Stem growth responses to varying water availability: Perspectives from the complementary Salgesch experiment

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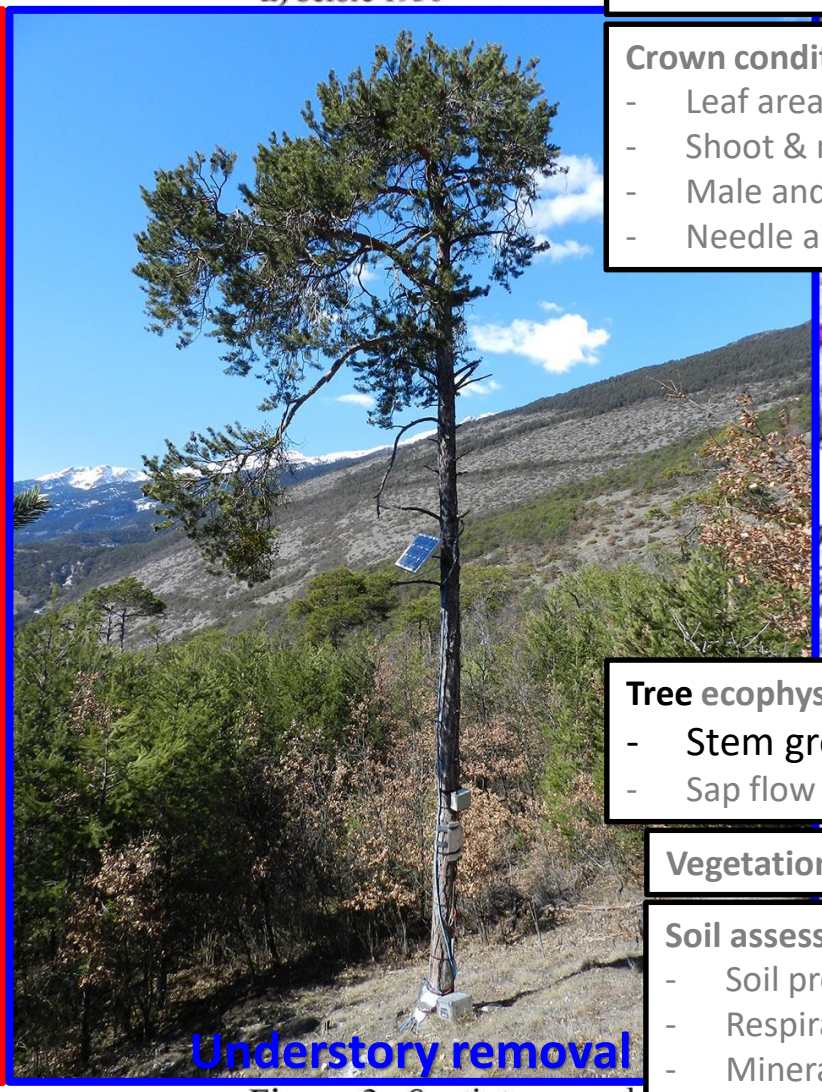
Topics

Pfynwald

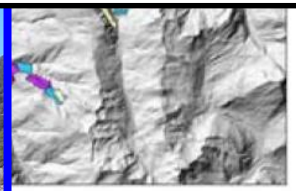
- **Manipulating the water availability in the Salgesch and Pfynwald experiments**
- **Evolution of growth responses to treatments in the last decade**
- **Monitoring the yearly growth using band dendrometers**
- **Disentangling biological and physical determinants of stem diameter variation**
- **Some conclusions**

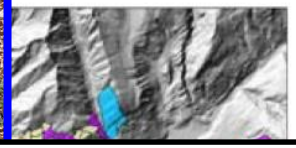
Effects of understory removal on pine tree vitality: the Salgesch experiment



Assessments:

Crown condition:
- Leaf area index
- Shoot & needle growth
- Male and female flowers
- Needle anatomy





Tree ecophysiology & growth:
- Stem growth
- Sap flow

Vegetation releves

Soil assessments:
- Soil profile
- Respiration
- Mineralisation
- 3 depths: temperature, water content

