Potential of thinning to increase drought tolerance of forests

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FoRISK

EFI

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- Thinning as an adaptation strategy
- Potential thinning effects on tree water relations
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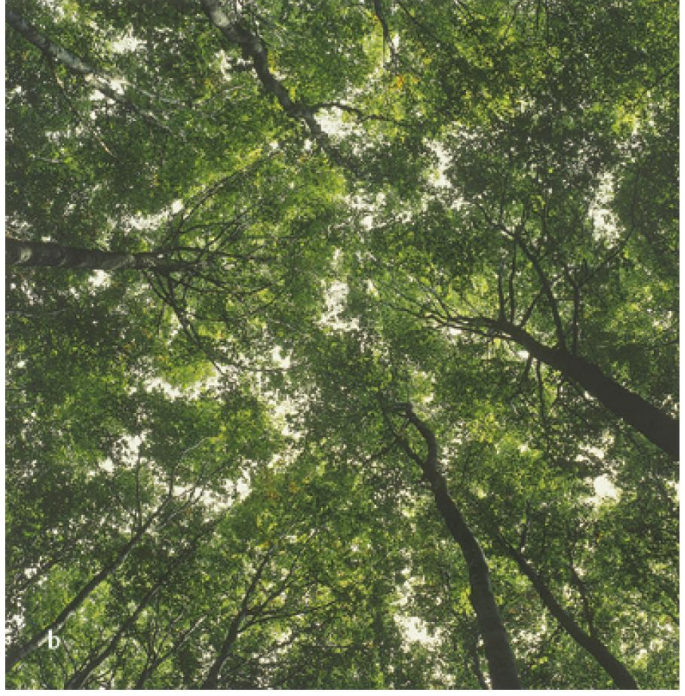


Röhrig et al. (2020). *Waldbau auf ökologischer Grundlage*

→ Adaptation strategies

Long-term

Short- to medium-term

Thinning

Silvicultural goal

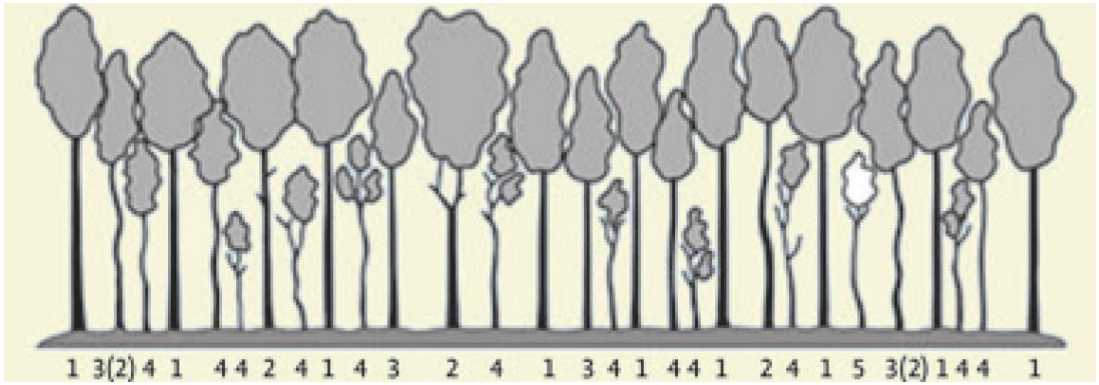
Promote fewer but highly competitive, vigorous trees of high wood quality

Thinning enhances tree growth by reducing competition for water, light and nutrients

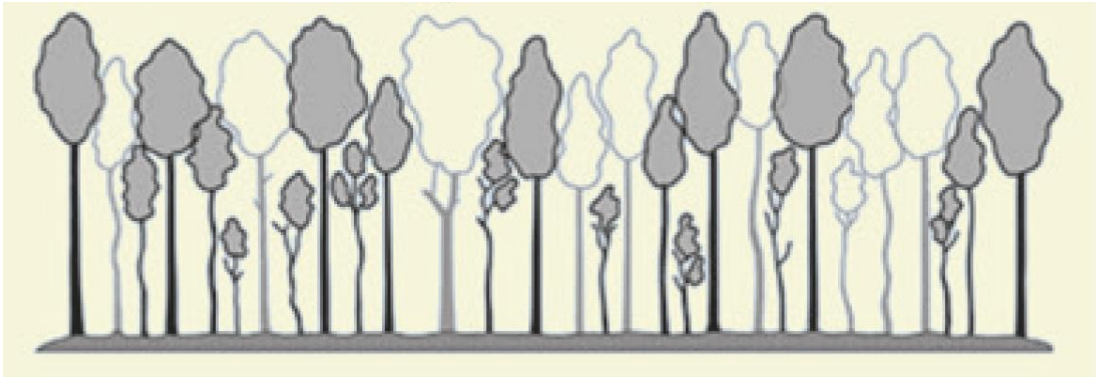
Photos by J.Schwarz

Thinning regime - Types

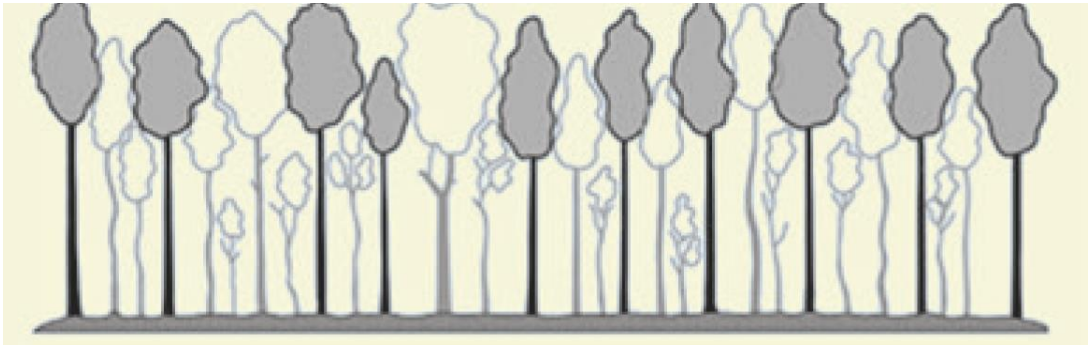
Unthinned stand



Crown thinning (from above, selective)



