Development of *Abies alba* seedlings during the years 2023 and 2024 in relation to microclimatic variables

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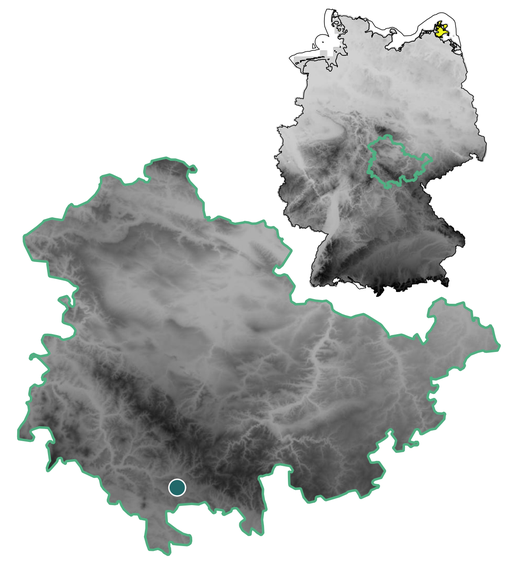
Introduction

Monospecific Norway spruce (*Picea abies*) dominated forests in Germany are vulnerable to the effects of climate change.
The (re)introduction of tree species such as Silver fir (*Abies alba*) might help to increase adaptability of forest ecosystems to climate change and to increase overall biodiversity. Direct seeding is a way to mimic natural regeneration to establish stable, climate-tolerant mixed forest ecosystems. The IntegSaat project aims to assess the influence of abiotic factors on the success of the direct seeding of Silver fir and other species under the shelter of Norway spruce.

Research Question

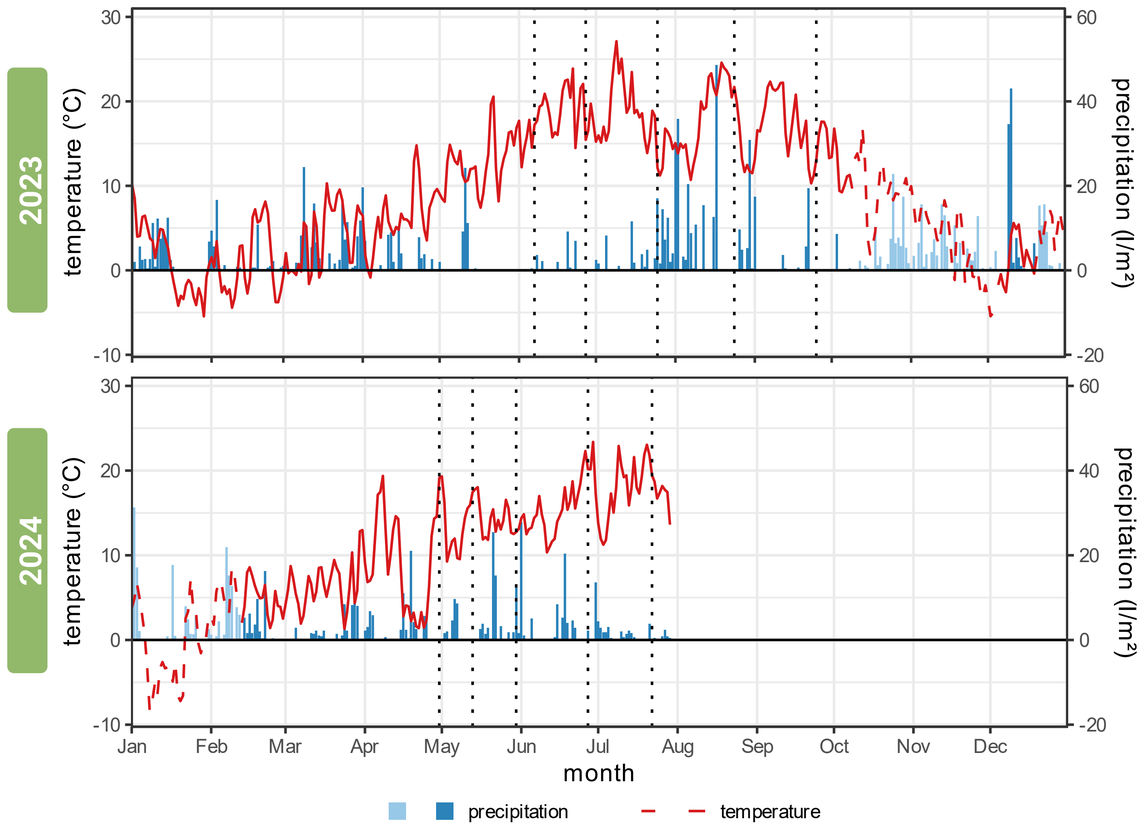
What influence do (micro)climatic factors have on the germination success of directly seeded *Abies alba* seedlings?



