

An aerial photograph of a Swiss forest landscape. The foreground is a dense forest with a mix of green and brown trees, suggesting some deadwood or autumn foliage. In the background, there are rolling hills with patches of forest and open fields. A semi-transparent dark box is overlaid on the top half of the image, containing the title text in white.

Growth and Nutrition of Trees in Swiss Permanent Forest Monitoring Plots

Sabine Braun ¹⁾, Sven E. Hopf ¹⁾, Simon Tresch¹⁾, Beat Rihm²⁾, Christian Schindler ³⁾

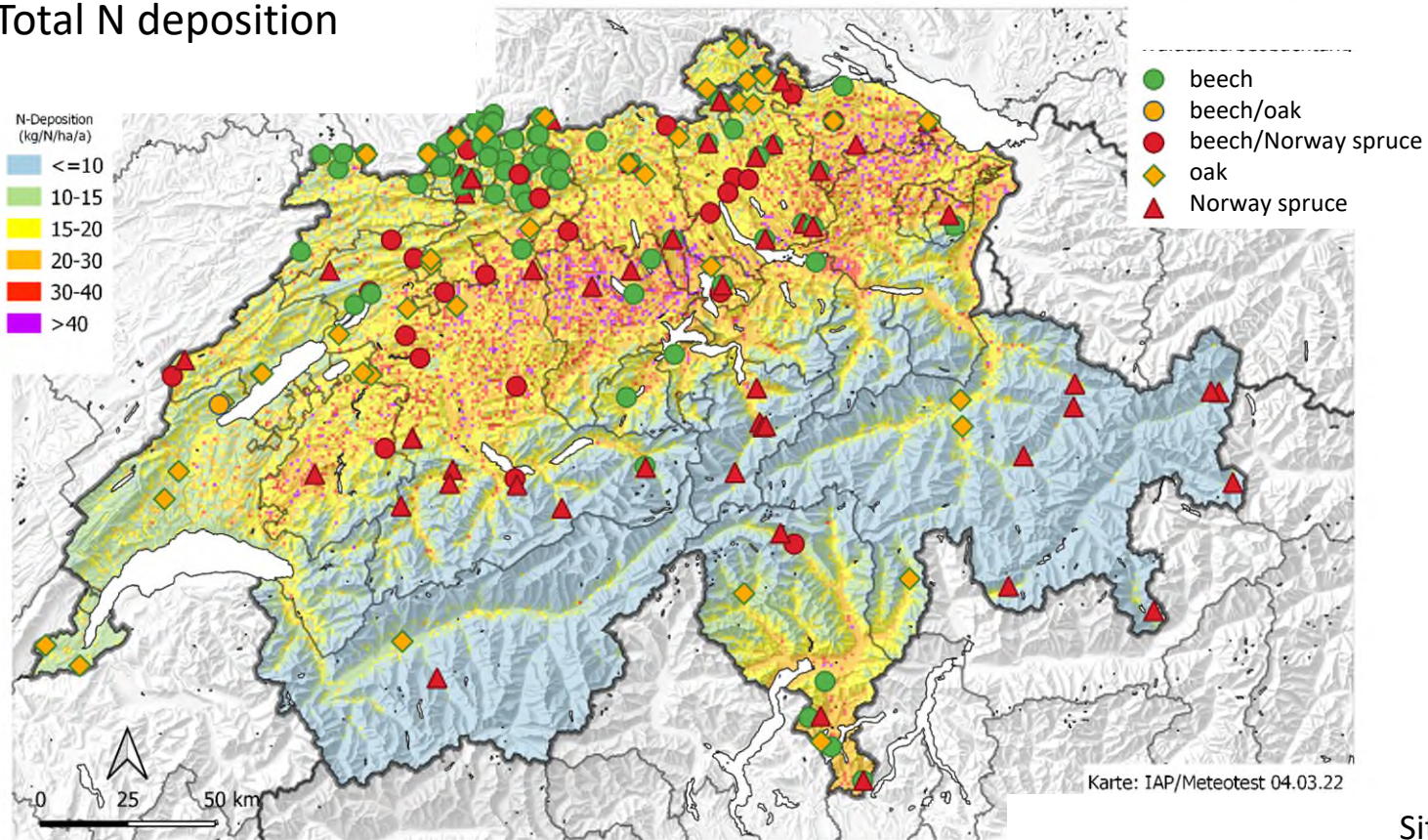
¹⁾ Institute for Applied Plant Biology, Witterswil, Switzerland

