ORIGINAL RESEARCH article

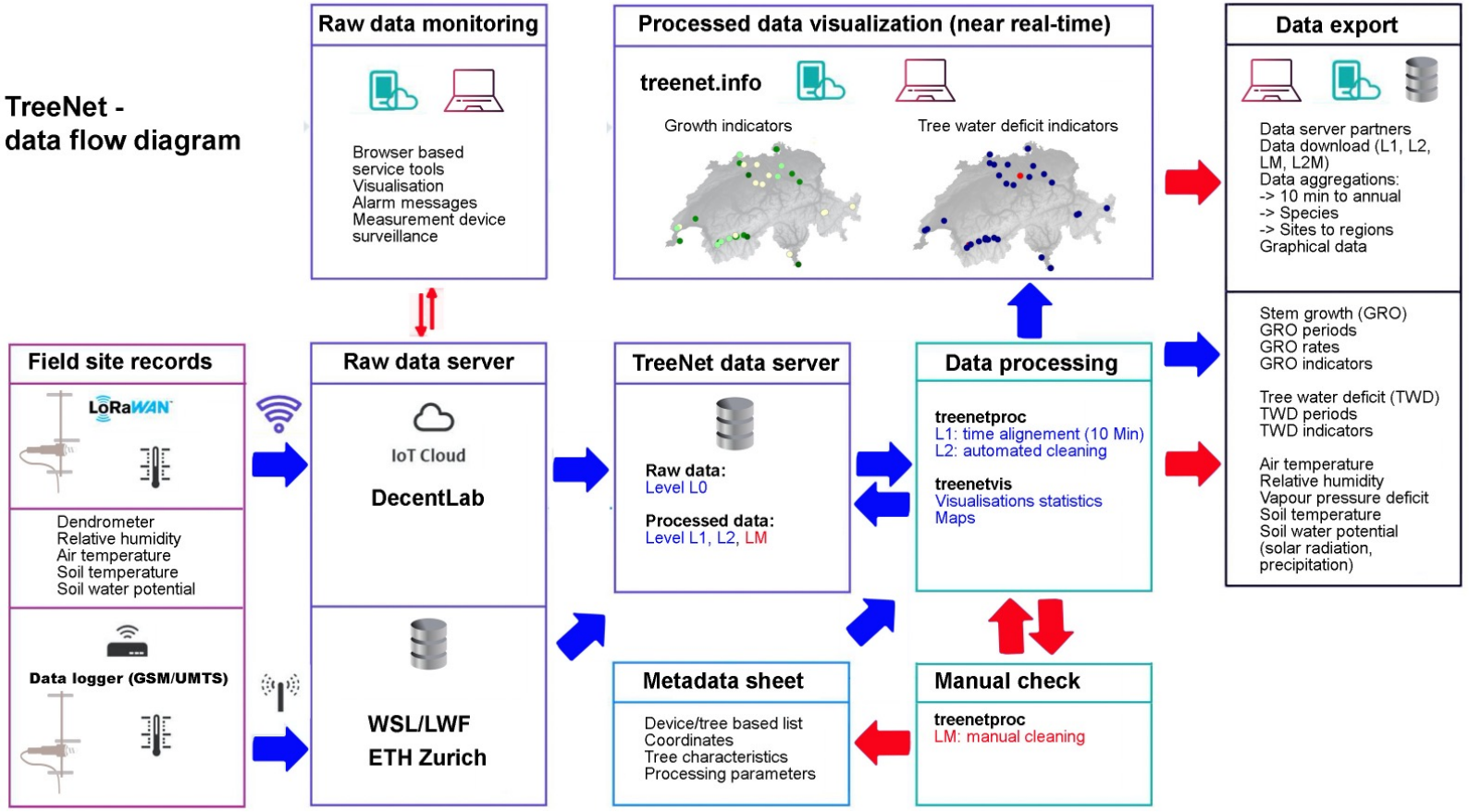
Frontiers 2021

TreeNet - The biological drought and growth indicator network

Roman Zweifel[1*], Sophia Etzold[2], David Basler[2, 3], Reinhard Bischoff[4], Sabine Braun[5], Nina Buchmann[6], Marco Conedera[2], Patrick Fonti[2], Matthias Haeni[2], Arthur Gessler[2], Guenter Hoch[7], Ansgar Kamen[3], Roger Koechli[2], Marcus Maeder[8, 9], Daniel Nievergelt[2], Martina Peter[2], Richard L. Peters[2, 10, 11], Marcus Schaub[2], Volodymyr Trotsiuk[2], Lorenz Walthert[2], Micah Wilhelm[2] and Werner Eugster[6]

- 450 trees with dendrometers
- 350 environmental sensors
- > 100 Mio data points

TreeNet - data flow diagram



Key factors for the infrastructure:

- High precision sensors
- LoRaWAN logger (low power, automatic data transfer into central DB)
- TreenetProc, R-package to handle automated data flow (data cleaning, processing)
- Theoretical background: zero growth concept
- TreenetVis, R-script for nowcasting