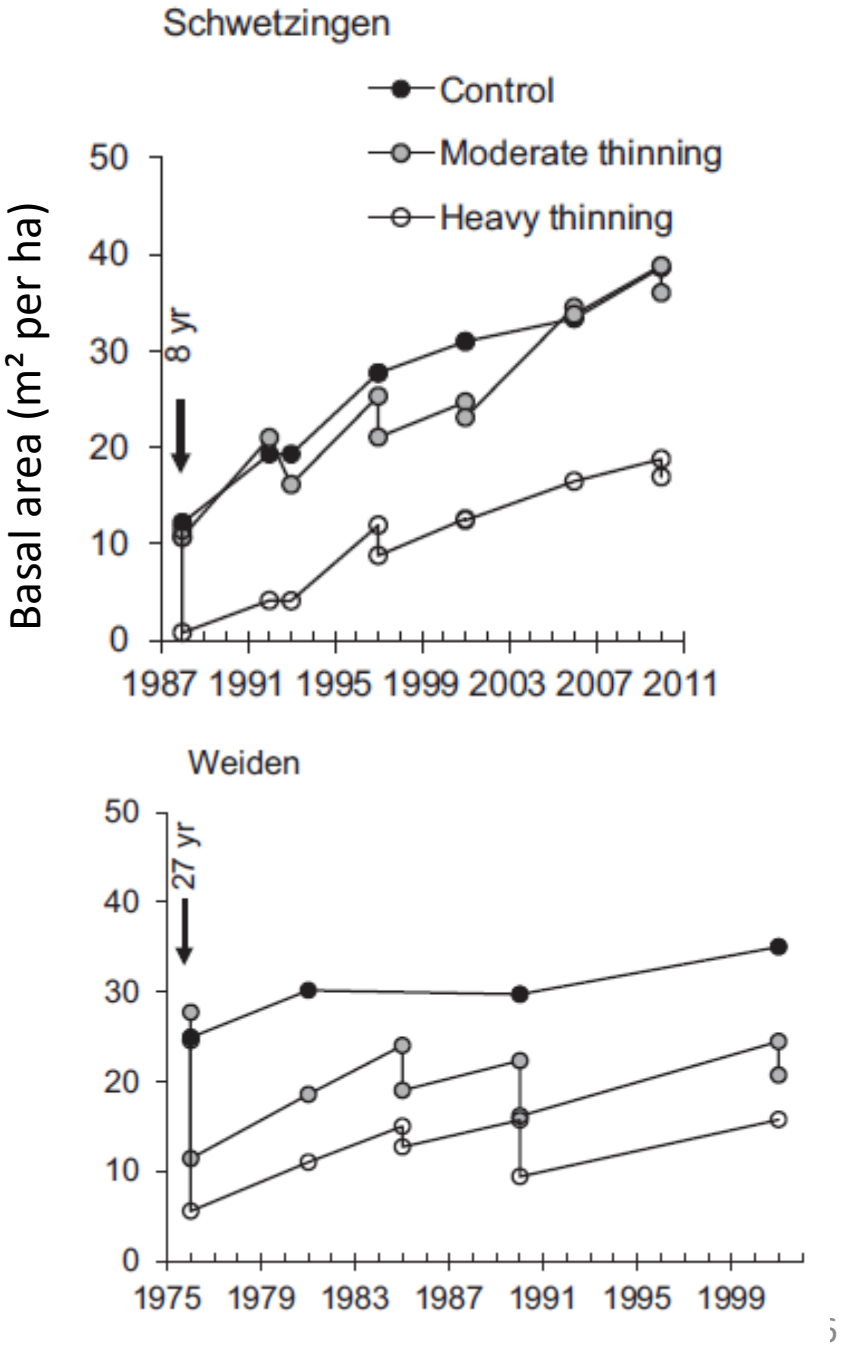
From below



Röhrig et al. (2020). *Waldbau auf ökologischer Grundlage*

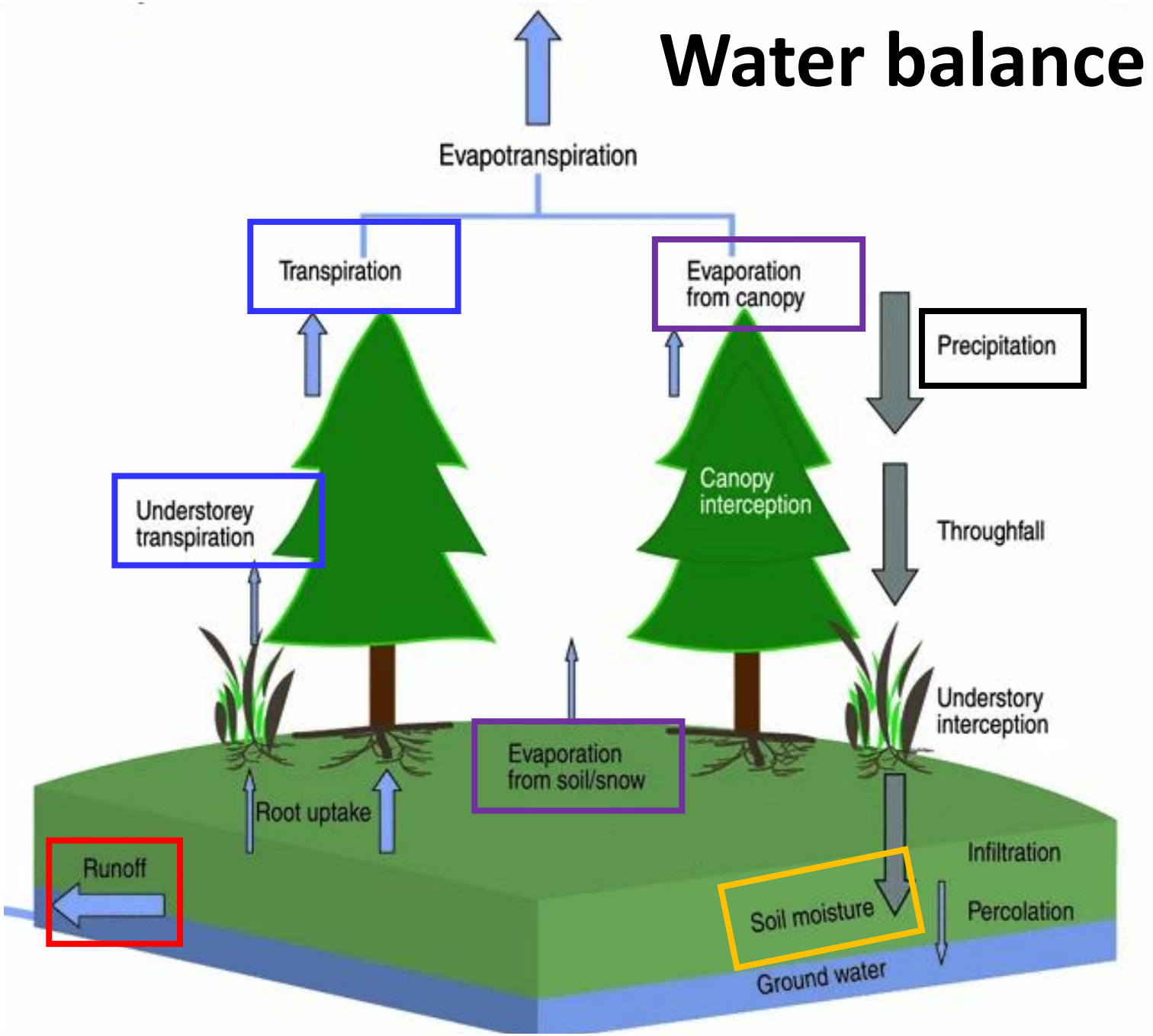
Thinning regime

- **Type**
  - from below
  - from above / selective
- **Intensity:** based on % of basal area reduction
  - weak,
  - moderate,
  - heavy
- **Age at first thinning & time since first/last thinning**
  - Responsiveness
  - Short-term vs long-term effects
- **Frequency:** e.g. every 5 or 10 years



Sohn et al. 2016 – ecol appl.