²⁾ Meteotest, Berne Switzerland

³⁾ Swiss Tropical and Public Health Institute, University of Basel, Switzerland

Intercantonal Forest observation network

Total N deposition

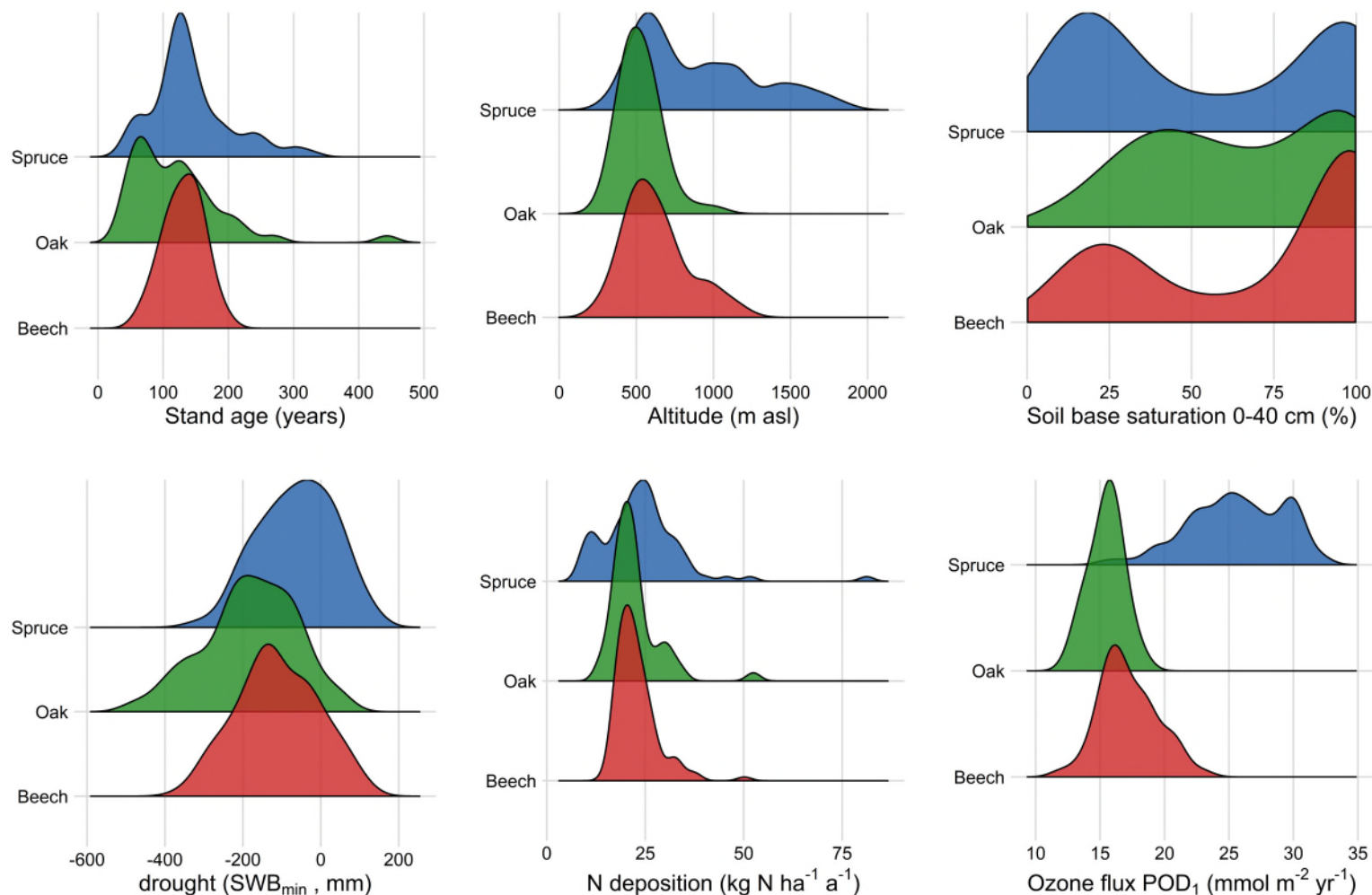


Situation 2020:

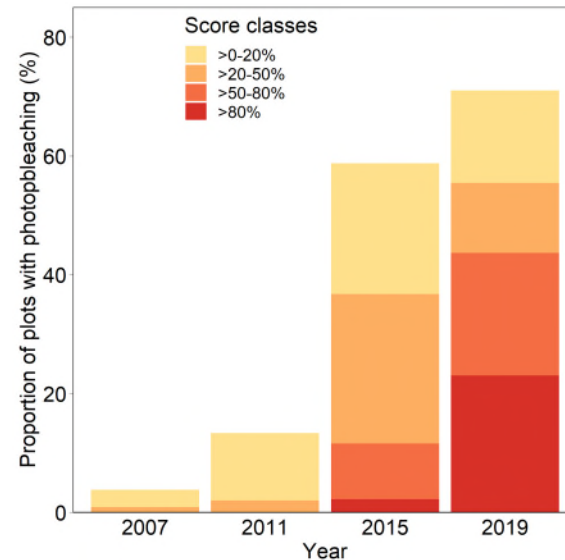
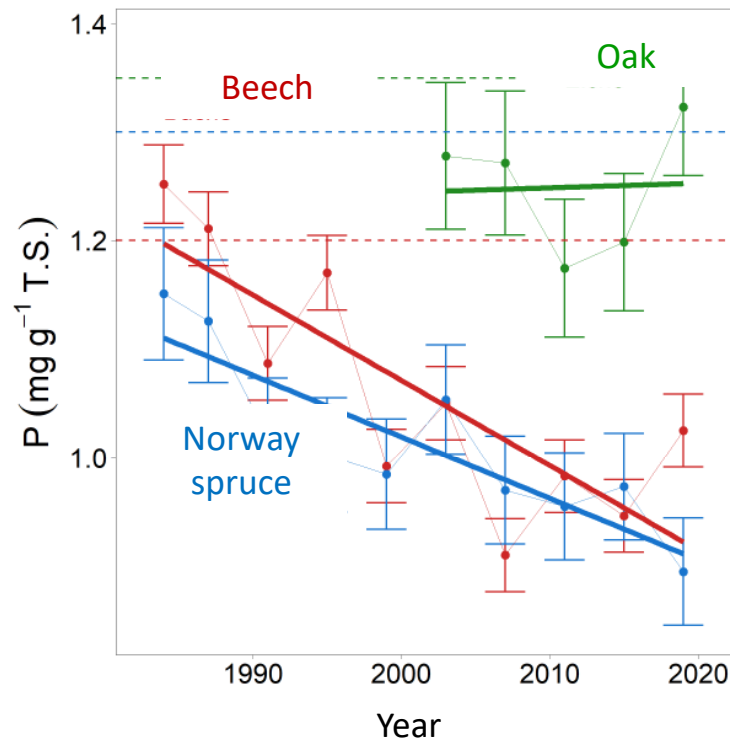
- 94 plots mit 6268 beech
- 75 plots mit 4547 Norway spruce
 - 50 plots mit 1858 oaks



