Intra-seasonal wood growth and tree water use at the TERENO-NE temperate forest observatory

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The drought year 2018 – Insights from the TERENO Observatories
TERENO Workshop
11-13 September 2019

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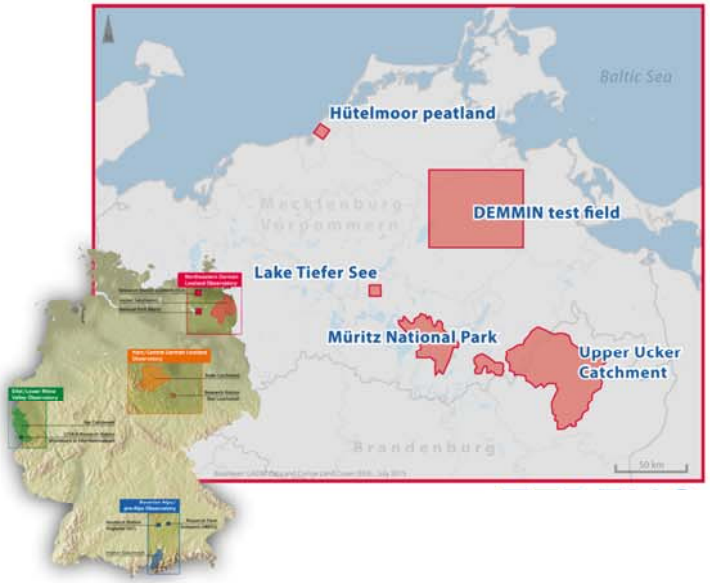
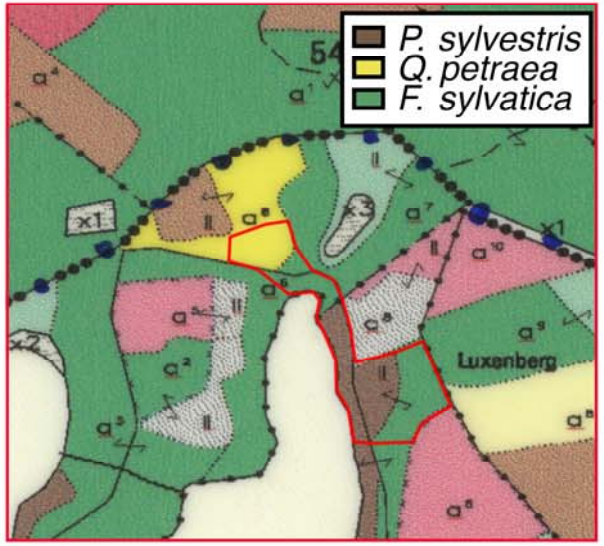
TERENO-NE German Lowland Observatory – Geoarchives WP





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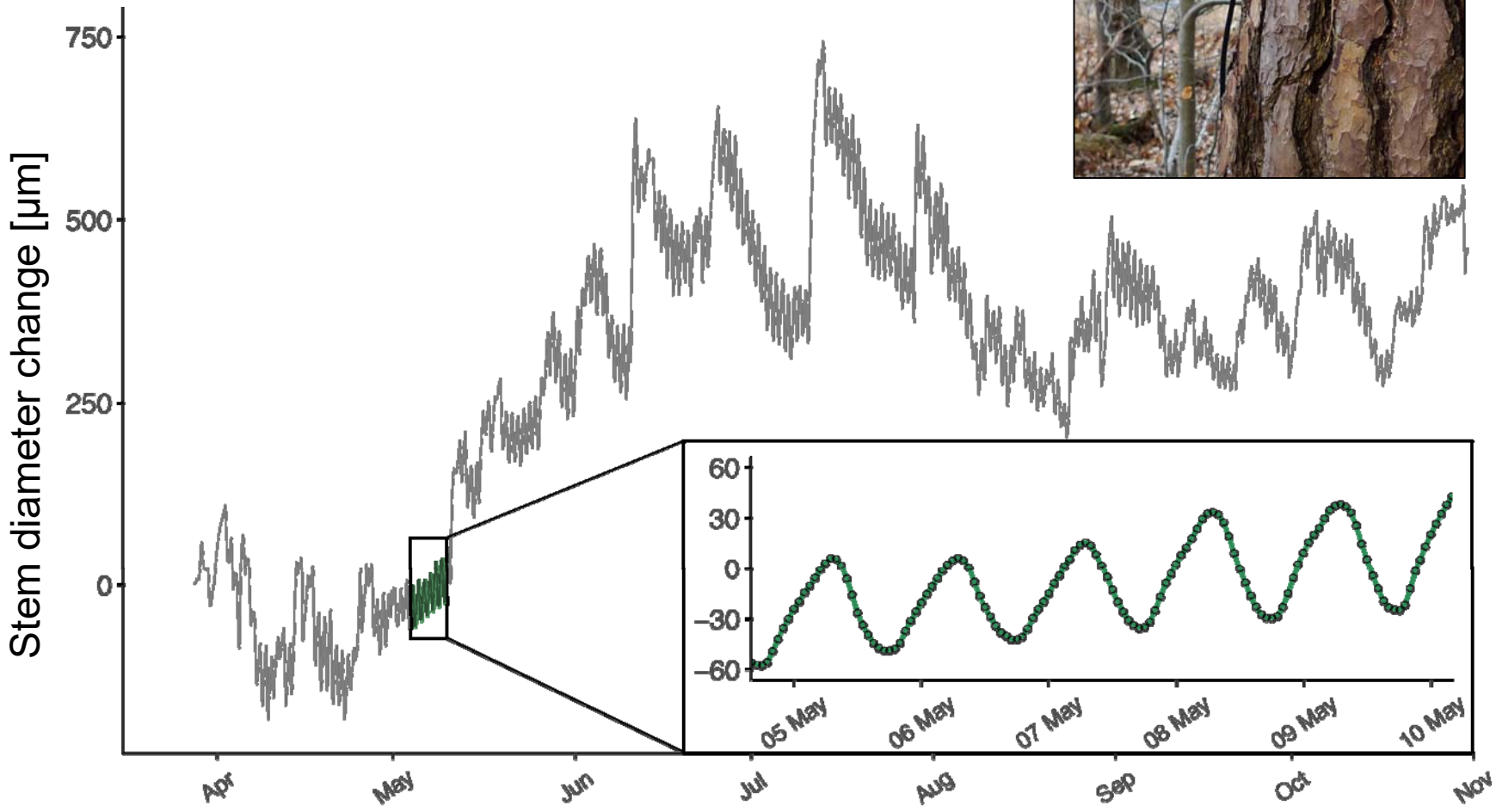
High-resolution monitoring of tree stem diameter variation at TERENO-NE

Overview

- Continuous intervals at 30-minute resolution since 2012
- Measurements at ~1um displacement



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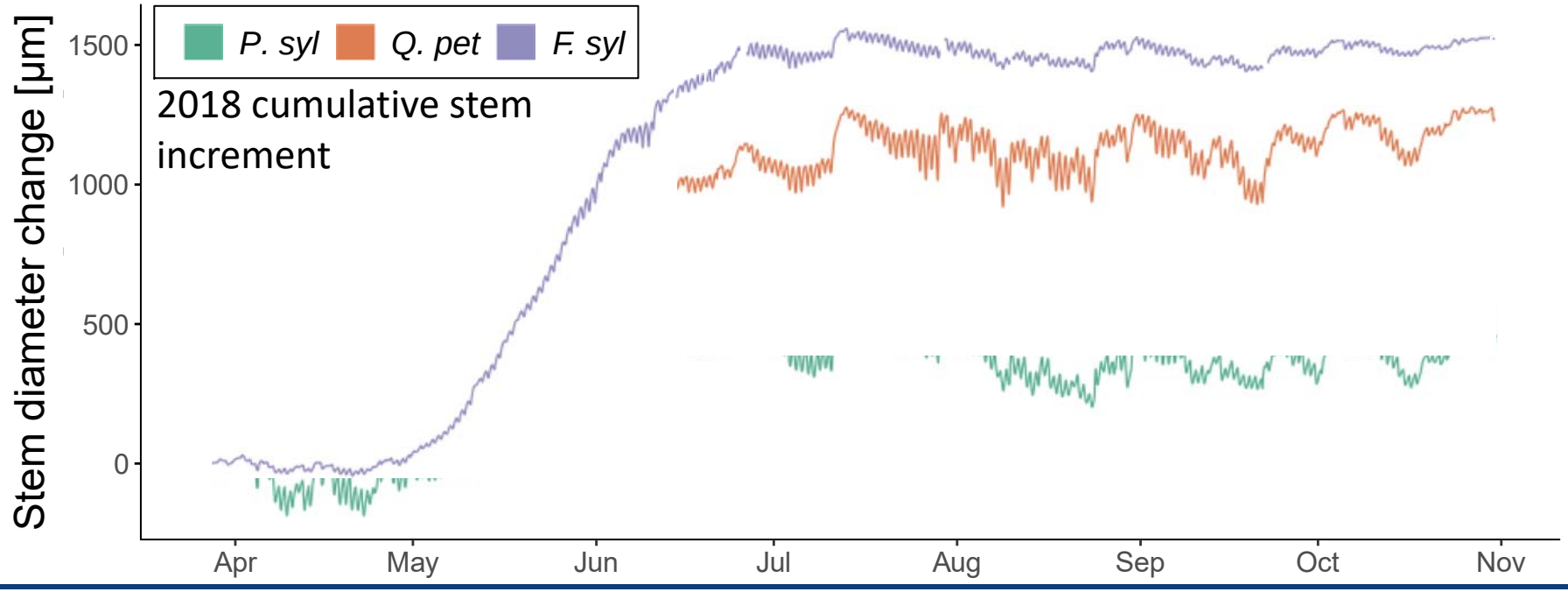
High-resolution monitoring of tree stem diameter variation at TERENO-NE

Overview

- Target species:
  - *Pinus sylvestris* (Scots pine)
  - *Quercus petraea* (Sessile oak)
  - *Fagus sylvatica* (European beech)
- 5 trees monitored per species



