Does competition influence tree response to drought?

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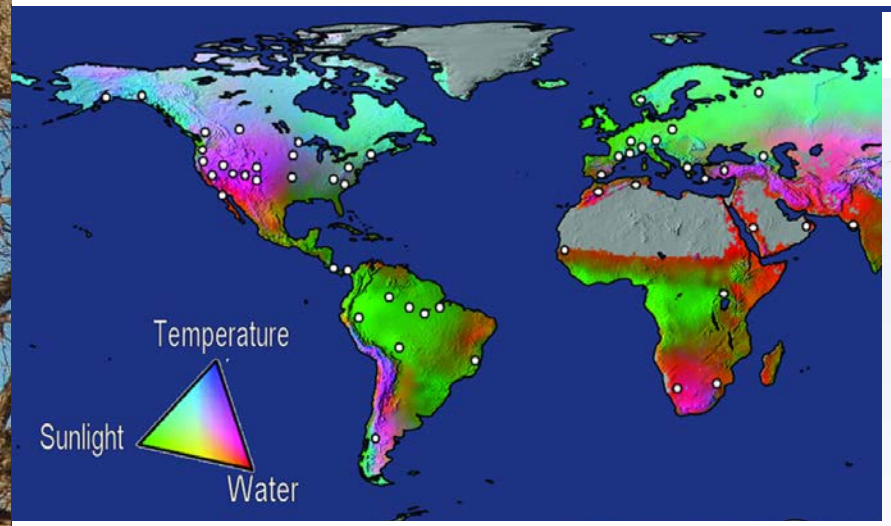
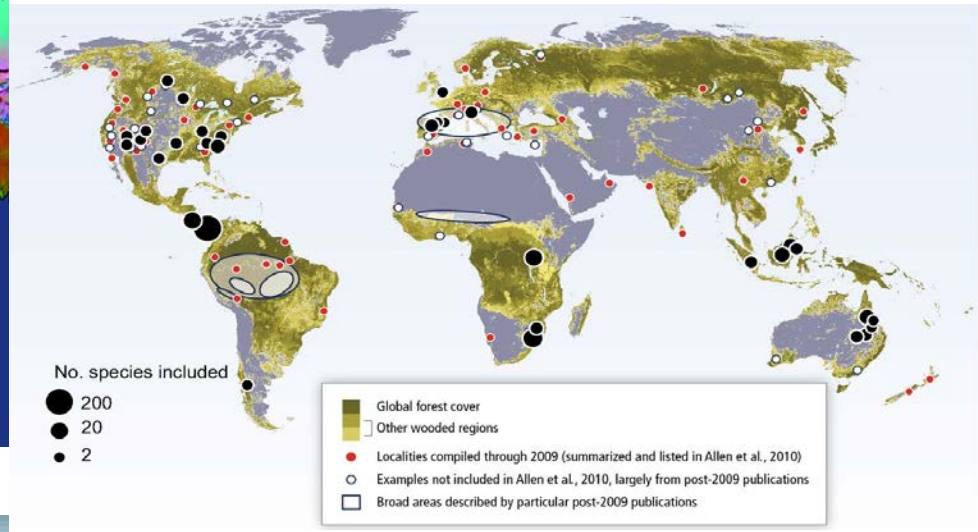
Increasing drought worldwide

Overview of drought and heat-induced tree mortality



Allen *et al*., 2010. *For. Ecol. Manage.*

Drought- and heat-induced regional tree mortality events



Anderegg *et al*., 2016. *PNAS*

Drought is projected to increasingly affect:

