Root pruning:

What we know, what we don't know, and some things we've learned recently

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8–11 September 2019

Arboricultural Association annual amenity conference. Exeter, UK. 11th September 2019

Why are roots important?

- Anchorage and stability
- Water and mineral uptake
- Carbohydrate storage
- Chemical signalling, e.g. abscisic acid

Why do we prune roots?

- Utility installation / repair
- Footpath / sidewalk repair
- Housing developments
- Transplanting
- Nursery / crop production

Photo credit: www.finegardening.com

A long time ago

2019

706 AD

Penjing, also known as *penzai*.

Earliest form of what is today referred to as "*bonsai*"

A long time ago

500 – 1500 AD

2019

706 AD

Ablaqueation

Medieval technique to promote fruiting

A long time ago

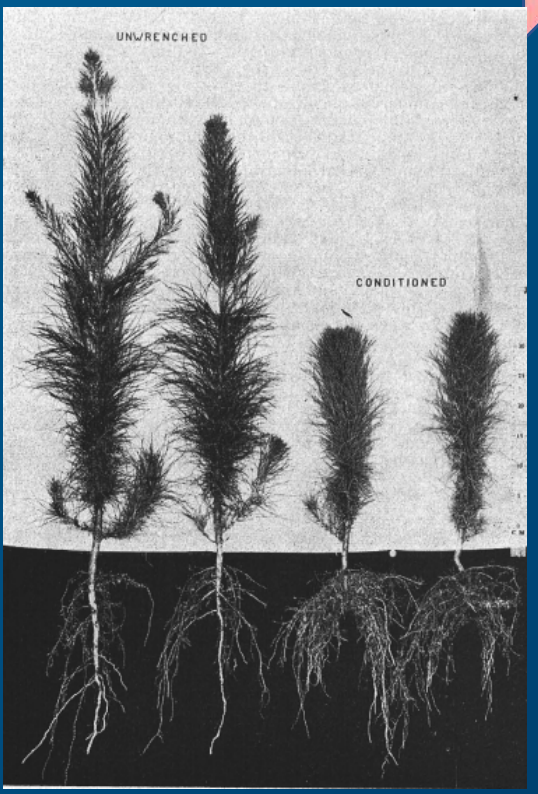
500 – 1500 AD

1963 - 1972

2019

706 AD

Undercutting / wrenching



Images: (Van Dorsser et al., 1972)

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A long time ago

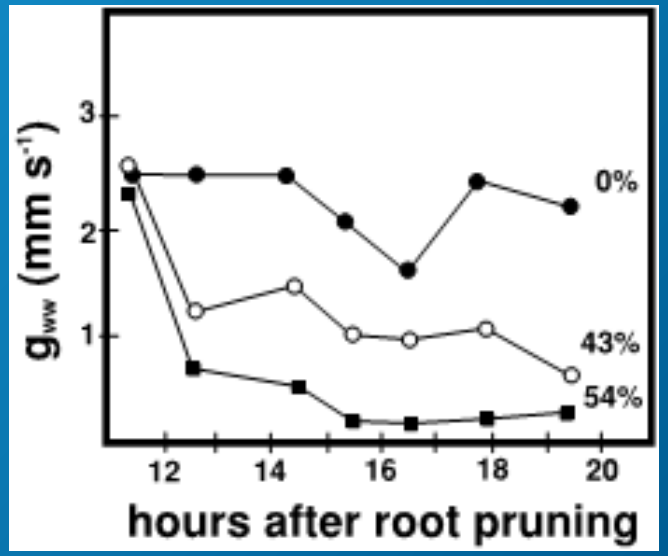
500 – 1500 AD

1963 - 1972

2019

706 AD

1983



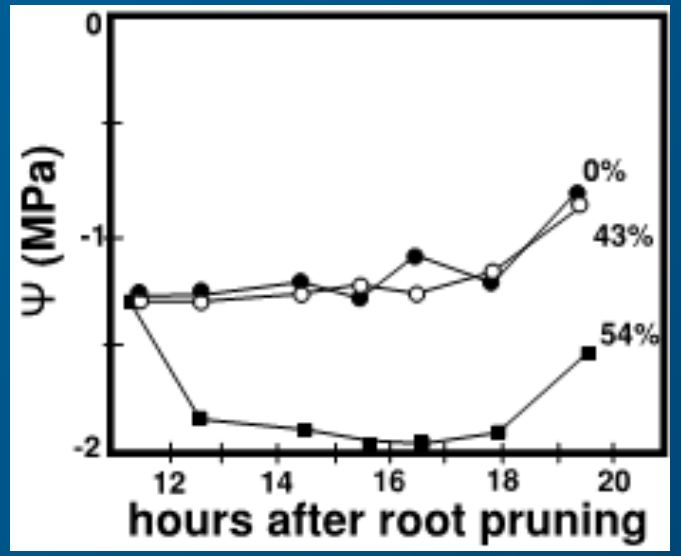



Photo credit: PS Micrographs @ www.researchinestonia.eu


Photo credit: www.missouribotanicalgarden.org

Teskey, R.O., Hinckley, T.M. & Grier, C.C., 1983. Effect of Interruption of Flow Path on Stomatal Conductance of *Abies amabilis*. Journal of Experimental Botany 34(147), 1251-1259,

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A long time ago

500 – 1500 AD

1963 - 1972

1998

2019

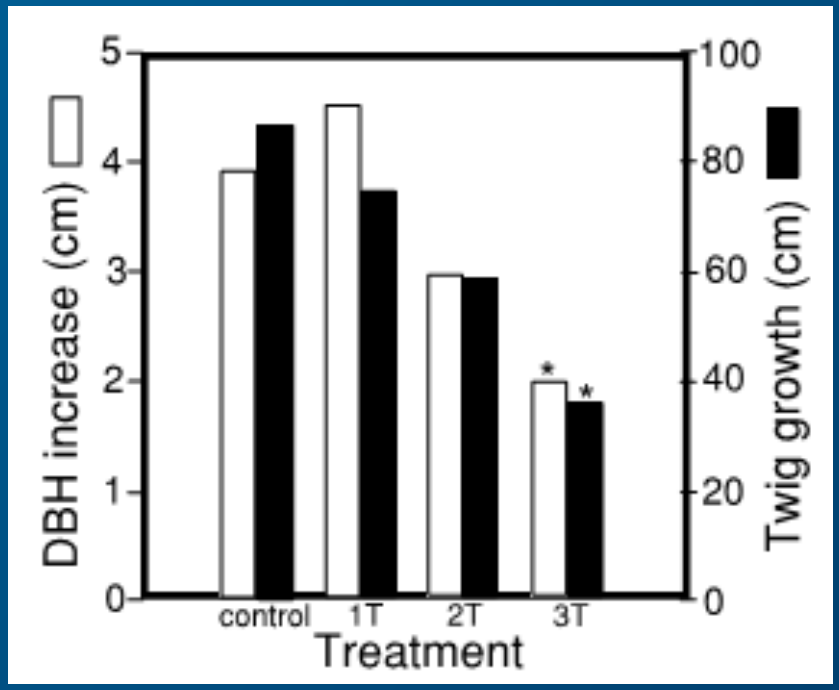
706 AD

1983

Journal of Arboriculture 24(1): January 1998

TREE GROWTH AFTER TRENCHING AND COMPENSATORY CROWN PRUNING

by Gary W. Watson



Root pruning resulted in reductions in trunk diameter growth and twig elongation for five years, as well as increased dieback / reduced vitality.