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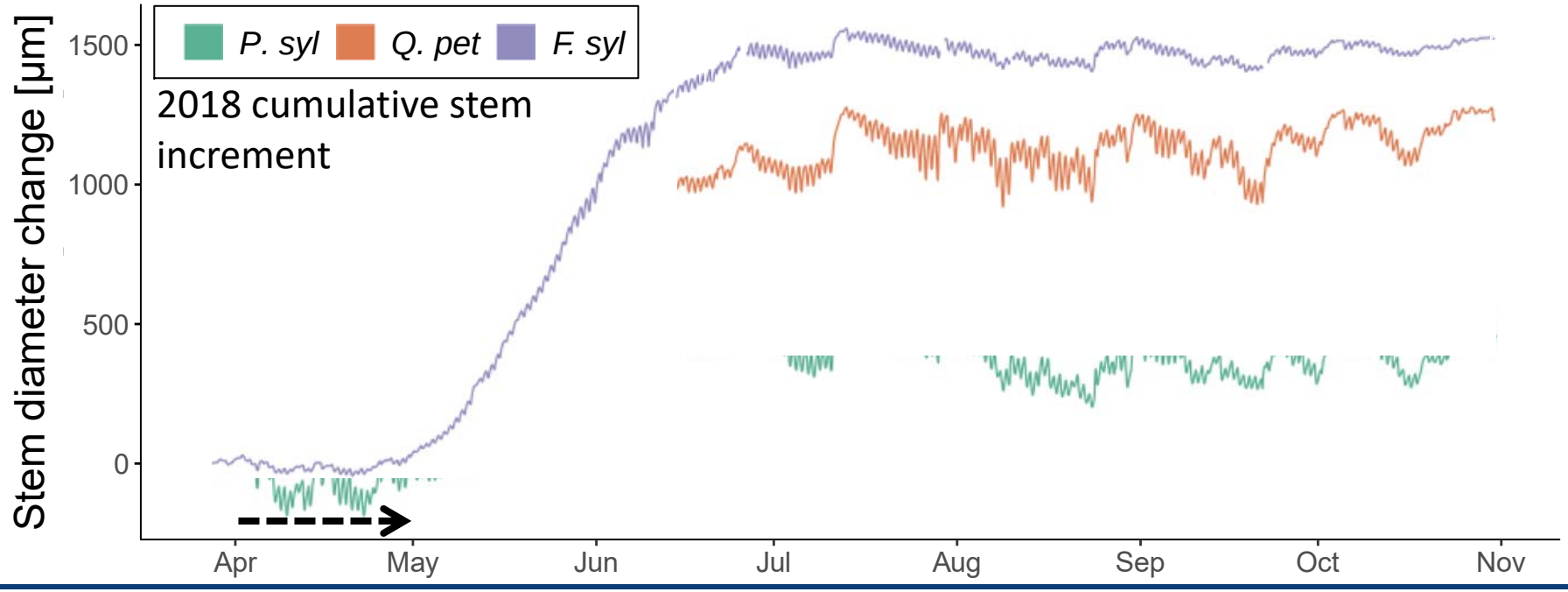
High-resolution monitoring of tree stem diameter variation at TERENO-NE

Insights

- **Sub-seasonal variation in radial growth**
- Stem water storage relations
- Physiological and mechanistic processes
- Dendroclimatology/signal transfer



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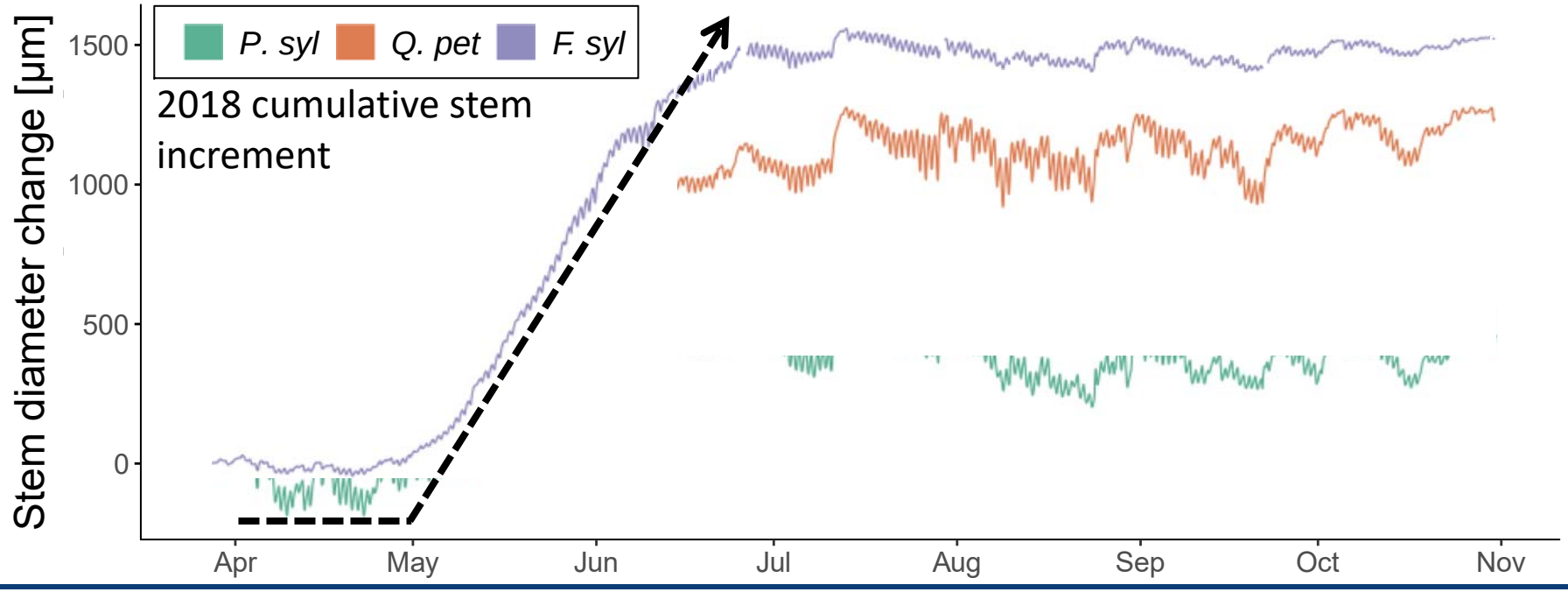

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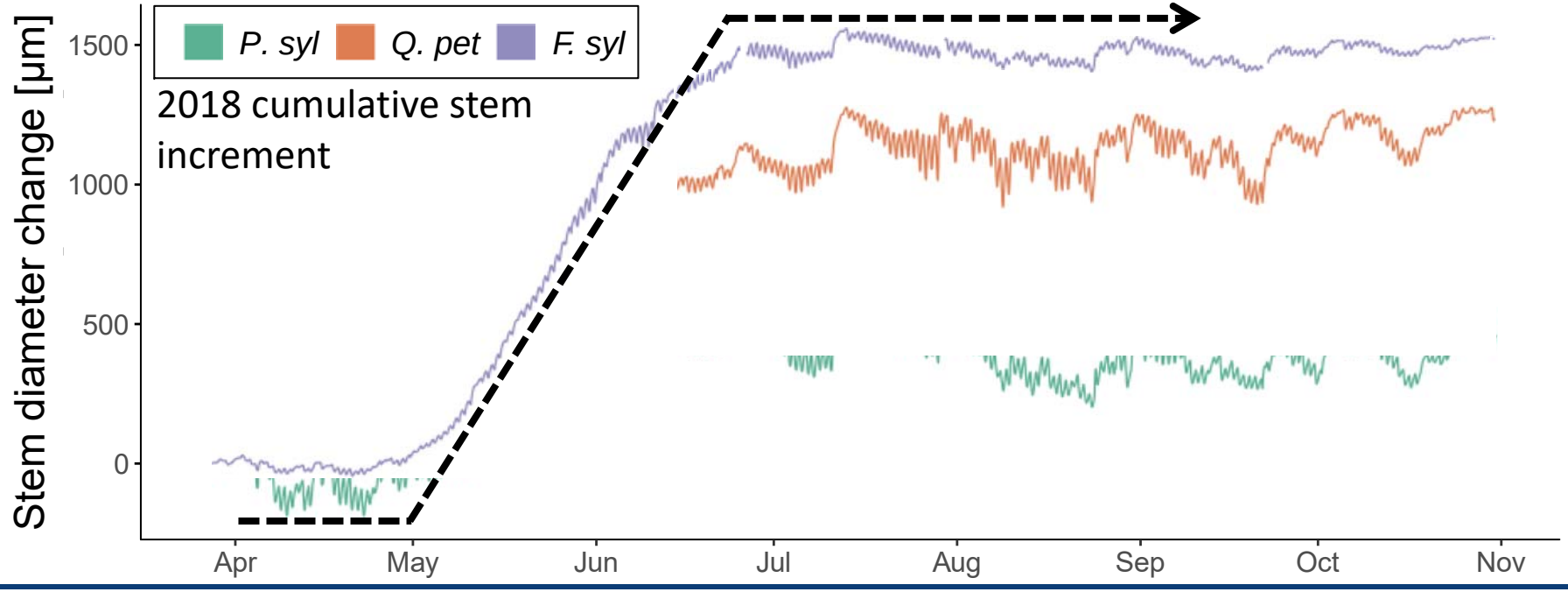