Methods

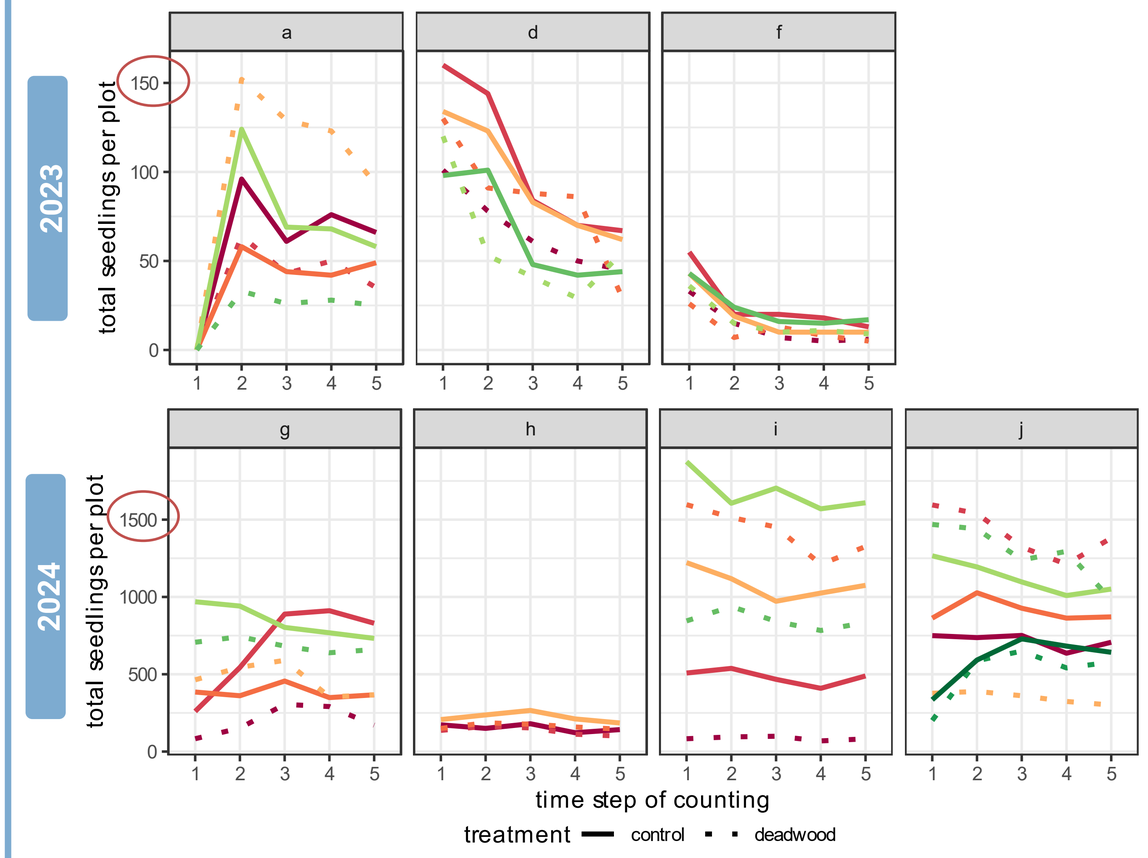
- Location: Municipality forest Hildburghausen (Thuringian Forest mountain range)
- 42 plots on 7 seeding sites under Norway spruce dominated stands with and without deadwood enrichment (C vs. DW)
- Monitoring of *Abies alba* seedlings during their first post-seeding vegetation period
- Weather data from on-site climate station
- Microclimate loggers (soil moisture/soil temperature loggers) on each plot