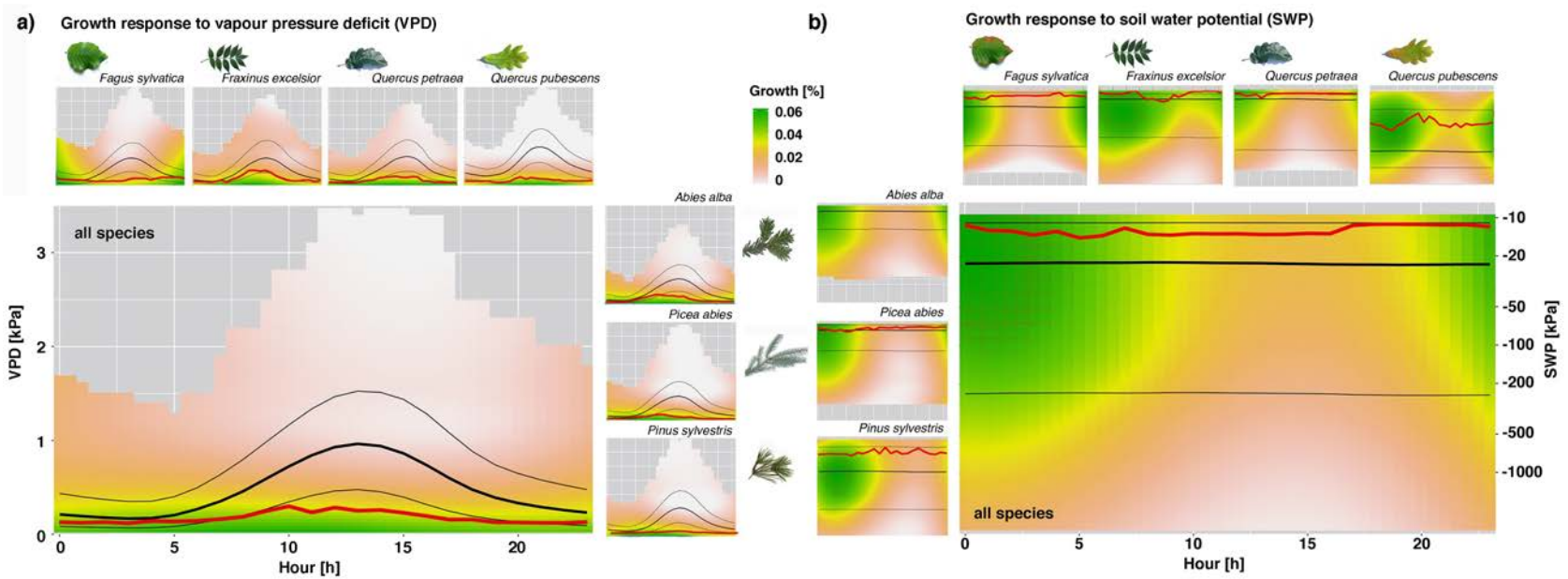
New Phytologist

Research

Why trees grow at night

Roman Zweifel[1], Frank Sterck[2], Sabine Braun[3], Nina Buchmann[4], Werner Eugster[4], Arthur Gessler[1], Matthias Häni[1], Richard L. Peters[1,5], Lorenz Walthert[1], Micah Wilhelm[1], Kasia Ziemińska[1,6] and Sophia Etzold[1]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, 8903, Birmensdorf, Switzerland; [2]Forest Ecology and Management Group, Wageningen University, 6708 PB, Wageningen, The Netherlands; [3]Institute for Applied Plant Biology, 4108 Witterswil, Switzerland; [4]Department of Environmental Systems Science, Institute of Agricultural Sciences, ETH Zurich, 8092 Zurich, Switzerland; [5]Laboratory of Plant Ecology, Ghent University, 9000 Ghent, Belgium; [6]Department of Plant Ecology and Evolution, Uppsala University, SE-751 05, Uppsala, Sweden



Why trees grow at night:

- Because trees need moderate water potentials for cell growth
- At night, the transpiration is low and the trees get replenished
  -> Main growth under very **low VPD** possible only (< **0.4 kPa**)
  -> Growth possible in **moderately dry soil** (> **-500 kPa**, topsoil)

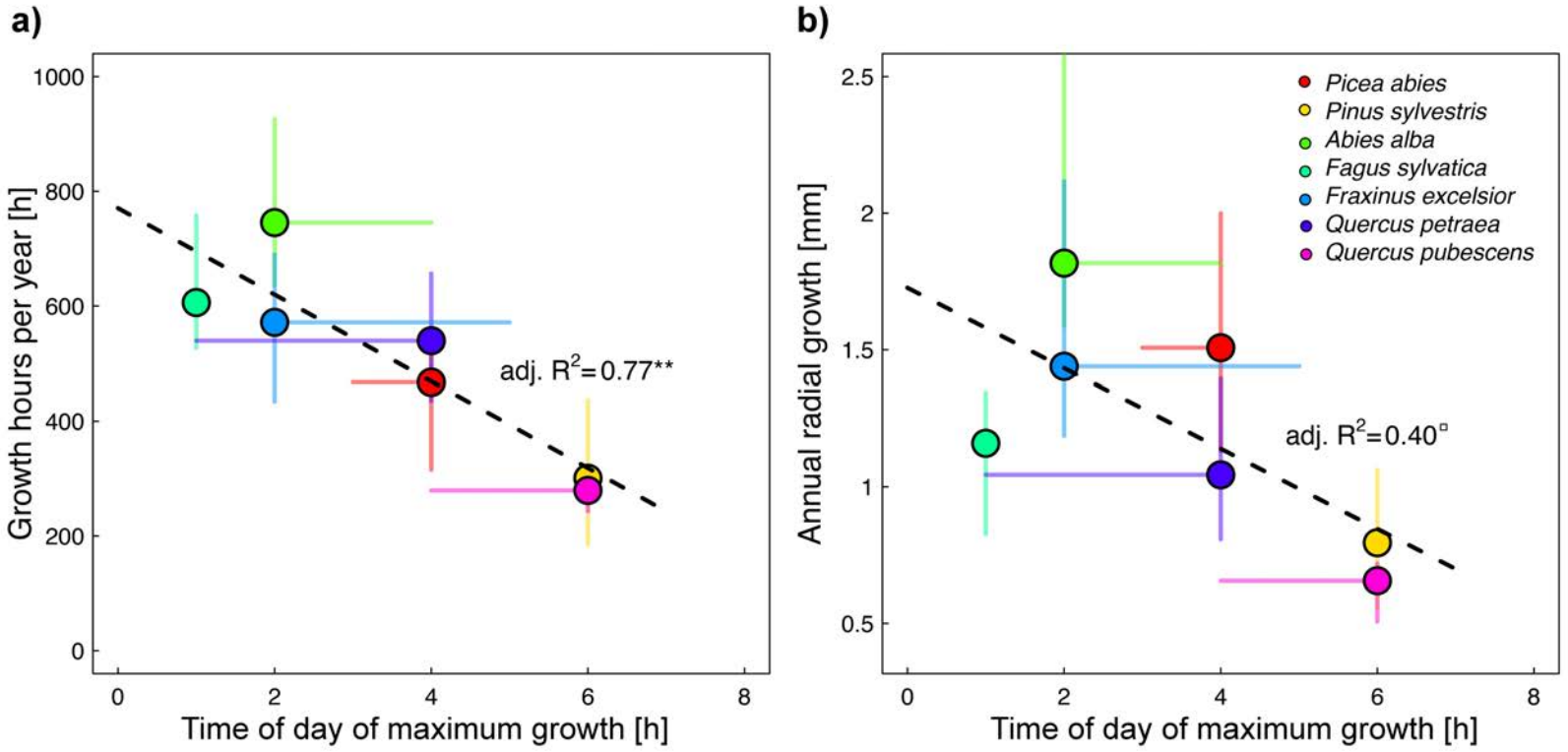
New Phytologist

Research

Why trees grow at night

Roman Zweifel[1], Frank Sterck[2], Sabine Braun[3], Nina Buchmann[4], Werner Eugster[4], Arthur Gessler[1], Matthias Häni[1], Richard L. Peters[1,5], Lorenz Walthert[1], Micah Wilhelm[1], Kasia Ziemińska[1,6] and Sophia Etzold[1]

[1]Swiss Federal Institute for Forest, Snow and Landscape Research WSL, 8903, Birmensdorf, Switzerland; [2]Forest Ecology and Management Group, Wageningen University, 6708 PB, Wageningen, The Netherlands; [3]Institute for Applied Plant Biology, 4108 Witterswil, Switzerland; [4]Department of Environmental Systems Science, Institute of Agricultural Sciences, ETH Zurich, 8092 Zurich, Switzerland; [5]Laboratory of Plant Ecology, Ghent University, 9000 Ghent, Belgium; [6]Department of Plant Ecology and Evolution, Uppsala University, SE-751 05, Uppsala, Sweden



Why trees grow at night:

- Because trees need moderate water potentials for cell growth
- At night, the transpiration is low and the trees get replenished
  -> Main growth under very **low VPD** possible only (< **0.4 kPa**)
  -> Growth possible in **moderately dry soil** (> **-500 kPa**, topsoil)
- Species which are able to grow earlier in the night show generally higher annual growth