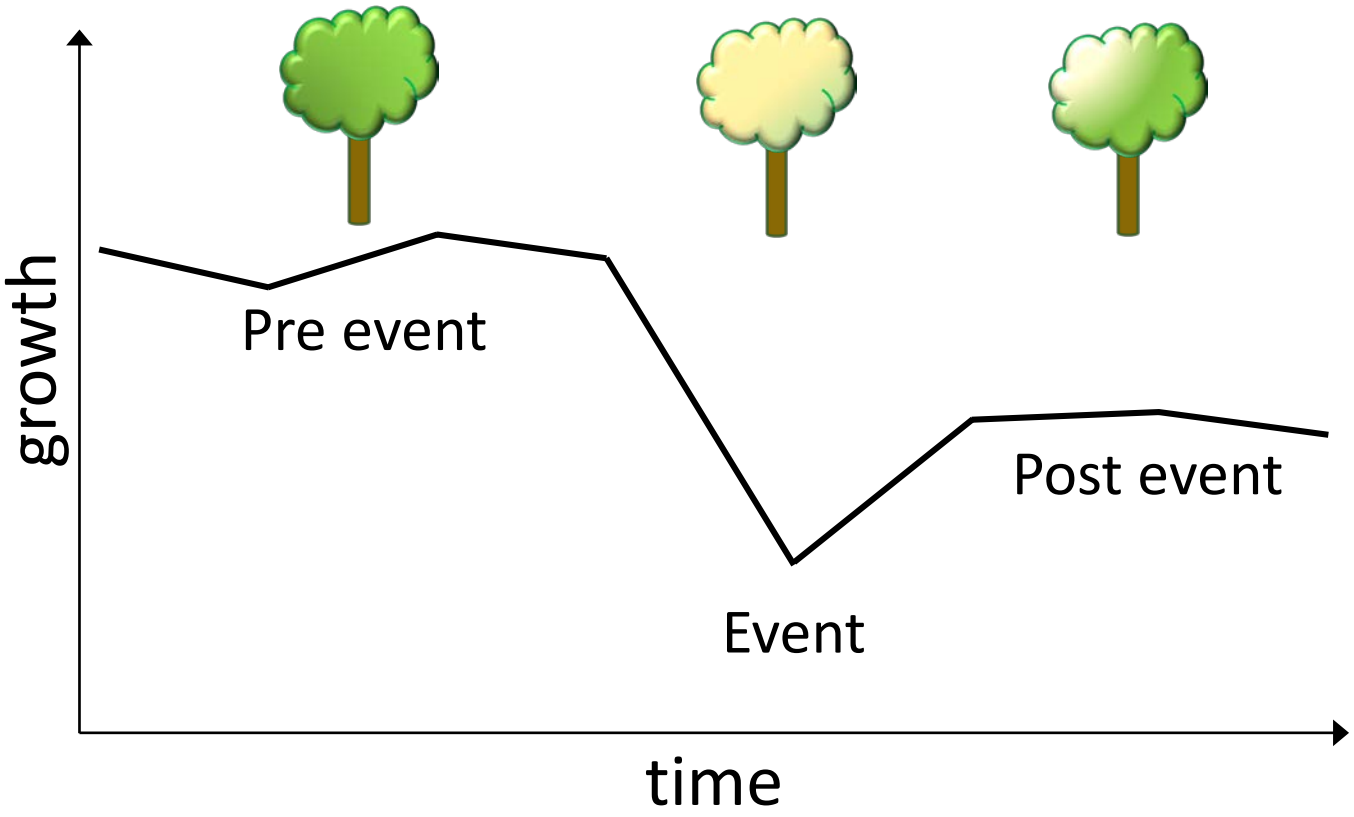
- tree reproduction (Bogdziewicz *et al*., 2020, *Nat. Plans*)
- regeneration (Clark *et al*., 2016, *Gl. Ch. Biol.*)
- primary productivity (Rita *et al*., 2019, *Gl. Ch. Biol.*)
- plant defenses (Anderegg *et al*., 2016, *PNAS*)
- radial growth (Anderegg *et al*., 2015, *Science*)

Growth resilience components

Resistance = $\frac{\text{Event}}{\text{Pre}}$

Recovery = $\frac{\text{Post}}{\text{Event}}$

Resilience = $\frac{\text{Post}}{\text{Pre}}$



What can affect growth response to drought? What can we modify?

