Session B1b

Relative importance of climate, thinning and light use efficiency on drought vulnerability of Norway spruce and silver fir in central European mixed forests

A. Bottero, D.I. Forrester, M. Cailleret *et al.*

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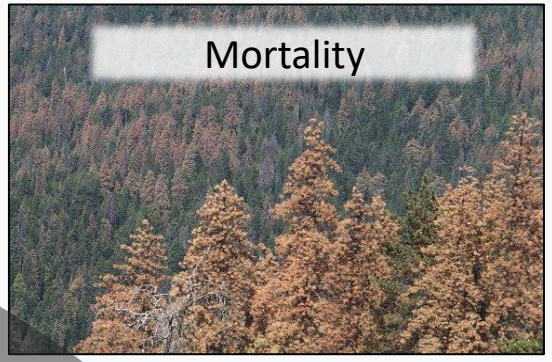
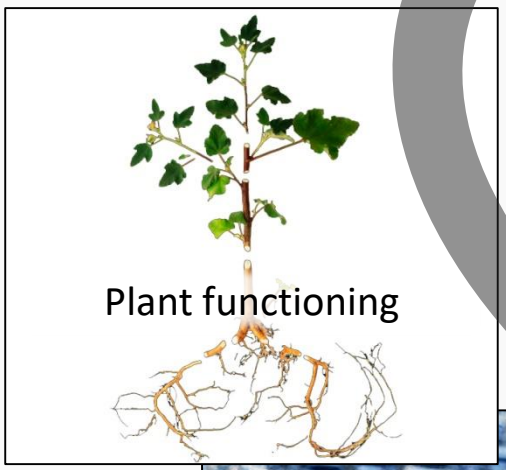
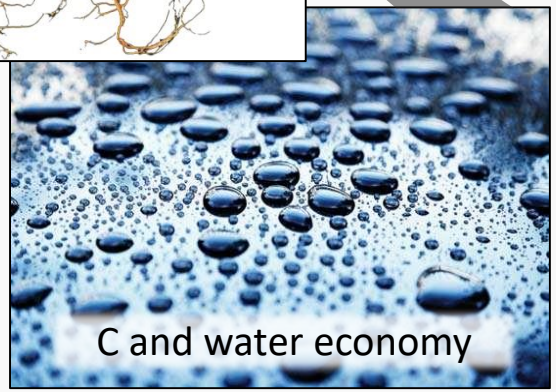
Drought & Forests

