Effect of stand density reduction on drought response in mixed Norway spruce and silver fir forests

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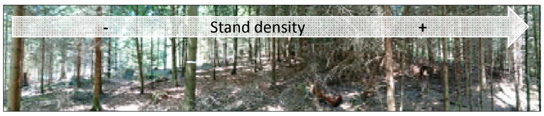
1. CONTEXT AND AIM

Droughts are predicted to increase in frequency and severity in many regions of the Northern Hemisphere, leading to unprecedented risks for forests health and productivity. **Maintaining stands at low density** levels is advocated as a possible mechanism for moderating drought-induced stress and growth reductions.

❖ To evaluate the most important processes to reduce tree drought vulnerability in the short- and long-term, such as the effect of stand density and structural characteristics on tree growth and photosynthesis.

2. METHODS

- ❖ Mixed *Picea abies-Abies alba* stands
- ❖ Precipitation and temperature gradient (Fig. 1A)
- ❖ Shelterwood experiment, SW Germany
- ❖ Establishment of experiment: 1980
- ❖ Management (different regeneration periods ~ thinning intensity): 3 sites x 4 'management intensities' (from heavy to increment control)



- ❖ Repeated forest inventory data (59'327 tree entries)
- ❖ Tree-ring data (529 tree-ring series)
- ❖ Tree- and stand-level approach
- ❖ Growth resistance, resilience, and recovery to drought (Lloret et al. 2011)

3. RESULTS

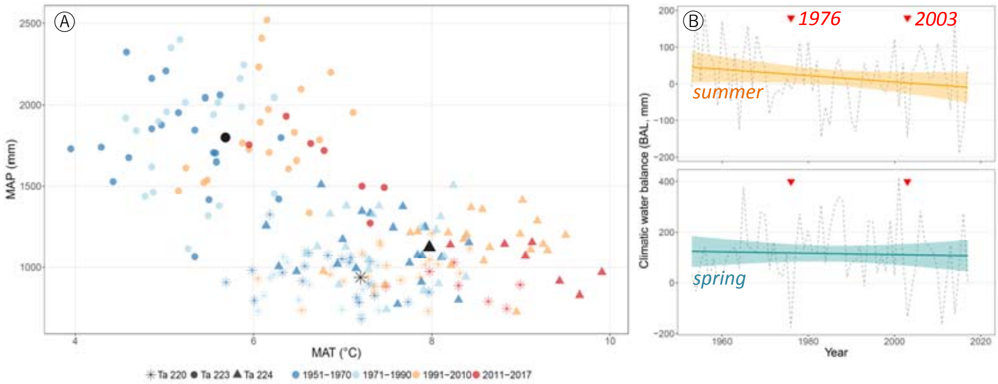


Fig. 1. A) Mean annual temperature (MAT) and precipitation (MAP) of the study sites. **B)** Trend of spring and summer climatic water balance (BAL = precipitation - potential evapotranspiration) for the period 1951-2017, red triangles point to the drought of 1976 and 2003.

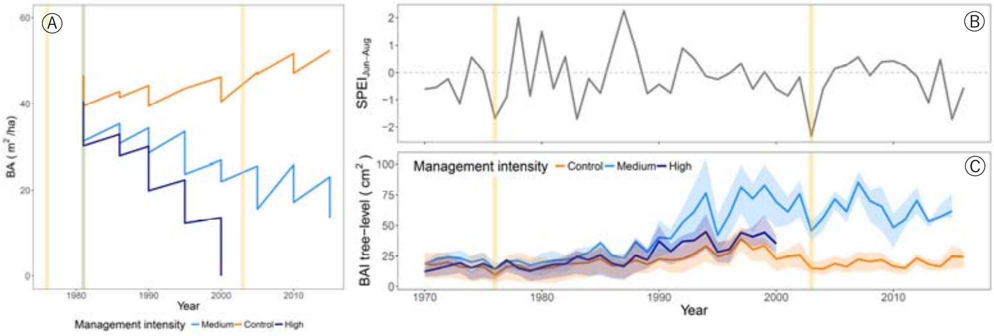


Fig. 2. A) Stand-level basal area (BA). The vertical green line indicates the beginning of the shelterwood experiment. **B)** Drought index (SPEI, June-August). Positive values denote water surplus, while negative values identify water deficit. **C)** Tree-level basal area increment (BAI) across different levels of management intensity and increment control. A,B,C) Vertical yellow lines highlight the drought of 1976 and 2003, site Ta 224.

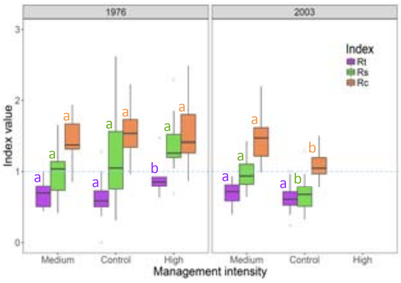
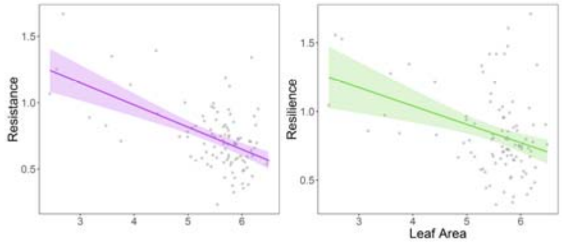


Fig. 3. Tree-level resistance (Rt), resilience (Rs), and recovery (Rc) to drought 1976 and 2003 in relation to management intensity (site Ta 224). Lowercase letters represent significant differences at α < 0.05 (ANOVA tests).



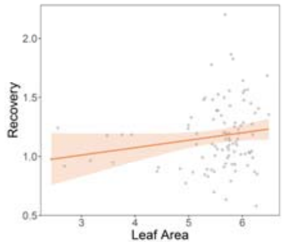


Fig. 4. Resistance, resilience, and recovery to drought 2003 as function of leaf area (LA) of individual trees. LA is ln-transformed to produce linear relationships. The slopes don't significantly differ among management intensities.

4. DISCUSSION

The period 1951-2017 showed increasing trend of temperature and summer drought (Fig. 1A, B).

Severe drought events (Fig. 2B) and management intensity (Fig. 2C) profoundly affect tree growth.

Management intensity affects the vulnerability to drought of tree growth (Fig. 3). Trees growing in less dense stands show higher resilience and recovery to drought.

Leaf area (LA) has significant influence on resistance, resilience and recovery to drought (Fig. 4). Trees with higher LA are less resistant and resilient to drought, but show higher recovery.

Next steps. Model Maestra (Wang & Jarvis 1990) to examine the relative importance of absorption of photosynthetically active radiation (APAR) and light-use efficiency (LUE) on drought responses.

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References:

Lloret, F., E. G. Keeling, and A. Sala. 2011. Components of tree resilience: effects of successive low-growth episodes in old ponderosa pine forests. Oikos 120:1909–1920.

Wang, Y., and P. Jarvis. 1990. Description and validation of an array model—MAESTRO. Agricultural and Forest Meteorology 51:257–280.