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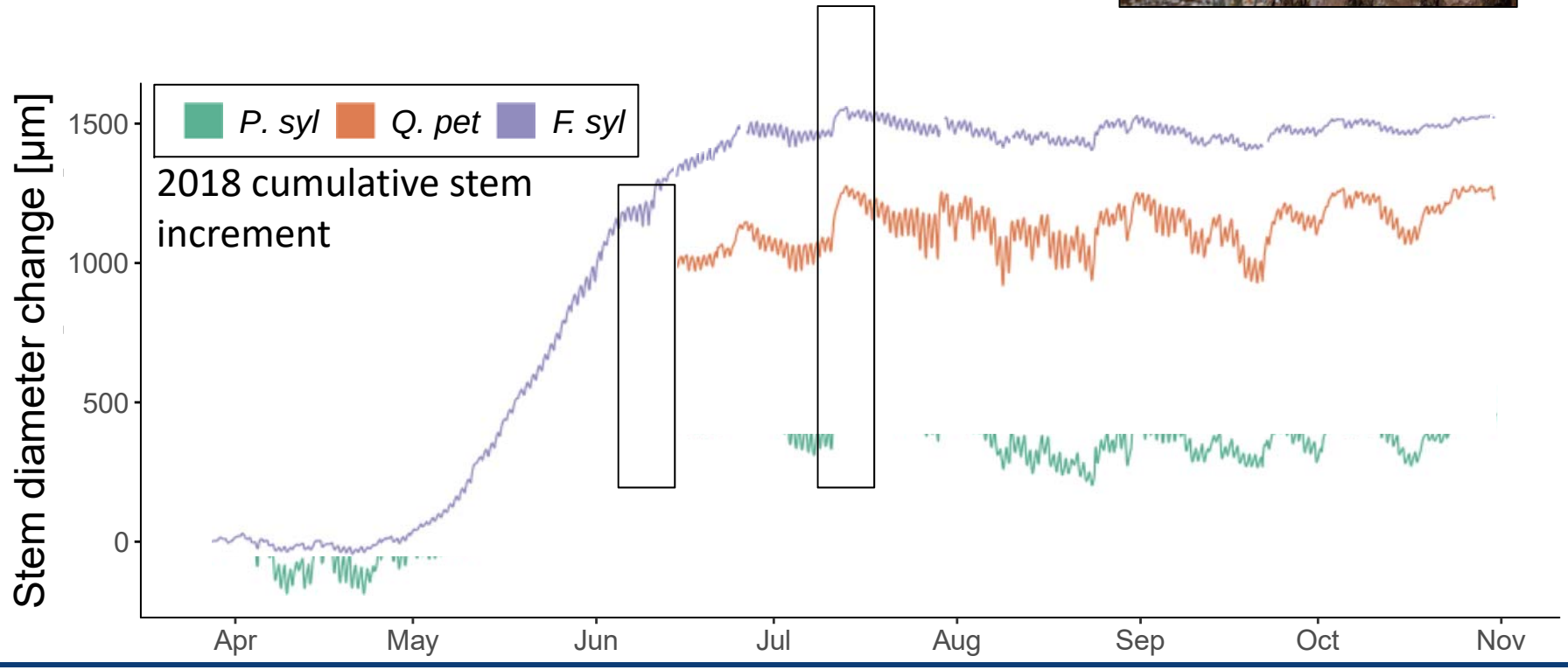

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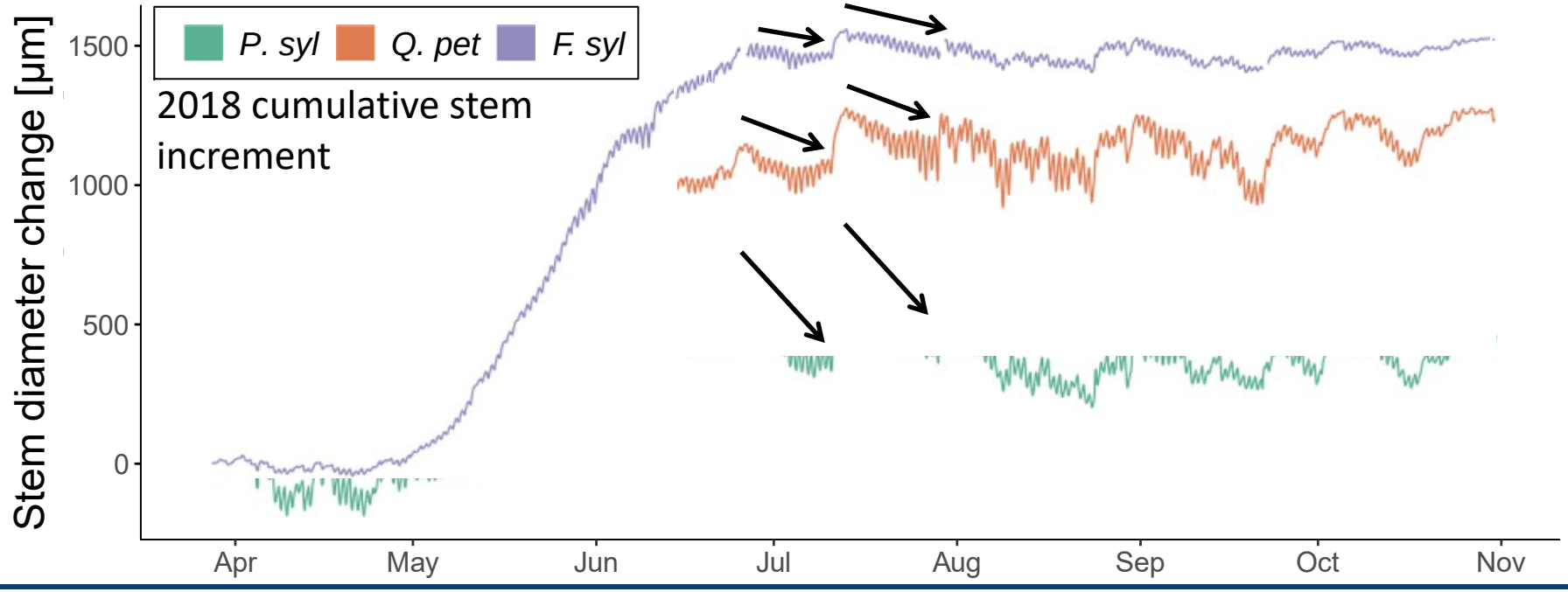

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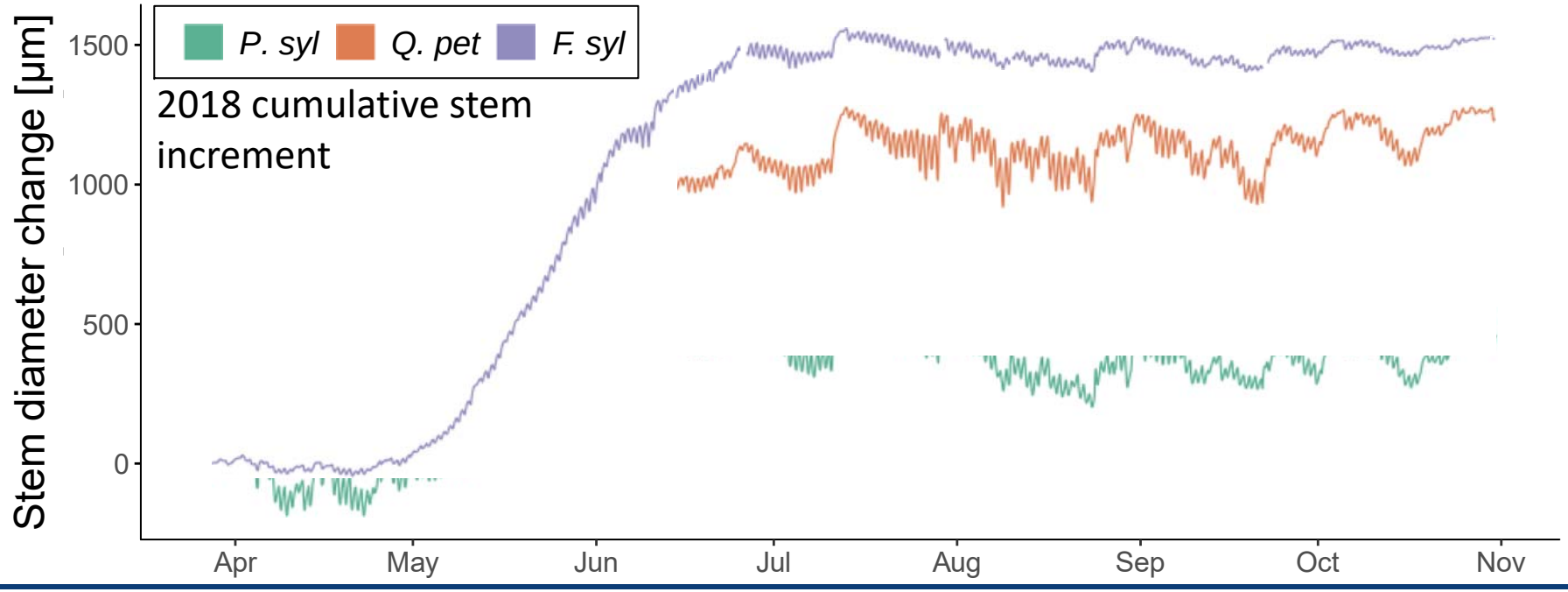

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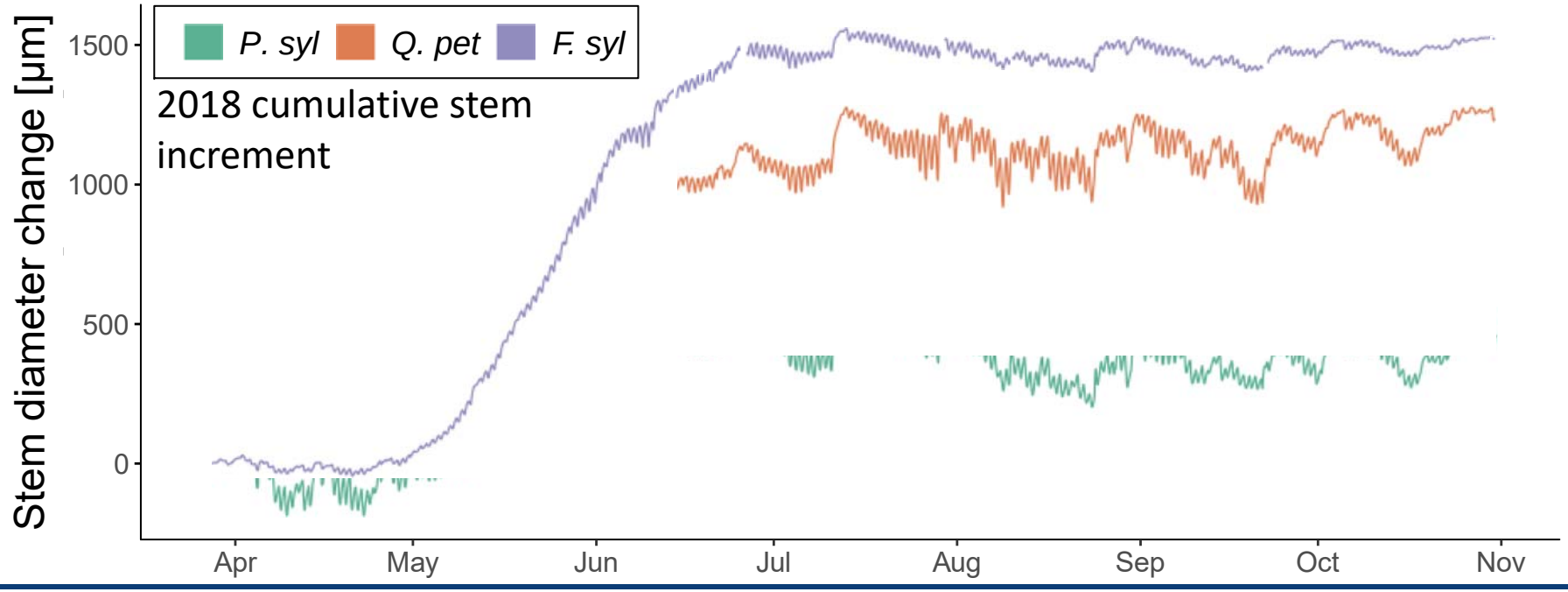