Forest observation plots: Environmental gradients



Development of foliar phosphorus concentrations



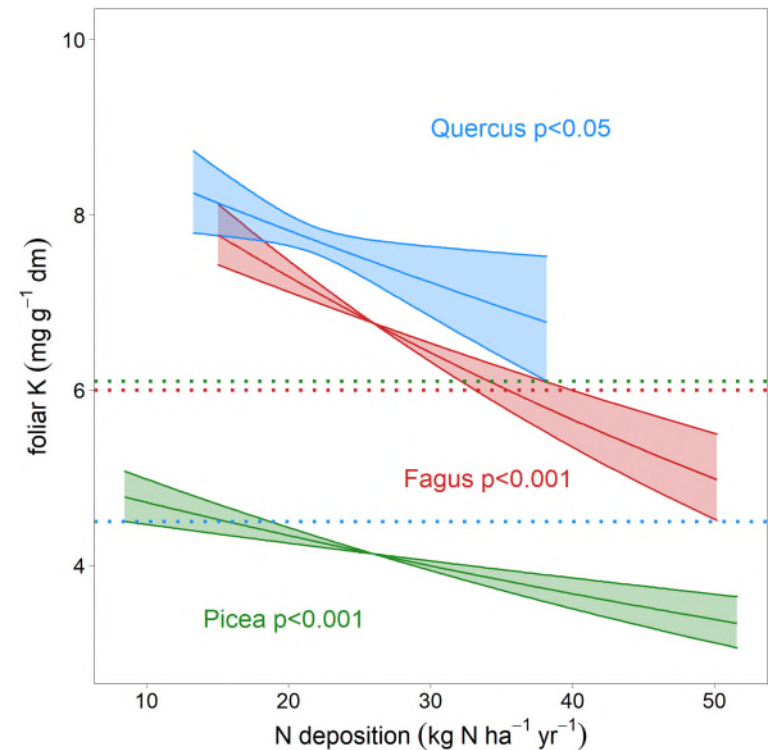
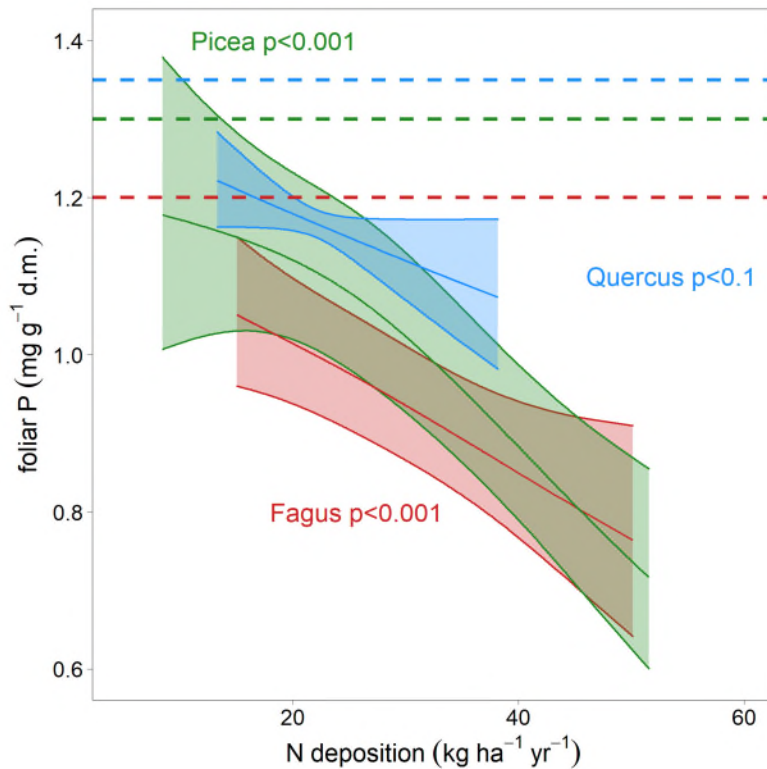
Nutrients: Braun, et al., 2020. Frontiers in Forests and Global Change

