

INTRODUCTION

At Swiss European beech stands of the Long-term Forest Ecosystem Research Programme (LWF) in 2018, beechnuts did not develop properly in the extremely hot and dry summer despite successful pollination in spring (Fig. 1). According to the Swiss Federal Office of Meteorology and Climatology (MeteoSwiss), the whole of Switzerland suffered the strongest summer heat period, and eastern Switzerland suffered also the strongest summer drought since the beginning of measurements in 1864. Comparable years with impaired fruit production in spite of abundant pollen release (mast failure) were 2002 and 2003 in Bettlachstock (BET), and 2006 in Schänis (SCH, Fig. 3).

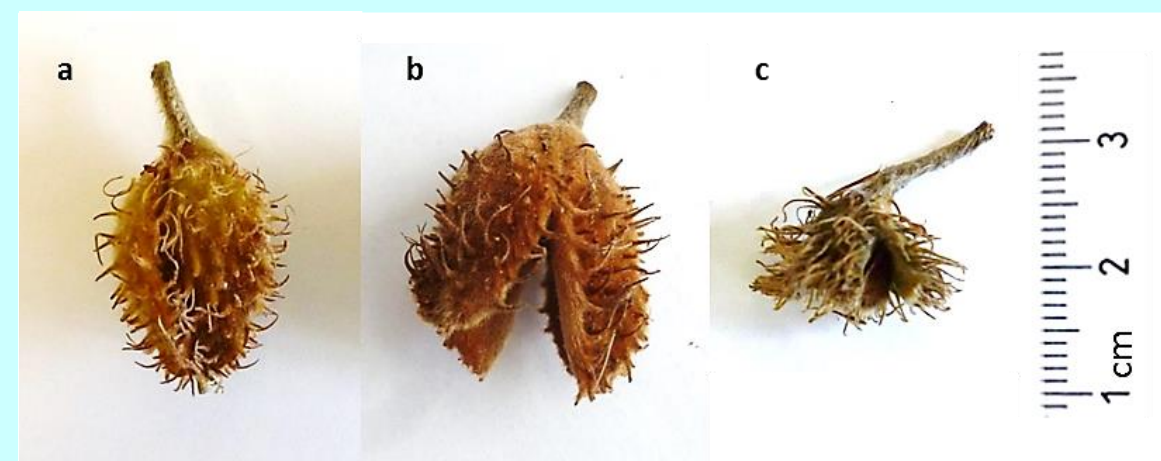


Figure 1: a regularly developing beechnut cupula with beechnuts in summer; b regularly developed beechnut cupula in autumn after release of beechnuts; c poorly developed beechnut cupula with beechnuts in summer found in litterfall traps two months before regular beechnut cupulas are typically falling. Photos by Anita Nussbaumer.