Water balance in a forest catchment



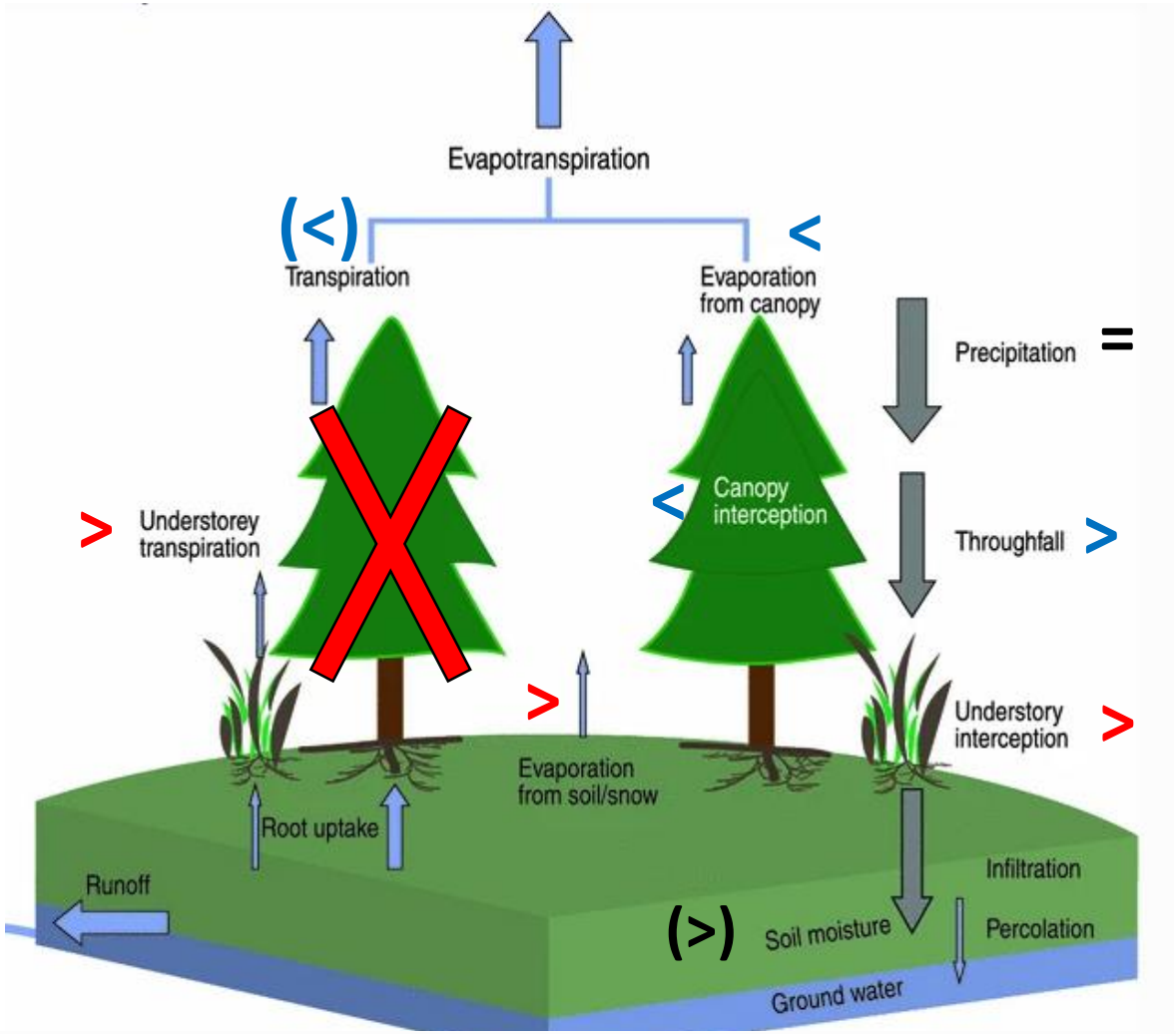
Change in water storage =
Precipitation - **Evaporation** -
Transpiration - **Runoff**

Example Mature Beech stand in SW Germany (Magh et al. 2019):

Water relations of stands differ under normal and dry conditions

Launiainen, S., Futter, M.N., Ellison, D. *et al.* Is the Water Footprint an Appropriate Tool for Forestry and Forest Products: The Fennoscandian Case. *AMBIO* **43**, 244–256 (2014).