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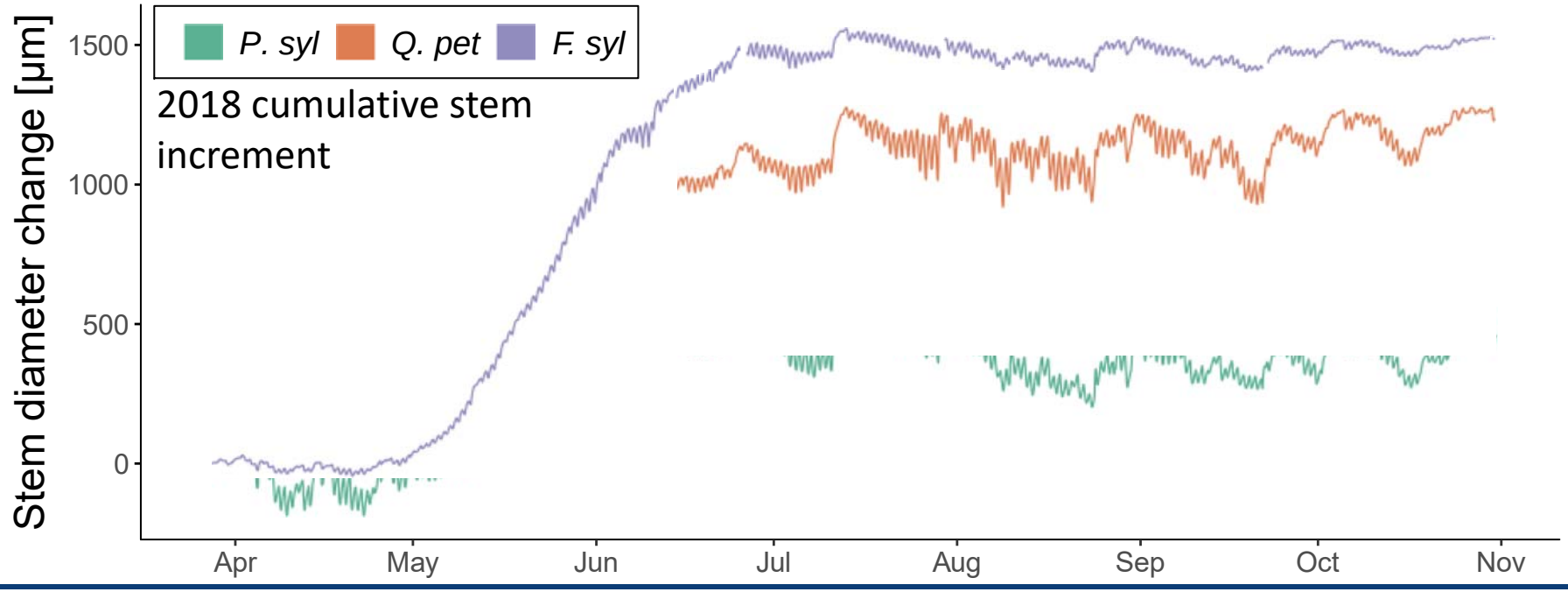
High-resolution monitoring of tree stem diameter variation at TERENO-NE

Applications

- Forestry – drought stress indictor (site and species)
- Forest monitoring - dynamic and long-term
- Plant physiology and plant function modelling
- Ecosystem modelling



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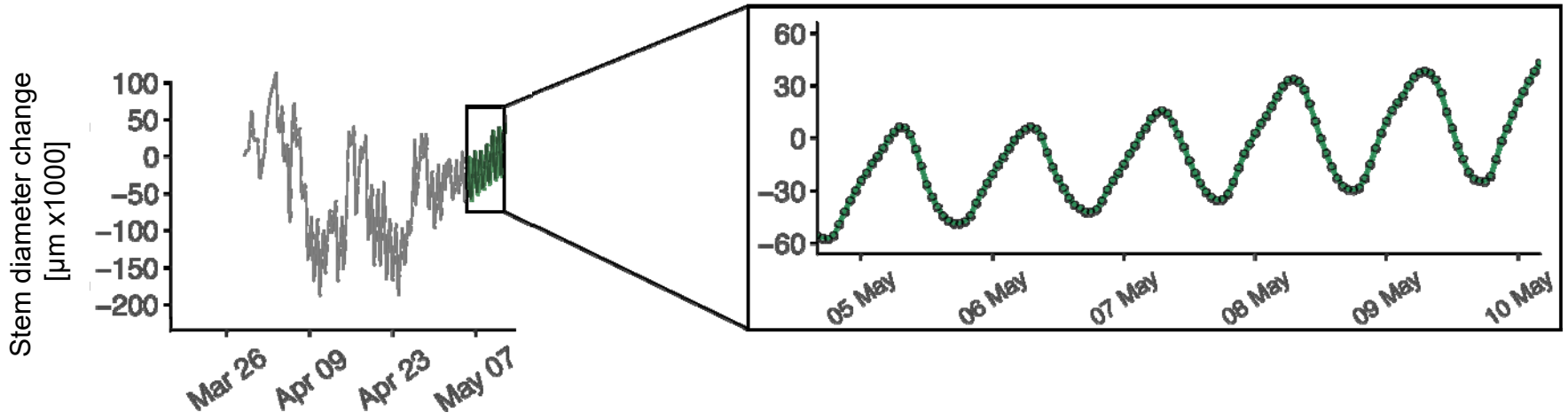
High-resolution monitoring of tree stem diameter variation at TERENO-NE

Biomechanics

- Rhythmic daily changes in stem size reflect stem hydration dynamics and growth
- Elastic shrinkage and swelling in living and dead tissue
  - **+** water uptake from soil
  - **+/-** water transport between tissues (xylem, phloem, bark)
  - **-** water loss through transpiration
- Irreversible expansion (growth)
- Magnitude of fluctuation is driven by soil **(source)** and atmospheric conditions **(sink)**



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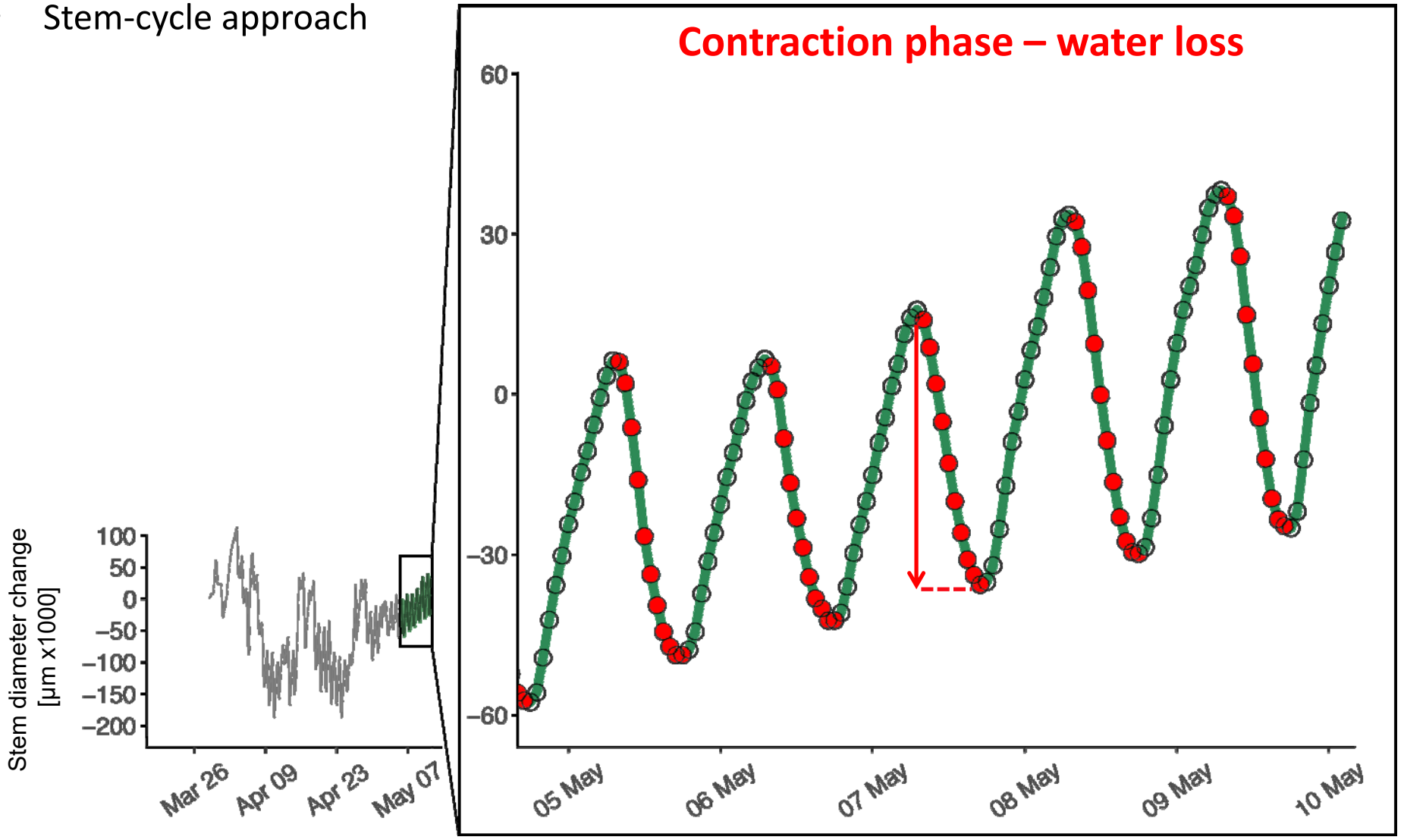
High-resolution monitoring of tree stem diameter variation at TERENO-NE