Major driver of ecosystem processes & services



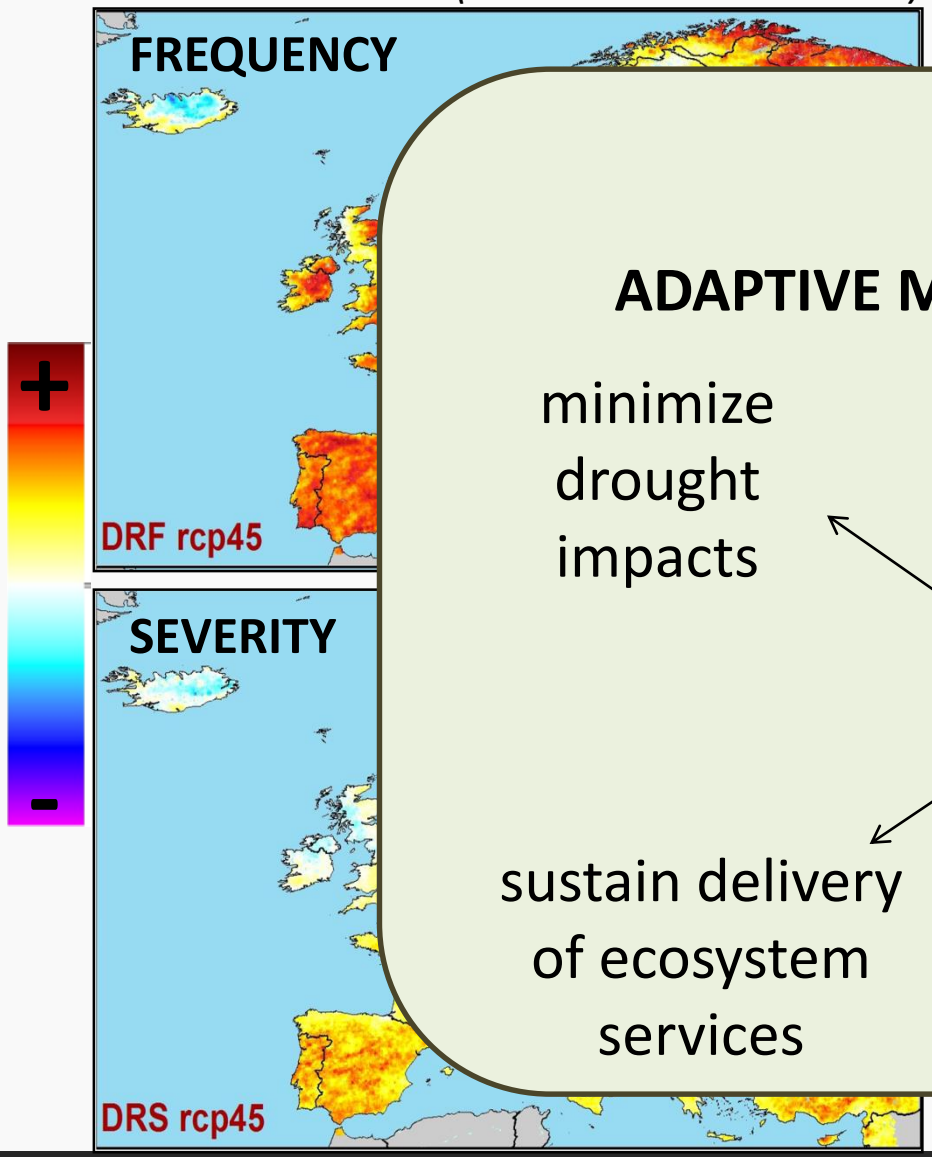




McDowell et al. 2008, Allen et al. 2010, Keenan et al. 2013, Rigling et al. 2013, Anderegg et al. 2015, Choat et al. 2018, Thrippleton et al. 2018, a.o.

Drought trends and challenges

Δ(2041-2070 – 1981-2010)



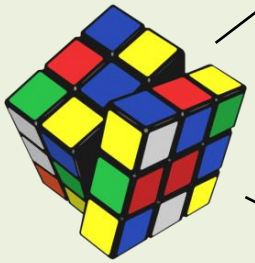
CHALLENGES

↓

ADAPTIVE MANAGEMENT STRATEGIES

minimize drought impacts

innovative



sustain delivery of ecosystem services

economically efficient

Research questions

Mechanisms and stand characteristics driving the resilience to drought of Norway spruce and silver fir in mixed stands in southwestern Germany