Photobleaching: Braun,S., et al. , 2021. Frontiers in Forests and Global Change

Photobleaching increased in parallel to the decreasing foliar P concentrations



Relation between foliar P and K with N deposition



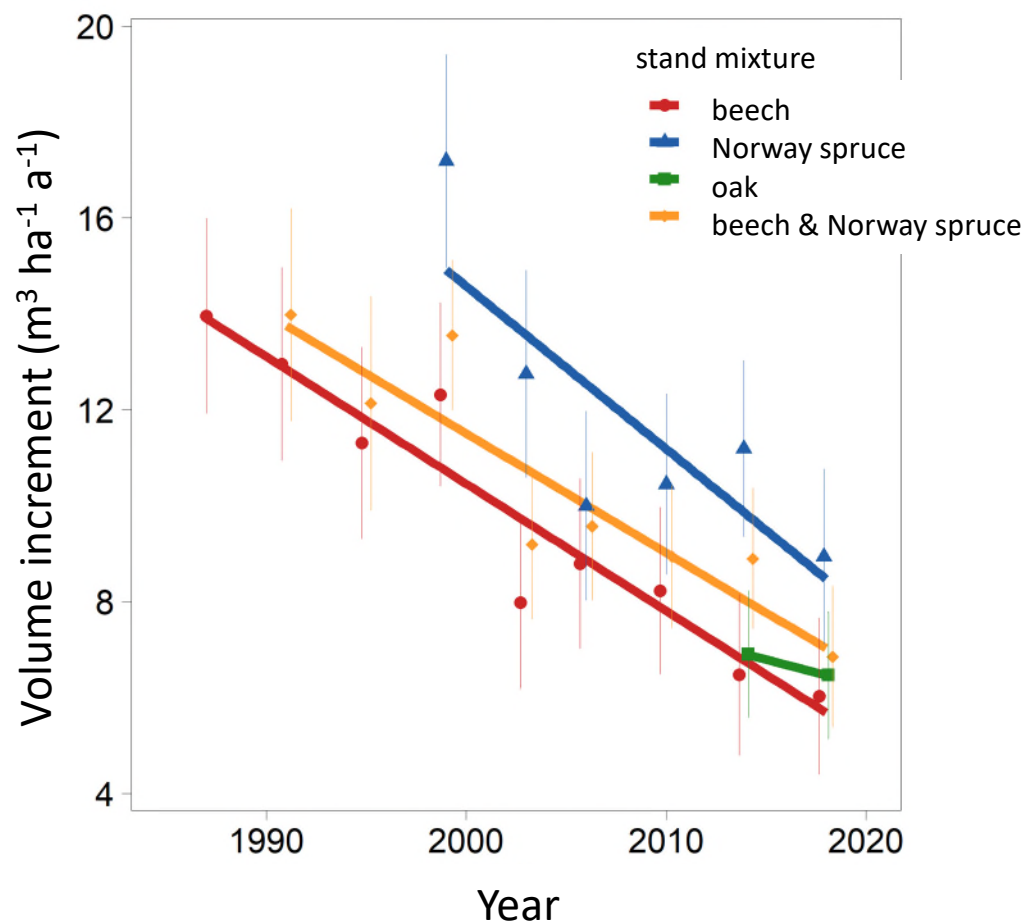
Dotted line: threshold for normal nutrition (Göttlein 2016)

Beech: Braun, S., et al., 2020. Frontiers in Forests and Global Change.

Foliar P and K concentrations are lower when N deposition is high



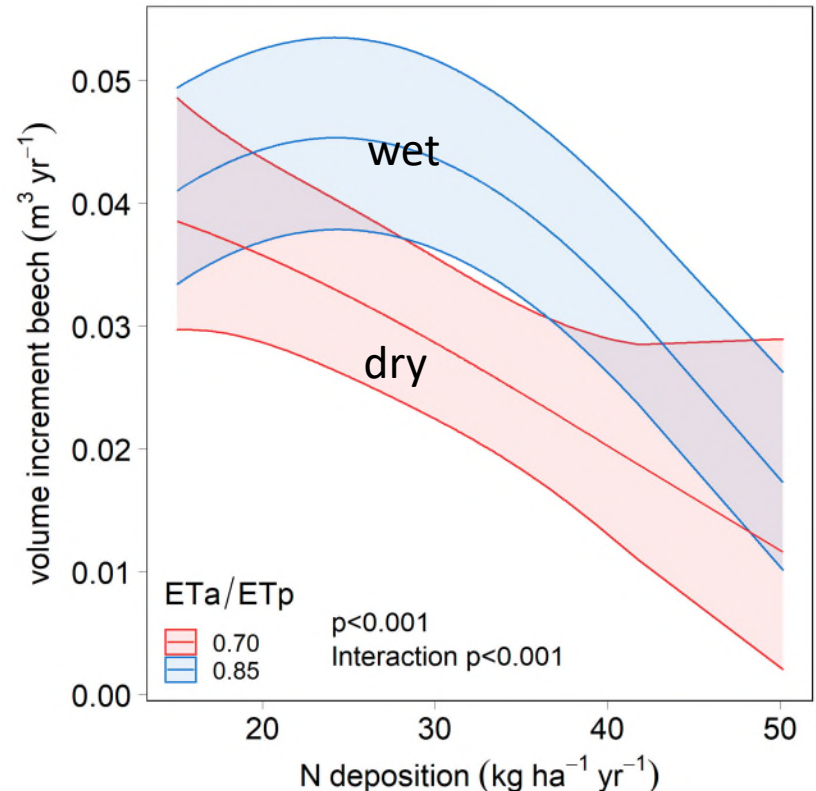
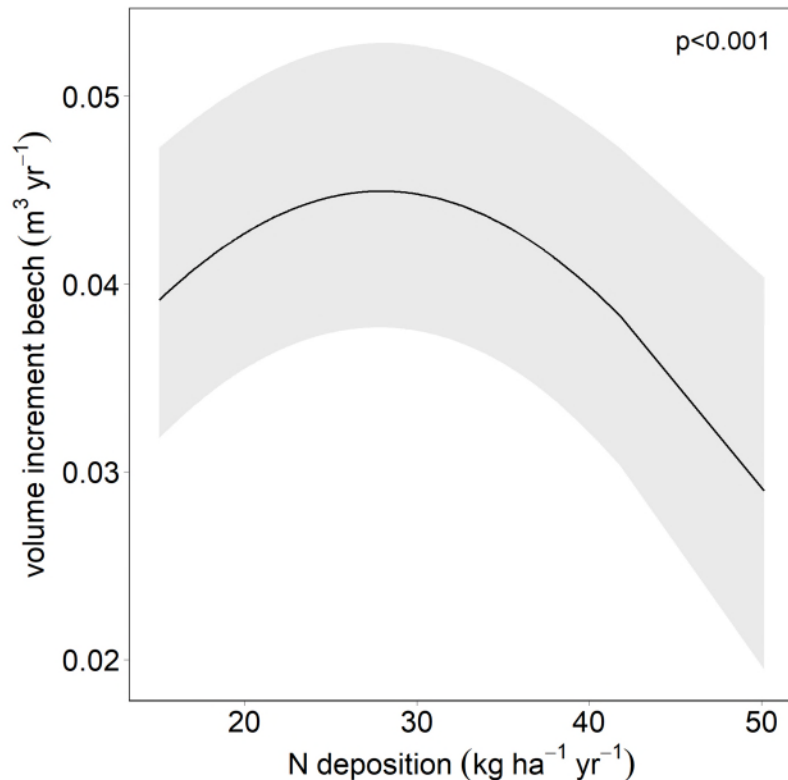
Development of volume increment 1984-2018



