

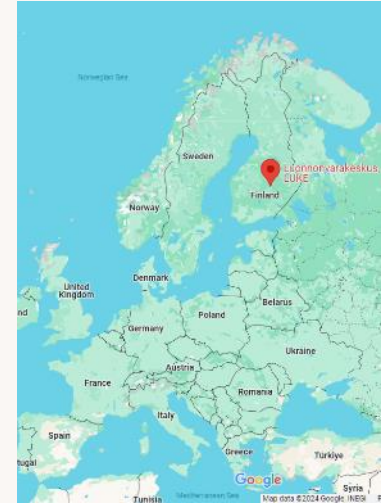
Interactive effects of warming and increased precipitation on the physiology, growth, visual condition and soil respiration of Norway spruce seedlings

Boreal Forest Regeneration Platform (BoFoReg)

Suonenjoki, Natural Resources Institute Finland (Luke), Finland

Minna Kivimäenpää & Riikonen Johanna, Luke

AnaEE Science Conference, Paris 8.-10.10.2024



Source: Map data ©2024 Google, INEGI



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Responses of Norway spruce (*Picea abies*) to climate change (2023-2024)

- Theme: Carbon sequestration, growth and climate tolerance of Norway spruce seedlings used for forest regeneration
- Challenges:
 - Norway spruce regarded as a climate sensitive species
 - Limited knowledge of climate change responses of Norway spruce seedlings
 - studies based on single seedling lots
 - Interactive effects of warming and changes in precipitation unknown
- Experiment conducted in BoFoReg's Stress Test Field



BoFoReg's Stress Test Field

- For experimental research on the responses of tree seedlings and other plants to climate change (warming, changes in precipitation)
- In operation since 2023, development continues
- Mineral forest soil



Photo: Esko Oksa/Luke



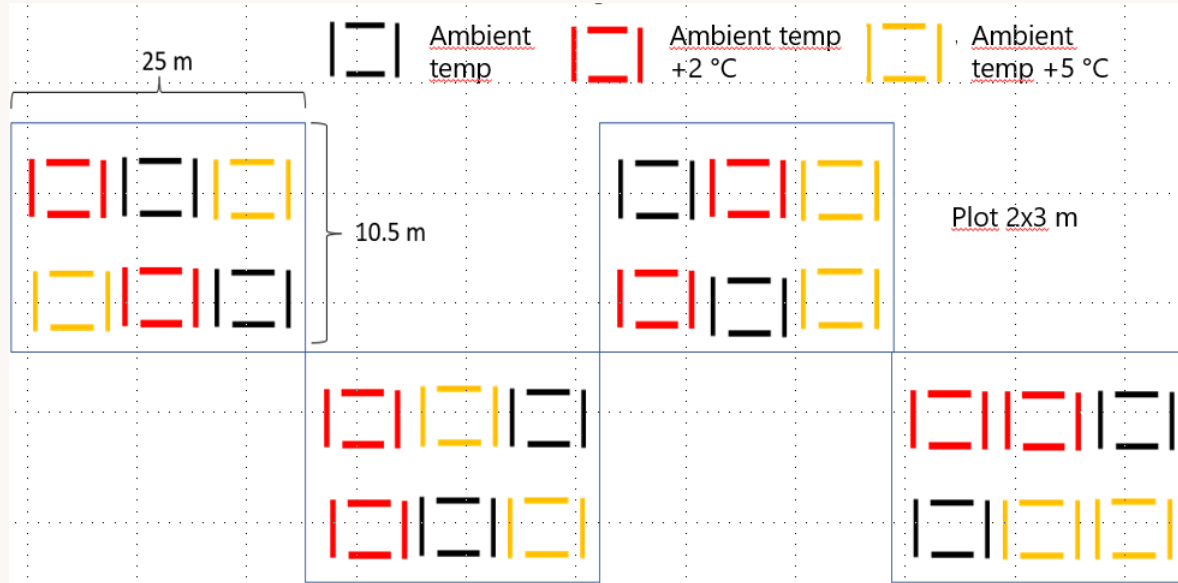
Photo: Johanna Riikonen/Luke



Photo: Minna Kivimäenpää/Luke

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Experimental setup 2023-2024



6 treatments, replicated 4 times:

- Ambient temperature and precipitation
- Ambient temperature and additional watering
- +2 °C and ambient precipitation
- +2 °C and additional watering
- +5 °C and ambient precipitation
- +5 °C and additional watering

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Stress test field

Warming and watering treatments

- Canopy warming with infrared heaters
- Below-ground warming by buried resistance cables
- Watering by subsurface drip irrigation