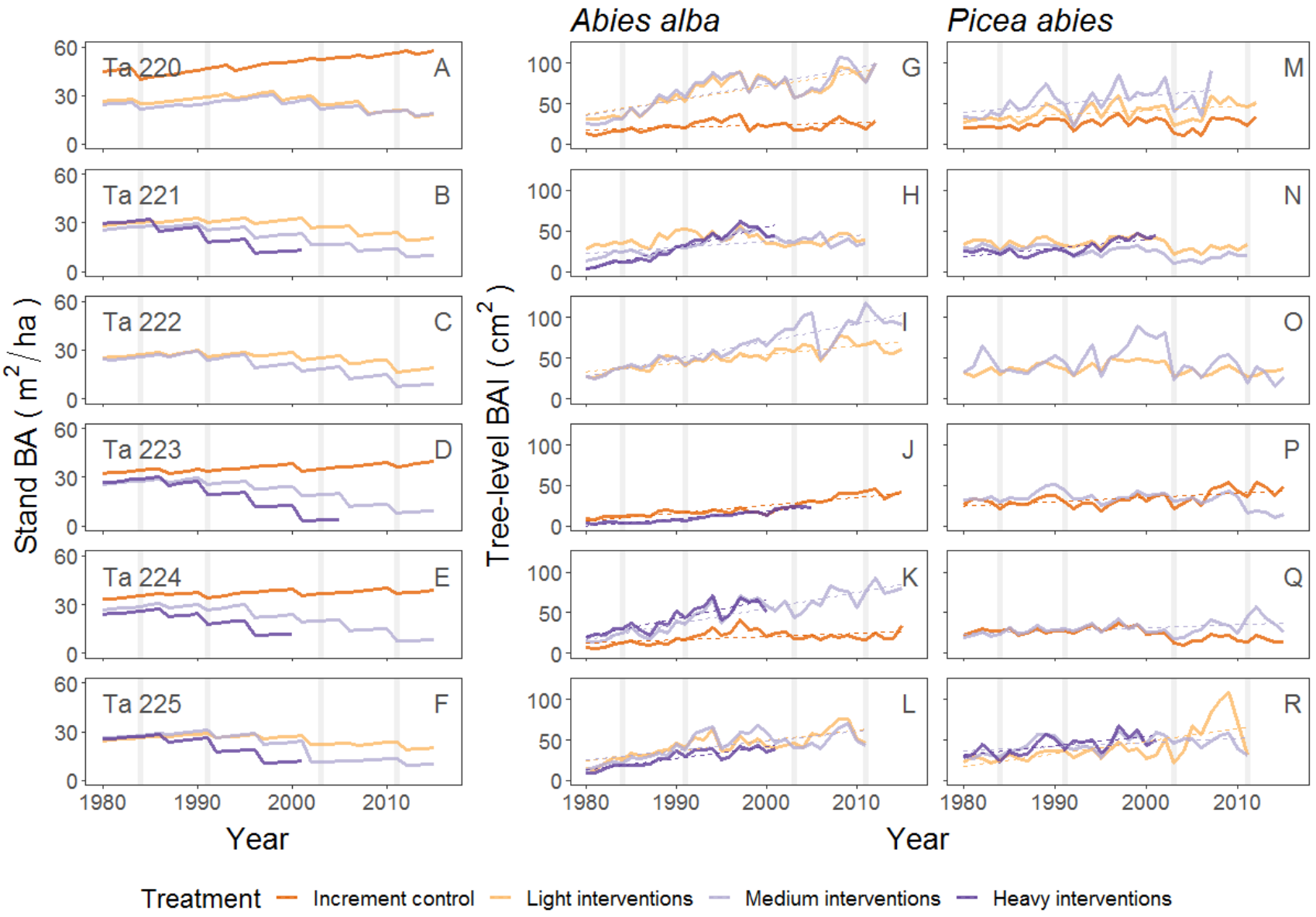
Focus on 4 droughts with contrasting seasonality and severity:

1. Compare the drought response of Norway spruce and silver fir.
2. Identify the management, tree- and stand- characteristics that most strongly influence tree- and stand-level drought responses.