Watson, G.W., 1998. Tree growth after trenching and compensatory crown pruning. Journal of Arboriculture 24(1), 47-53

A long time ago

1963 - 1972

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2019

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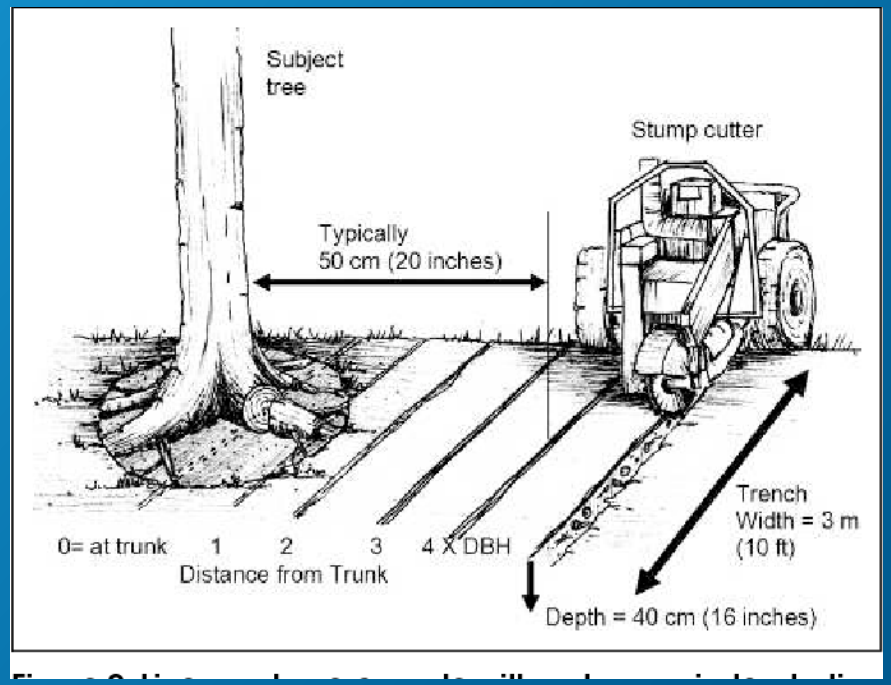

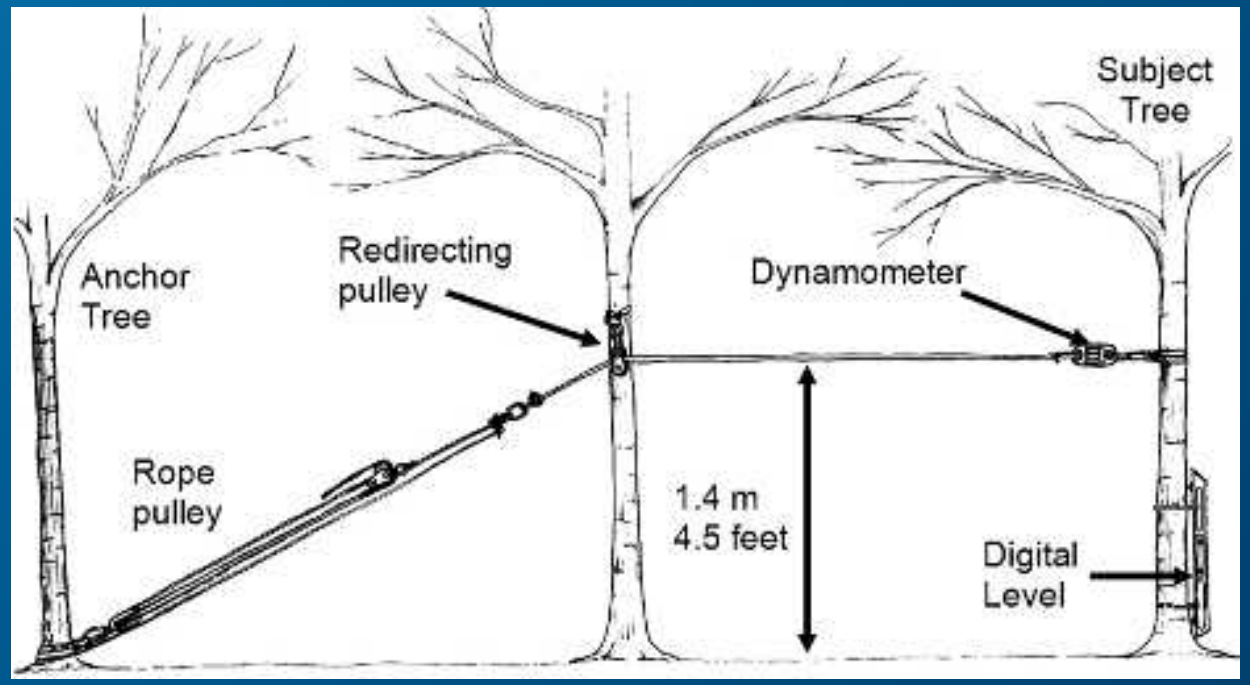

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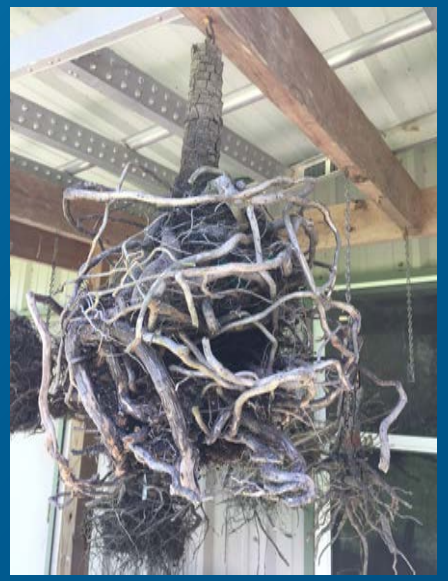
1998

2008 - 2014

2016

2019

(Gilman et al., 2015)



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Gilman, E.F., Paz, M. & Harchick, C., 2016. Effect of container type and root pruning on growth and anchorage after planting *Acer rubrum* L. into Landscape Soil. Arboriculture and Urban Forestry 42(2), 73-83,