Site and Climate

- ✓ Topography
- ✓ Soil
- ✓ Regional climate
- ✓ Drought intensity and duration

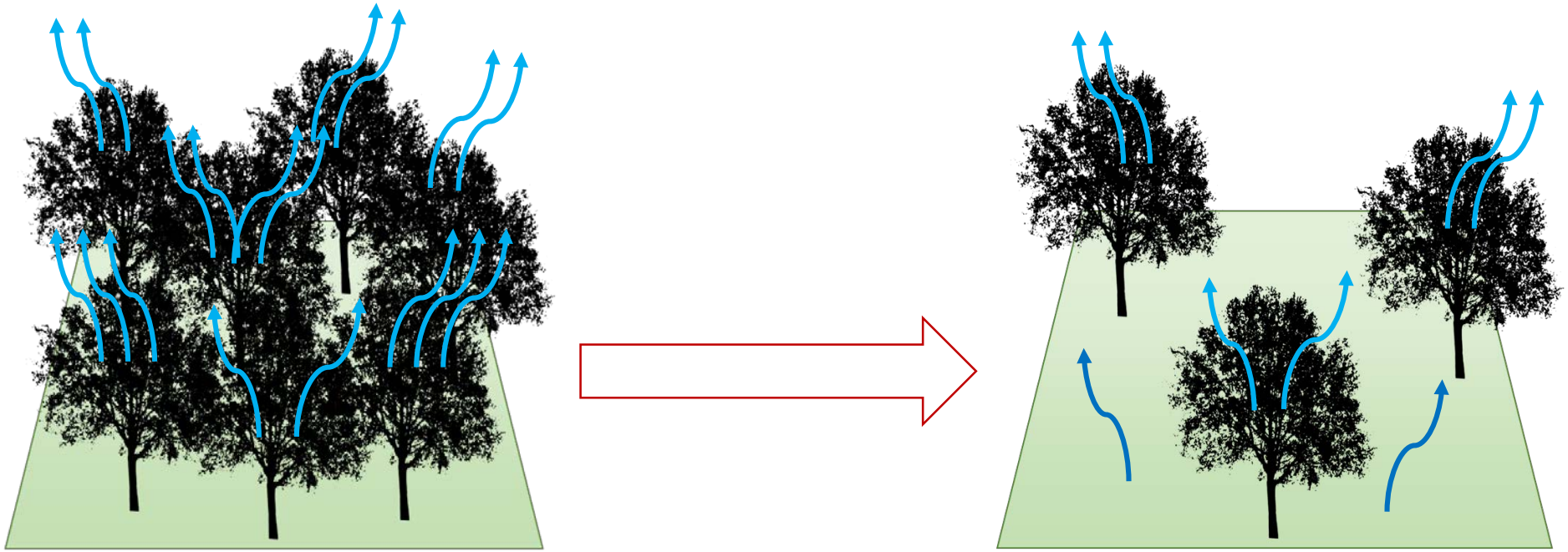
Species

- ✓ Conifer/broadleaves
- ✓ Genus and species
- ✓ Mixed/pure
- ✓ Provenance

Structure

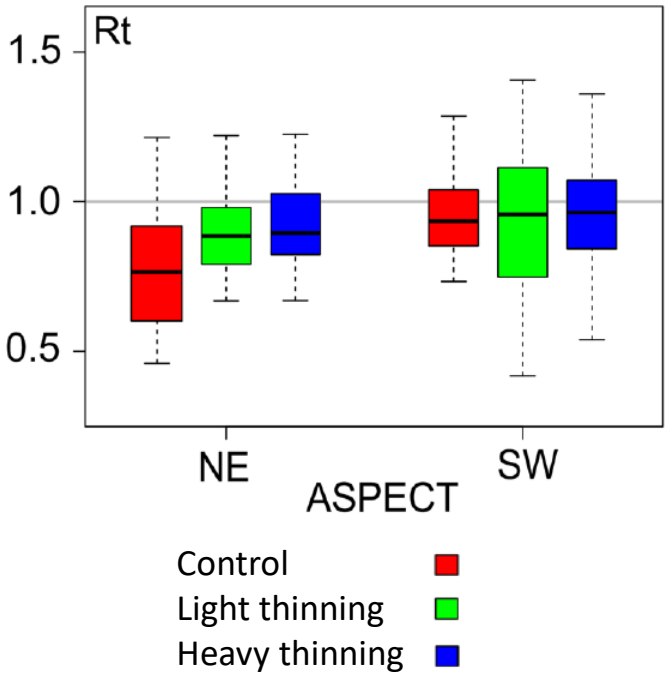
- ✓ Age (un/even-aged)
- ✓ Vertical structure
- ✓ Horizontal structure
- ✓ **Density**