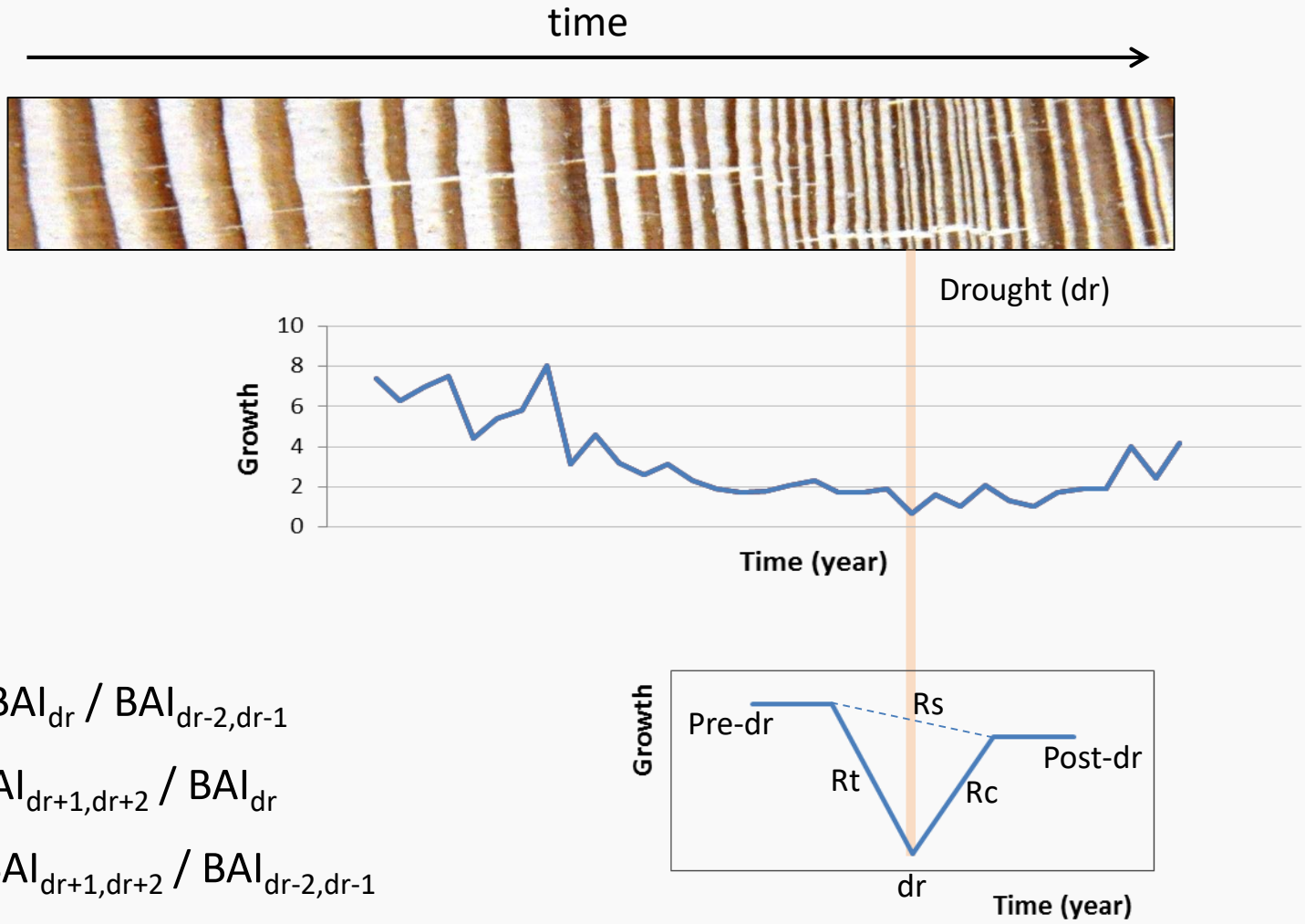
Study sites

- Six sites from SW Germany
- 21 mixed-stands with Norway spruce and silver fir (and European beech)
- Long-term shelterwood experiment
- Inventory data + Tree-ring data (discs)

Study sites


Abies alba
Picea abies
Ta 220
Ta 221
Ta 222
Ta 223
Ta 224
Ta 225
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
Stand BA (m² / ha)
Tree-level BAI (cm²)
Year
Year
Treatment
Increment control
Light interventions
Medium interventions
Heavy interventions