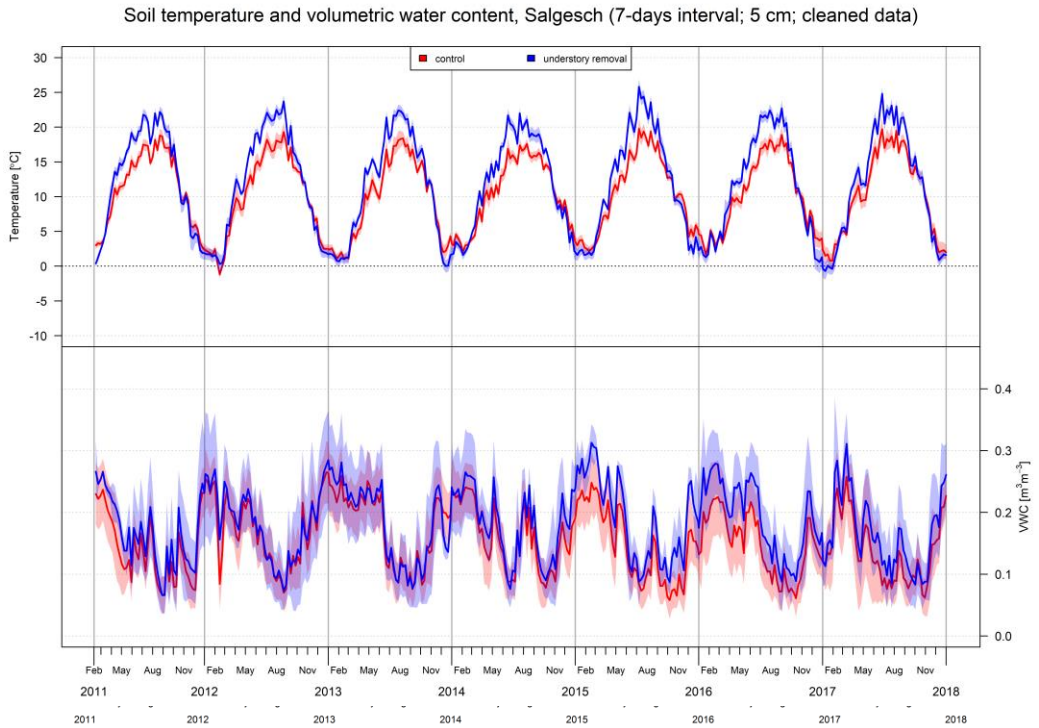
5 m circular plot arranged in pairs (N = 6), with or without understory removal
Plot centered on one dominant pine tree (*P. Sylvestris*) 120-160 year-old
Experiment started in 2010.

Figure 3. Spatiotemporal
and forest litter collectin
before and after 1930.

Gimmi et al. (2008) Ecosystems 11, 113-24

Manipulative effects on the water table and soil temperature

Salgesch



2005-2014 precipitations = 620 mm (elevation: 627 m asl)

2010-2014
change in temperature and mean soil volumetric water content

Soil depth (cm)	VWC (%)	Temperature (%)
5	10	19
30	14	15
60	16	15

Giuggiola et al. (2014) Forest ecol. manag. 409, 241-49

Pfynwald

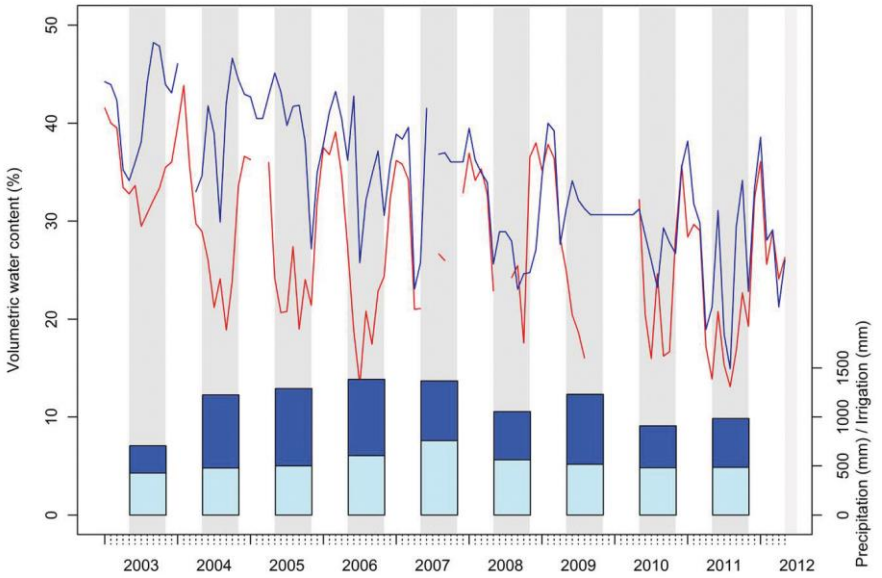


Figure 2. Monthly mean volumetric water content (%) **of the irrigated (blue) and the control (red) plots over the experiment period (2003-2012).** The annual precipitation (light blue bars) and the applied annual irrigation (blue bars) in millimetres are plotted on the second y-axis. Irrigation periods are indicated as grey bars.