Analytical methods

- Stem-cycle approach



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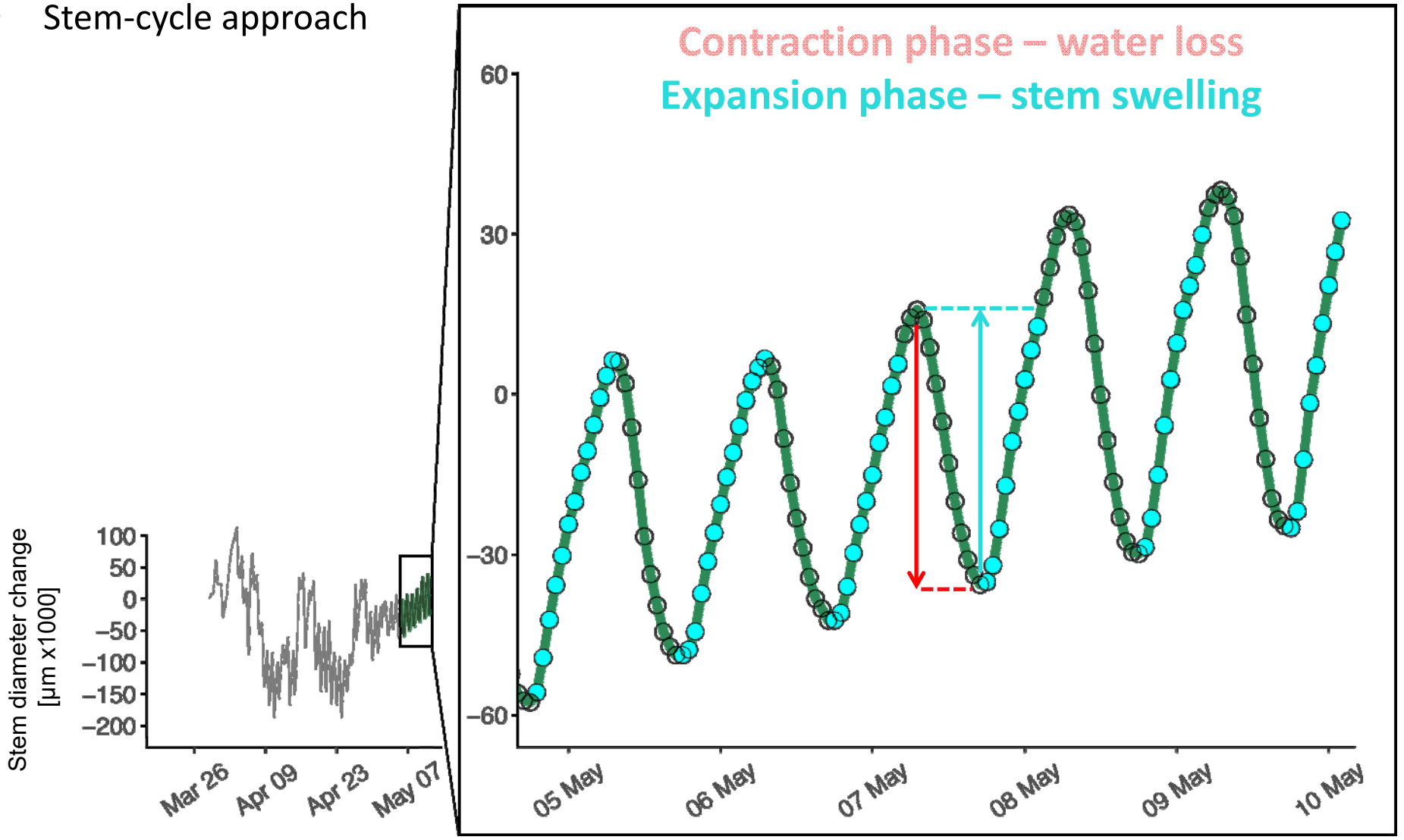

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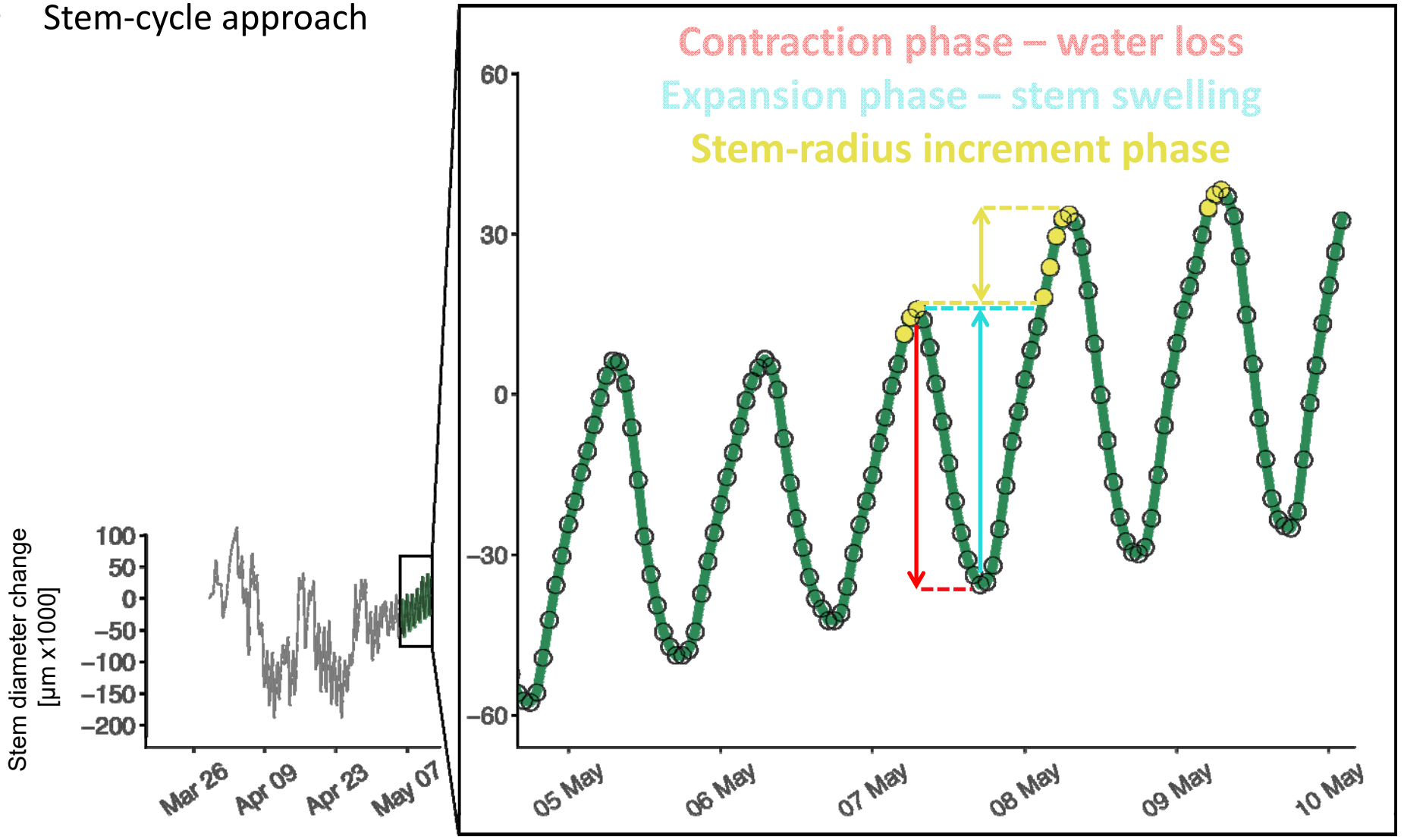

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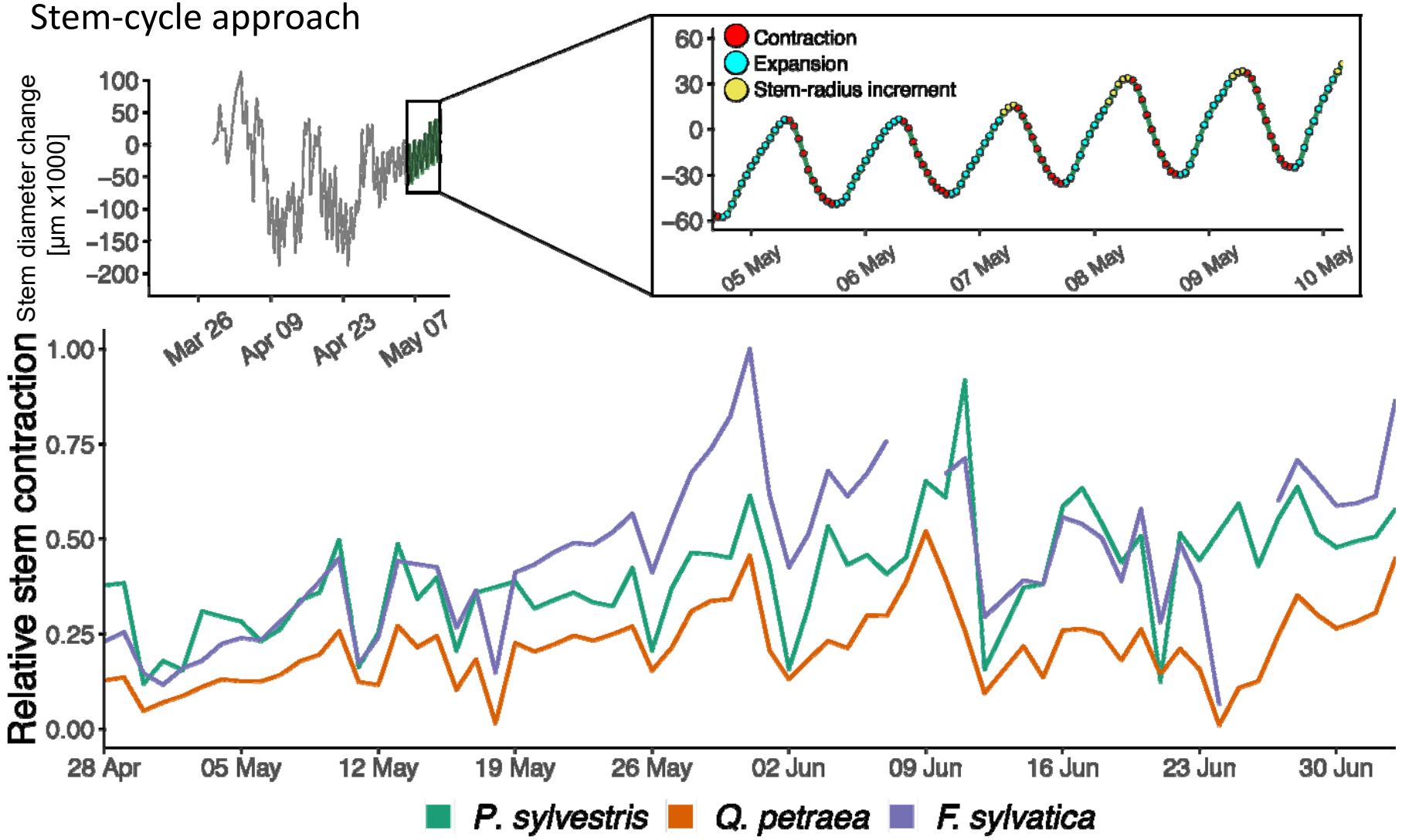