Growth resilience to drought



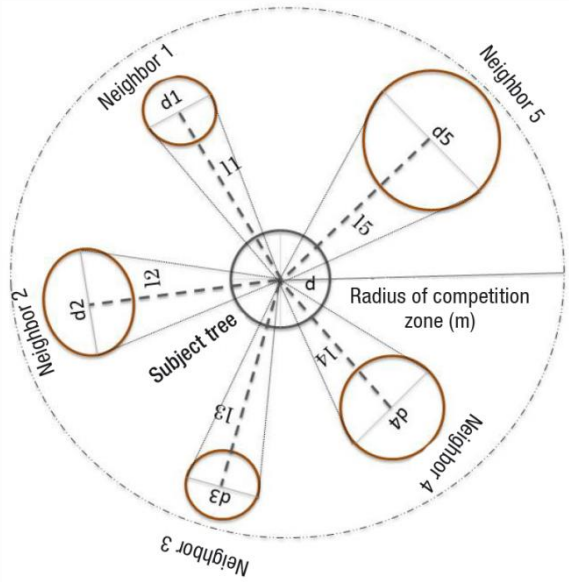
Resistance (Rt) = $BAI_{dr} / BAI_{dr-2,dr-1}$

Recovery (Rc) = $BAI_{dr+1,dr+2} / BAI_{dr}$

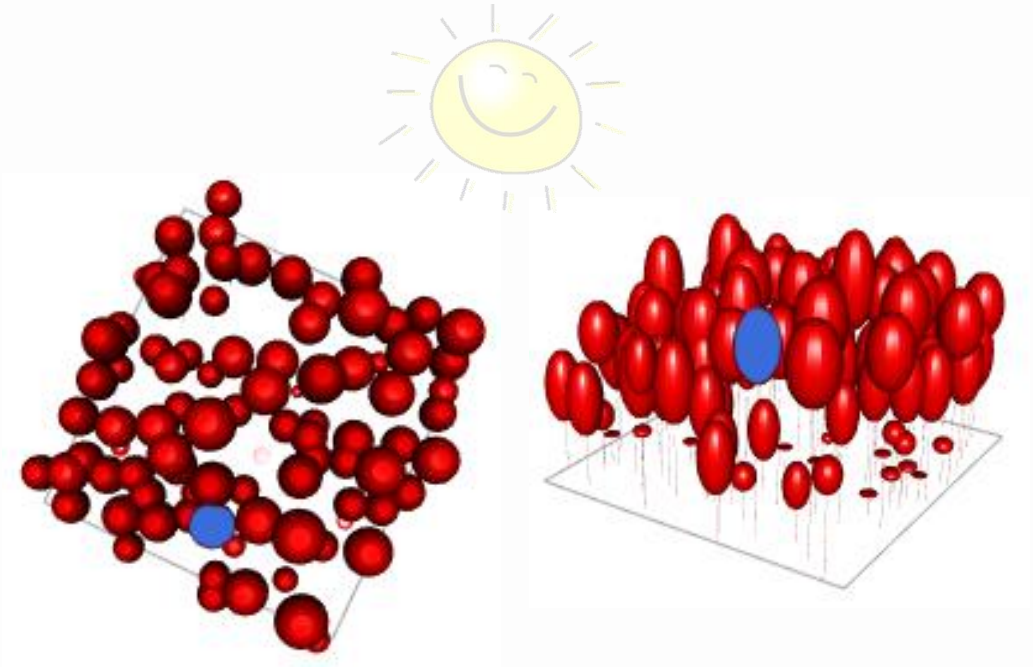
Resilience (Rs) = $BAI_{dr+1,dr+2} / BAI_{dr-2,dr-1}$

Predictors of drought response

Several variables reflecting stand structure, composition, management, and tree resources availability



Competition index NI
(spatially explicit, r = 10m)



Individual-tree absorption of photosynthetically active radiation (APAR, GJ/tree/year)

3D tree-level model Maestra

Statistical analyses

Tree-level drought responses

- 12 linear mixed-effects models (4 droughts x 3 drought response indices)
- Species interactions