2003-2012
precipitation + irrigation =
518 + 587 = 1105 mm
(elevation: 615 m asl)

soil volumetric water content (10 cm depth)
Irrigated: VWC = 34.3 %; Control: VWC = 27,8 %
difference: 6,5 %

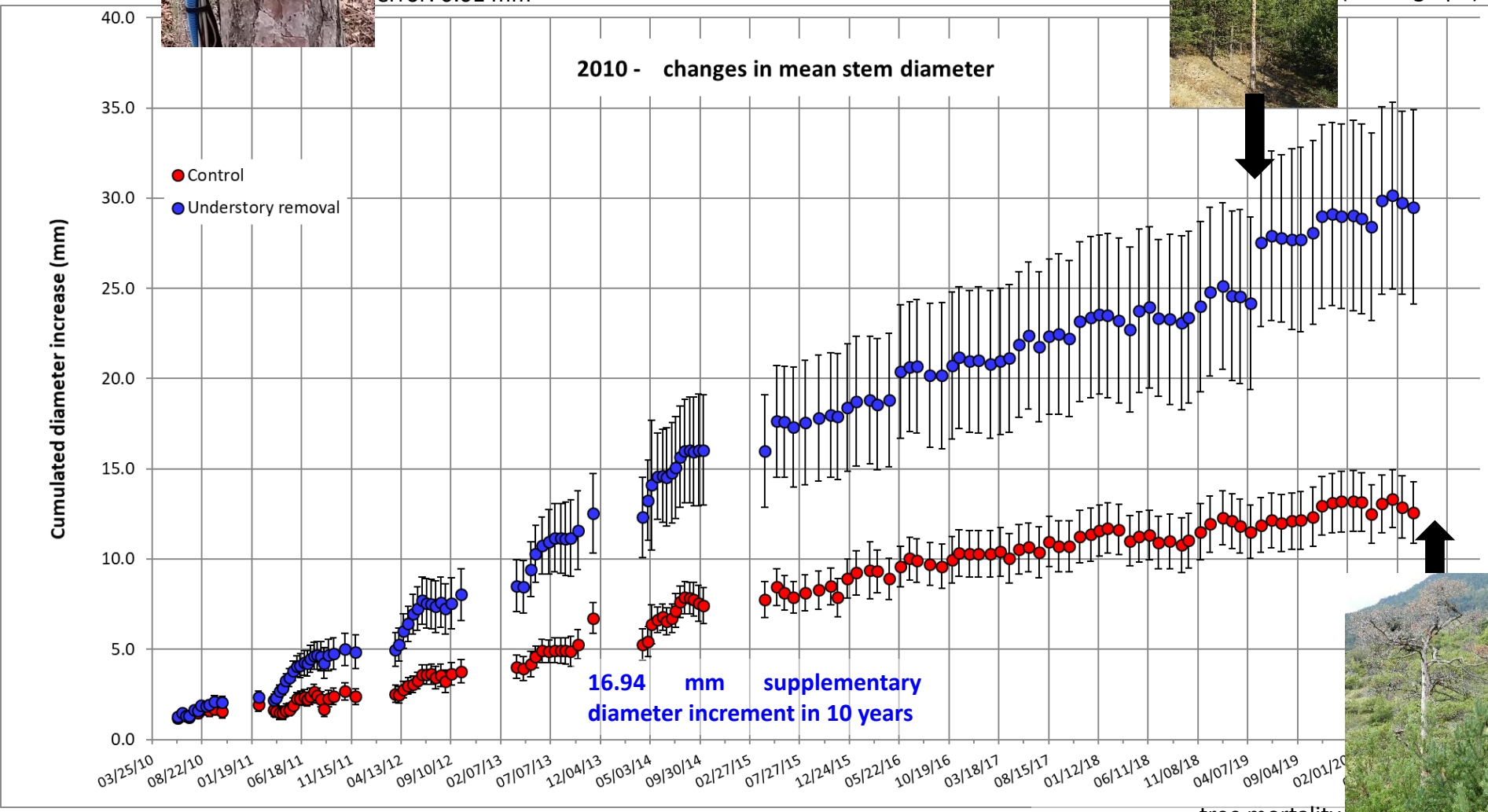
Herzog et al. (2014) PLoS ONE 9(5): e96321.