Contents lists available at ScienceDirect

Science of the Total Environment

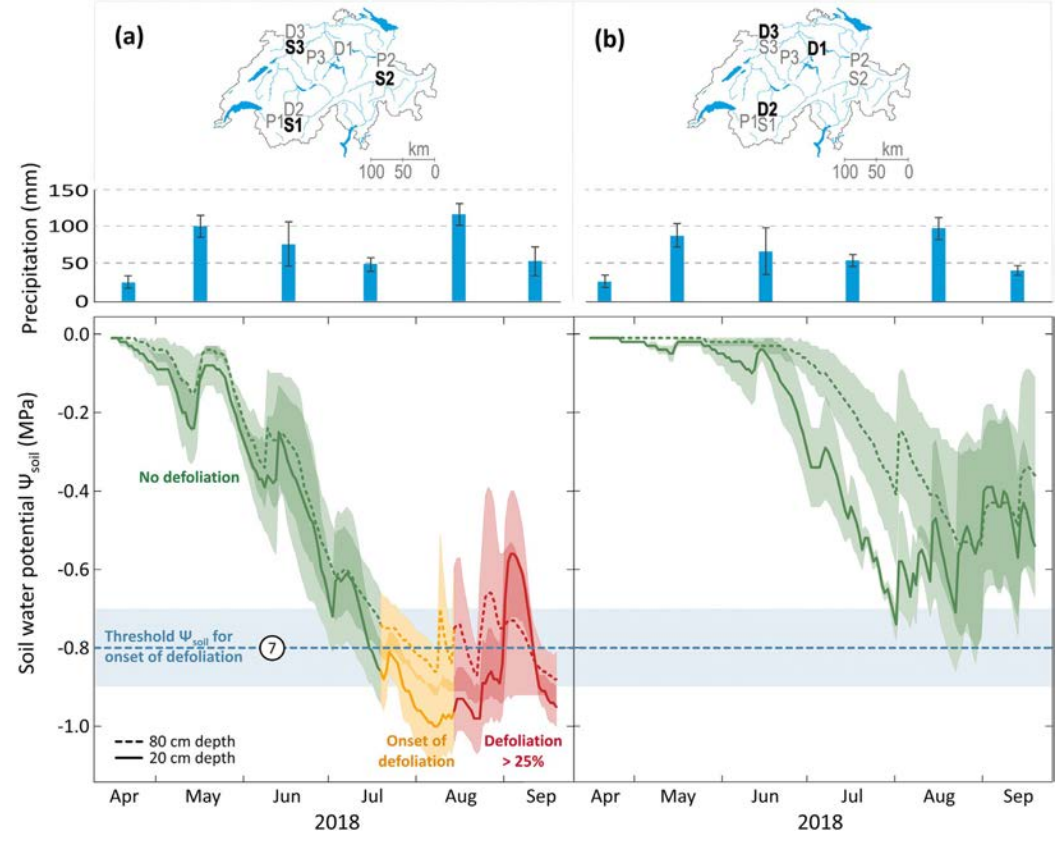
journal homepage: www.elsevier.com/locate/scitotenv

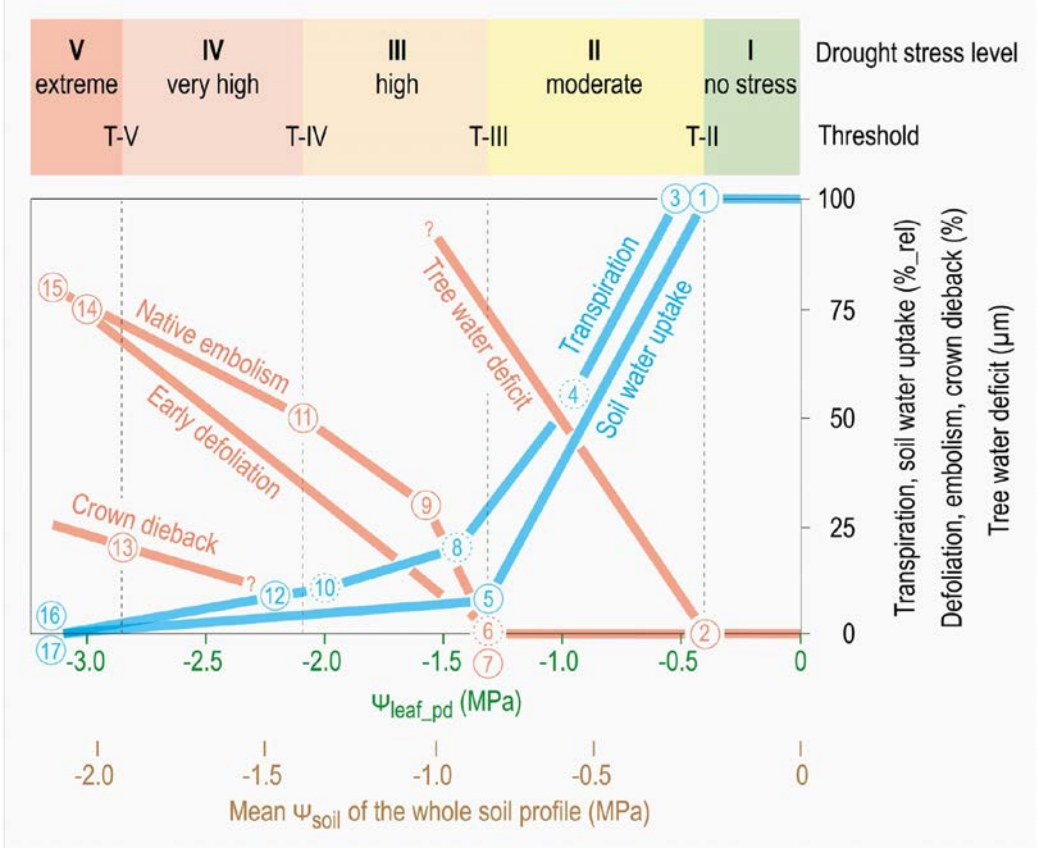
From the comfort zone to crown dieback: Sequence of physiological stress thresholds in mature European beech trees across progressive drought

Lorenz Walthert [a,*], Andrea Ganthaler [b], Stefan Mayr [b], Matthias Saurer [a], Peter Waldner [a], Marco Walser [a], Roman Zweifel [a], Georg von Arx [a]

Key findings

- Stress diagram for beech trees over a huge range of conditions
- Critical thresholds for drought stress
- Findings based on soil, plant and atmosphere data