Decrease: beech 57%, Norway spruce 48%, oaks 6.4%



Volume increment in relation to N deposition

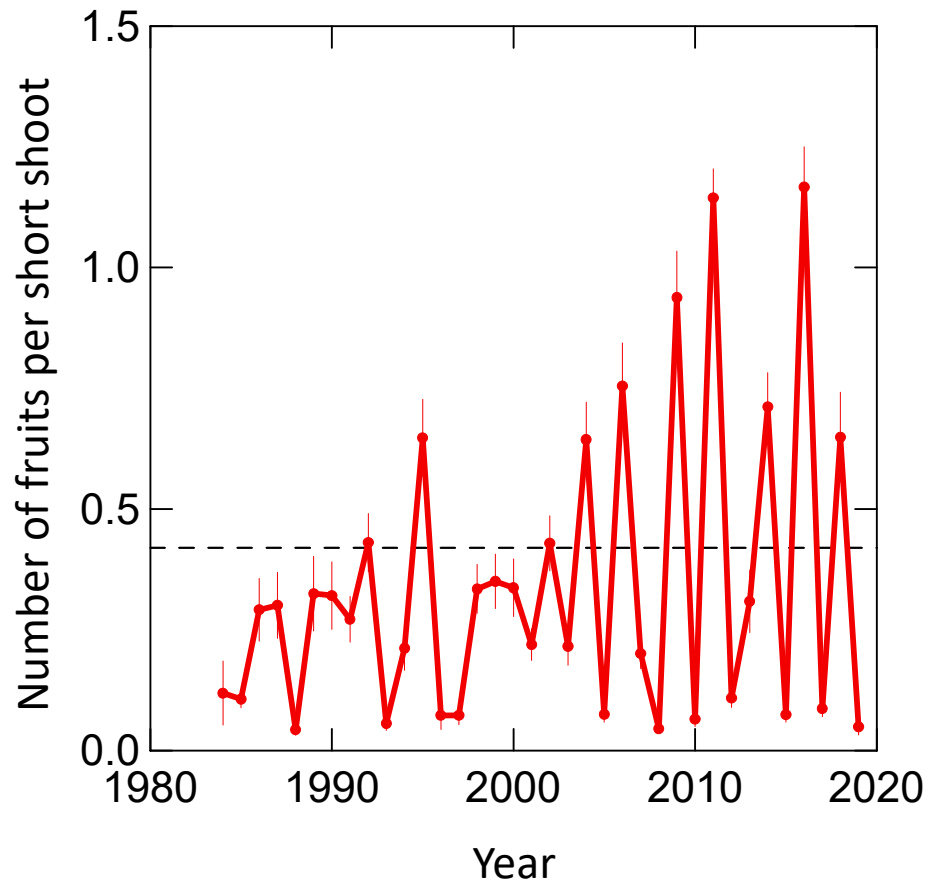


Braun, S., et al., 2022. Plants.