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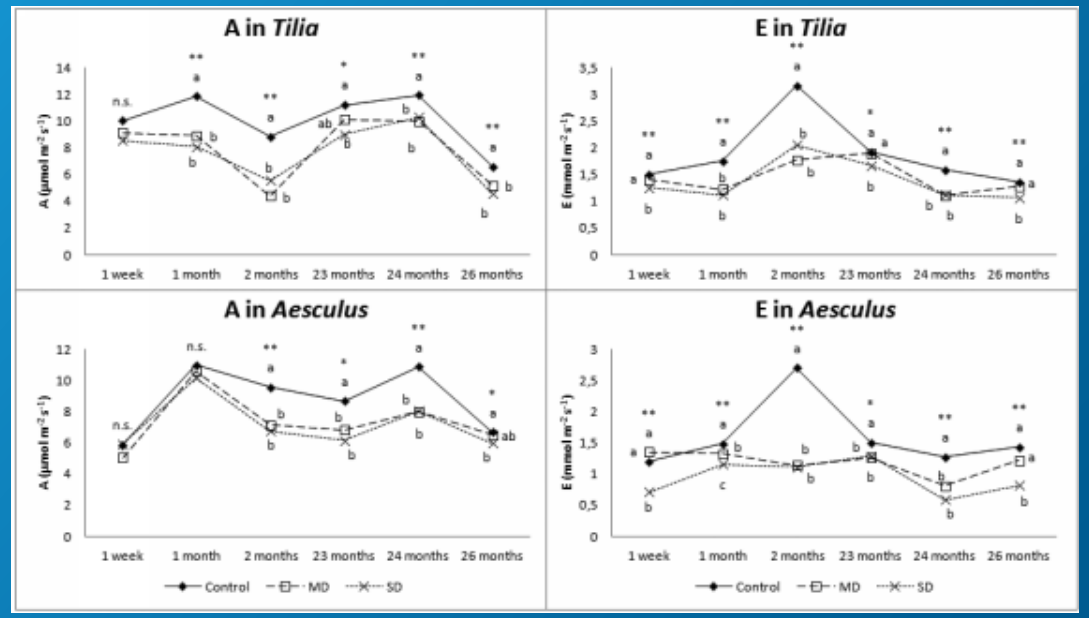
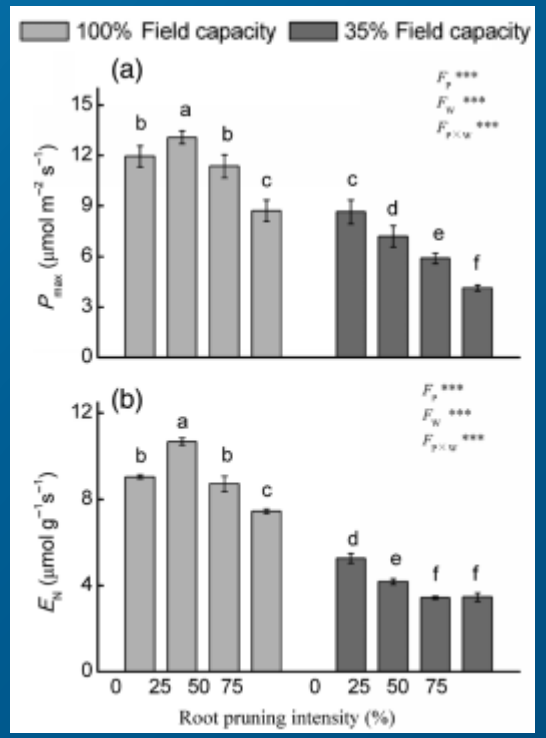
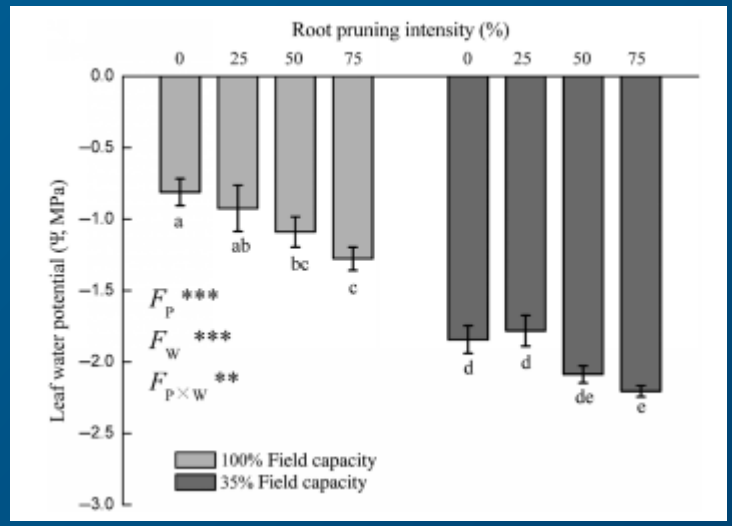


(Fini et al., 2013)





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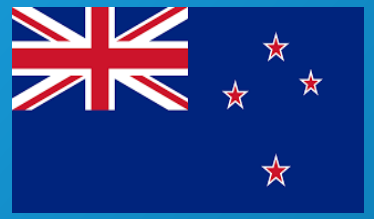
What the research tells us: Things we know

- Root pruning can negatively affect tree growth & vitality
- Root pruning can negatively affect tree stability
- Root pruning can improve root system architecture and post-transplant success of nursery trees
- Root pruning can negatively affect tree physiology, by inducing a chronic, but mild water stress

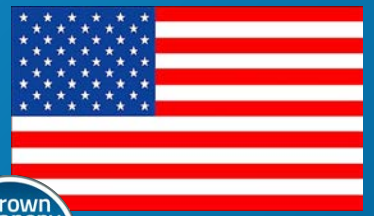
Current guidelines



- NZArb, 2011, A Guideline for Tree and Bush Protection on Development Sites (New Zealand)
- Auckland Council, 2018. Auckland Unitary Plan (Operative in Part). Auckland E.17.6.3: 2(a)i (New Zealand)

- BS5837: 2012 - Trees in relation to design, demolition and construction – Recommendations (UK)
- National Joint Utilities Group 2007. 4: Guidelines for the Planning, Installation and Maintenance of Utility Apparatus in Proximity to Trees (UK)

- AS 4970-2009 - Protection of Trees on Development Sites (Australia)



- ANSI A300 - Management of Trees and Shrubs During Site Planning, Site Development, and Construction (USA)

Some unanswered questions: Things we don't know...