Stem growth – assessments using band dendrometers

Salgesch

monthly readings
measurement accuracy: 0.05 mm
error: 0.01 mm

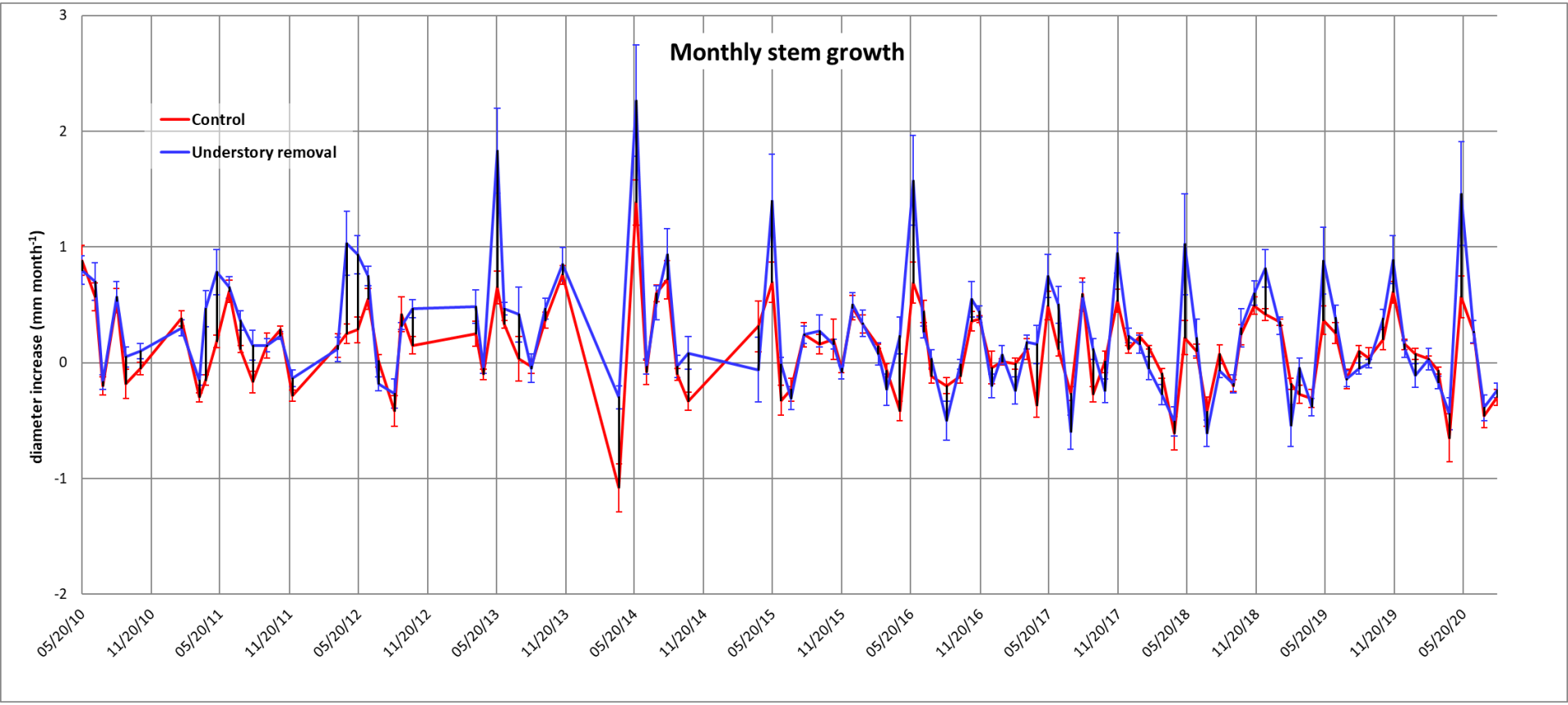
tree mortality by bark beetles (chalcograph)



tree mortality (without apparent reasons)