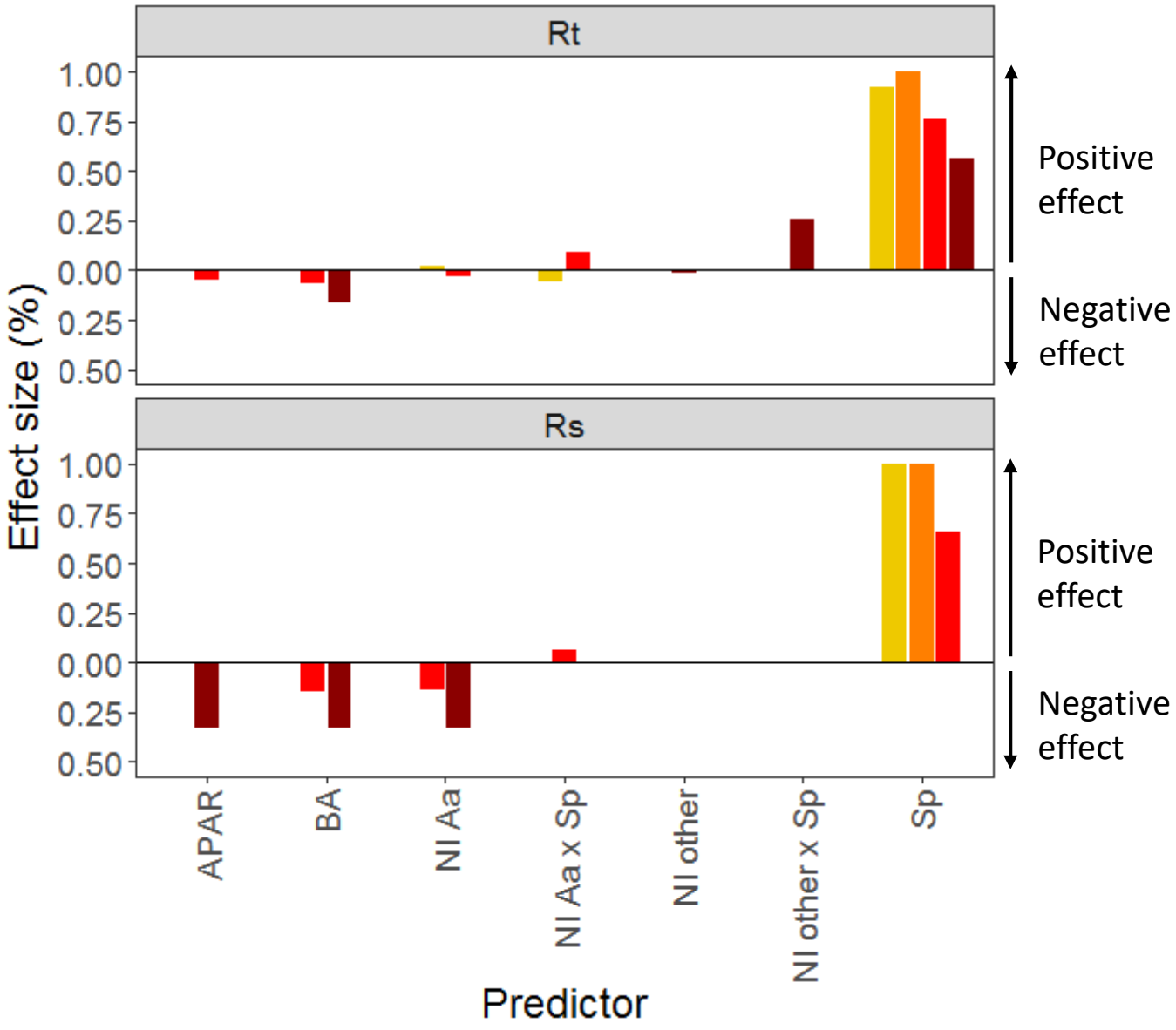
Stand-level drought responses

- 3 linear mixed-effects models (3 drought response indices)
- Interactions with drought year

Selected predictors

- Variables in models: correlation < 0.5, variance inflation factor (VIF) < 2
- Tree-level (5): Sp = species, APAR = absorption of photosynthetically active radiation, NI Aa = competition by Abies alba, BA = stand basal area.
- Stand-level (6): Yr = drought year, BA = stand basal area, DBH = mean stand DBH, Pa = proportion of Picea abies, $Last_{th}$ = years since last intervention, BA_{th} = basal area removed.