..... yet

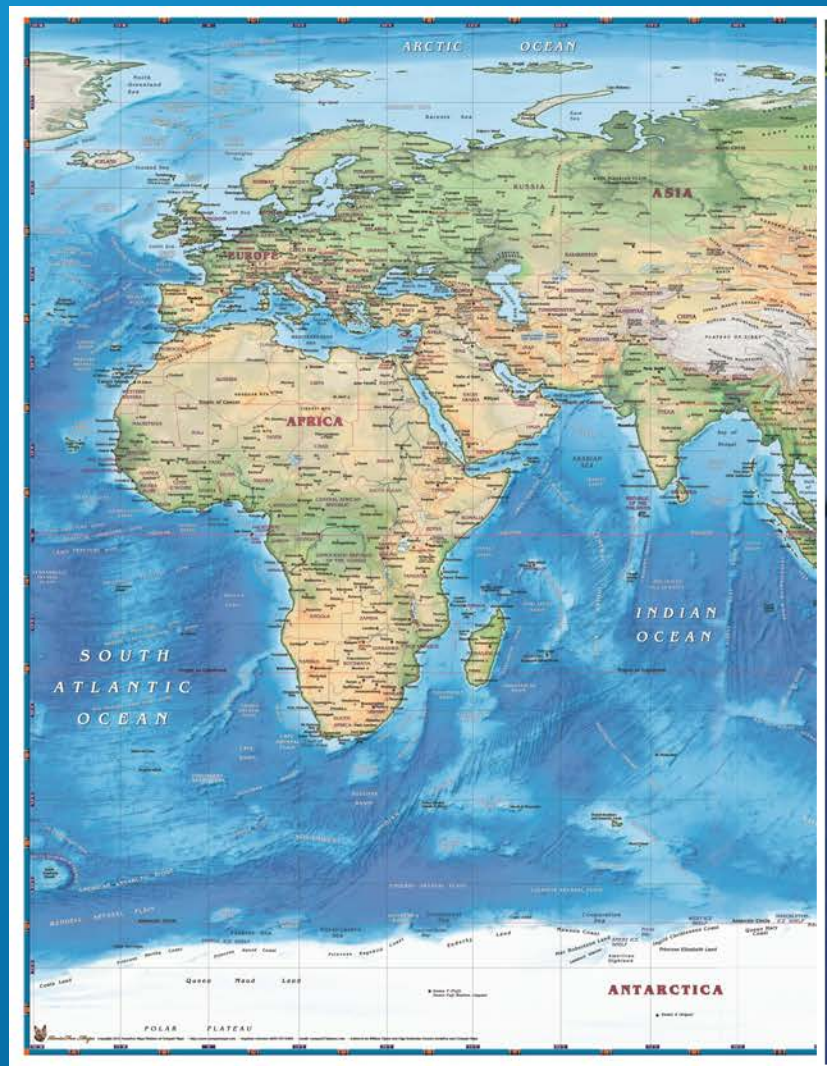
- How big does a tree protection zone need to be to avoid negative effects on tree health?
- How close to a tree can we trench without causing lasting negative health effects?
- How do we account for cumulative root loss relative to the size of the tree when roots are selectively removed, and how many - and of what size - can we remove without causing problems?

1998

2008 - 2014

2016

2019



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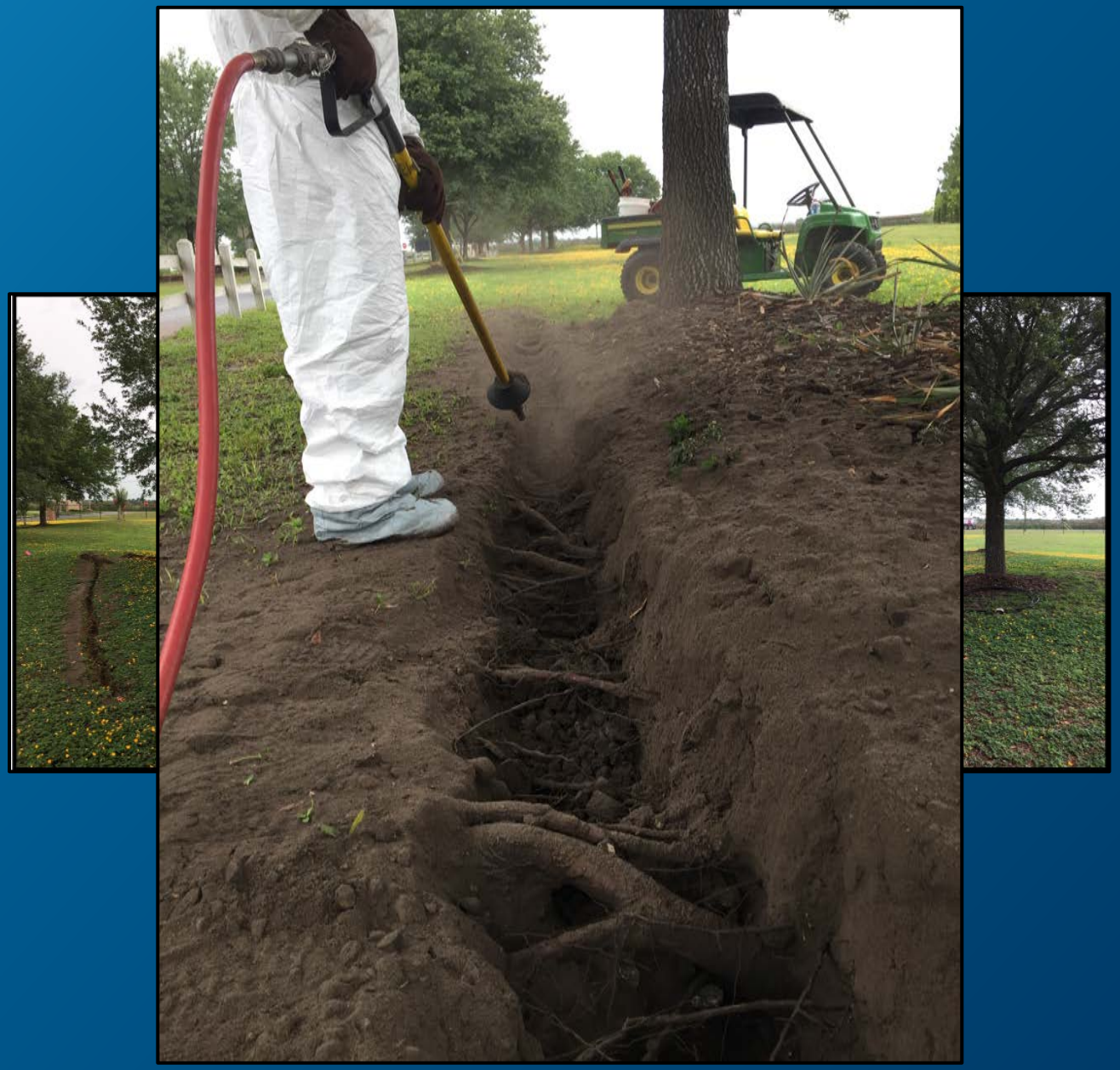
Experiment 1