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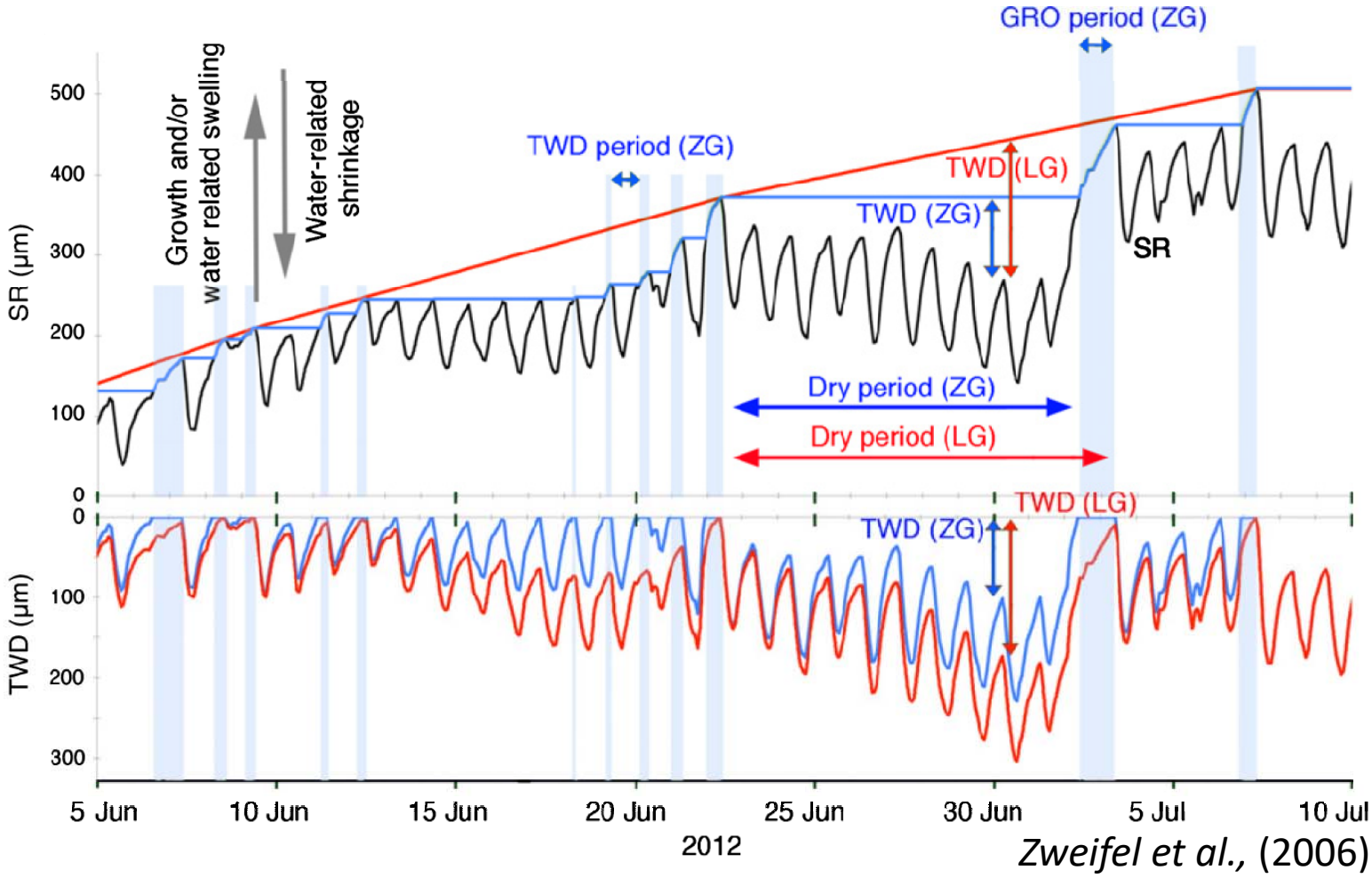
High-resolution monitoring of tree stem diameter variation

Analytical methods

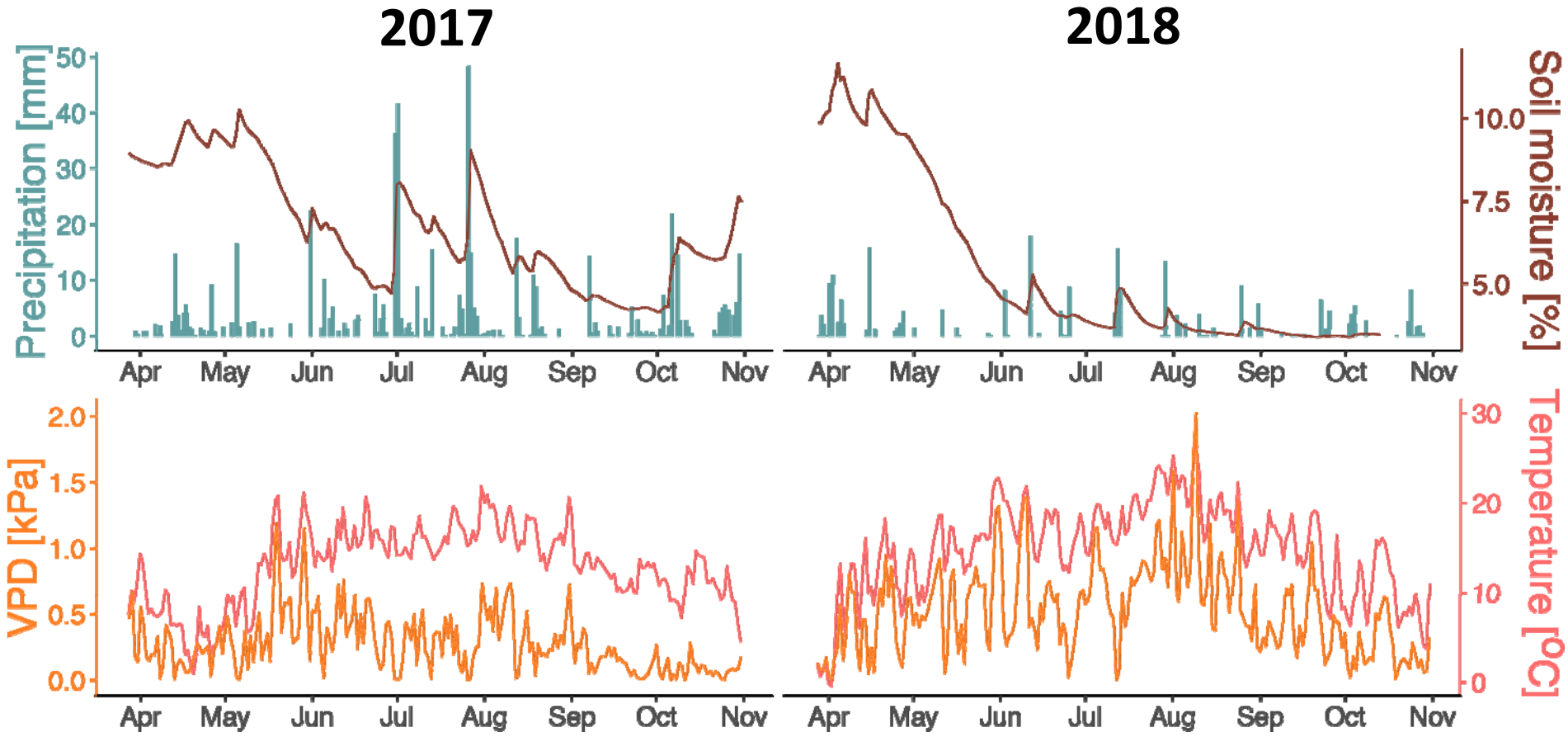
- Removal of growth trend to extract information on tree water status/water stress
- **Tree water deficit**



Zweifel et al., (2006)

High-resolution monitoring of tree stem diameter variation at TERENO-NE

- Stem diameter variation coupled to environmental conditions at the site
  - Precipitation, temperature, relative humidity, vapour pressure deficit, radiation and soil moisture
  - Apply statistics to determine the link between tree biomechanics and ecophysiologically relevant environmental processes