Monitoring

- Air temperature and RH
- Soil temperature, moisture, electrical conductivity at 15 cm depth (+ additional measurements at various depths)

IR-heaters on the racks
(target +5 °C in the picture)



Photo: Minna Kivimäenpää/Luke



Kuva: Johanna Riikonen/Luke

Installing soil resistance cables

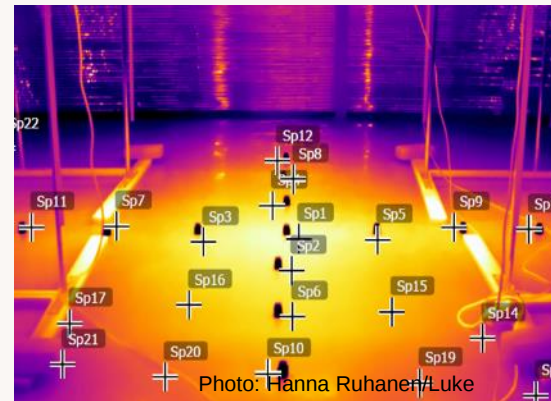


Photo: Hanna Ruhanen/Luke



Photo: Hanna Ruhanen/Luke

Drip-irrigation tubes before installing

How well were the exposures realised?

See: <https://anaee2024.sciencesconf.org/browse/author?authorid=966096>

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Responses of Norway spruce (*Picea abies*) to climate change (2023-2024)

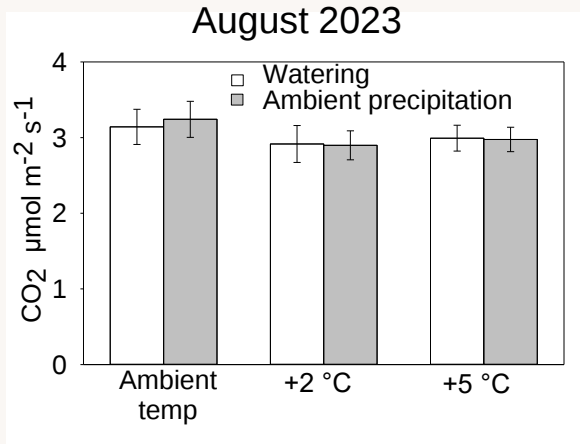
- Eleven lots of one-year-old seedlings
 - From four commercial tree seedling nurseries
 - Lots grown from genetically improved seed orchard seeds
- Planted in early June 2023, >2000 trial seedlings
- Warming until early October
- Under natural snow until mid-April 2024
- Harvested in May 2024
- Measurements: Net photosynthesis, stomatal conductance, chlorophyll fluorescence, soil respiration, seedling growth, visual condition, bud opening after winter (and much more, data not yet ready)



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Net photosynthesis

- Climate treatments had no effects on net photosynthesis
- Some differences between the seedling lots



Photosynthesis measurement

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Chlorophyll fluorescence (Fv/Fm)

Higher Fv/Fm

- Improved Photosystem II function
- Less stress

July:

- Warming increased Fv/Fm
- Advanced needle phenology?

September:

- Watering decreased Fv/Fm in ambient temperature
- Warming increased Fv/Fm (in ambient precipitation)

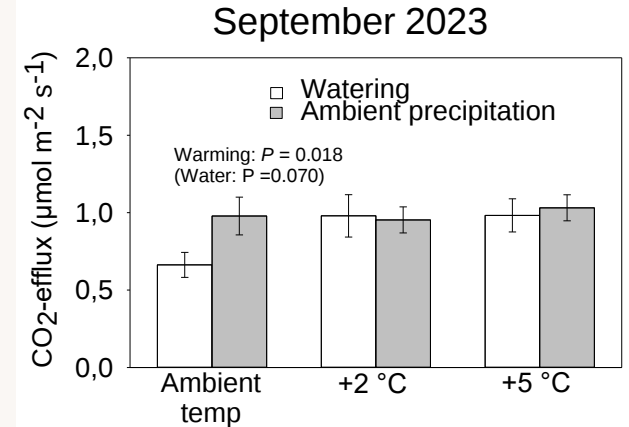
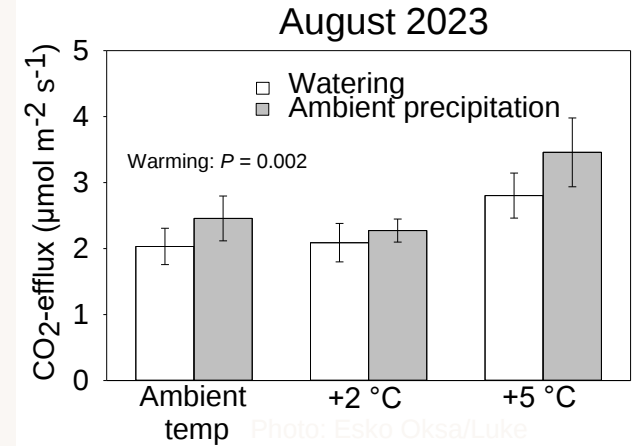
Fv/Fm increases with needle maturation