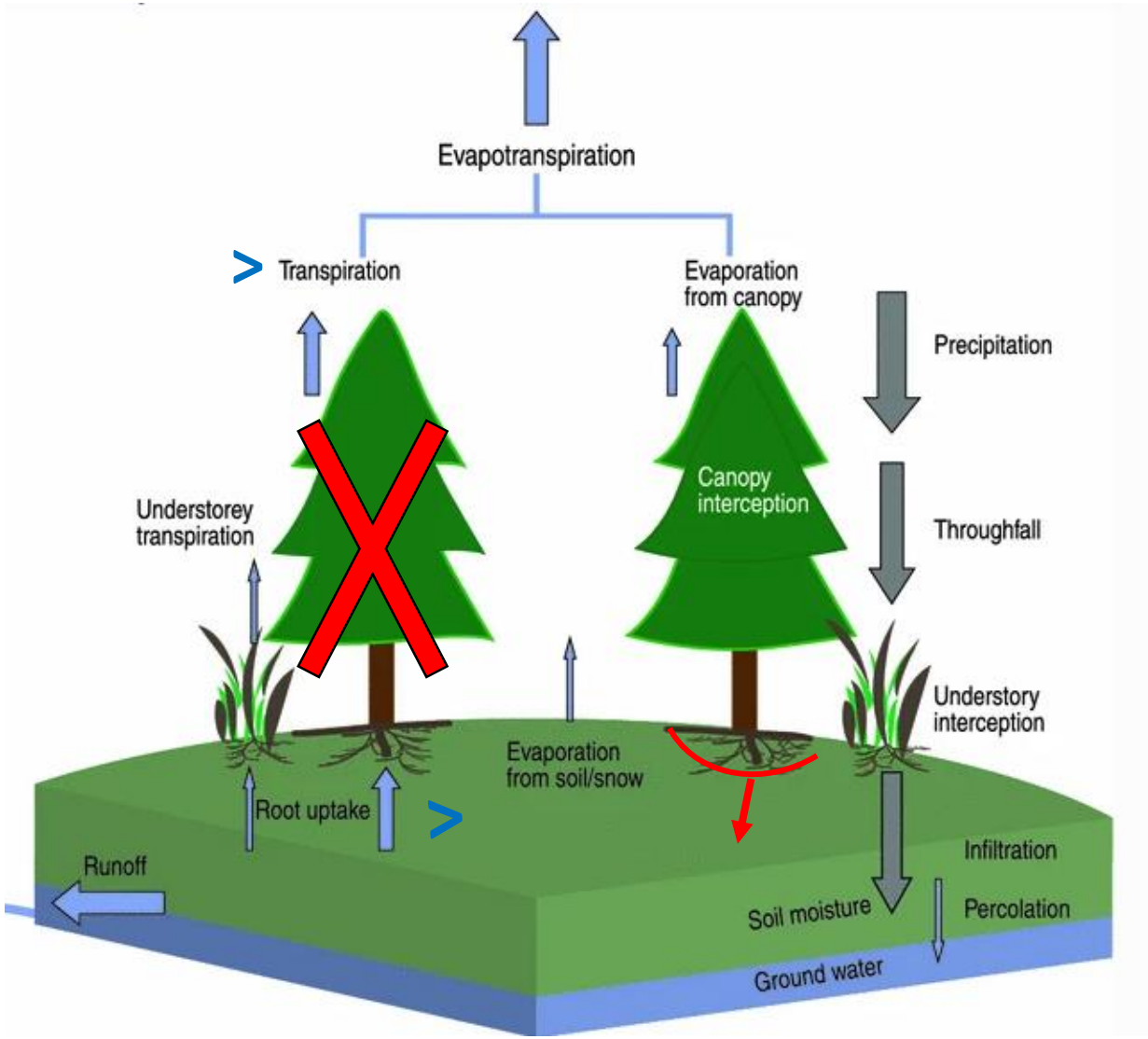
Short-term thinning effects on water balance at the stand level



- LAI reduced → less evaporation & often less transpiration & less interception → more extractable soil water
- More Solar radiation → Higher soil evaporation
- More Understory growth → Increased water consumption by ground vegetation
- **Soil moisture can increase**

Launiainen, S., Futter, M.N., Ellison, D. *et al.* Is the Water Footprint an Appropriate Tool for Forestry and Forest Products: The Fennoscandian Case. *AMBIO* **43**, 244–256 (2014).

...but also short-term thinning effects on water balance at the tree-level:

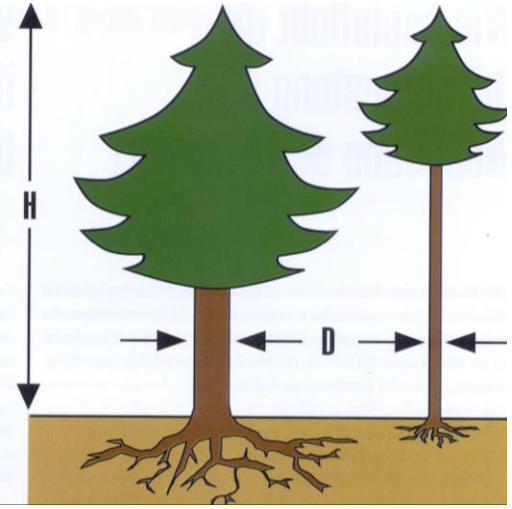


More growing space = reduced competition for resources above- and below-ground!