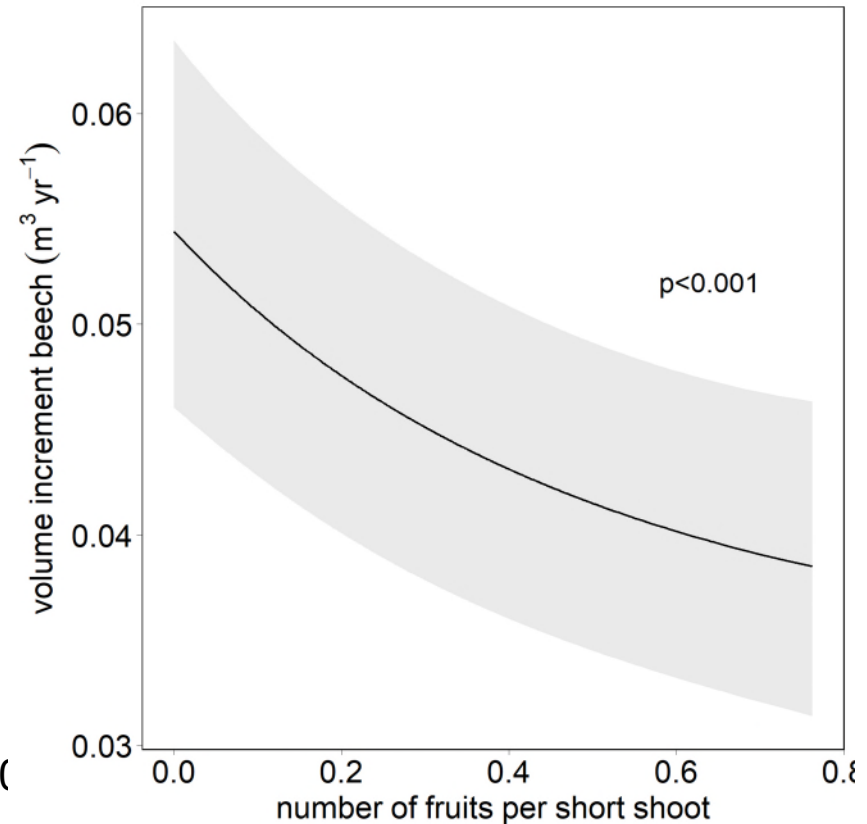
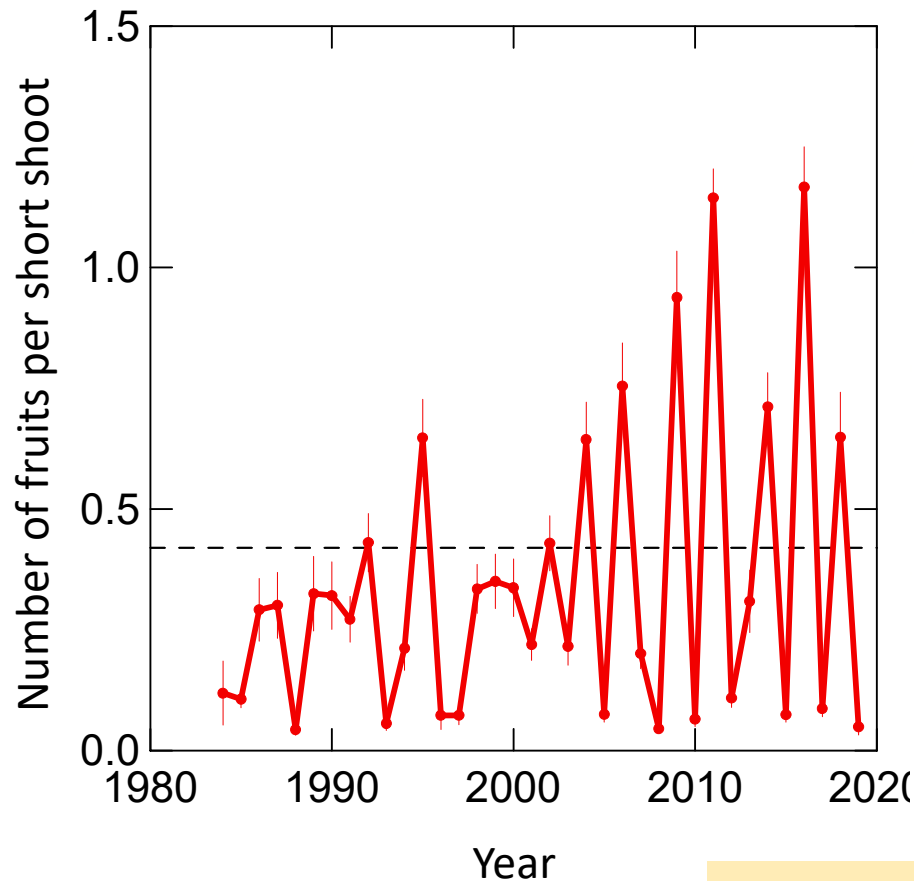
Under drought there is no longer a growth increase by N deposition. This interaction explains the largest part of the observed growth decrease



Development of fructification in beech



Development of fructification in beech



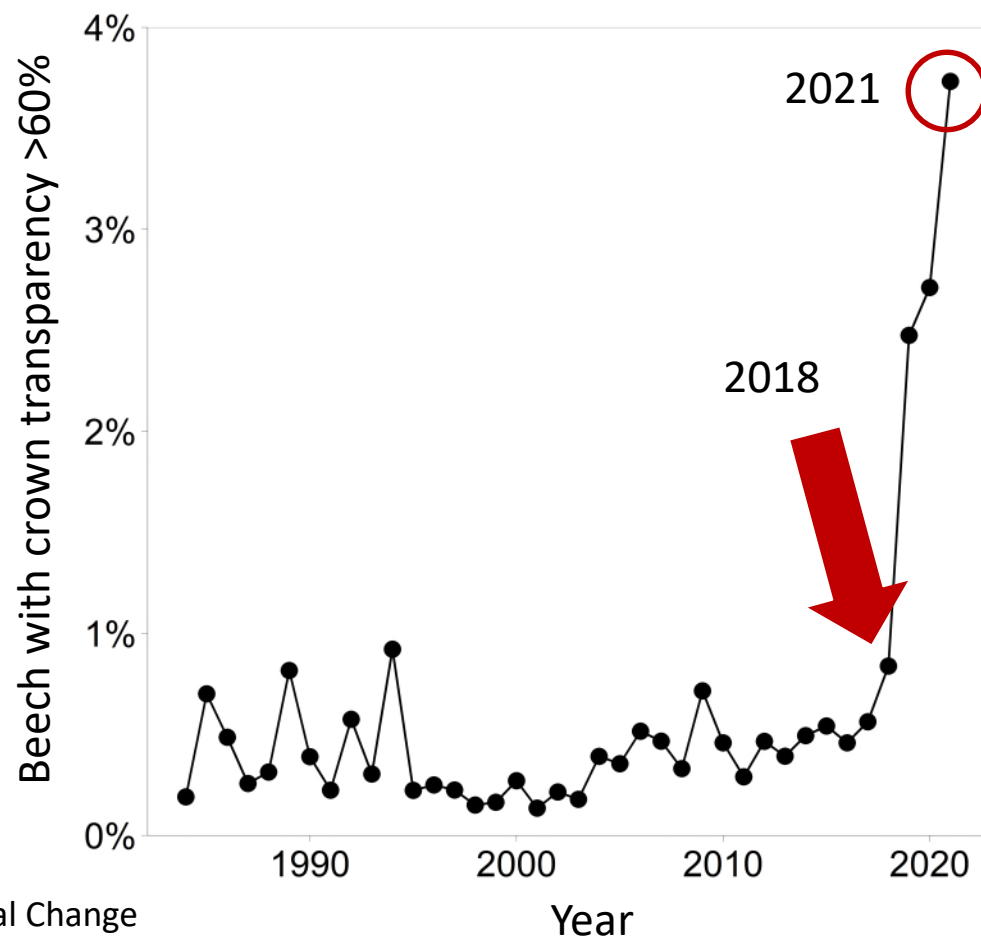
The increasing fructification explains 18% of the growth decrease (Braun et al. 2017, STOTEN)