Reducing density: thinning



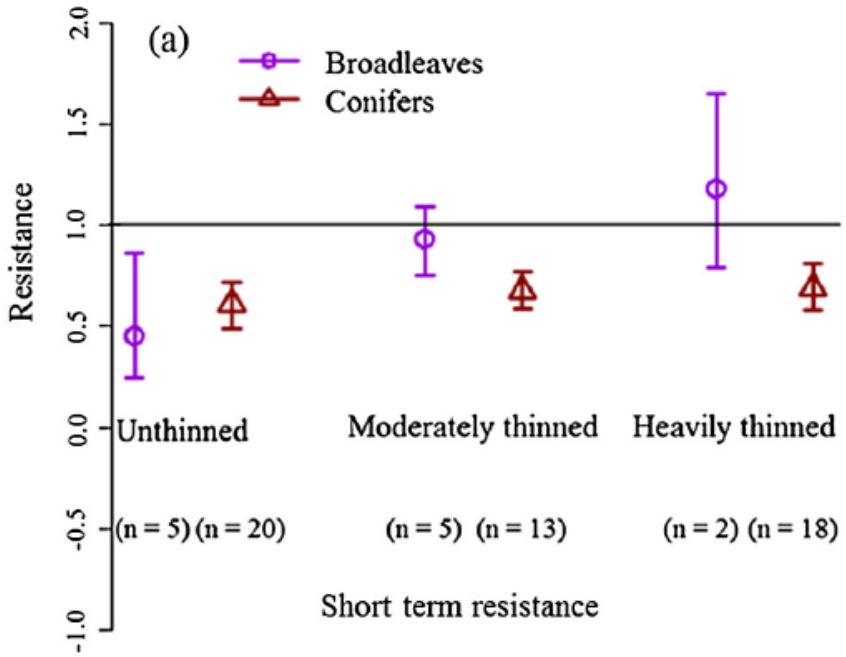
Previous analyses mostly suggest
to perform thinning to improve
growth resistance, recovery and/or resilience

...but results were not always consistent!



Northeast Vs. Southwest
Diaconu *et al.*, 2017, *EJFR*

Different results within and between studies



Conifers Vs. Broadleaves
Sohn *et al.*, 2016, *FEaM*

We wanted to investigate common patterns and differences in previous studies: meta-analysis

Literature search

"forest* OR tree*"
"growth OR tree-ring*"
"competition OR density"
"drought*"

Selection of study cases with quantitative data on competition and resilience components

Statistical meta-analysis

R package Metafor,
one model for each component

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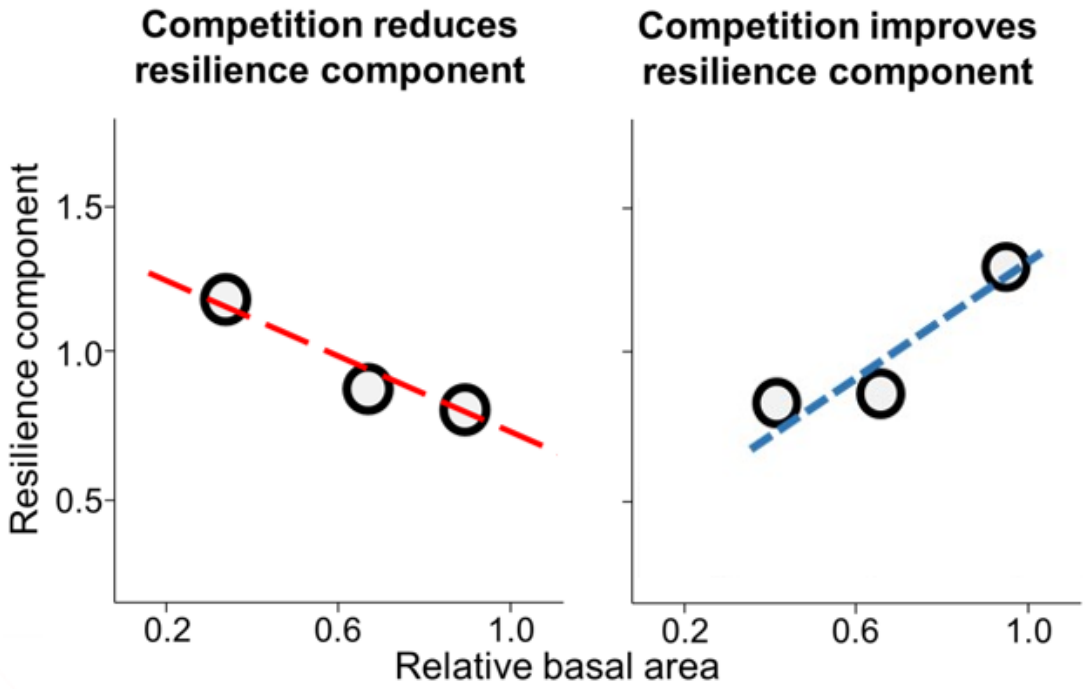

Conceptual frame

What factors can explain outcome variability?