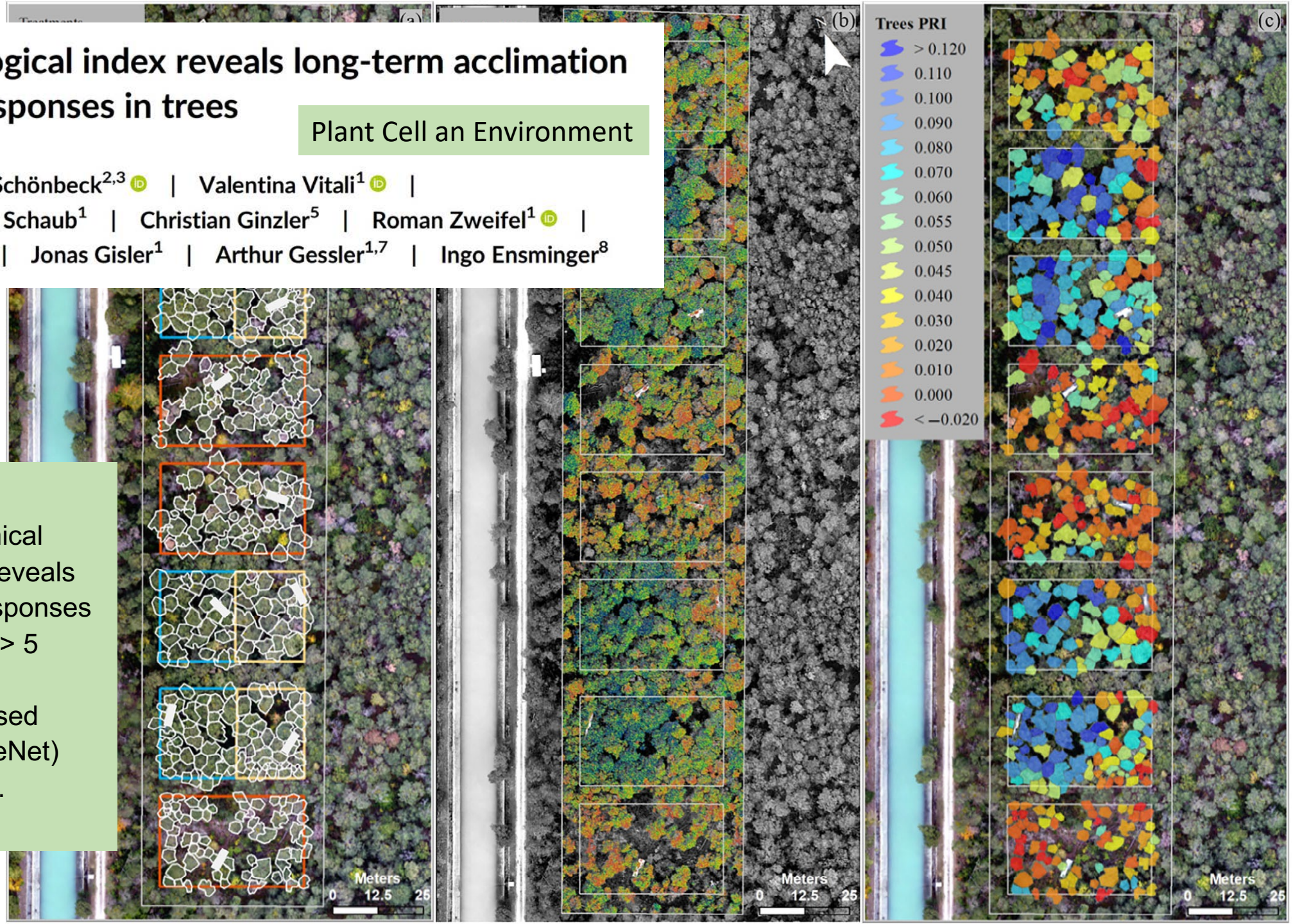




Drone-based physiological index reveals long-term acclimation and drought stress responses in trees

Plant Cell an Environment

Petra D'Odorico[1] | Leonie Schönbeck[2,3] | Valentina Vitali[1] |
Katrin Meusburger[4] | Marcus Schaub[1] | Christian Ginzler[5] | Roman Zweifel[1] |
Vera Marjorie Elauria Velasco[6] | Jonas Gisler[1] | Arthur Gessler[1,7] | Ingo Ensminger[8]



Key findings

- Drone-based photochemical reflectance index (PRI) reveals physiological drought responses
- Legacy effects of PRI of > 5 years
- Link between ground-based measurements (e.g. TreeNet) and satellite images (e.g. sentinel-2)

TreeLab and Silva – two interdisciplinary projects at the interface between art and science

Marcus Maeder and Roman Zweifel

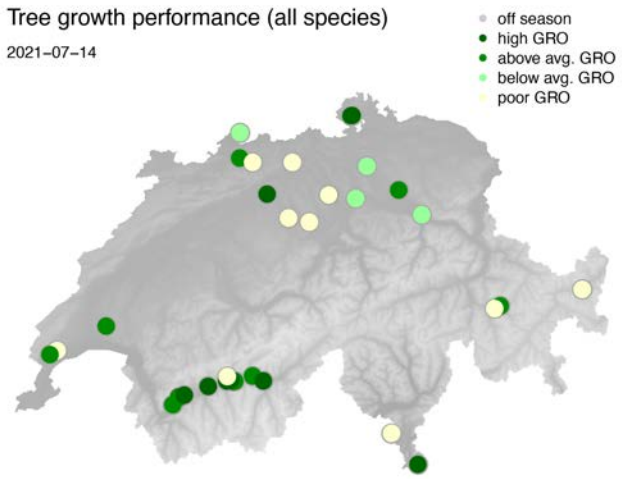
Kunsthaus Zürich, Earth Beats - TreeLab

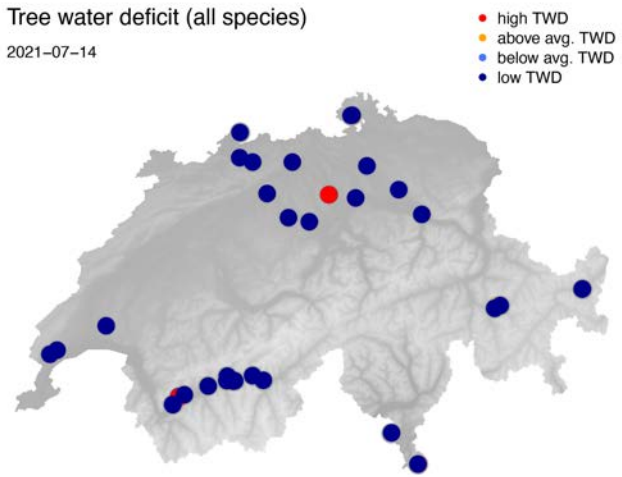
Estonian National Museum, Tartu Silva

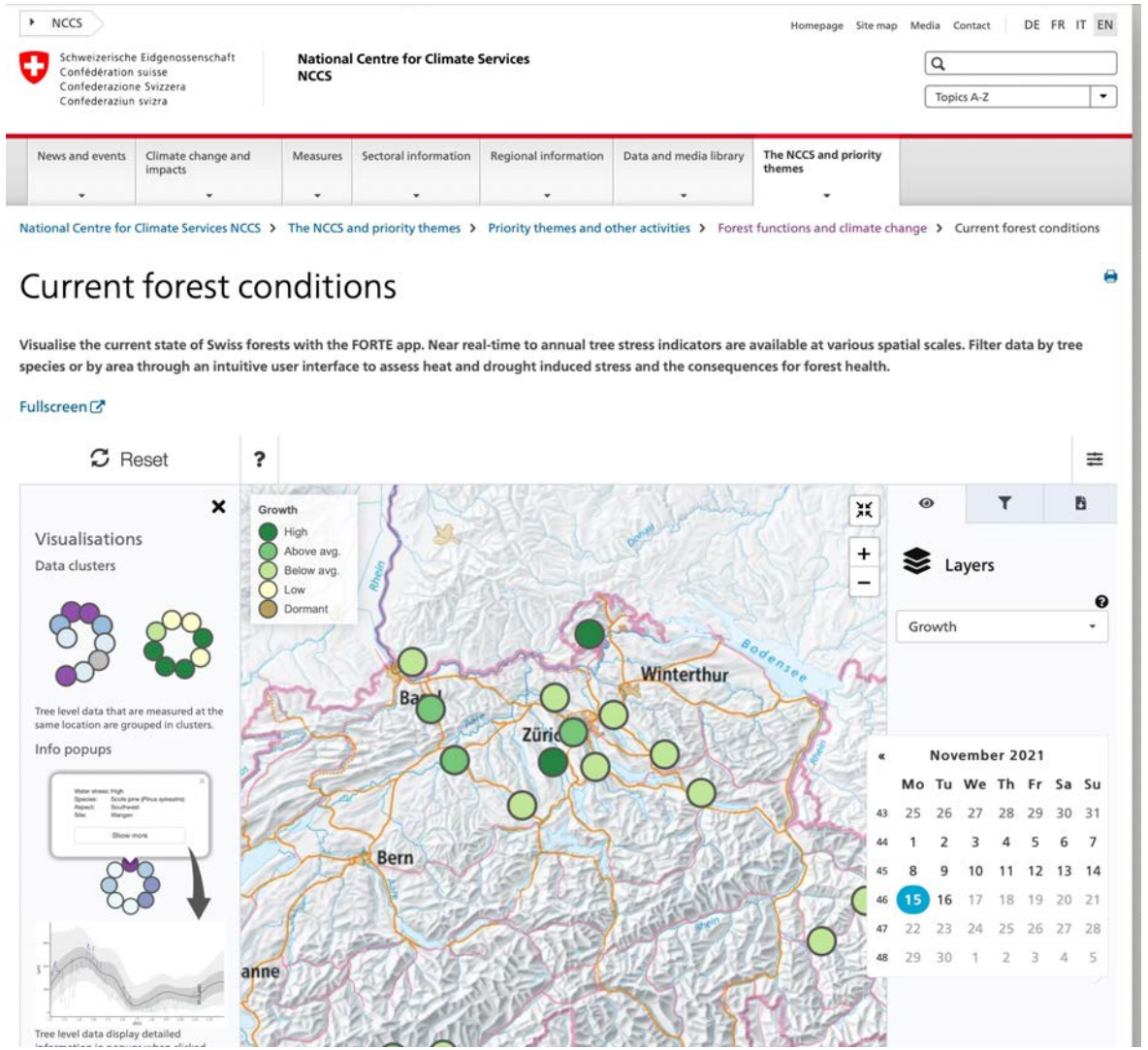
Sounds from trees and their environment in an audio-visual installation in time lapse

TreeNet is Nowcasting!