- 18 *Quercus virginiana*
- Approx. 8 m tall
- Approx. 25 cm DBH
- Circular trench 500 mm deep
- Radii equal to 15, 12, 9, 6 and 3 times trunk diameter plus control
- All roots severed (except control)
- Three replicates
- One growing season (2017)

Experiment 2

- 31 *Quercus virginiana*
- Approx. 10 m tall
- Approx. 35 cm DBH
- Single trench 10 m long 500 mm deep
- 12, 6 and 3 times DBH plus control
- All roots severed
- Eight replicates plus seven controls
- Two growing seasons (2017 – 2018)



Methods - root cross-sectional area

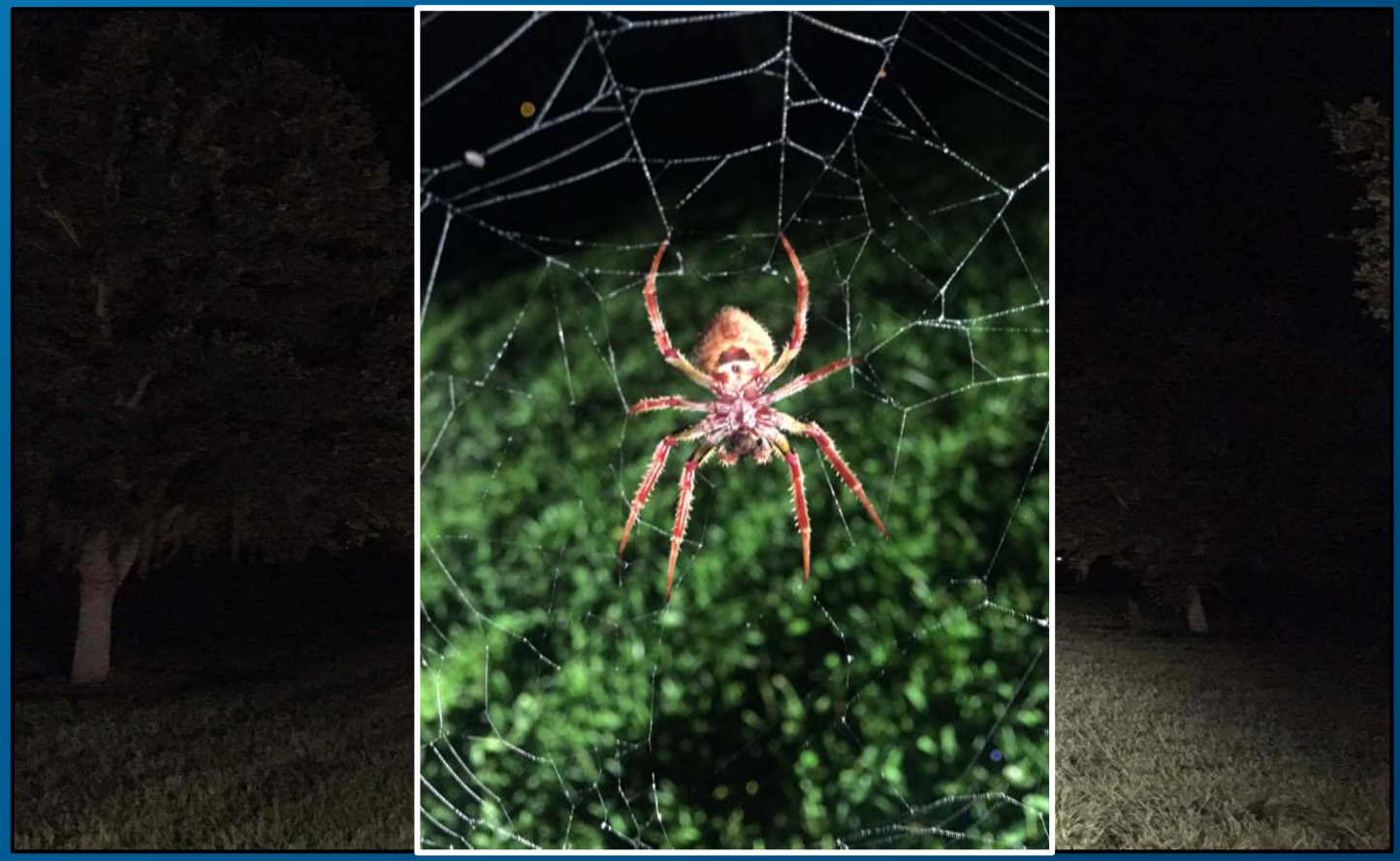
$$\textit{Root cross sectional area ratio } (Ar_{(x)}) = \frac{\textit{Combined root cross sectional area}}{\textit{Trunk cross sectional area at height} = x\ m}$$