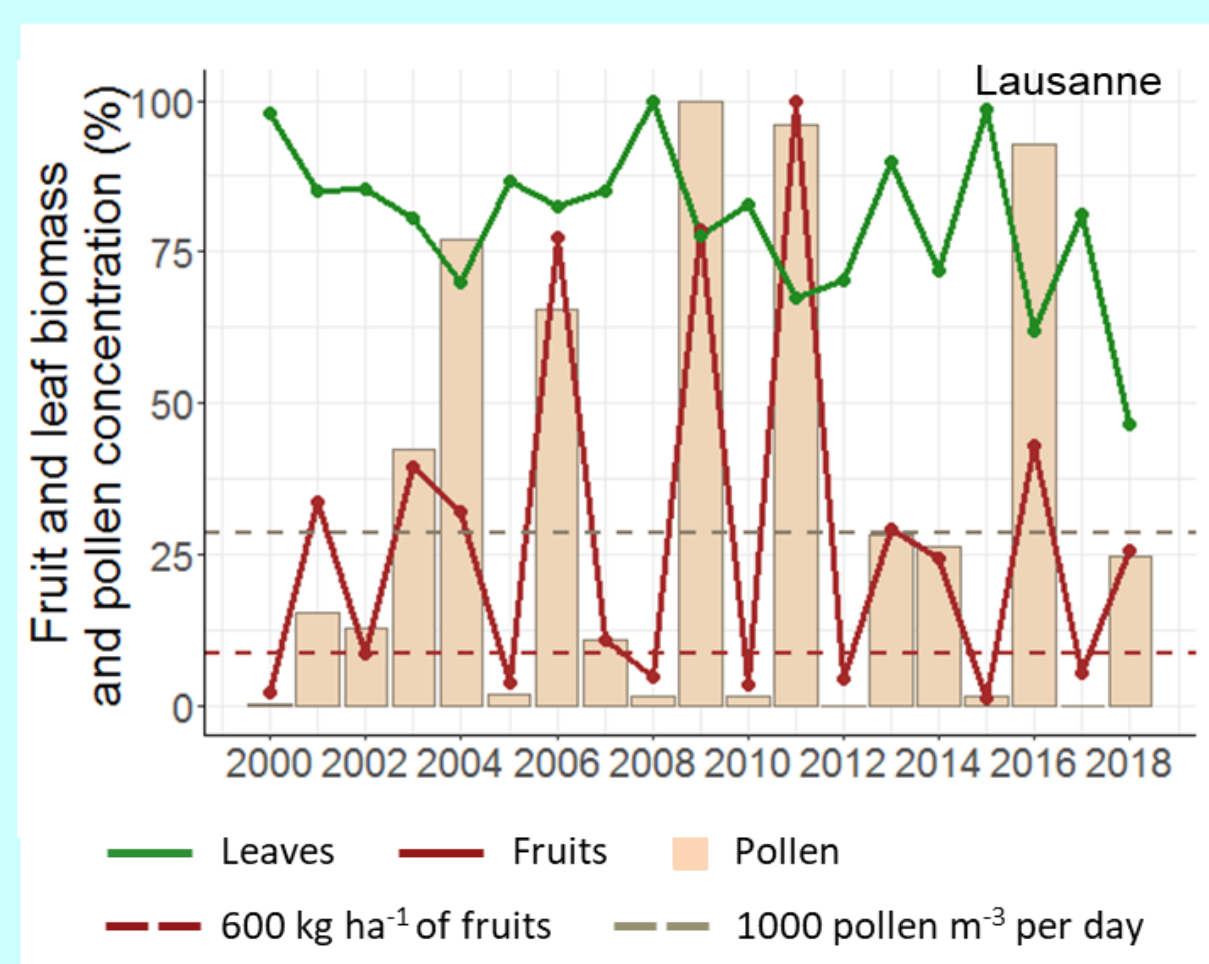


Figure 2: Annual pollen integral APIn (pollen day m⁻³) and leaf and fruit biomass (kg ha⁻¹) of European beech in percent of maximum value per site the LWF plot Lausanne. Thresholds for definition of years with fruit abortion: not less than 1000 pollen day m⁻³; no more than 600 kg ha⁻¹ of fruits per year.