TreeNetVis and FORTE





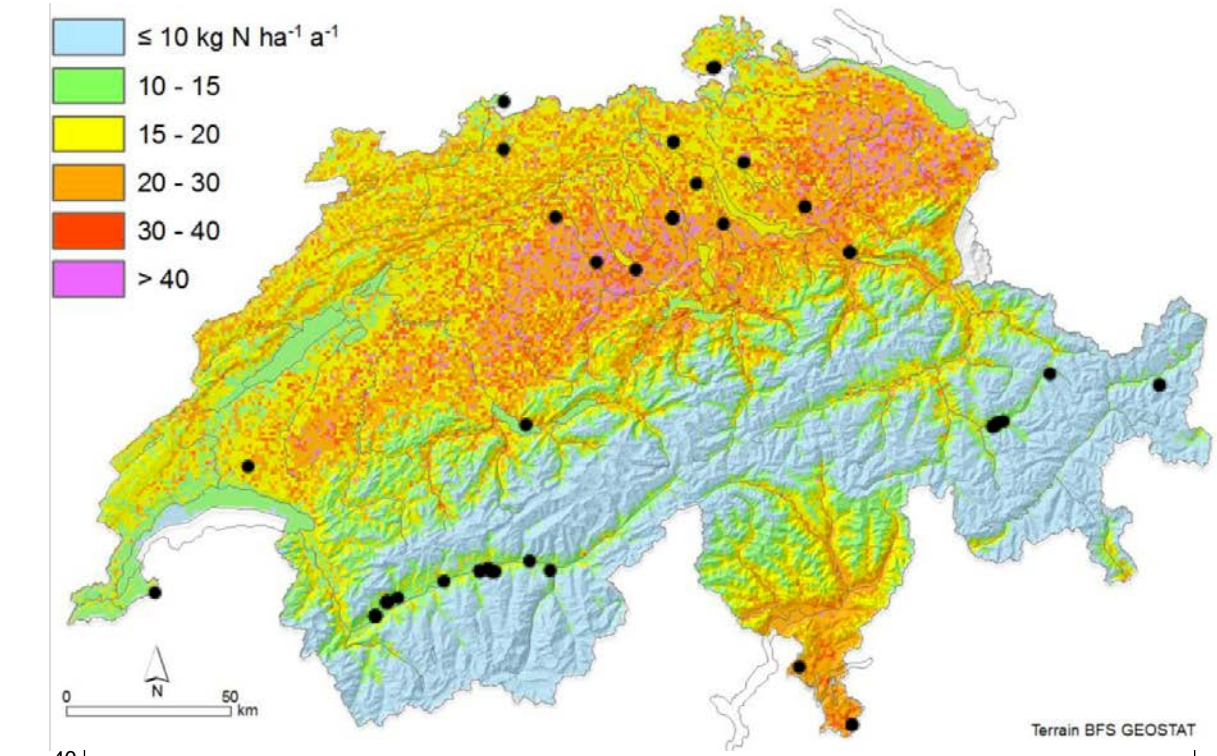


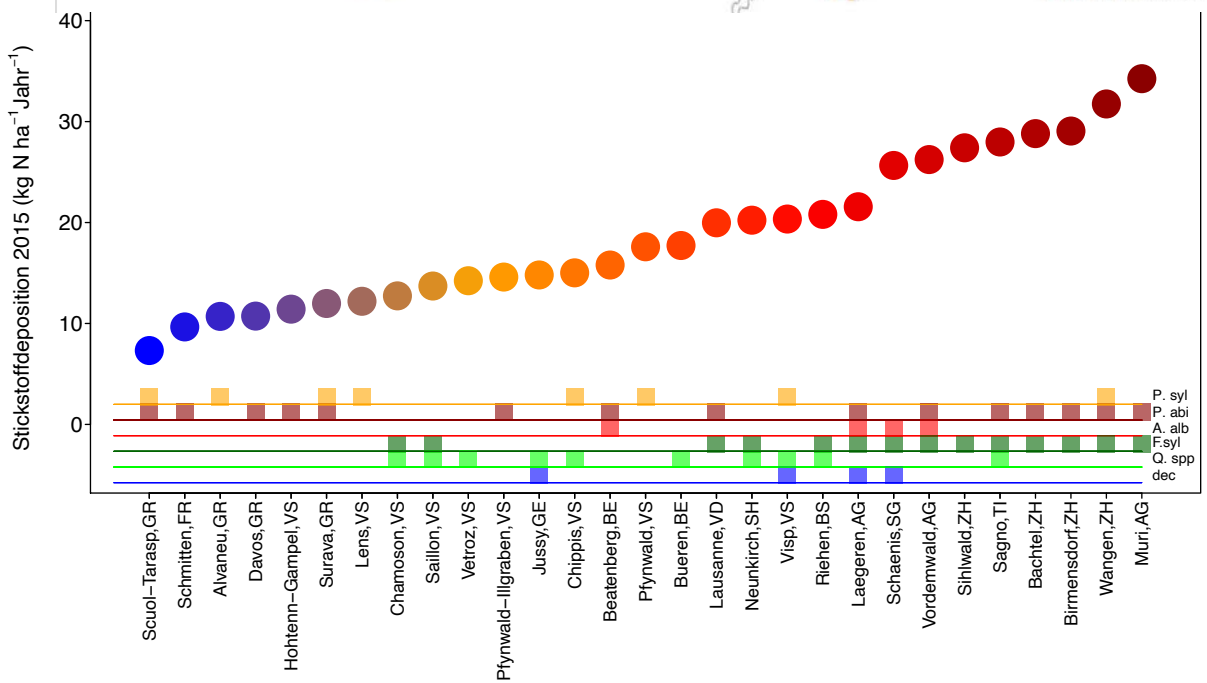
Stickstoffdeposition – ab wann ist es zu viel für das Baumwachstum?|