Development of trees with crown transparency >60%



The proportion of beech with crown transparency >60% increased strongly after 2018



Braun, S., et al. 2021. Frontiers in Forests and Global Change



Staining of active vessels of beech

After the 2018 drought in July 2019

145 harvested branches of trees, 10 plots



Healthy beech

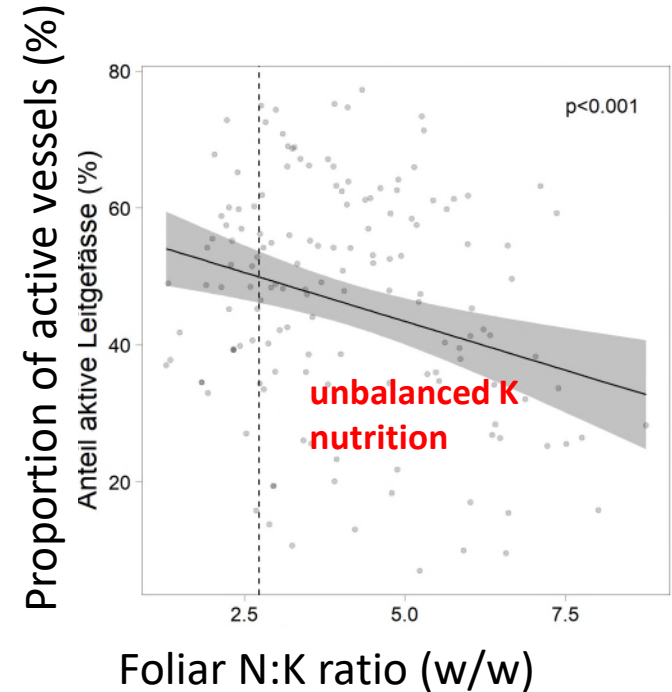


Damaged beech

The active vessels were related to drought of the previous year

Dotted line: threshold for normal nutrition (Göttlein 2016)

Braun, S., et al., 2021. Frontiers in Forests and Global Change



Cavitation is increased when K nutrition is out of balance



Regression output for beech with crown transparency >60%

Mixed binomial model

	Est.	S.E.	z val.	p
(Intercept)	-6.5617	0.1911	-34.3309	0.0000
drought one year before	-0.2664	0.0799	-3.3331	0.0009
drought two years before	-0.0898	0.0822	-1.0449	0.2961
drought three years before	-0.3212	0.0739	-4.3492	0.0000
potassium	-0.3033	0.0951	-3.1874	0.0014
phosphorus	-0.1329	0.0624	-2.1297	0.0332

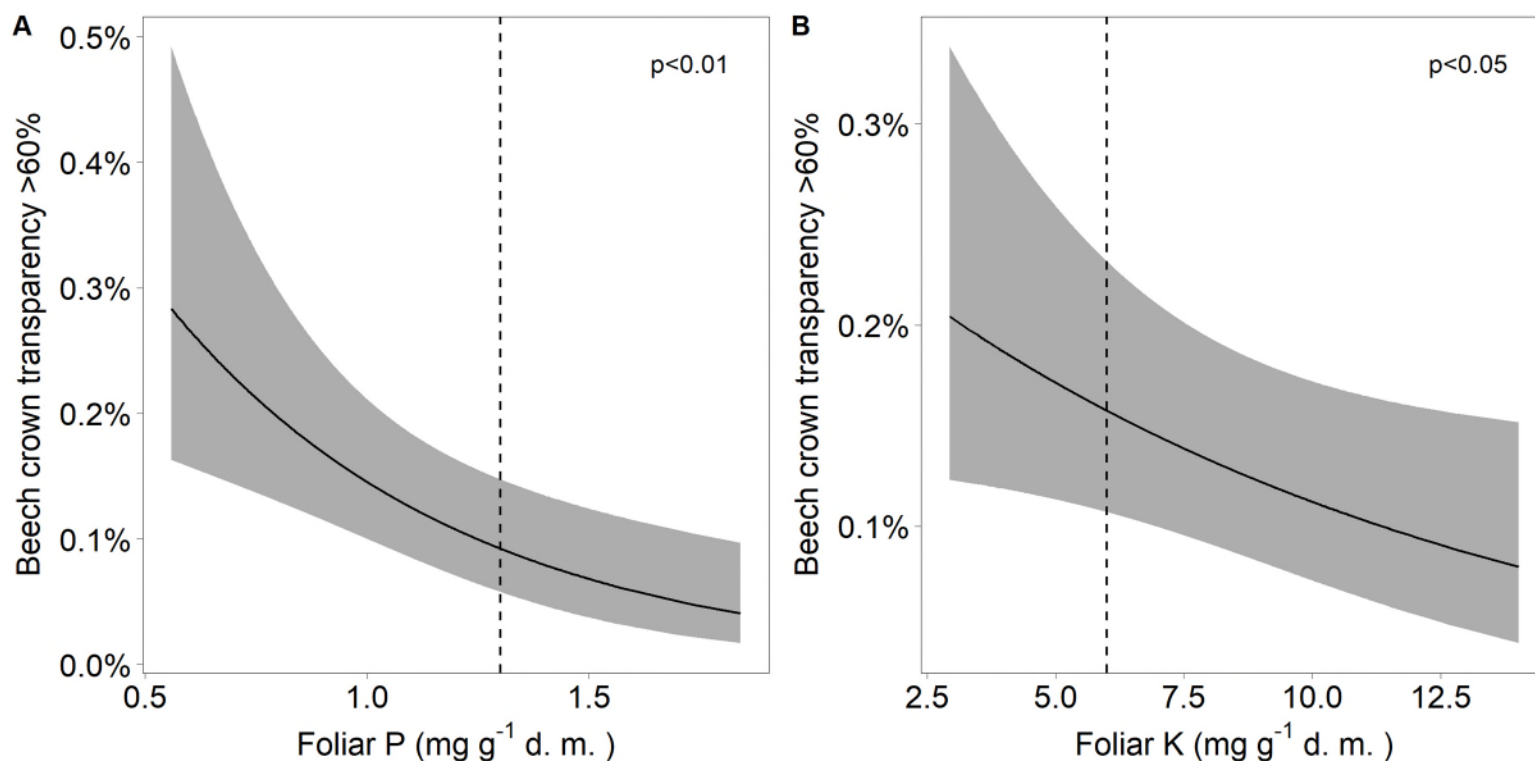
Pseudo-R ² (fixed effects)	0.031	100 plots
		25 years
Pseudo-R ² (total)	0.4455	9826 trees