Climate

- ✓ Mean temperature
- ✓ Mean precipitation
- ✓ Site dryness (De Mart. index)
- ✓ Drought event intensity (SPEI)

Stand structure

- ✓ Age
- ✓ Un/even-aged
- ✓ Mono/multi-layered
- ✓ Years since the last thinning

Species

- ✓ Conifer/broadleaf
- ✓ Species
- ✓ Drought tolerance
- ✓ Shade tolerance

Study design

- ✓ Observ./treatment
- ✓ Number of sampled trees

Resistance

Competition has a negative effect on resistance...

... but result variability is high

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Recovery

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Competition has a positive (!) effect on recovery...

Resilience

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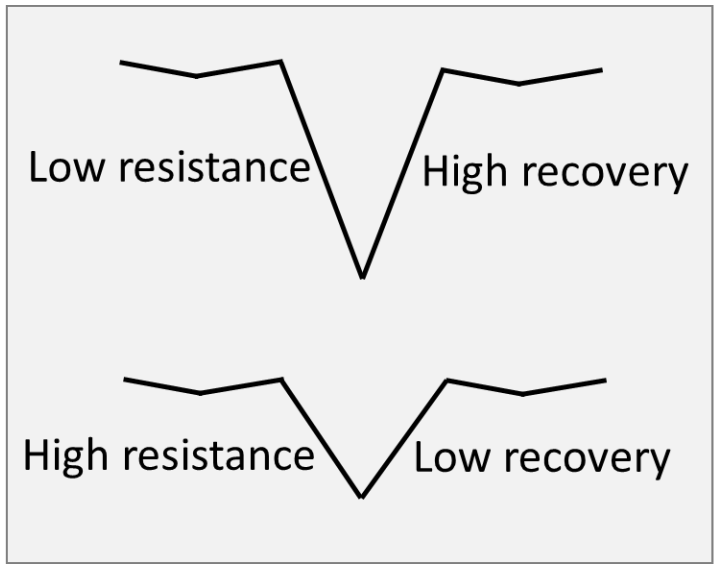
...and no effect on resilience

Does competition really increase recovery?!

Pay attention to the relationships among the three components,

they are NOT indipendent!



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What factors can explain slope variability?

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Stand structure, climate and species did not explain result variability

What factors can explain slope variability?

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to copyright restrictions

- ✓ Competition reduces resistance to low-intensity droughts
- ✓ For intense droughts, all stands show similar resistance