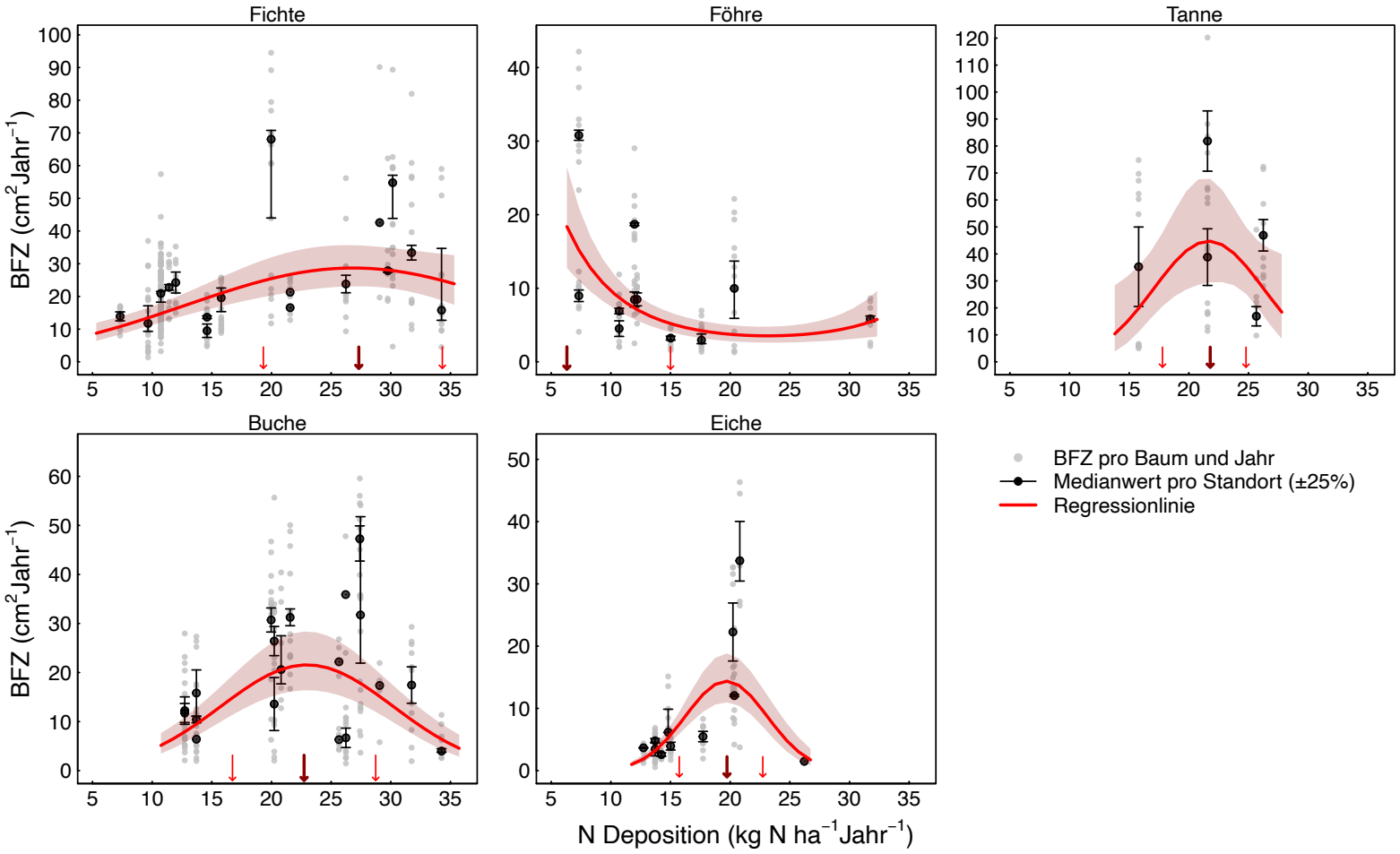
Sophia Etzold, Werner Eugster, Sabine Braun, Anne Thimonier, Peter Waldner, Roman Zweifel

Wald und Holz 12/21

Stickstoff-gradient






Fichte
Föhre
Tanne
Buche
Eiche
BFZ (cm²Jahr⁻¹)
N Deposition (kg N ha⁻¹Jahr⁻¹)
BFZ pro Baum und Jahr
Medianwert pro Standort (±25%)
Regressionlinie

How does a tree grow during a year?

Number of growth days and not length of the growth period determines radial stem growth of temperate trees

Sophia Etzold, Frank Sterck, Arun K. Bose, Sabine Braun, Nina Buchmann, Werner Eugster, Arthur Gessler, Ansgar Kahmen, Richard L. Peters, Yann Vitasse, Lorenz Walthert, Kasia Ziemińska, Roman Zweifel

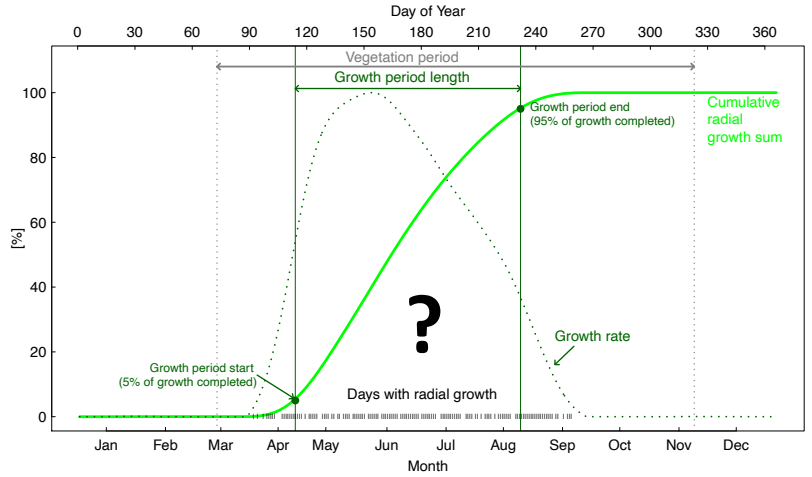
Akzeptiert in Ecology Letters

How does a tree grow during a year?

Number of growth days and not length of the growth period determines radial stem growth of temperate trees

Sophia Etzold, Frank Sterck, Arun K. Bose, Sabine Braun, Nina Buchmann, Werner Eugster, Arthur Gessler, Ansgar Kahmen, Richard L. Peters, Yann Vitasse, Lorenz Walthert, Kasia Ziemińska, Roman Zweifel