- Fine-roots expand rapidly
- Higher transpiration rates due to higher stem conductivity

Launiainen, S., Futter, M.N., Ellison, D. *et al.* Is the Water Footprint an Appropriate Tool for Forestry and Forest Products: The Fennoscandian Case. *AMBIO* **43**, 244–256 (2014).

What happens over time?



Tree-level:

- Larger tree crowns: > transpiration
- More extensive root systems: > water extraction capacity

→ **Higher growth rates**

Heavy Thin: 200 trees/ha

Stand level:

- Leaf area of overstory increases fast
- Additional LAI of understory

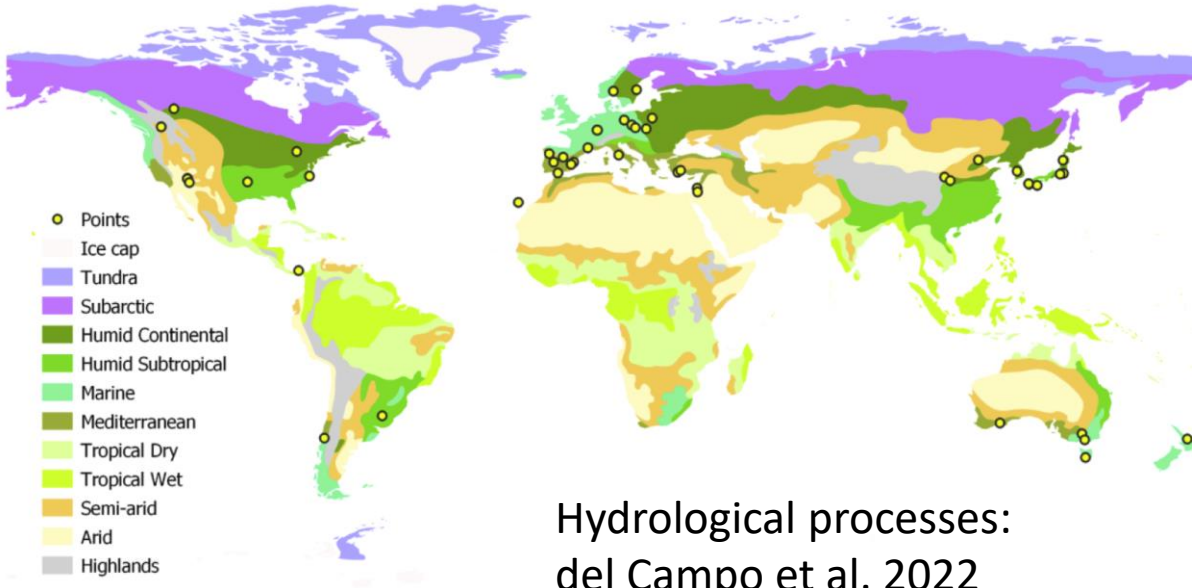
> Evapotranspiration over time since last intervention

Unthinned stand 1.100 trees/ha

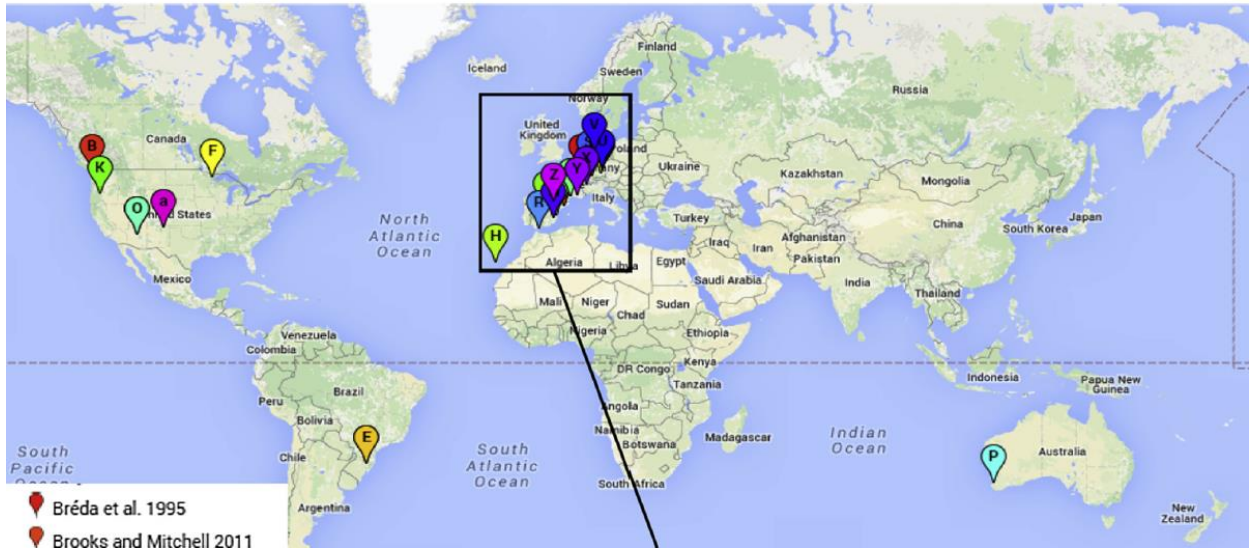
The extent of (dis)advantages depends on

- Thinning regime
  - how strong and how often
- Site & climatic conditions
- Stand characteristics
  - tree species
  - stand age

