

# The effect of ozone and nitrogen deposition on the vitality of *Fagus sylvatica* and *Picea abies* in Switzerland

SABINE BRAUN <sup>a</sup>, LUCIENNE C. DE WITTE <sup>a</sup>, SVEN-ERIC HOPF <sup>a</sup>, SIMON TRESCH <sup>a</sup>, BEAT RIHM <sup>b</sup> and CHRISTIAN SCHINDLER <sup>c</sup>

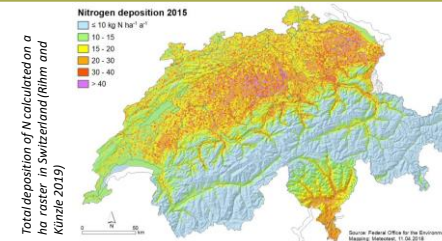
a) Institute for Applied Plant Biology AG, Benkenstrasse 254A, CH-4108 Witterswil, Switzerland; b) Meteotest AG, Fabrikstrasse 14, CH-3012 Berne, CH; c) Swiss Tropical and Public Health Institute, University of Basel, Socinstrasse 57, CH-4051 Basel, CH



## Conclusions

- High N deposition decreased growth of beech, especially under drought.
- N deposition increased the drought sensitivity of Norway spruce mortality clearly.
- Mortality of beech strongly increased at low foliar P concentrations which is an indirect effect of N deposition.
- Ozone flux was negatively related with volume increment. The observed growth reduction confirmed the dose-response relationships from experiments for beech and was stronger for Norway spruce

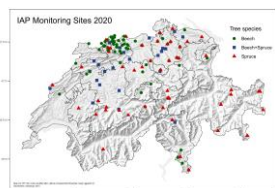
IAP 2019: Drought damages to beech trees in Ajoie, Jura mountains, Switzerland



## Methods

### Long-term forest monitoring in Switzerland since 1984

Health, growth and nutrition of trees are monitored in 95 beech (*Fagus sylvatica*) and 75 spruce (*Picea abies*) plots that are part of the long-term Inter-cantonal Forest Observation Program in Switzerland (Braun et al. 1999). Foliar nutrient concentrations and stem increments were measured at intervals of 4 years. Mortality was observed every year and related to the population of the preceding year.



### Nitrogen deposition

Total nitrogen (N) deposition per year was modelled at a spatial resolution of 1 ha (Rihm and Künzle 2019). Nitrogen deposition in the plots varied between 8.5 and 81 kg N ha<sup>-1</sup> yr<sup>-1</sup>.

### Ozone flux

Annual ozone flux was mapped according as described in Braun et al. (2014).

### Drought

Drought was calculated using a hydrological model (WaSIM-ETH) on a daily basis. It was quantified either as average ratio between actual and potential evapotranspiration during the first 90 days of the season (ETa/ETp) (see Braun et al. 2015).

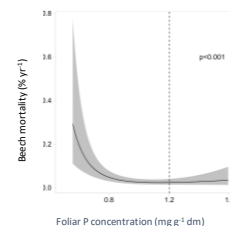
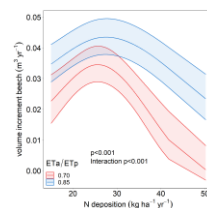
### Statistical analysis

Data were analyzed using generalized linear or binomial mixed effect models (GLMEM) with site and year as random factors. Significant predictors were tested systematically for interactions and linearity. The importance of the lagged time effects of drought indicators were tested with a polynomial distributed lag model. Thereafter an average drought effect was calculated taking into account the cumulated drought effect of 3 years for beech and spruce.

## Results

### Beech volume increment

Volume increment showed a bell shaped relation with N deposition, with increment decreasing at N deposition >30 kg N ha<sup>-2</sup>yr<sup>-1</sup>. The decrease was much stronger when it was dry (red curve, ETa/ETp=0.7) and the decrease started at lower N deposition values.

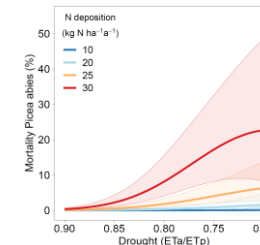


### Beech mortality

Mortality was increased under drought and at low foliar P and K. These relations with foliar nutrient concentrations are an indirect N deposition effect.

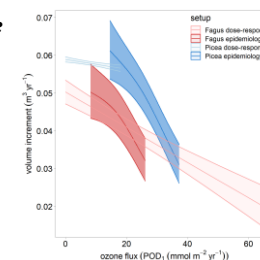
### Norway spruce mortality

Mortality was increased by drought and modified by N deposition and foliar K concentration. The latter is an additional indirect N deposition effect.



### Volume increment and ozone

Volume increment was negatively related to ozone flux. In beech the relation confirmed the dose-response relationship from the experiment used to derive the critical level very well, in Norway spruce it was stronger.



## References

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## FINANCIAL SUPPORT

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