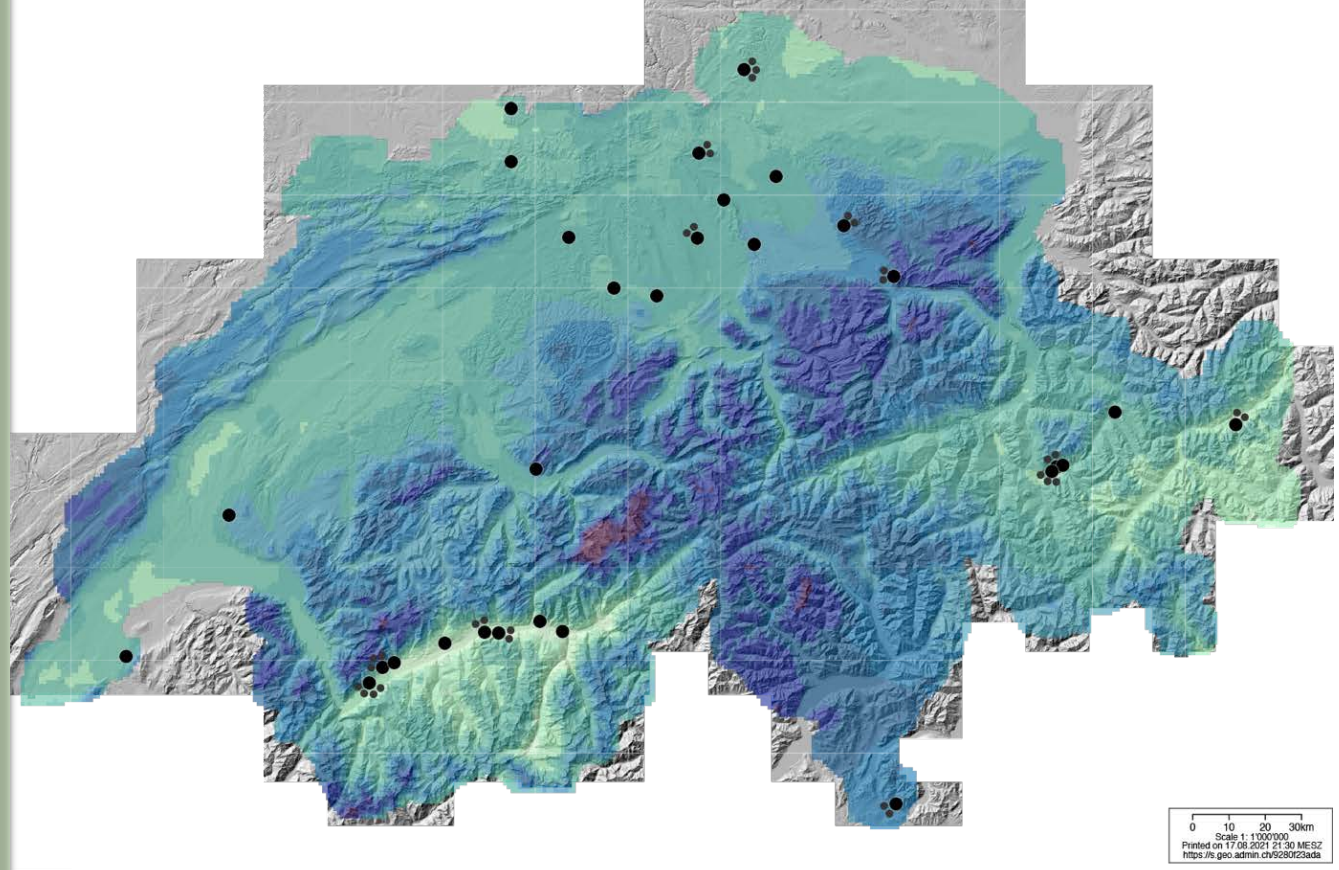
Akzeptiert in Ecology Letters



TreeNet Annual Meeting 2021

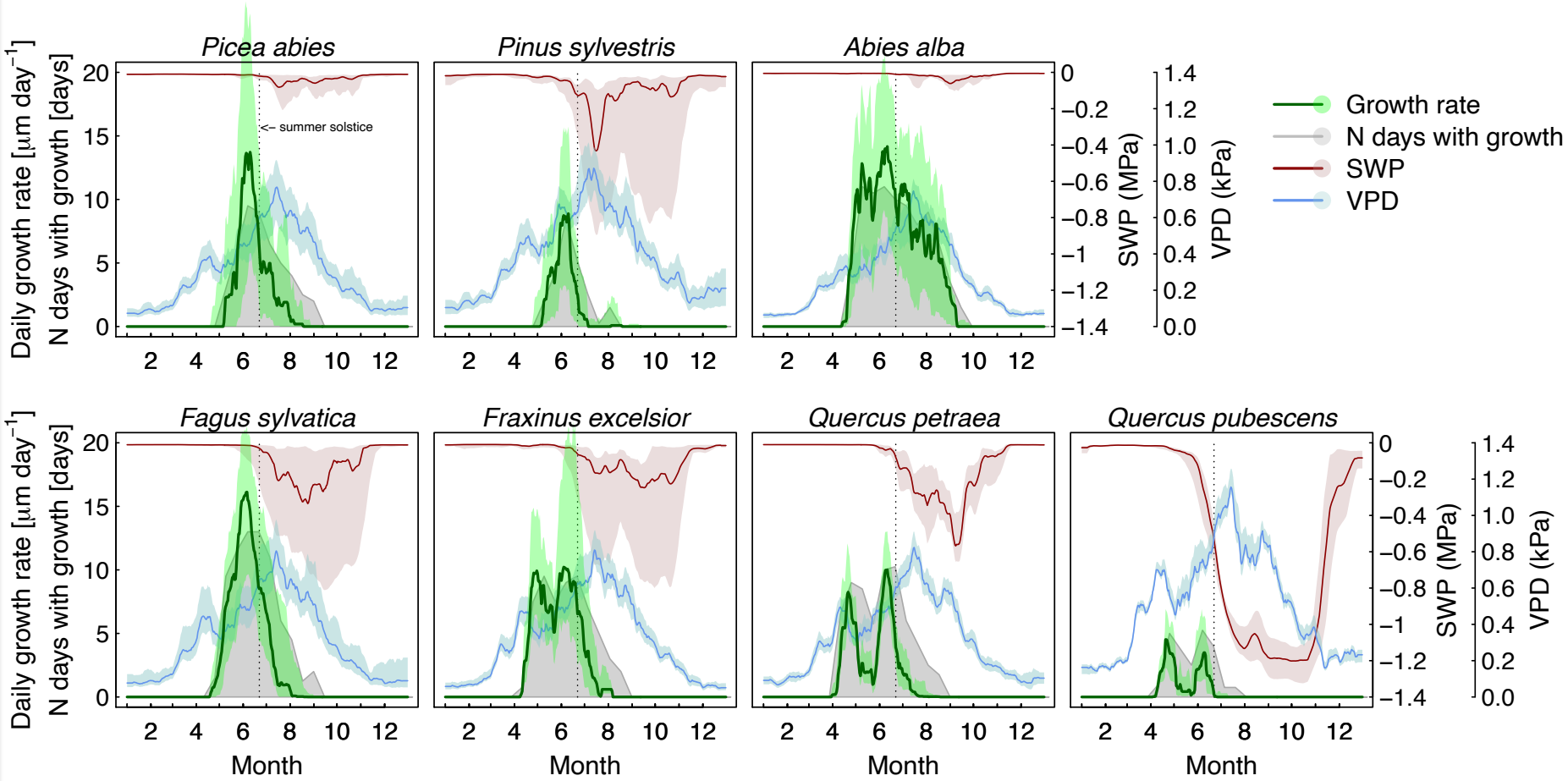
TreeNet

https://treenet.info/

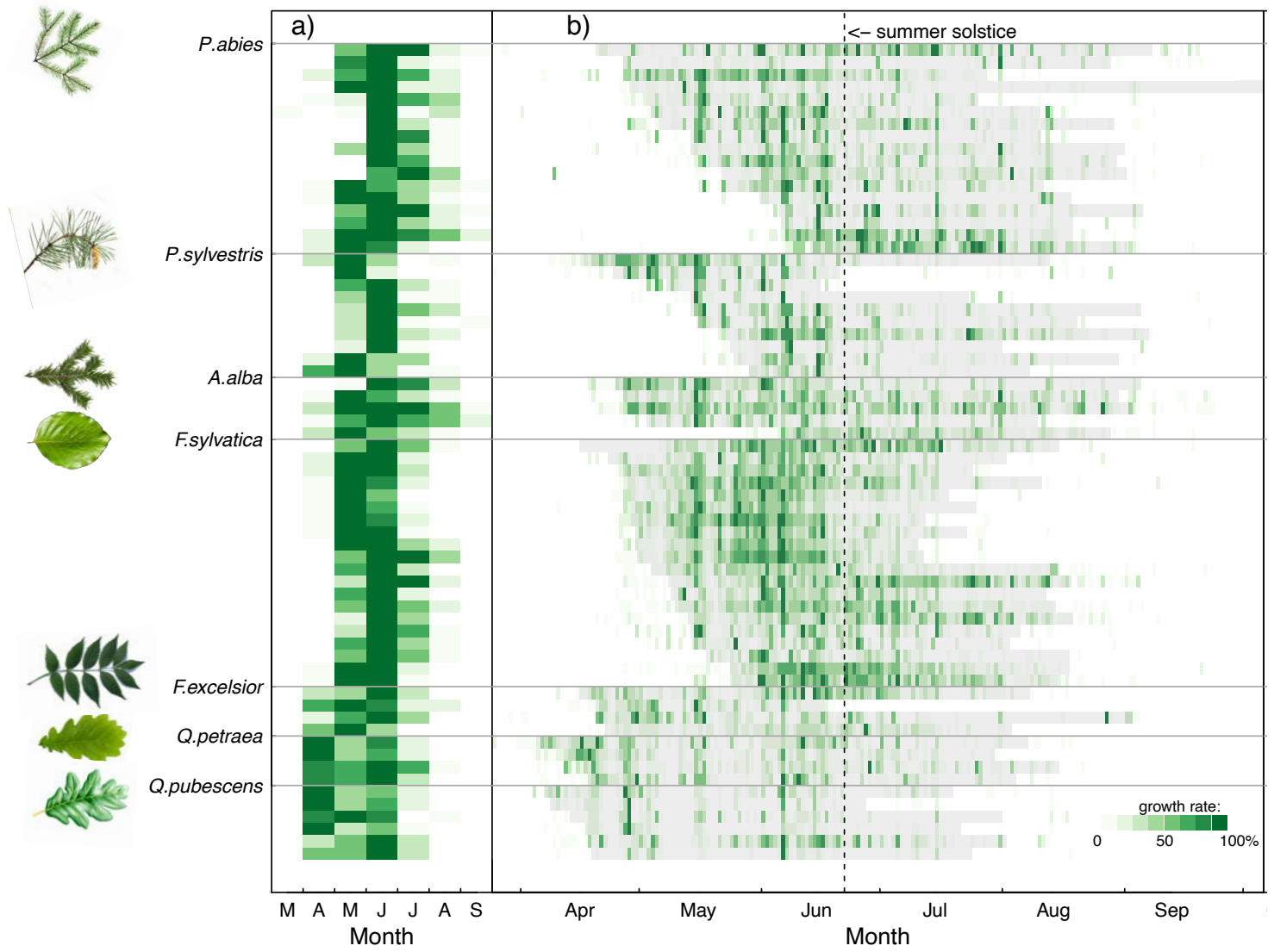


- 47 study sites with 160 trees
- 7 tree species: Pine, Spruce, Fir, Beech, Ash, Sessile and Downy Oak
- Stem radius changes at 10-min resolution for 2 to 8 years since 2011 with dendrometers