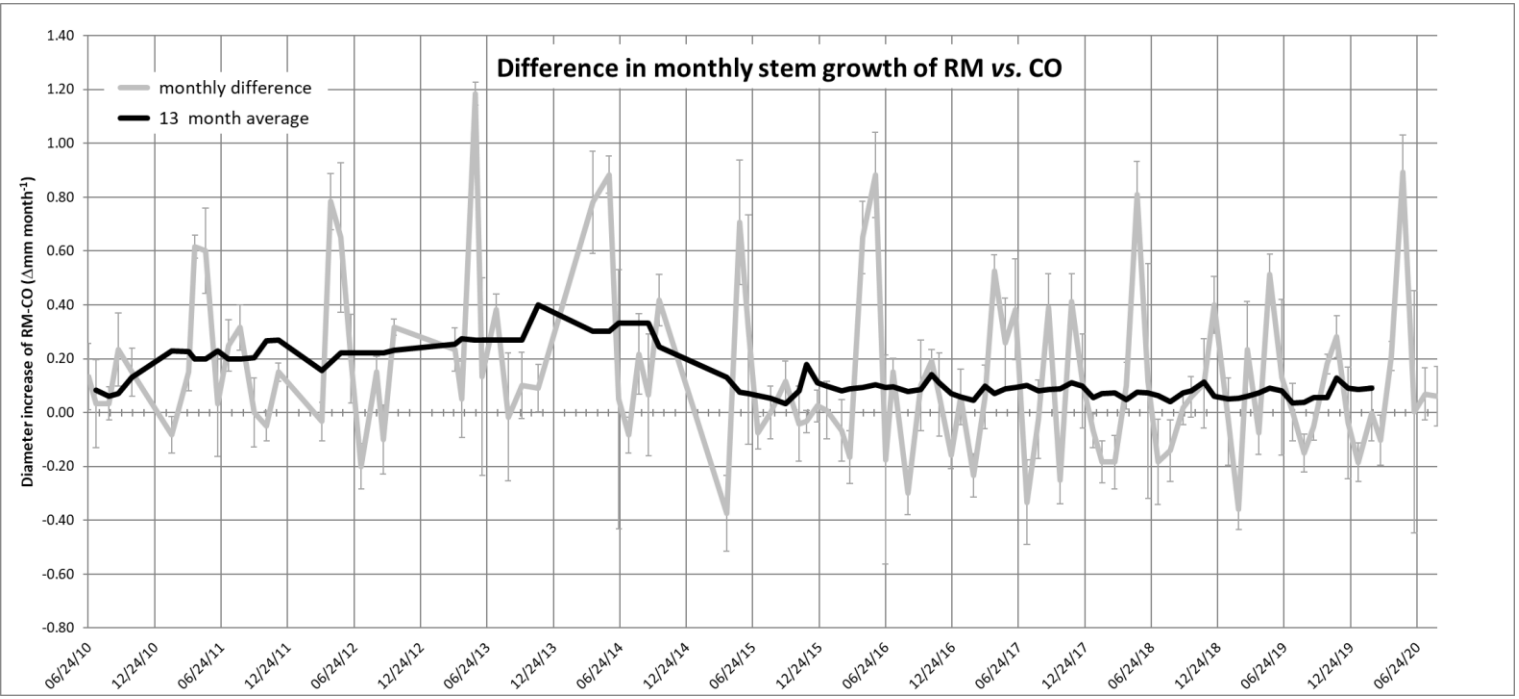
Stem growth – monthly increments

Salgesch



- growth and growth peaks throuhout the year, separated by period of stem constriction
- mostly superior stem growth in the understory removal *versus* control treatment

Stem growth – response to treatments



Salgesch

smaller treatment effects after 4 year

Pfynwald

tendency to smaller treatment effects after 7 years

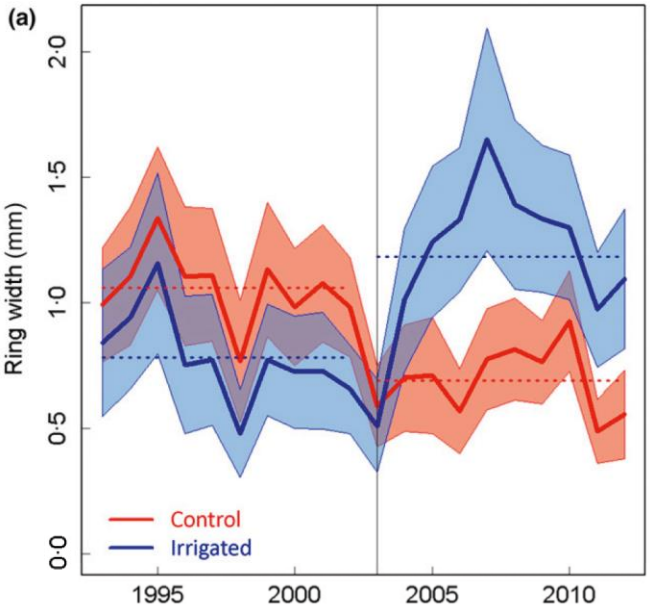
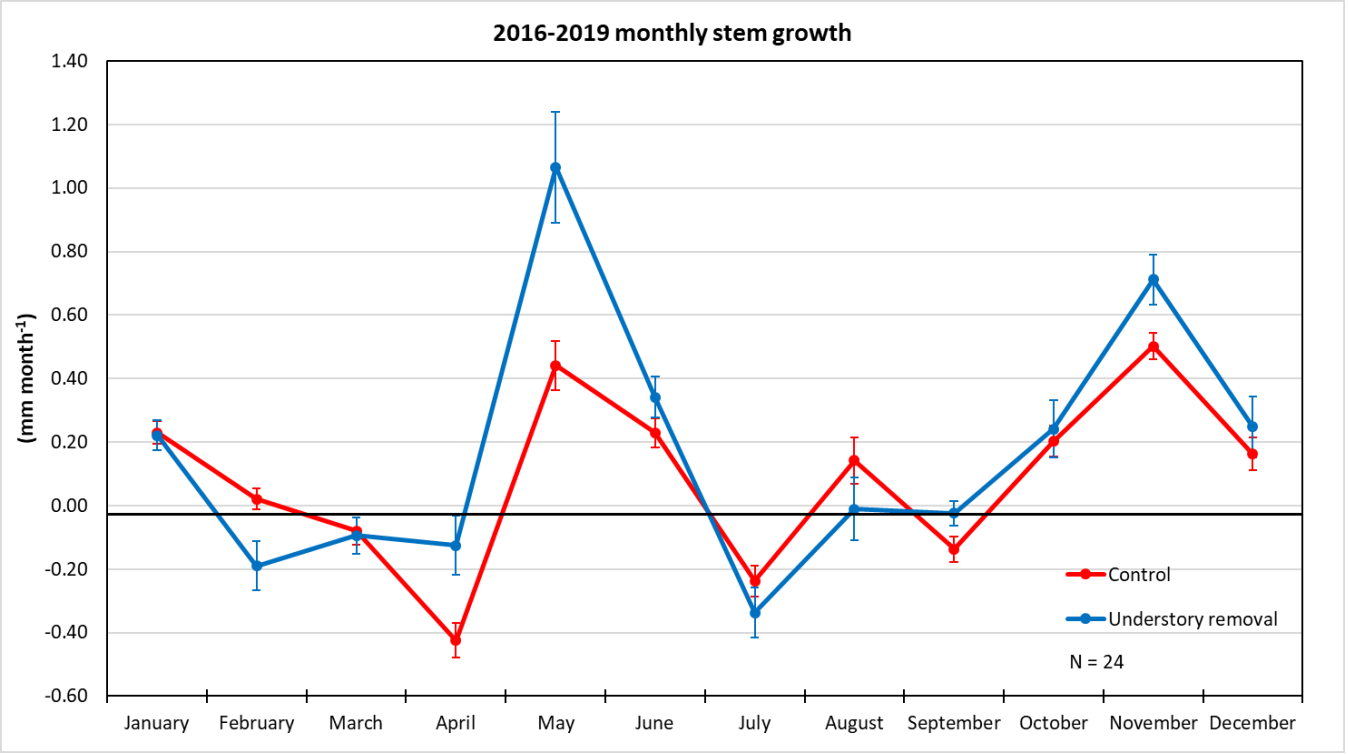