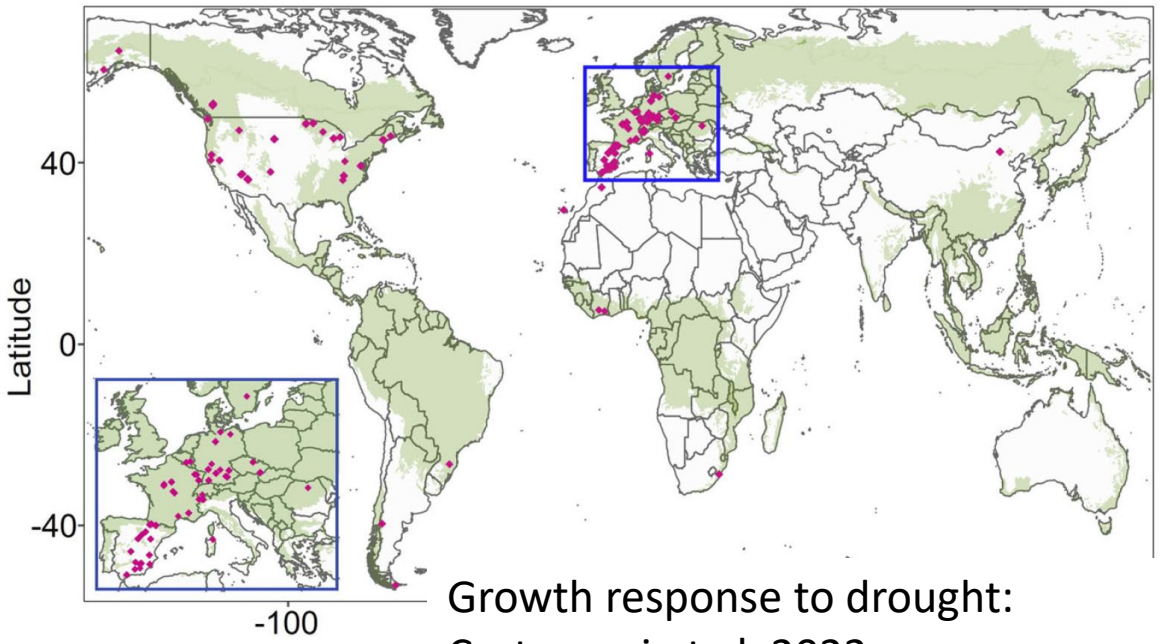
so what is the evidence?



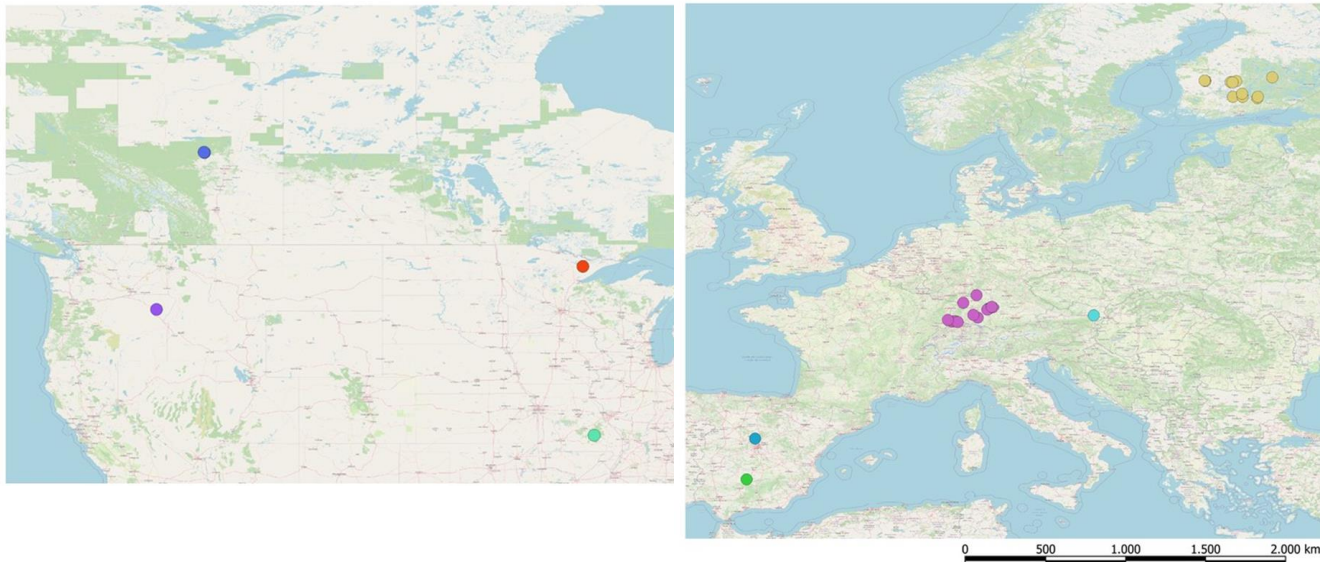
Hydrological processes:
del Campo et al. 2022



Tree performance during and after drought: Sohn et al. 2016



Growth response to drought:
Castagneri et al. 2022

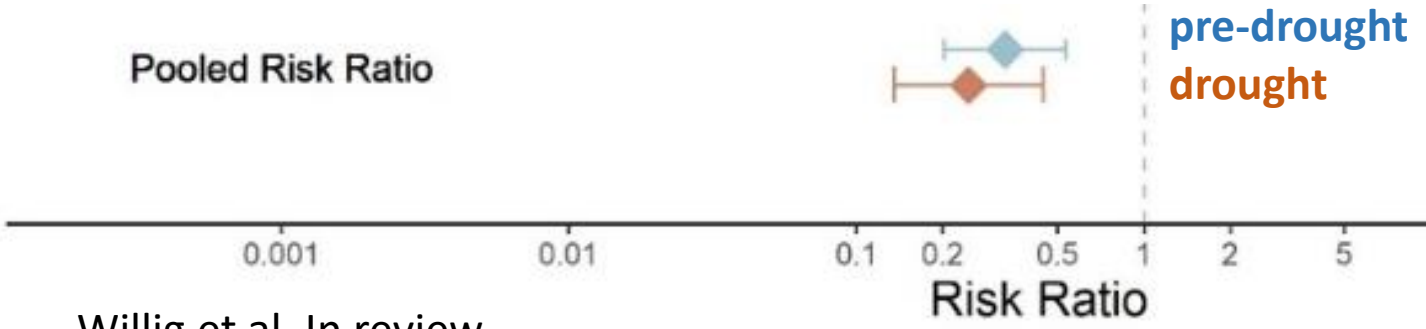


Drought-related mortality: Willig et al. In review

Thinning effects on water balance, tree growth & mortality

- Thinning increases net precipitation (+19%), soil moisture (+14%) and tree-level water use (+56%) and decreases stemflow (-62%) and transpiration (-40%) (del Campo et al. 2022)
- Thinning increases growth resistance and recovery (Sohn et al. 2016, Castagneri et al. 2022)