The drought effect on crown transparency lasts over 3 subsequent years

Braun,S., et al., 2021. Frontiers in Forests and Global Change



Predictors for crown transparency >60%



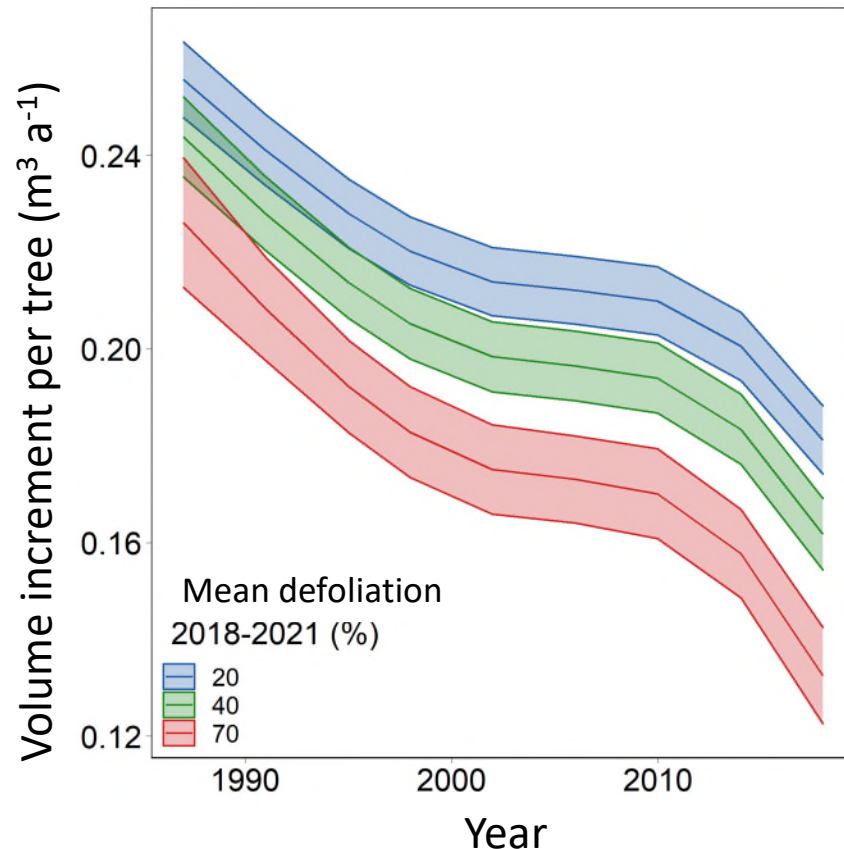
Dotted line: threshold for normal nutrition (Göttlein 2016)

Braun, S., et al., 2021. Frontiers in Forests and Global Change

The acute P deficiency may have contributed to the strong crown damages after 2018



Volume increment of beech with different defoliation classes



Defoliation $p < 0.001$
Interaction with time $p < 0.01$

- Better correlation with defoliation as continuous variable
- There are also significant differences for the lower transparency classes

The trees with lower vitality were damaged more by the drought

Similar results from dendrochronological analysis by Anna Neycken (7 selected beech plots) and Stefan Klesse (9 plots Ajoie)



Summary on foliar nutrients and beech vitality

- Volume increment has strongly decreased since the 1980s.
- Foliar P concentrations decreased strongly.
- Foliar P and K concentrations are negatively related with N deposition.
- Photobleaching as a symptom of P deficiency increased.
- The proportion of beech with a crown transparency >60% is increased at low foliar P and K concentrations.
- Fructification of *Fagus sylvatica* has strongly increased, with consequences for growth.
- Cavitation is increased at high foliar N:K ratios, i.e. at low K supply.
- It is suggested that the dead branches of *Fagus sylvatica* with crown transparency >60% are caused by cavitation.
- Slow growing trees were mostly affected by the 2018 drought.



Thank you for your attention!



Funding organisations:

Forest authorities of the cantons AG, BL, BS, GR, SO, TG, ZH,
Environmental Offices of Central Switzerland (LU, NW, OW, SZ, UR, ZG),
Federal Office for the Environment