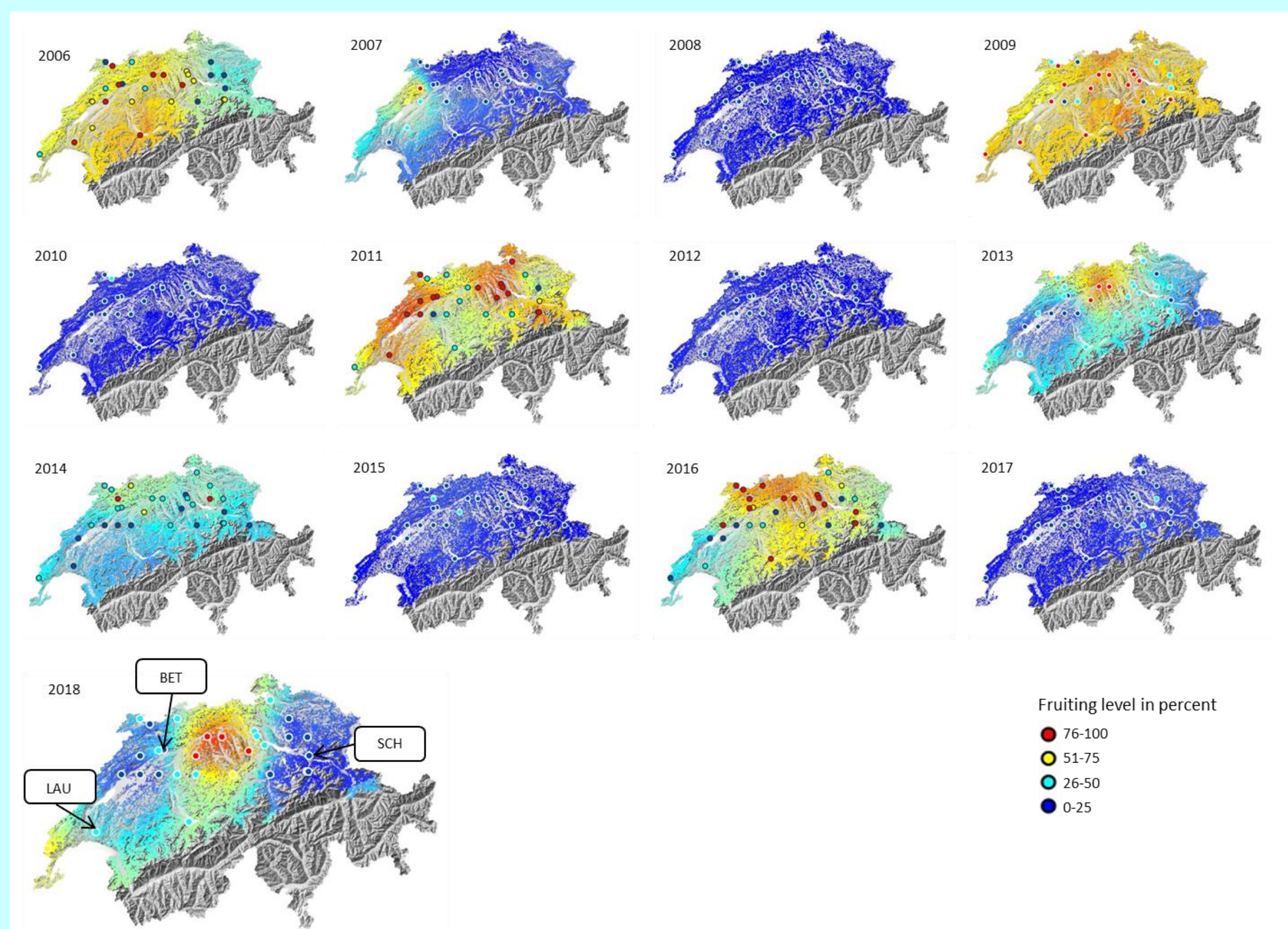


Figure 3: European beech fruiting levels from 2006-2018 for the Swiss Plateau, the Prealps, Northern Alps and the Jura Mountains, based on the potential distribution of European beech (Wüest et al. 2020). Measurements on stand scale derive from the Sanasilva programme, the LWF and further stand information (Nussbaumer et al. 2016). BET Bettlachstock, LAU Lausanne, SCH Schänis.

METHODS AND DATA

- *t* tests: difference of mean summer temperatures, summer precipitation sums, and soil matric potential in 15cm, 30cm, 50cm and 80cm depth, between years with mast failure (fruit abortion) and successful mast years
- geospatial interpolation of observed fruiting intensity per year from 2006-2018 (Bayesian empirical kriging, Krivoruchko and Gribov, 2014)

- Annual pollen integral APIn (pollen day m⁻³, MeteoSwiss)
- Fruit and leaf biomass (kg ha⁻¹, LWF (litterfall))
- Meteorological measurements (°C, mm precipitation, LWF (meteo and deposition))
- Soil matric potential (-hPa in 15, 30, 50 and 80 cm depth, LWF (soil water))

QUESTIONS

- Do extremely hot and dry summer lead to fruit abortion in European beech early in the fruit development season?
- Is there evidence of a biennial mastling cycle in European beech?

RESULTS

- Summer mean temperatures were 1.5°C higher, and summer precipitation sums were 45% lower in years with mast failure than in successful mast (Fig. 4). Soil matric potential was also reduced but due to the measurement method, the difference was not significant (Fig. 4). It has to be assumed that the soil was much drier than -700 hPa, the measurement limit of the tensiometers.
- There is evidence for a basic biennial mastling cycle in European beech (Figs. 2 and 3).