- Drought mortality risk is lower in thinned stands (Willig et al. under review):

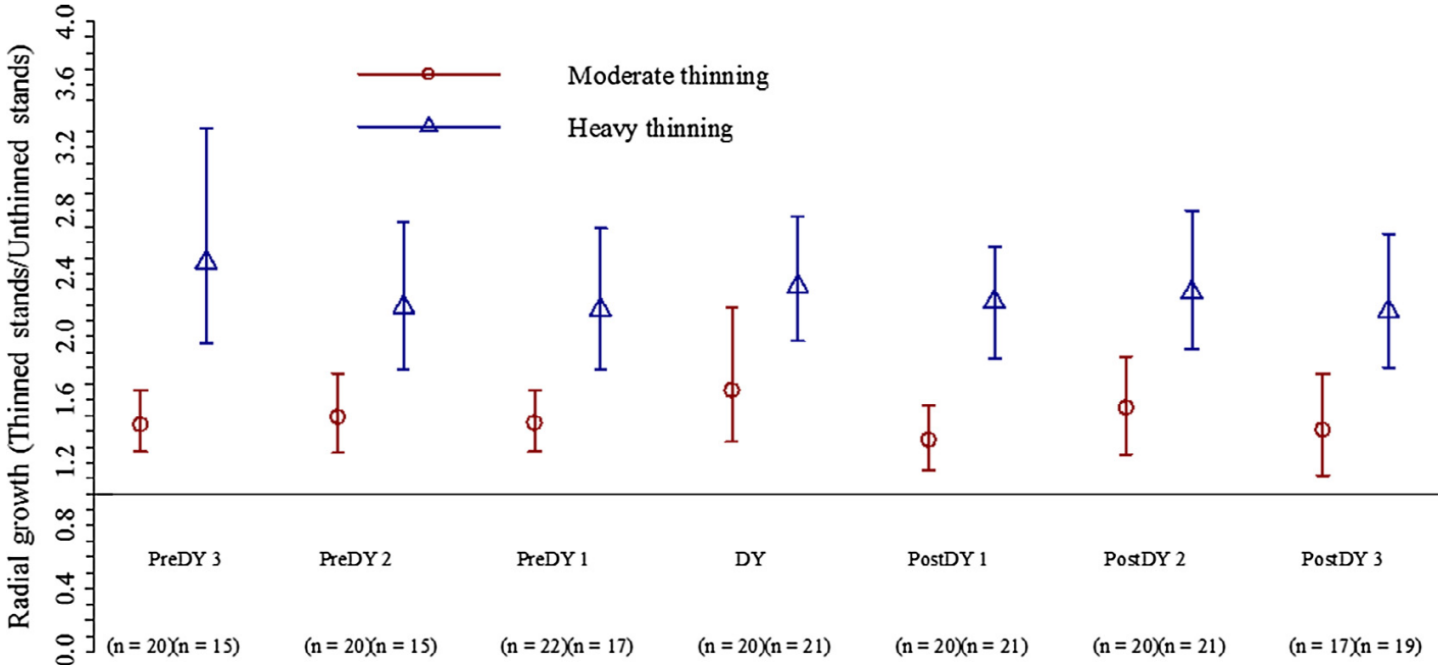


Willig et al. In review

→Thinning mitigates mortality and growth declines during drought likely due to higher soil water availability and water extraction capacity

What is the best intensity and how long do the effects last?

- Thinning intensity of ca. 50% of stand density = threshold for significant changes in hydrological processes (del Campo et al. 2022)
- Both moderate and heavy thinning lead to higher tree growth levels throughout drought
- Benefits increased with thinning intensity (Sohn et al. 2016)



Sohn et al. 2016

- Thinning benefits for up to 4 years for throughfall & up to 8 years for soil moisture and transpiration (del Campo et al. 2022)
- Recent thinning can increase and decrease growth recovery (Sohn et al. 2016, Castagneri et al. 2022)
  → possible interaction with thinning intensity (and species and site)

Drought severity matters (more than thinning regime)

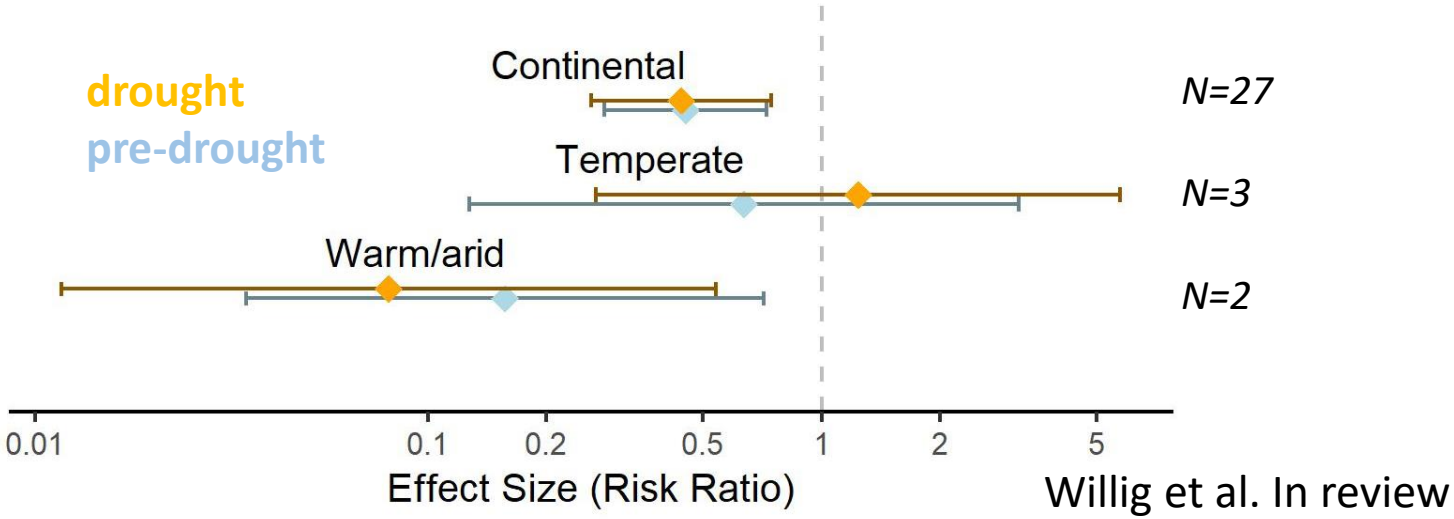
- During moderate droughts: growth response is improved by thinning BUT