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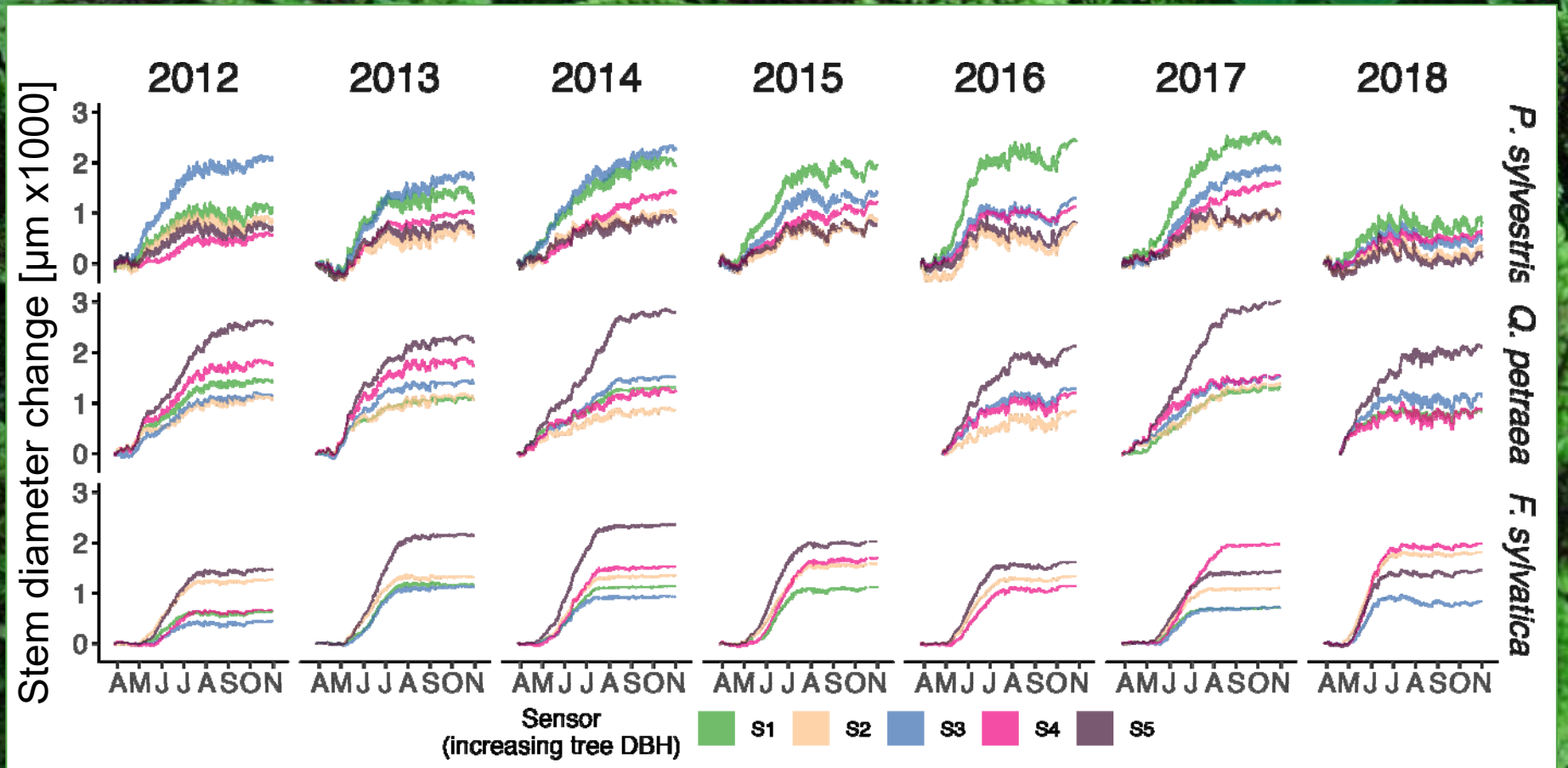
Growth dynamics



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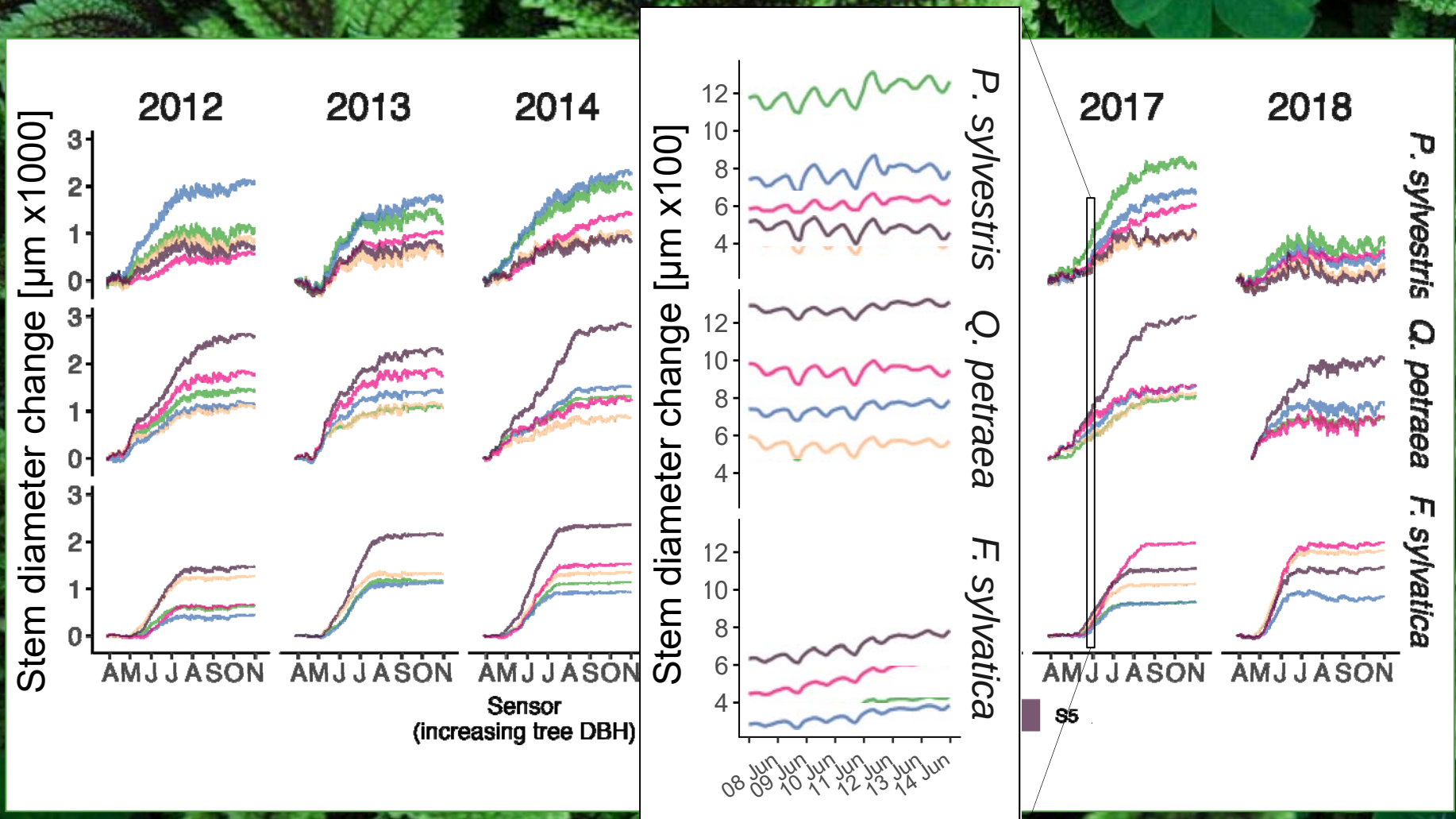

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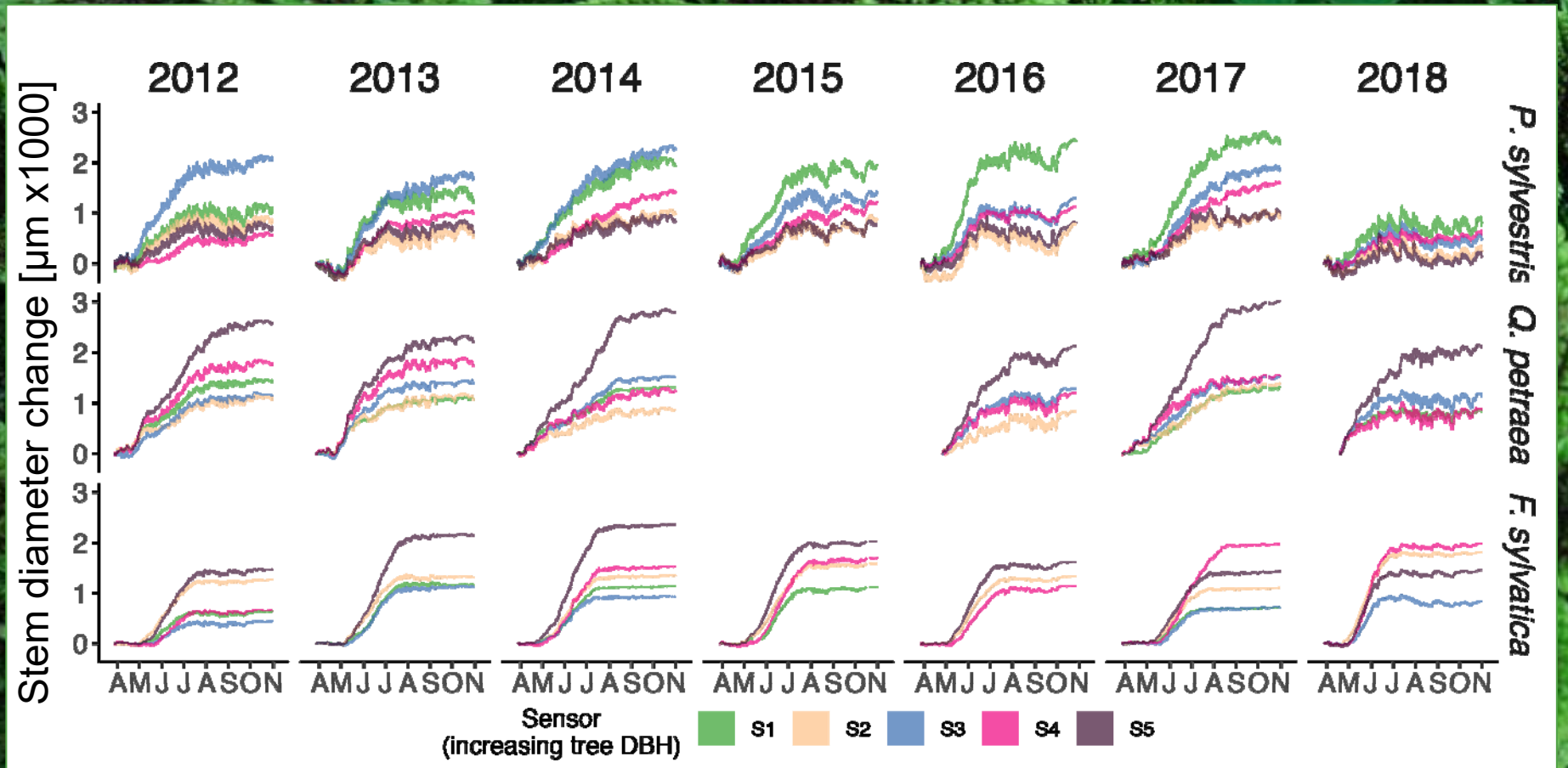