Recommendation for future studies

1. Should be performed on many trees in controlled condition (treatments)

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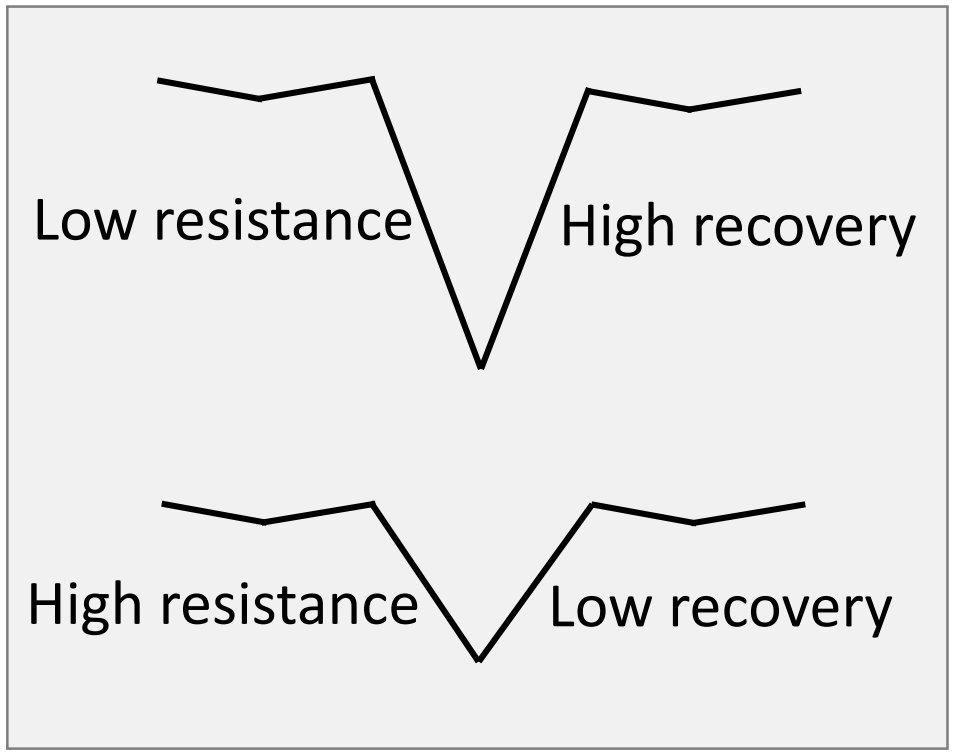
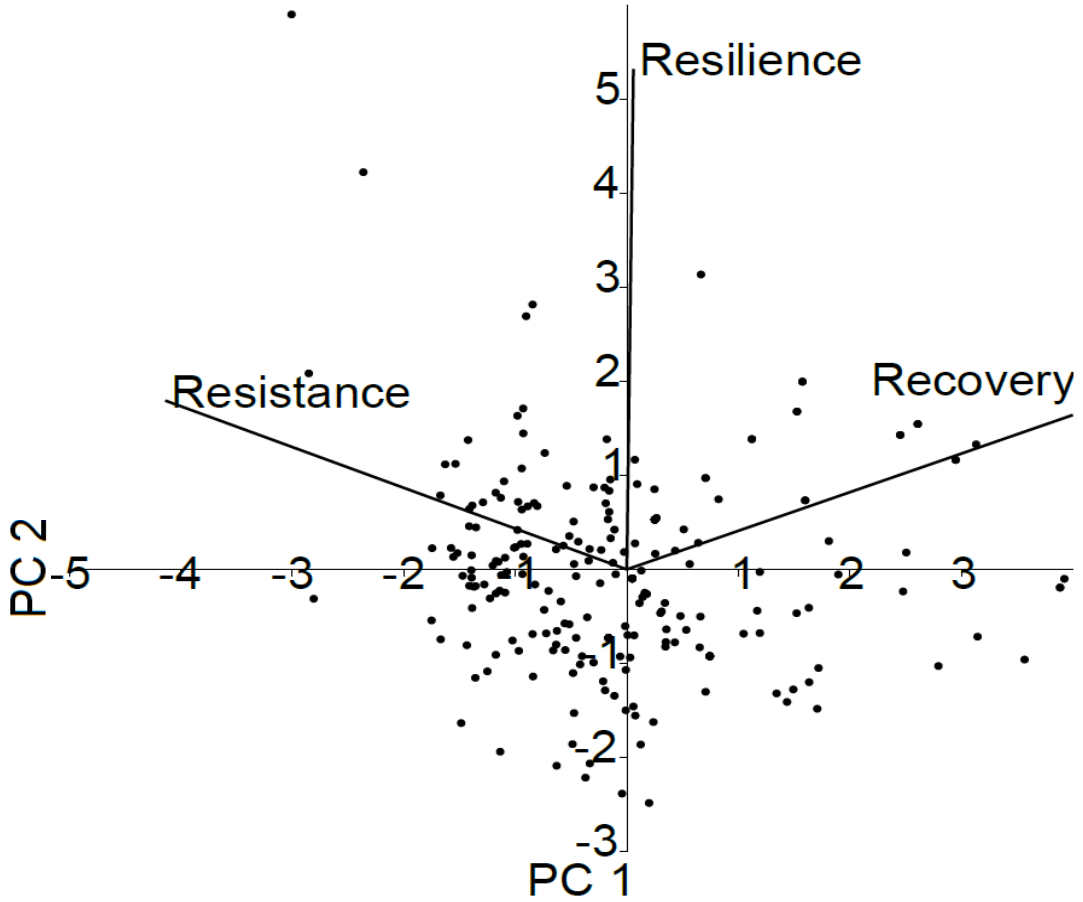
Recommendation for future studies