  During intense droughts: No thinning effects on growth response to drought

  (Castagneri et al. 2022)

→ Effects of prolonged droughts not yet analysed

- Site aridity matters as well: Benefits highest for mortality at continental sites



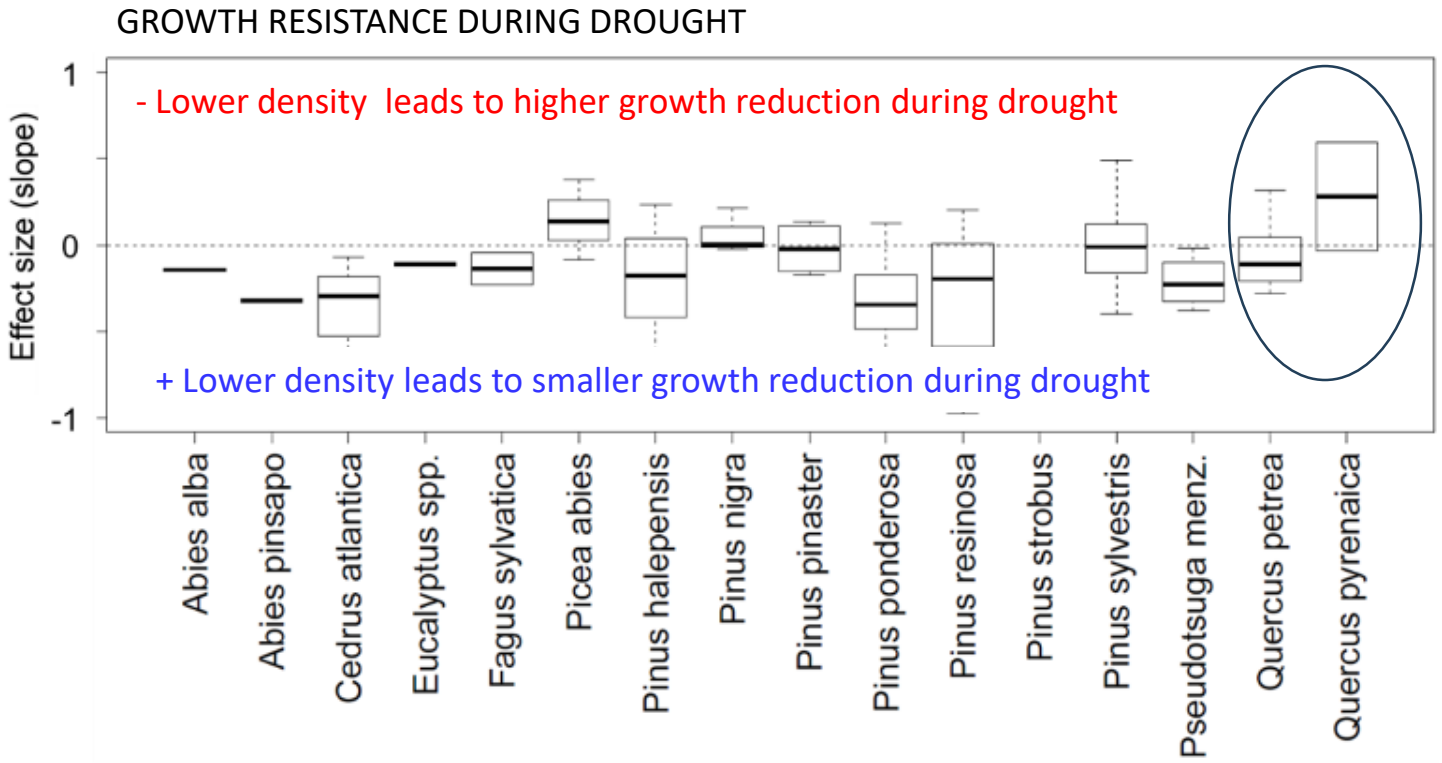
Willig et al. In review

→ **Local site conditions** that affect drought severity/duration should matter as well but are rarely reported

What about different tree species or stand ages?

- Tree response to drought is species-specific
- No significant difference among tree species regarding drought-related mortality (Willig et al in review) and growth response to drought (Castagneri et al. 2022)

→Incorporating local conditions may lead to different results



Castagneri et al. 2022

No or mixed effects of tree age on

- growth response to drought (Castagneri et al. 2022, Sohn et al. 2016)
- drought-related mortality (Willig et al. In review)

→ Age effects likely modified by thinning regime such as age at first intervention

The extent of thinning benefits for drought tolerance of forests

- Depends on thinning regimes→ repeated & (at least) moderate thinning interventions seem most promising
- Depends on climatic and site conditions
  - Larger during moderate and reduced during extreme droughts
  - Large in continental regions
- No consistent effects found for stand age and tree species

→Need to consider

→ local site and stand conditions

→climatic conditions in pre- and post-drought period

→Interactions among factors

Thanks for your attention!