


Shallow groundwater sites
Deep groundwater sites
Representative DTG time series at a shallow groundwater site (K75)
Basal area growth index
(dimensionless)
Tree growth in areas of historically shallow GW is higher during average & wet years and when GW is relatively shallower (DTG < 2.25 m)
Tree growth in areas of historically shallow GW decreases (and becomes more similar to growth in deep groundwater areas) during dry years and when the DTG deepens to and deeper than ~2.25 m
Total MJJA precip
average
wet
dry
A
D
A
D
W
A
W
A
D
W
A
DTG
(meters below land surface)
Below root depth?
Calendar year