Climate



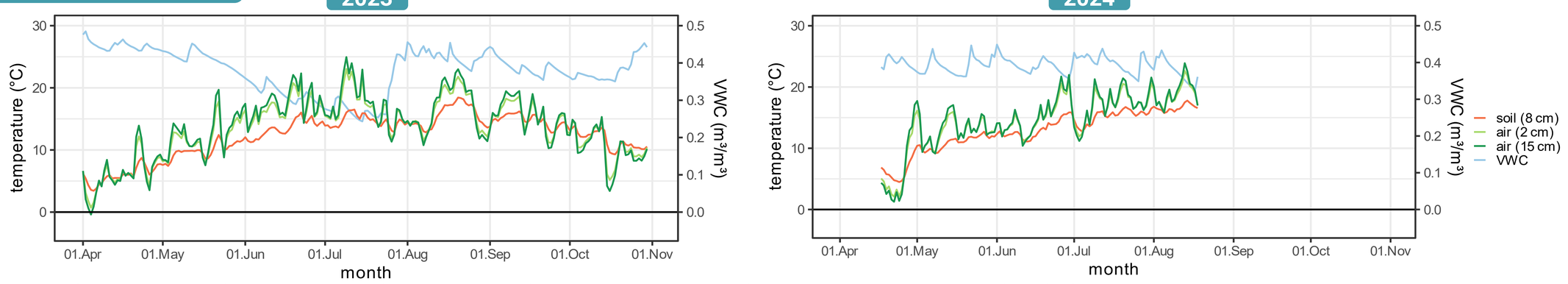
Daily mean temperature and precipitation during the years 2023 and 2024. Dotted temperature lines indicate approximate values calculated based on a nearby DWD-weather station. Dotted horizontal lines mark the dates of seedling counting.

Seedling rates



Seedling development over the course of the vegetation period during the years 2023 and 2024. Letters (a-j) indicate the seeding sites.

Microclimate



Mean values of soil temperature (8 cm below ground), air temperature (2 and 15 cm above ground) and volumetric water content (VWC) of one site each during the vegetation periods 2023 and 2024.

Results and Discussion

- In 2024, temperature thresholds relevant for plant growth were reached **one month earlier** than in 2023 (5°C: end of March vs. end of April; 10°C: end of April vs. end of May), although there was a late frost in April in 2024 which also showed in temperature data from near ground measurements.
- *A. alba* seedlings from the same seeds sown in comparable periods of the year have shown considerably different germination success in both years (**up to 10 times higher in 2024**).
- Monitoring campaigns at comparable points in the year showed similar temperature and precipitation totals (campaigns 1-3 2023 vs. 3-5 2024), though it was warmer and wetter at the respective times in 2024.
- Microclimate loggers show the conditions to which the seedlings are exposed. The phase of decreasing soil moisture since May 2023 in contrast to more constant levels in 2024 may have had a strong influence on seedling rates.
- Seedling rates showed an overall decline over the vegetation period with a slight increase at the end of the vegetation period 2023 and a more apparent increase between June and July 2024.

Outlook

- Inclusion of further microclimate data and environmental conditions
- Analysis of the developmental stages of seedlings over time
- Differentiation between deadwood-enriched and control plots

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THE INFLUENCE OF ENVIRONMENT ON THE DEVELOPMENT OF *ABIES ALBA* AND *QUERCUS ROBUR* SEEDLINGS

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Introduction

Low mountain range forests in Germany are mostly dominated by Norway spruce (*Picea abies*) and are susceptible to climate change. Introducing additional tree species into these forests improves their ability to cope with climate change and may increase the biodiversity of flora and fauna.
Direct seeding is similar to natural regeneration and allows for the (re)introduction of species currently absent at a site. Additionally, direct seeding does offer multiple advantages over planting.

Research Question

Which microsite conditions influence the development of directly seeded *Abies alba and Quercus robur* seedlings?