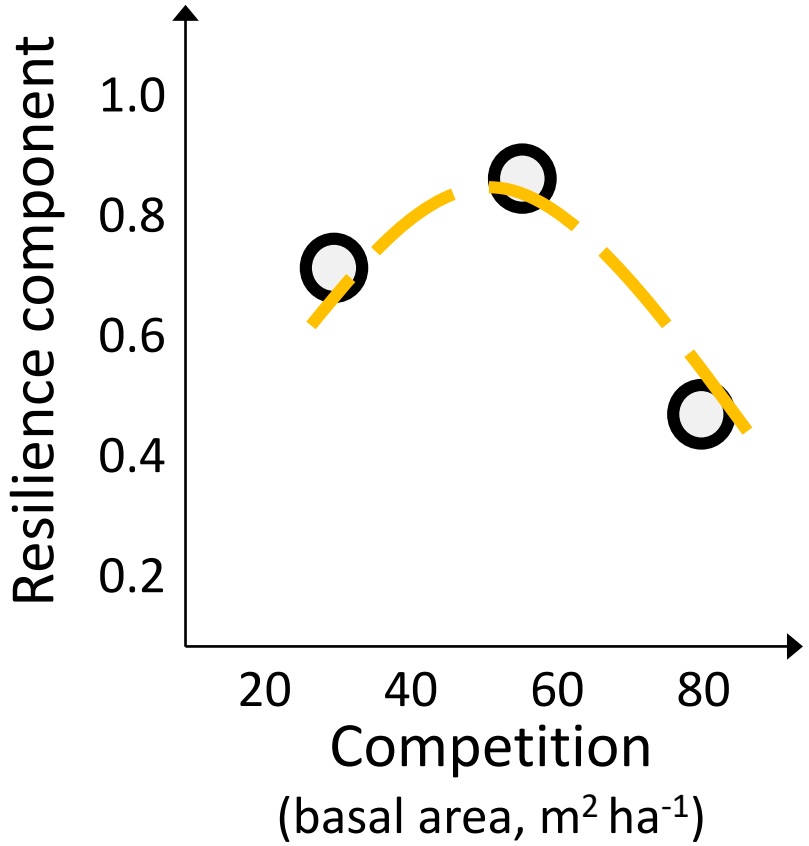
2. Should consider relationships between the three components