Fig. 4. Chronologies of ring width (a) […] ±95% confidence intervals for the 10 years before (1993- 2002) and the 10 years after (2003- 2012) the onset of irrigation for *Pinus sylvestris* growing at the Pfynwald irrigation experiment (Salgesch, Switzerland). Means are based on 20 individuals for each treatment. […]. Vertical lines separate the pre- from the post-irrigation period. Horizontal lines give mean values for each treatment and period. Ring width showed a significant decrease (control) and increase (irrigated) from the pre- to the post-treatment period (t-test, $P \leq$ 0-001), […].

Von Arx et al. (2014) Funct. Ecol. 31, 1371–1382.

Stem growth – yearly patterns

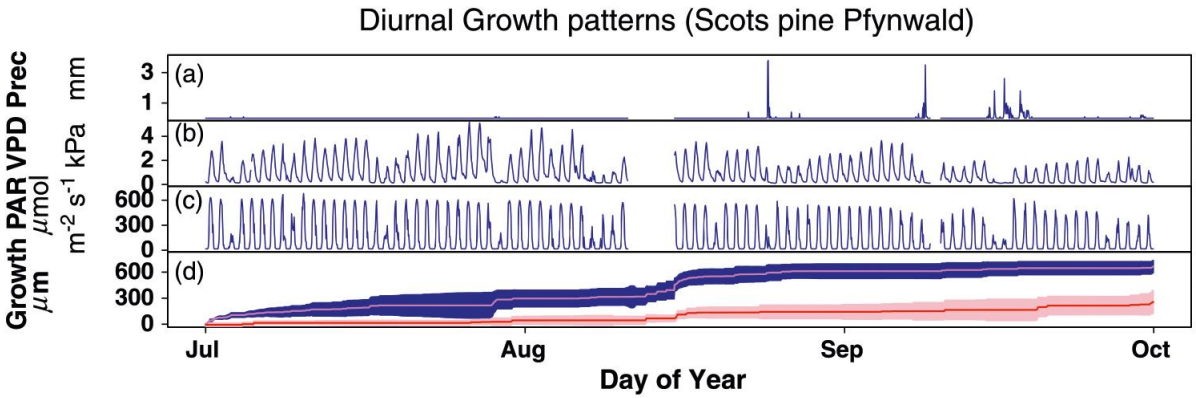


Salgesch

one spring (May, earlywood) and one late autumn growth peak

Pfynwald

main period of radial growth from early July until the end of September, without marked peaks



Mencuccini et al. (2016) Plant cell environ 40, 290-303

Figure 4. […] Panels a to c at the top provide environmental information for the summer of 2013 (early July through to end of September), which coincided with the main period of radial growth at this site. Top panels represent traces of precipitation events Precip (panel a), air vapour pressure deficit VPD (panel b), photosynthetically active radiation PAR (panel c) and mean seasonal growth rates for trees in the control (pink) and the irrigated (blue) plots (panel d). […] the central lines within each band give the mean curves. Control trees grew more slowly than irrigated trees […]. Differences in absolute rates of growth […] between control and irrigated trees were highly significant ($P < 0.001$).