Results: tree-level responses

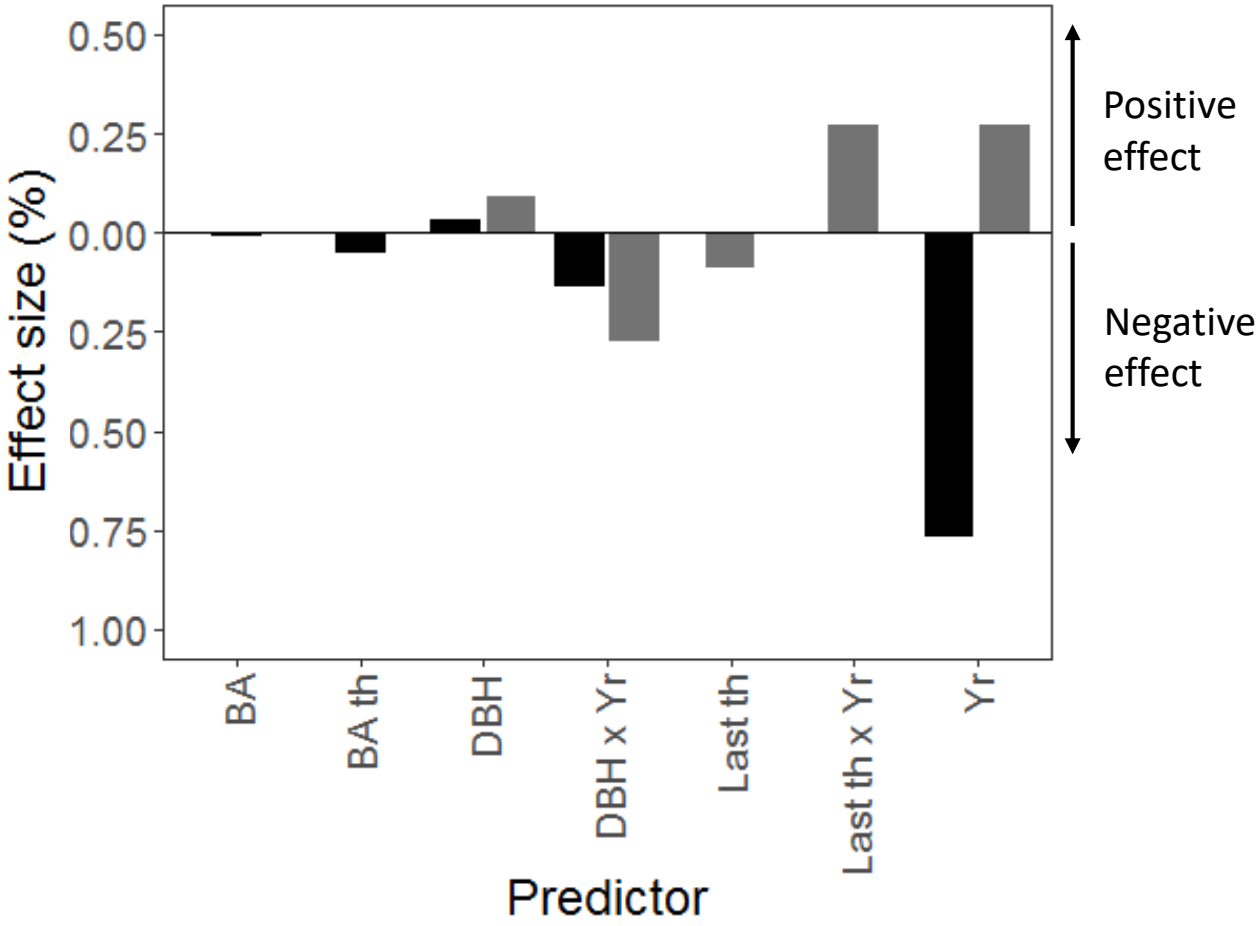


R^2 from 0.16 to 0.47

Drought
1984
1991
2003
2011

Sp: factor:
Abies alba (Aa) vs.
Picea abies (Pa)