Methods

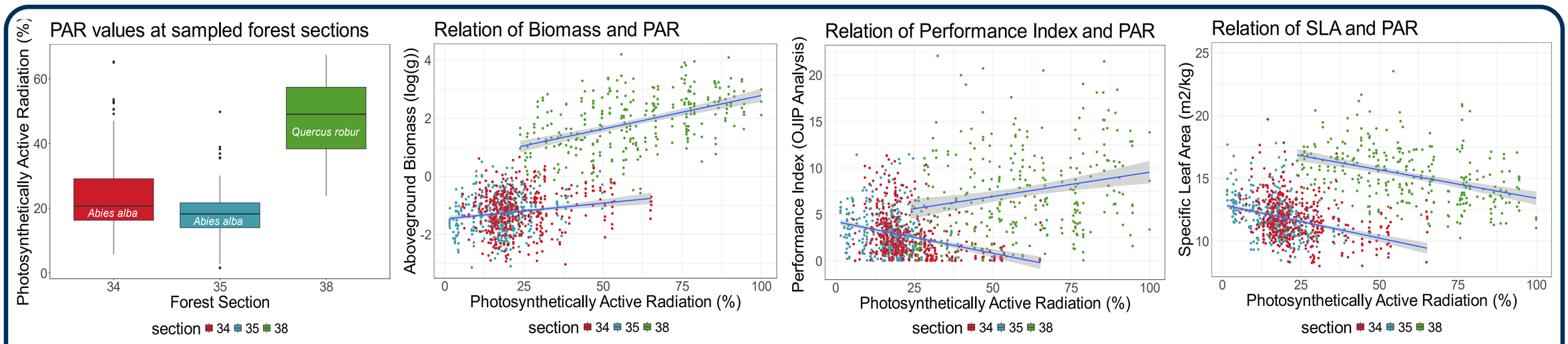
- Location: Municipal forest Hildburghausen (Thuringian Forest mountain range)
- 3 sites on acidic soil, differently affected by bark beetle
- Soil sampling and harvesting of 4-year-old seedlings of *Abies alba* and *Quercus robur*
- Surveying of microsite conditions like PAR and soil moisture
- Analyzing plant growth, leaf traits and soil characteristics

Why fir and oak?

- Possible climate change winners
- Projected to cope well with climate change
- Drought tolerant (taproot)
- Stabilize existing forests
- High shade tolerance of seedlings under canopy
- Formerly widespread local species

Plant variables	Soil moisture		Soil pH		Soil buffer		PAR		Browsing		Soil nutrients †		Leaf nutrients †		Moss /Litter	
	A. alba	*Q. robur*	*A. alba*	*Q. robur*	*A. alba*	*Q. robur*	*A. alba*	*Q. robur*	*A. alba*	*Q. robur*	*A. alba*	*Q. robur*	*A. alba*	*Q. robur*	*A. alba*	*Q. robur*
Biomass							** ↑	*** ↑	*** ↕				** ↑ N, Mn	* ↑ Al		
Shoot- / root-length									*** ↓						*** ↓	
Allocation-ratio Leaf / stem weight								* ↓	*** ↓					** ↕ Fe, S		
SLA			** ↑		** ↓	** ↑	*** ↓	*** ↓				** ↓ Mn	** ↕ N, Mn, Na, P			
Fv/Fm							*** ↓					* ↕ C, S	** ↑ Al	** ↕ C, Fe, Mg, Mn, S		
Performance Index							*** ↓	** ↑				* ↑ Ca	** ↕ Mg, Na, P	** ↕ N, Ca, Fe	* ↓	

Significance levels (* = P < 0.05,** = P < 0.01, *** = P < 0.001) and trends of the influence of environmental variables on the measured plant variables of *A. alba* and *Q. robur* seedlings.



PAR values of the three surveyed forest sites and correlations of both species' biomass, performance indices, and SLA with the percentage of PAR of the open field reference.

Results and Discussion

- Biomass production of both species increased with greater PAR availability.
- Fv/Fm (chlorophyll fluorescence) values of *A. alba* decreased with increasing PAR while *Q. robur* showed no relation.
- *A. alba's* decrease in PI with increasing PAR aligns with its preference for low-light environments; however, the biomass increase shows its adaptability to brighter conditions. - *Q. robur* showed the opposite PI and Fv/Fm trends.
- This indicates that *A. alba* is suitable for establishing the next forest generation under an intact canopy, while *Q. robur* is better for areas with clear-cuts.
- Soil nutrient contents didn't affect *A. alba*, but influenced *Q. robur's* photosynthesis. Leaf nutrient contents were important for both species.
- *A. alba's* biomass allocation is driven by browsing and bare soil presence. - *Q. robur's* aboveground biomass increases with PAR, leading to more branches.

Take Home: Directly seeded *A. alba* and *Q. robur* perform well in acidic spruce forests, depending on the light regime

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