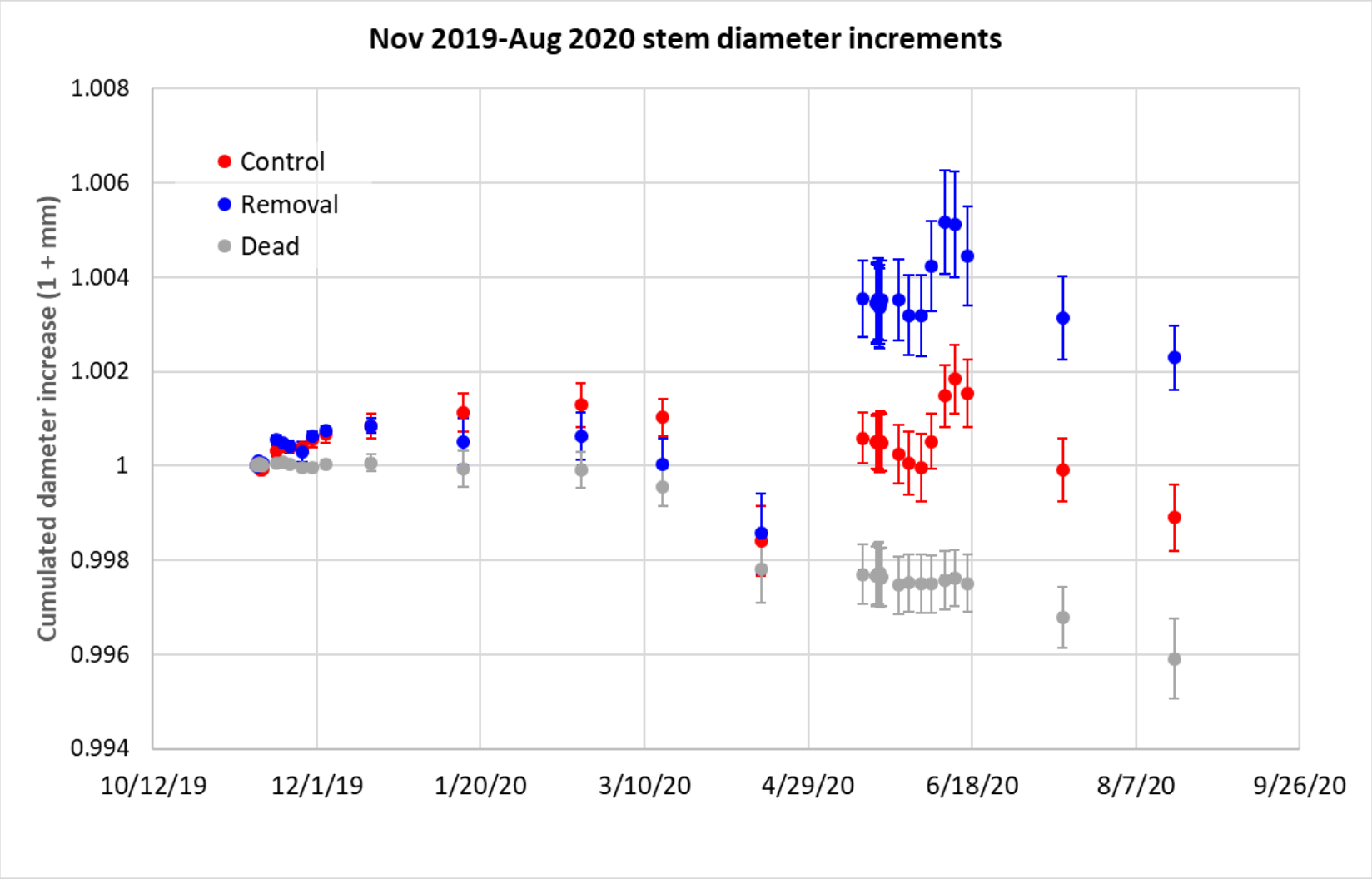
Physical and biological determinants – dead tree treatment