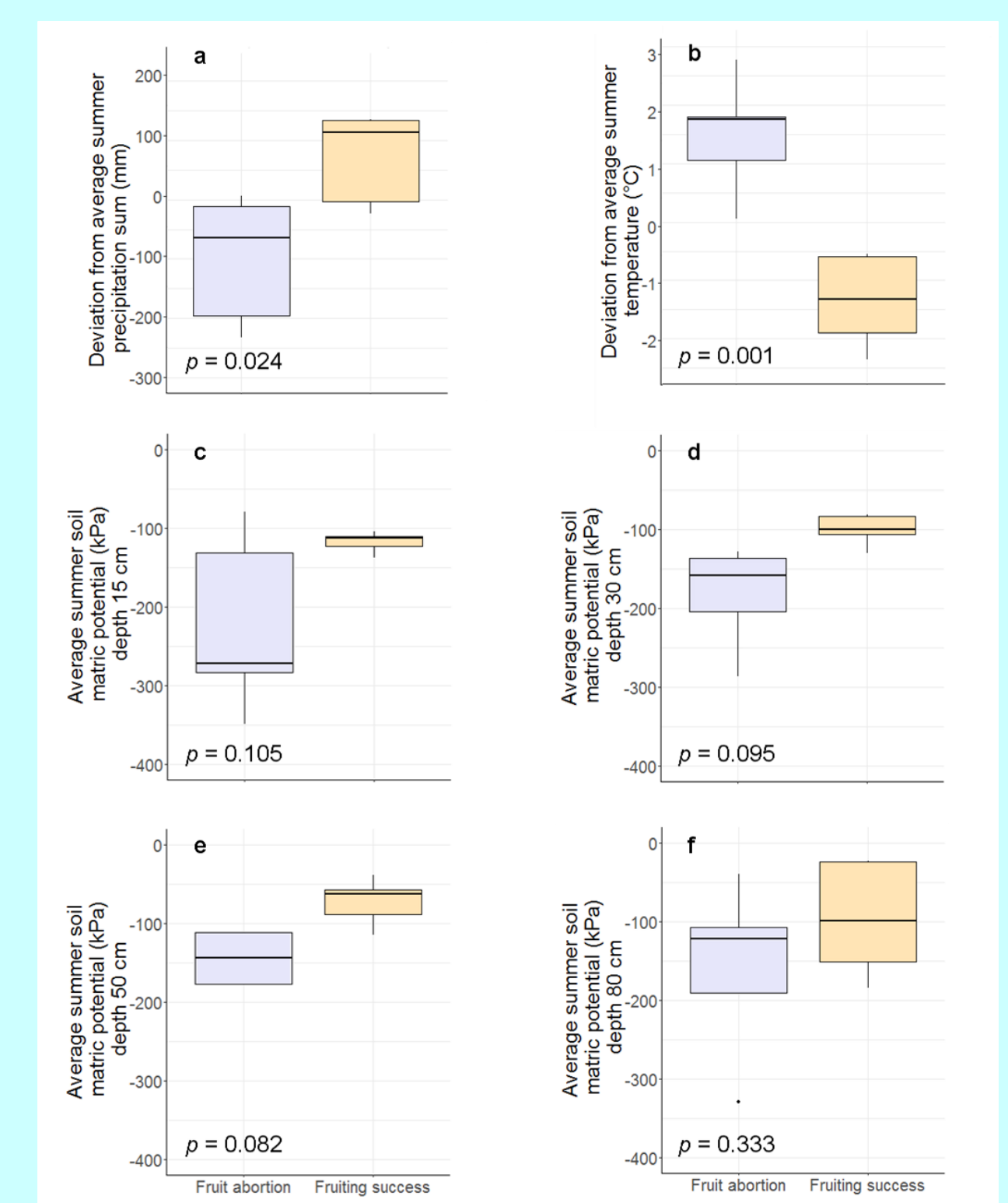


Figure 4: Differences of summer weather conditions and deviations of long-term mean summer soil matric potential between years with fruit abortion and years with fruiting success in European beech inside stands. Deviations from average summer conditions: a precipitation sums, b mean temperatures, summer soil matric potential in c 15 cm, d 30 cm, e 50 cm and f 80 cm soil depth. *p* values from two-sided *t* tests.

CONCLUSIONS

- Fruit production is inhibited if weather conditions are unfavourable during flowering.
- Fruit production is abandoned if weather conditions are unfavourable during fruit development.
- In European beech, the assumed biennial mast cycle is interrupted by these environmental vetoes.
- Frost during flowering period has been known as such an environmental veto.
- Summer heat and drought are newly described as other environmental vetoes.
- In years with fruit abortion, flower buds will be produced for next year.