Methods - Morphological response

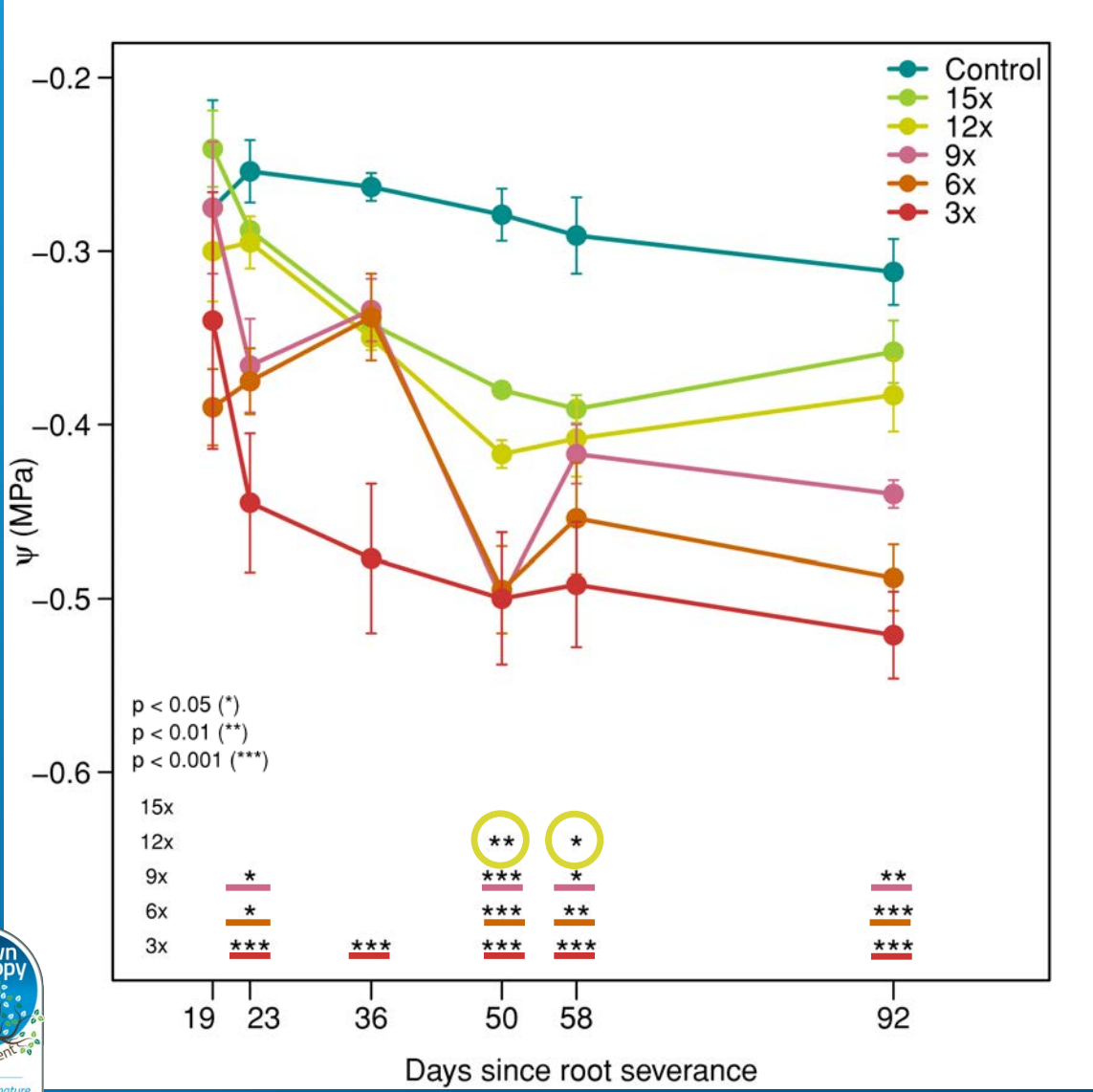
- Trunk diameter growth
- Shoot extension (18 new terminal shoots per tree)
- Leaf area (ten sun leaves per tree)

Methods – Pre-dawn leaf water potential

- 03:00 to 05:00
- A highly sensitive measure of water stress
- One or two fully expanded sun leaves per tree

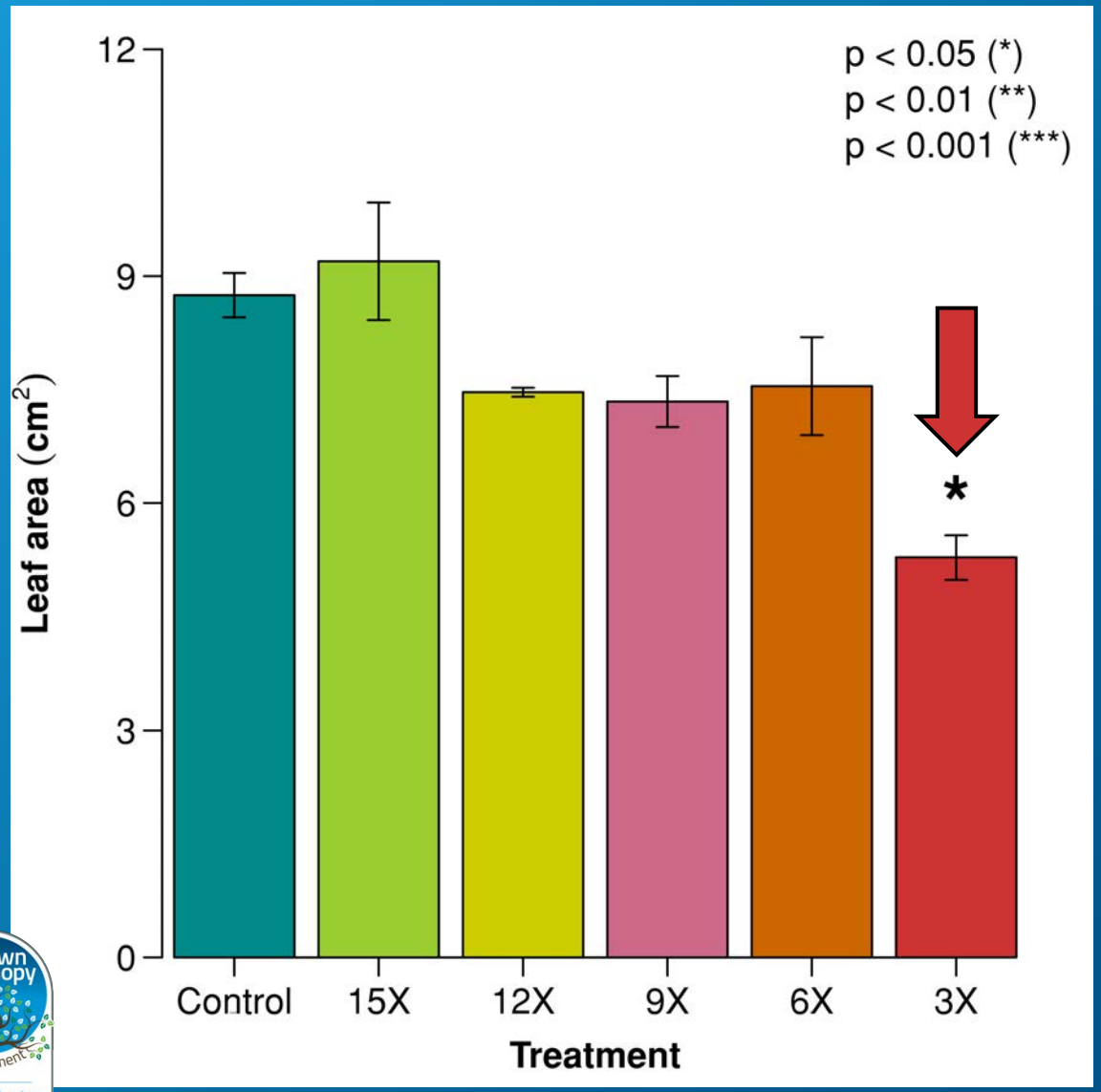


Results– Experiment 1 (water potential)