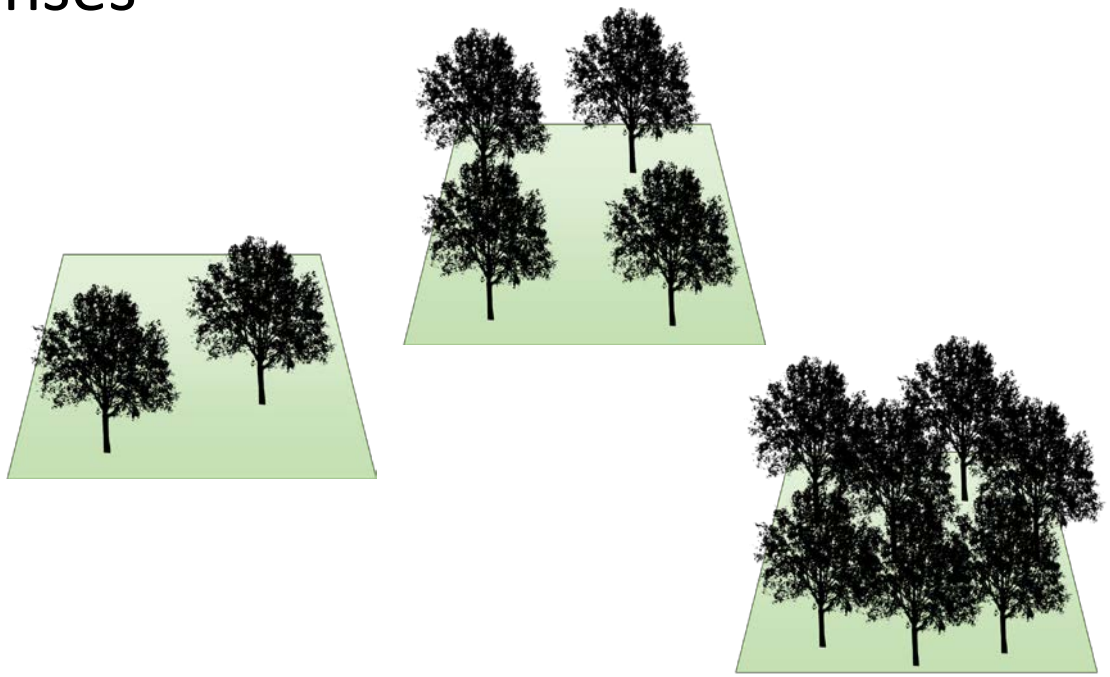




Recommendation for future studies

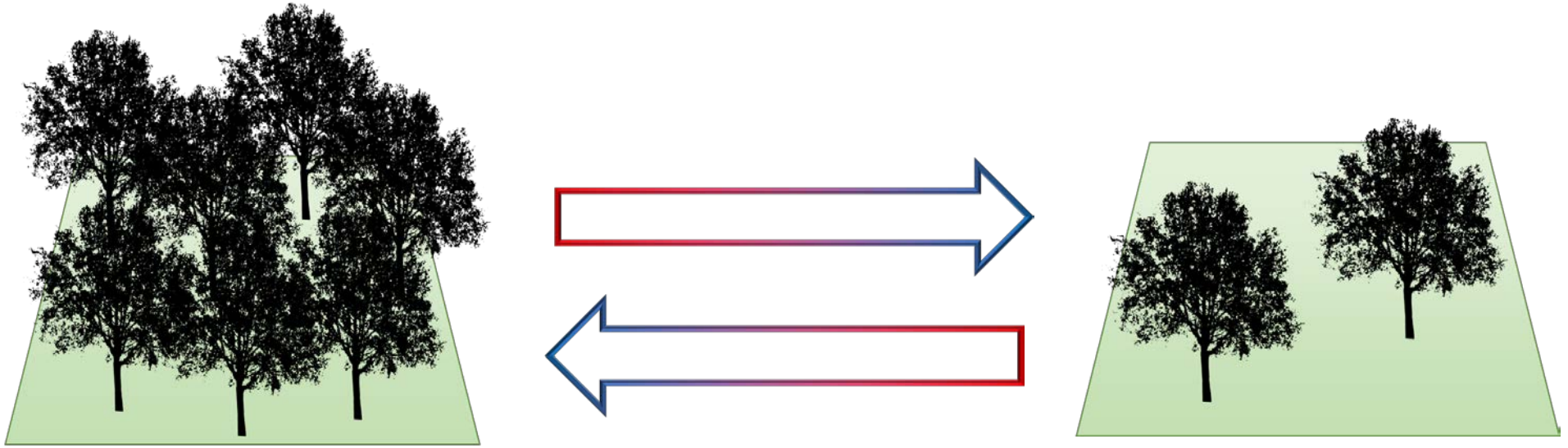
3. Should test for non-linear relationship between competition and responses





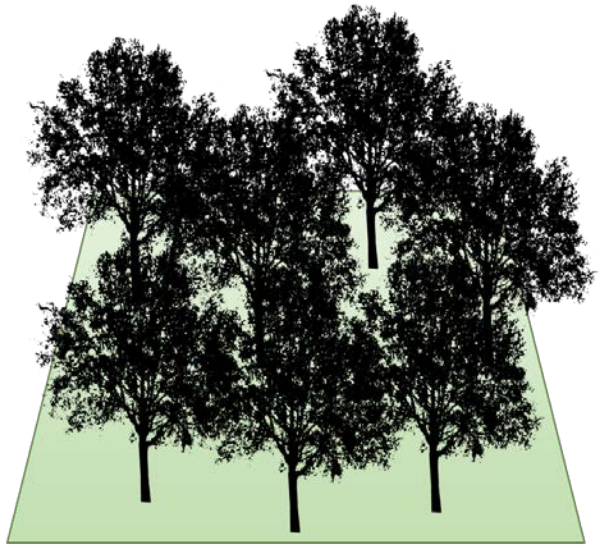
Recommendation for future studies

4. Evidence (and explore) results that do not indicate positive effects of thinning on the resilience components



Ecological considerations and Management implications

- ✓ **Competition generally reduces growth resistance**, but there are **no generalizable effects on resilience**
- ✓ **Thinning may reduce immediate effects of drought** on growth
- ✓ But there is **no universal prescription**. Adaptive management strategies require investigation at the local level



Thanks for your attention!

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