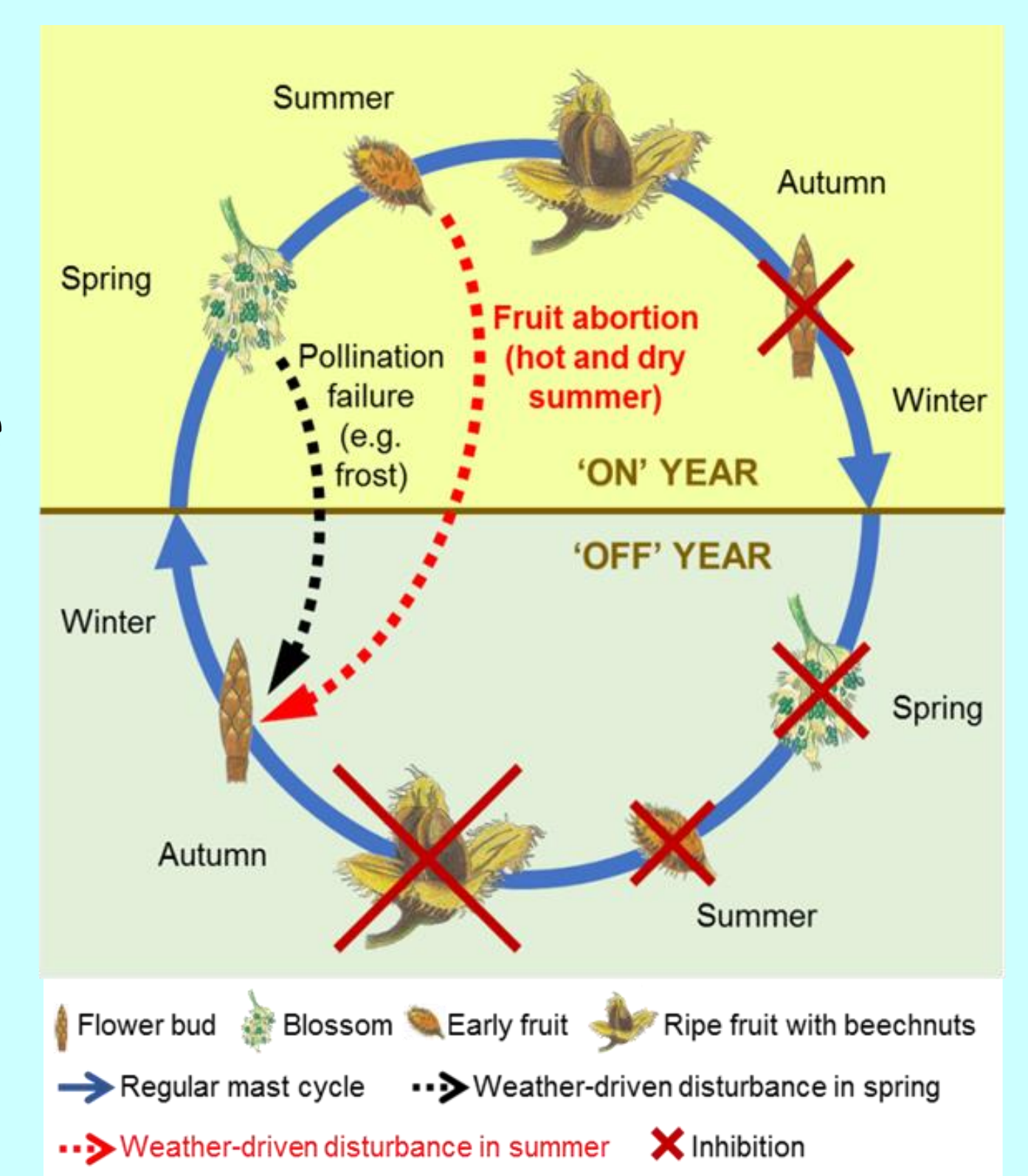


Figure 5: Model of biennial mast cycle in European beech. Basic biennial mast cycle of European beech with weather-driven disturbances in spring leading to pollination failure (dashed black arrow) and, newly postulated, in summer due to extremely hot and dry conditions leading to fruit abortion (red arrow). 'On' year = potential mast year, 'Off' year = year after successful mast year, without flower buds. Scheme according to Lavee (2007). Original artwork by Anita Nussbaumer.

REFERENCES

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- Poster based on: Nussbaumer, A.; Meusburger, K.; Schmitt, M.; Waldner, P.; Gehrig, R.; Haeni, M.; Rigling, A.; Brunner, I.; Thimonier, A., 2020: Extreme summer heat and drought lead to early fruit abortion in European beech. *Scientific Reports*, 10, 1. doi: 10.1038/s41598-020-62073-0