- Daily stem radial increment (μm)
- Meteorological data: Temperature, Precipitation, VPD, Soil water potential, Daylength

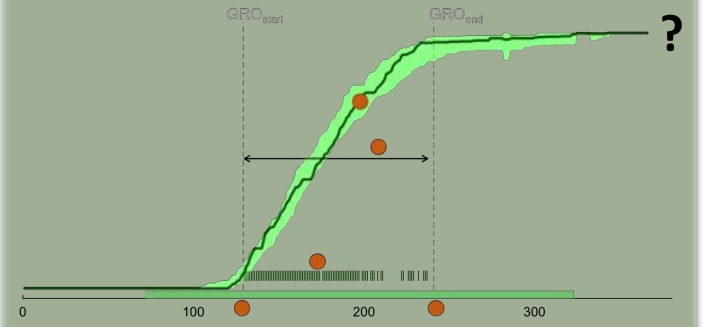
Seasonal Growth Patterns

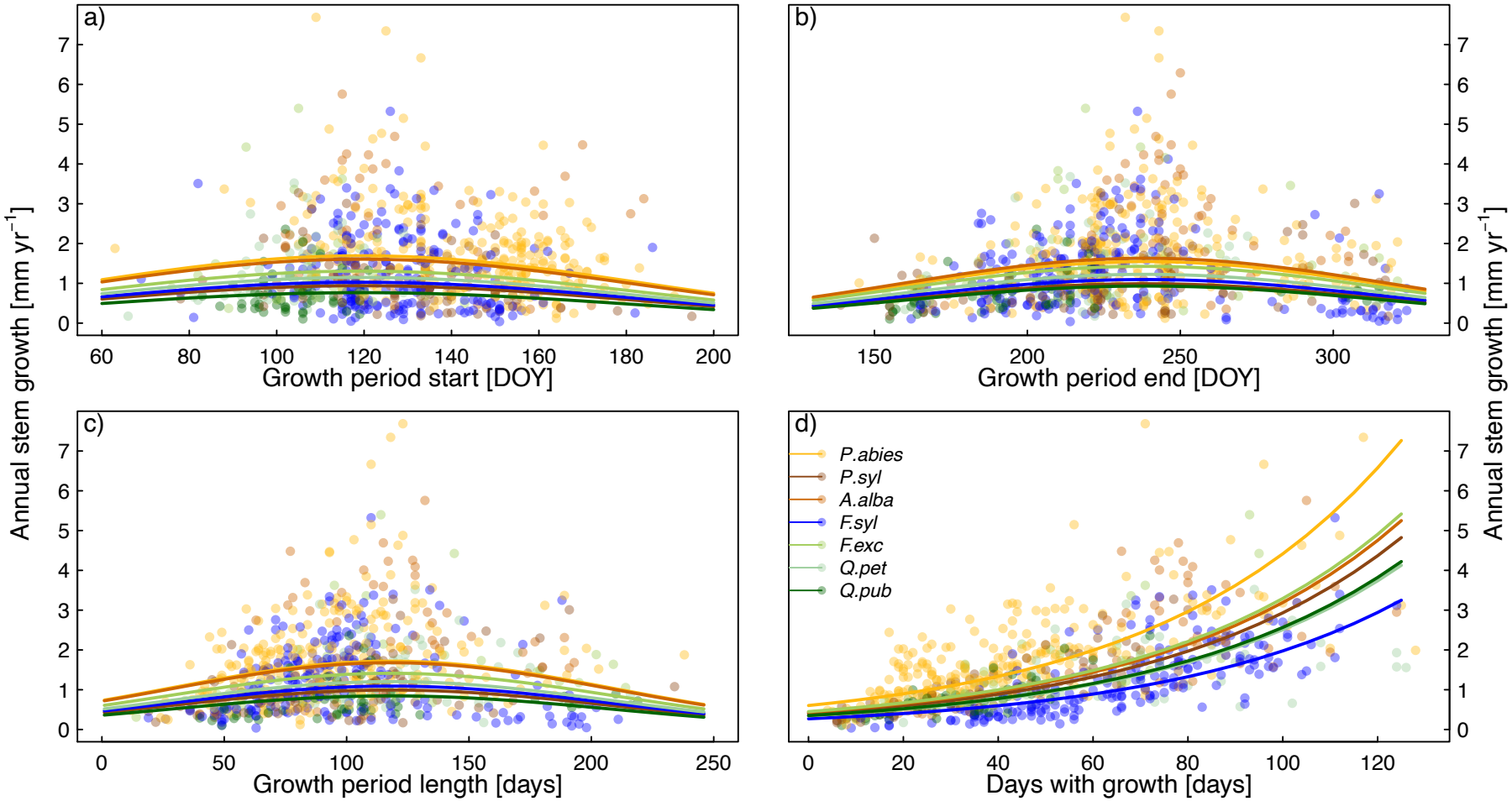


Daily Growth Patterns

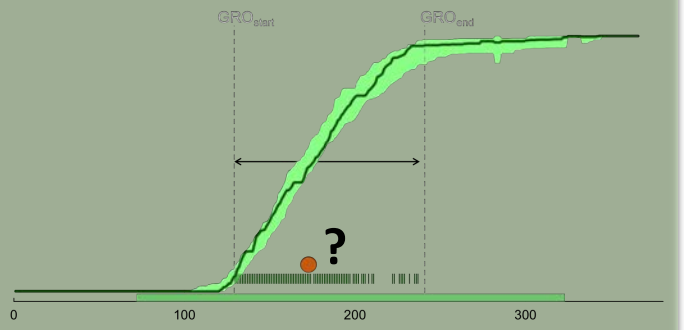


What drives annual increment ?





What makes a day a growth day?



Probability of growth ~