Treatment	Fv/Fm July Average (SE)	Fv/Fm August Average (SE)	Fv/Fm Sept. Average (SE)
Ambient temp. Watering	0.694 (0.016)	0.759 (0.007)	0.792 (0.007)
Ambient temp. Ambient precip.	0.702 (0.013)	0.773 (0.006)	0.812 (0.006)
+2 °C Watering	0.711 (0.011)	0.768 (0.009)	0.817 (0.007)
+2 °C Ambient precip.	0.692 (0.012)	0.776 (0.008)	0.823 (0.007)
+5 °C Watering	0.741 (0.009)	0.790 (0.006)	0.820 (0.005)
+5 °C Ambient precip.	0.736 (0.010)	0.781 (0.008)	0.817 (0.008)

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Soil respiration

- Warming increased soil (root) respiration
- → Reduces the carbon balance of young spruce plantations in a warmer climate



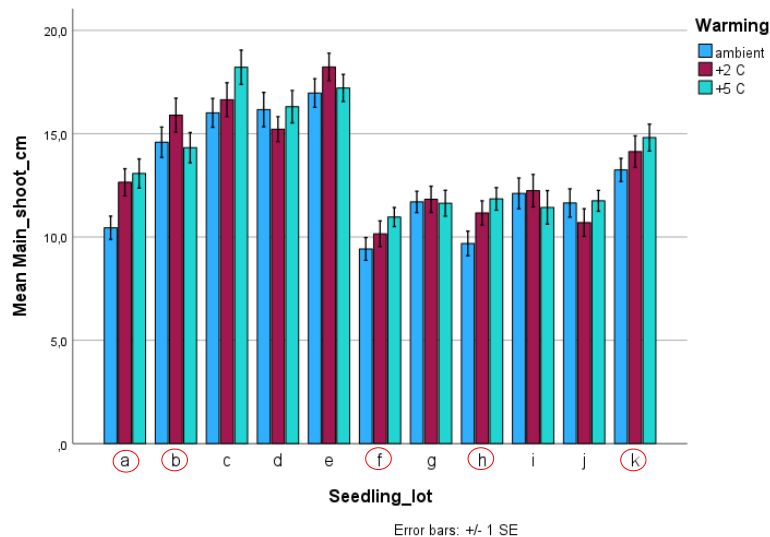
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Seedling growth (height, basal stem diameter)

Climate change responses differed between seedling lots

- Warming increased main shoot length and basal stem diameter in five of eleven seedling lots
 - in ambient precipitation
 - one benefited from +2 °C warming
 - other six were not affected
- Two seedling lots benefited, two suffered, seven were unaffected by watering

2023 main shoot length in ambient precipitation



Seedling condition at the end of August 2023

- Symptoms of abiotic stress, insect damage, fungal disease mild
- Seedling mortality negligible
- Treatments did not affect symptoms



Photo: Minna Kivimäenpää/Luke

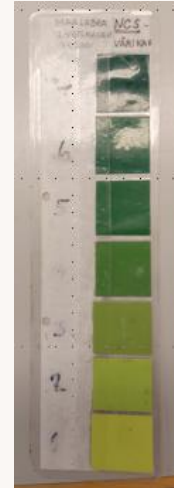


Photo: Minna Kivimäenpää/Luke

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Seedling condition after winter

- Lower Fv/Fm for watering treatments just after snowmelt in April
 - 0.570 ambient precipitation
 - 0.530 watering
- Watering treatments reduced the probability of healthy-looking seedlings
 - 90 % ambient precipitation
 - 85 % watering
- More yellow needles in watering treatments
- Greener needles in warming treatments