Results: stand-level responses

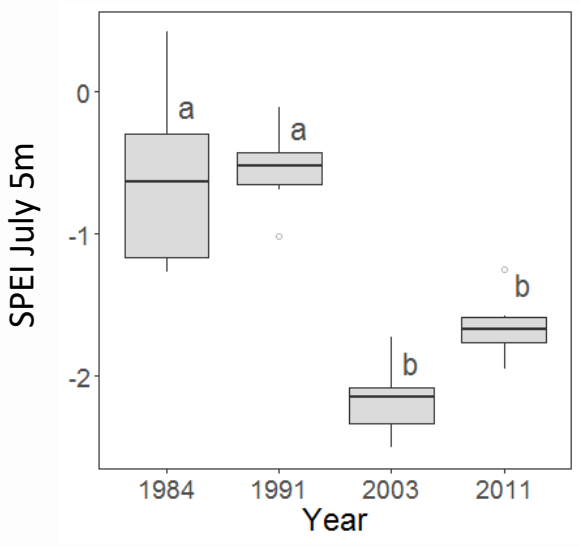


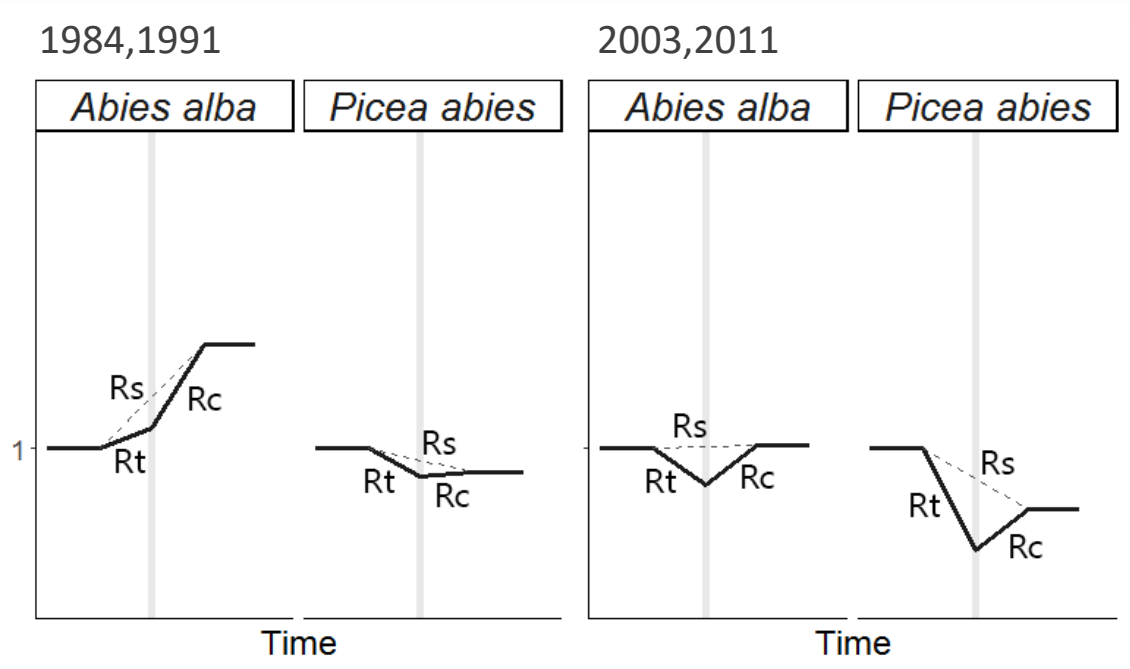
R^2 from 0.51 to 0.74

Index
Rt
Rs

Yr: factor
- 1984, 2003, 2011
- Reference 1991

Discussion





Higher resistance and resilience of fir than spruce

Discussion: implications for forest management

- Species main variable influencing individual drought response.
- Larger trees suffer more to drought.
- Stand basal area has negative influence on drought response.
- Influence of drought on the interplay among predictors.

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