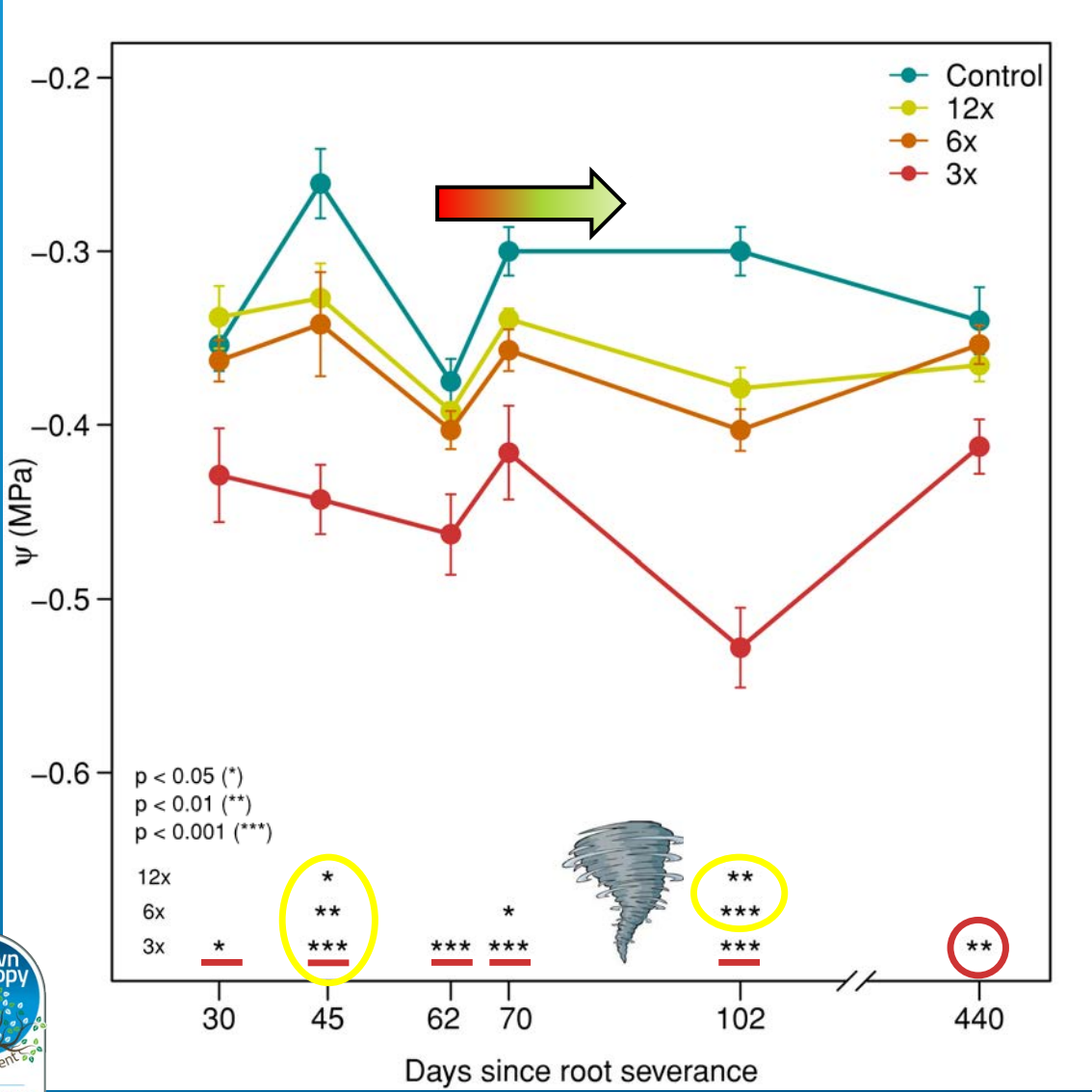
- 3x, 6x and 9x treatments showed sustained water stress symptoms during the first growing season after root severance
- The 12x treatment showed statistical separation from the control on two days approximately eight weeks after roots were cut

Results– Experiment 1 (tree growth)



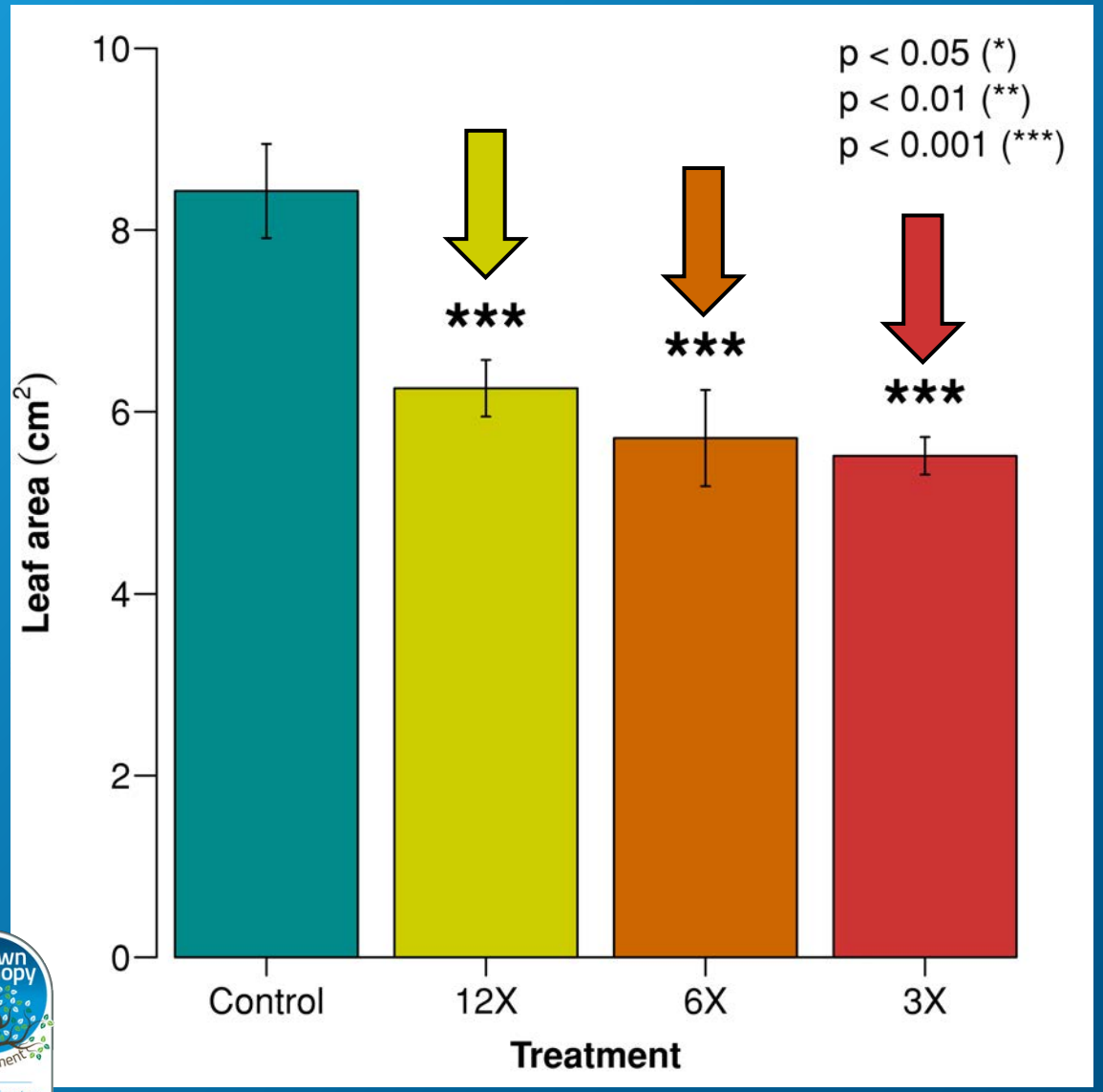
- Only the 3x treatment differed significantly for the trunk diameter growth response
- 3x, 6x and 9x treatments differed significantly from control for the new shoot extension response
- Only the 3x treatment differed significantly for the leaf area response