Salgesch

since november 2019, repeated assessments at monthly or higher time resolution

Physical and biological determinants – raw and corected results

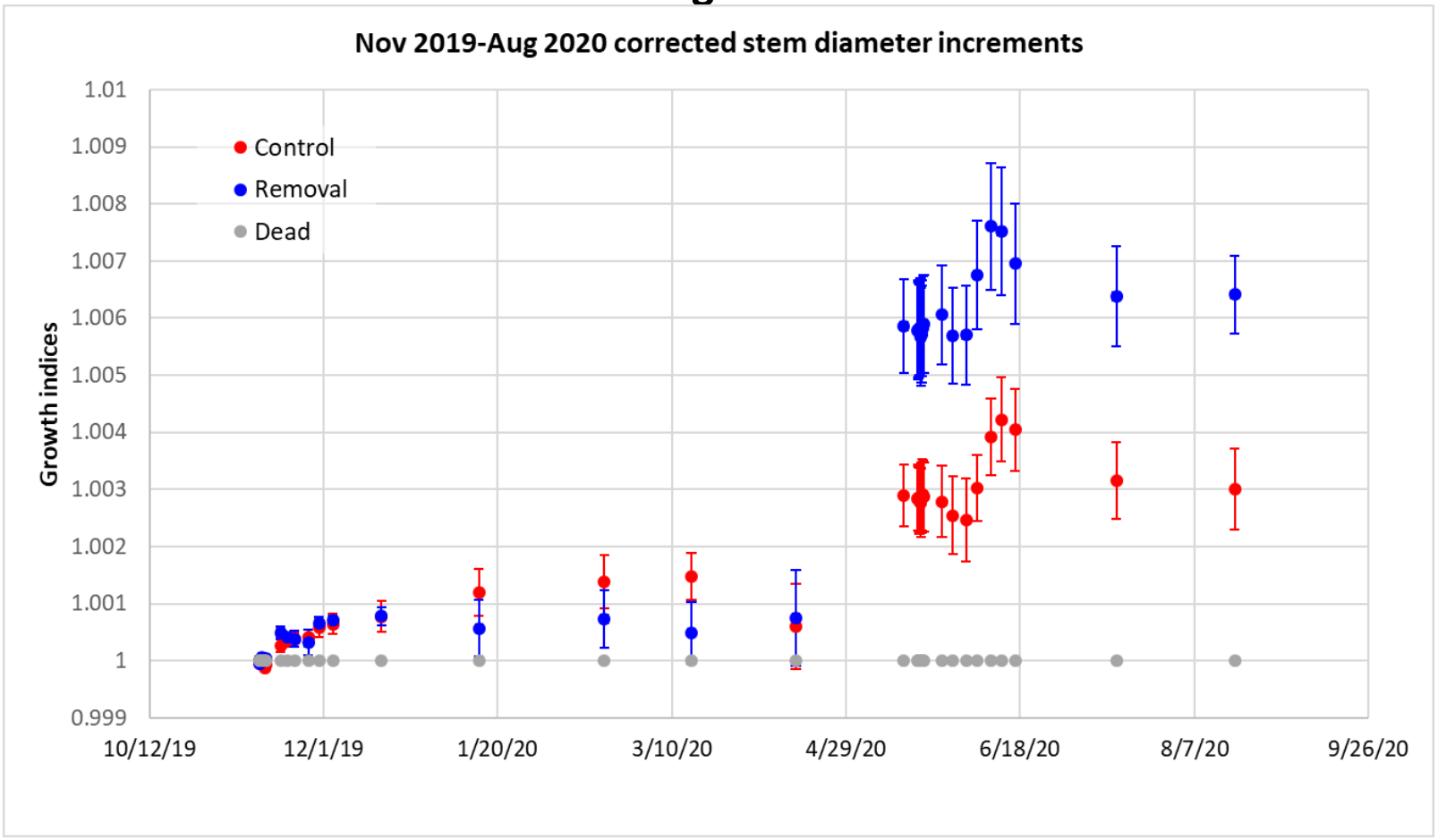
Salgesch



- **stem constriction observed in all three treatments**
- **stem growth observed in living trees only**

Physical and biological determinants – raw and corrected results

Salgesch



Correction of monthly stem growth values for variation triggered by physical determinants, on the basis of mean stem variation in dead trees

- **late Autumn and May growth steps well resolved and confirmed by correction based on dead tree data**
- **unaccounted constriction during the vegetation season (April-August) suggest sap flow-driven effects**

A few conclusions

- **Given similarities and contrasts in ecological context, research questions or treatments, the Pfynwald and Salgesch experiments provide complementary insights on Scots pine forest responses to changes in climate and land use**

- **Despite slightly higher precipitations, Salgesch is drier than Pfynwald. The understory removal in Salgesch has a slightly larger effect on soil water content than the irrigation at Pfynwald**

- **A lesser treatment effect after a few years has been observed at both Pfynwald (7) and Salgesch (4)**

- **By contrast with Pfynwald, both a Spring and late Autumn growth peak has been observed in Salgesch**

- **After data correction based on dead tree stem variation, the remaining stem constriction may relate to sap flow-driven effects**


Thank you for your attention!