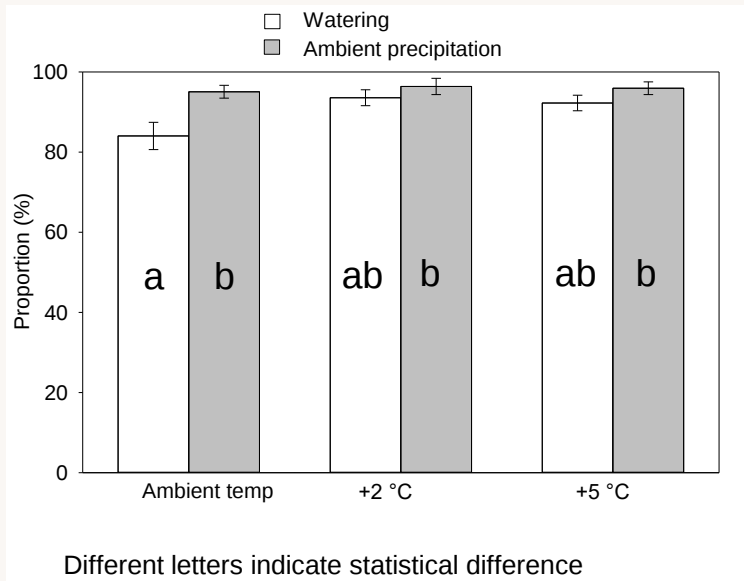
Photos: Minna Kivimäenpää/Luke

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Growth potential after winter

- Watering reduced growth potential after winter especially at ambient temperatures

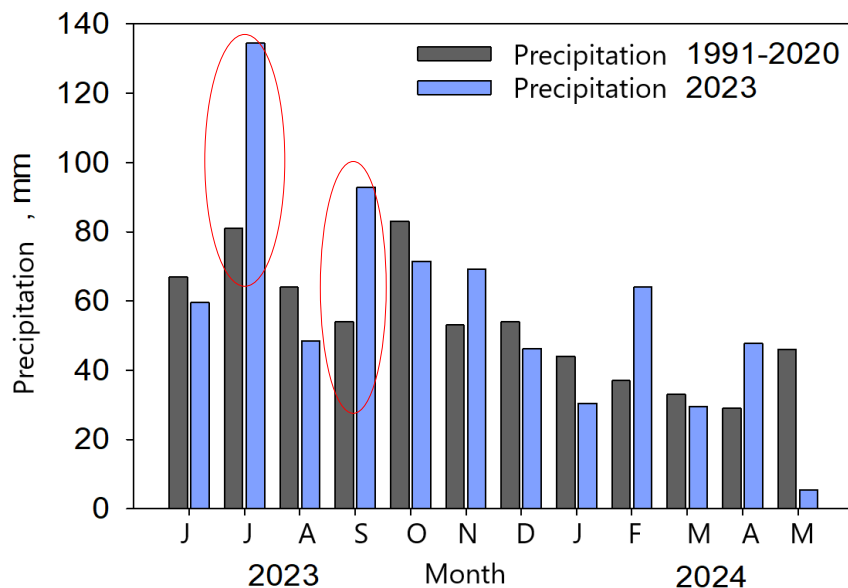
Proportion of seedlings with main bud burst



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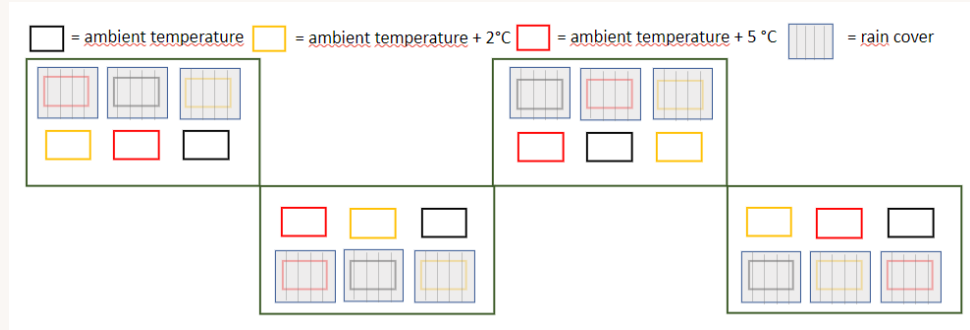
Conclusions

- Rainy summer → watering treatment had negative effect on Norway spruce post-winter seedling vitality
- Warming ameliorated some negative effects of increased precipitation
- **Effects of climate change on growth depend on seedling material**
- Growth may benefit from warming under ambient precipitation
- Norway spruce seedlings may not be as sensitive to warming as earlier thought



Stress Test Field development has continued

- Additional field ditching
- Automatic rain covers in 2025
- Datalogging, operation monitoring and alarms for soil heating
- Sensor data upload to Luke's Azure blob storage
- Wireless soil sensors



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Thank you!

- <https://www.luke.fi/en/projects/ilmastotaimet>



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