Results– Experiment 2 (water potential)



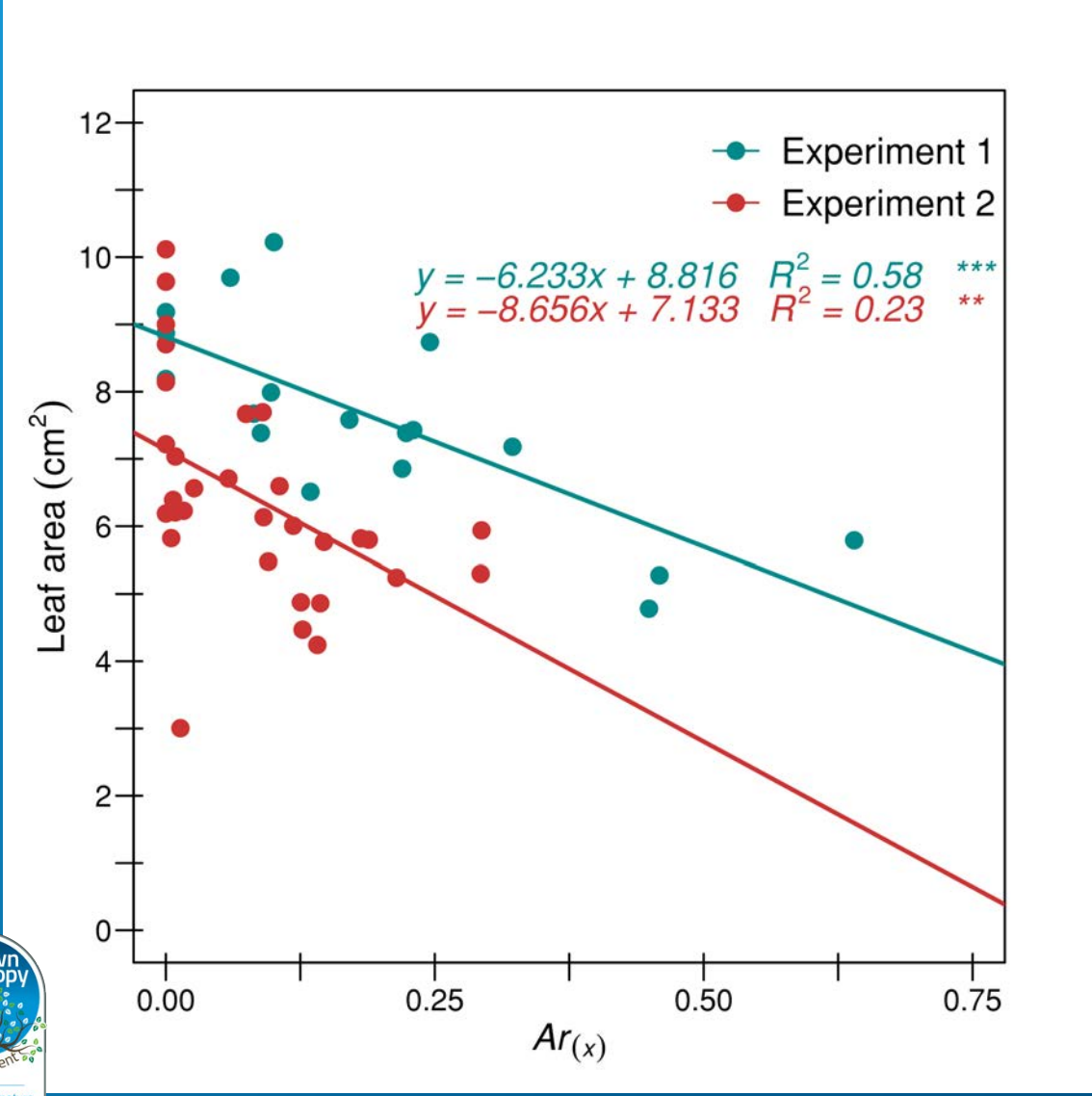
- All treatments showed signs of water stress 45 days after root loss
- A period of recovery for 12x after the initial effects of root loss
- The 3x treatment displayed sustained water stress symptoms for 440 days following root severance

Results– Experiment 2 (tree growth)



- No treatment effects on trunk diameter growth after one growing season
- Shoot extension negatively affected by all root pruning treatments
- Leaf area negatively affected by all root pruning treatments
- All treatment effects absent in second growing season

Results– Using allometry ($Ar_{(x)}$)



- Water potential is sensitive to changes in $Ar_{(x)}$ after one growing season
- Useful for predicting changes in trunk growth when roots severed in circular trenches
- Shoot elongation response is highly variable. $Ar_{(x)}$ useful when roots are severed in circular trenches
- Useful for predicting changes in leaf area when roots severed in circular trenches

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Some things we've learned recently

How big does a tree protection zone need to be, to avoid negative effects on tree health?

To avoid all water stress symptoms, the TPZ radius needs to be bigger than 12 times trunk diameter at 1 m

To avoid negative growth effects, the TPZ radius needs to be bigger than 9 times trunk diameter at 1 m

Some things we've learned recently

How close to trees can trenching be undertaken without sustained negative effects?

Water stress effects were alleviated in the 12x and 6x treatments after 440 days and persisted in the 3x treatment.

Some things we've learned recently

- How do we account for cumulative root loss relative to the size of the tree when roots are selectively removed, and how many - and of what size - can we remove without causing problems?

  $Ar_{(x)}$ accounts for cumulative root loss and is useful for predicting tree responses, but relationships were linear and no clear threshold was revealed.

  The most effective way to account for cumulative root loss is to estimate a percentage of root zone which has been removed.

Take home messages

- To achieve an optimum standard of tree care, implement a tree protection radius equivalent to 15 times DBH.
- To avoid sustained negative effects on tree health, do not undertake trenching closer to the tree base than a distance equivalent to 6 times DBH (approx. 25% of the root system).
- Avoid root cutting if you can.
- Improve cultural practices after root cutting (e.g. irrigation)

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A test of tree protection zones: Responses of *Quercus virginiana* Mill trees to root severance treatments

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Responses of mature roadside trees to root severance treatments

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