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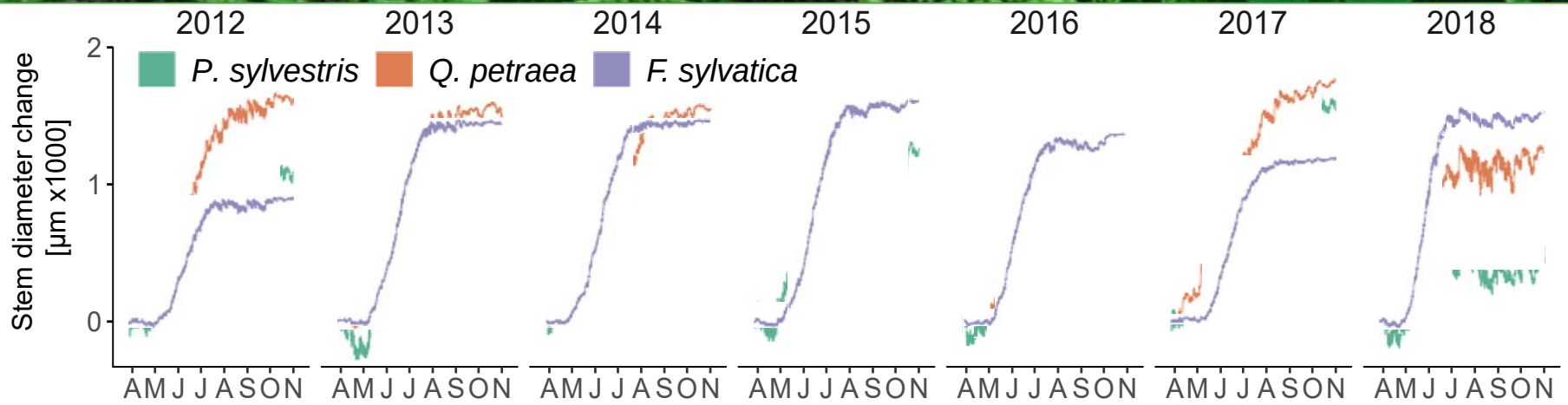

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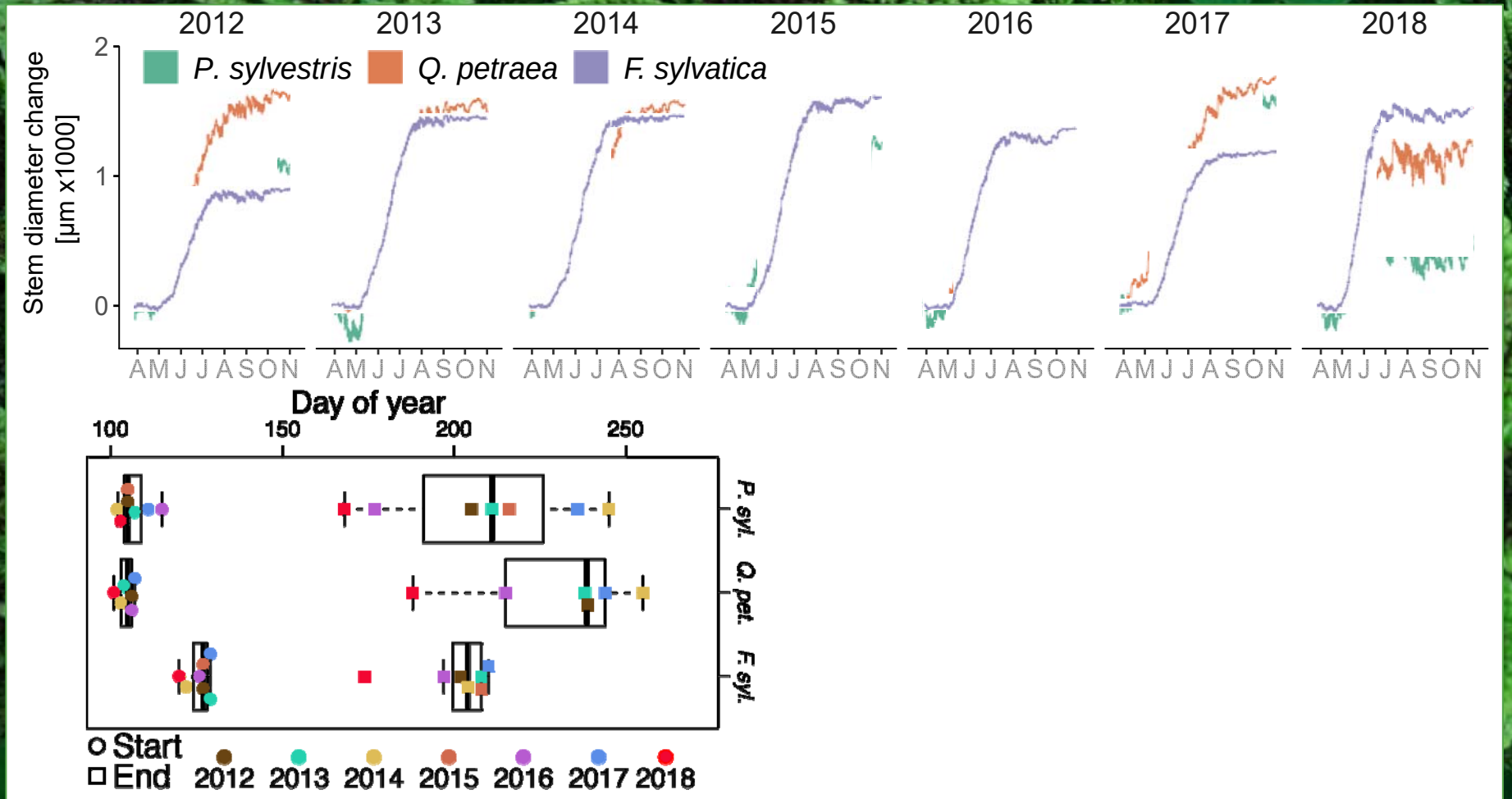

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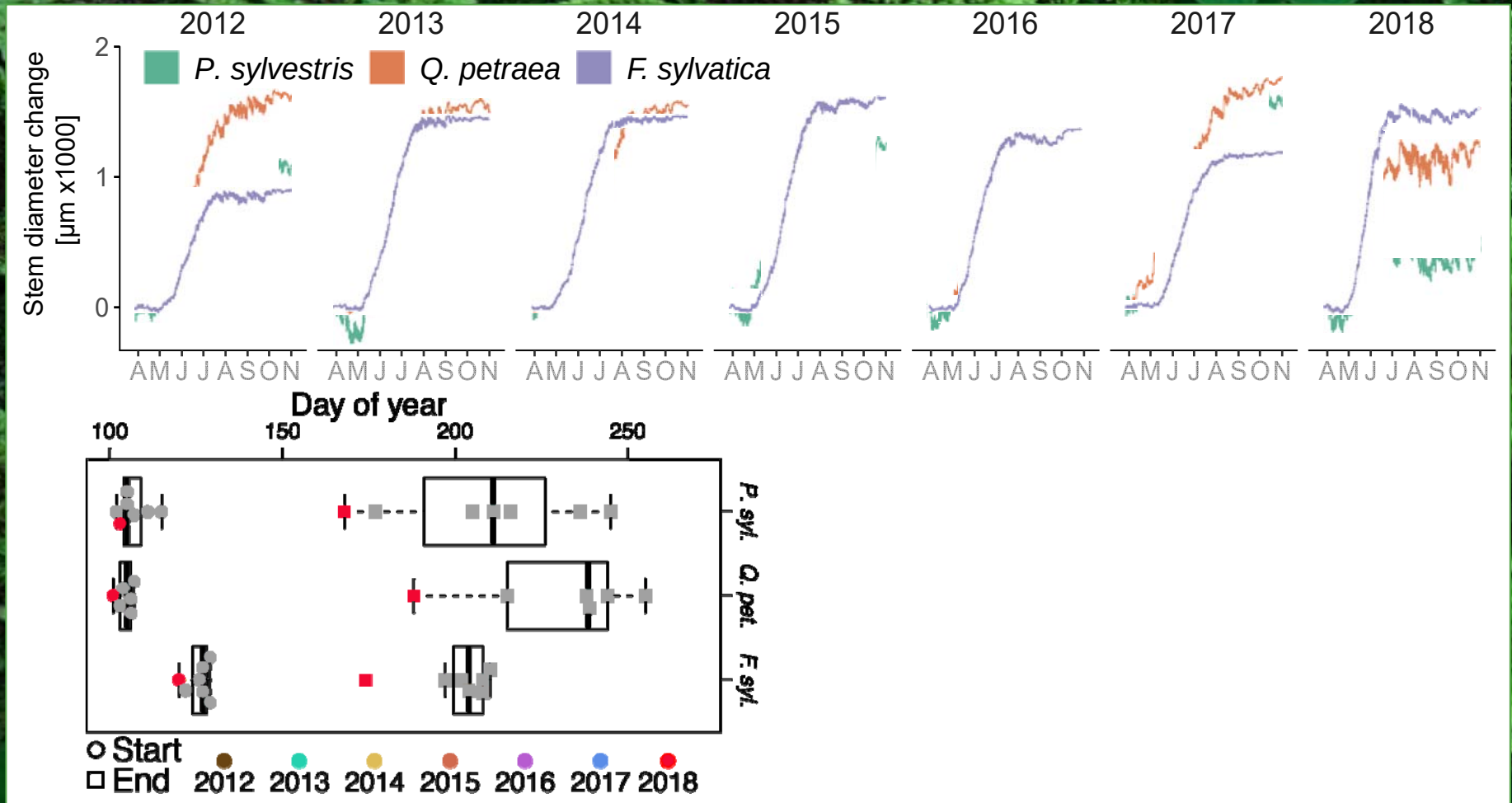

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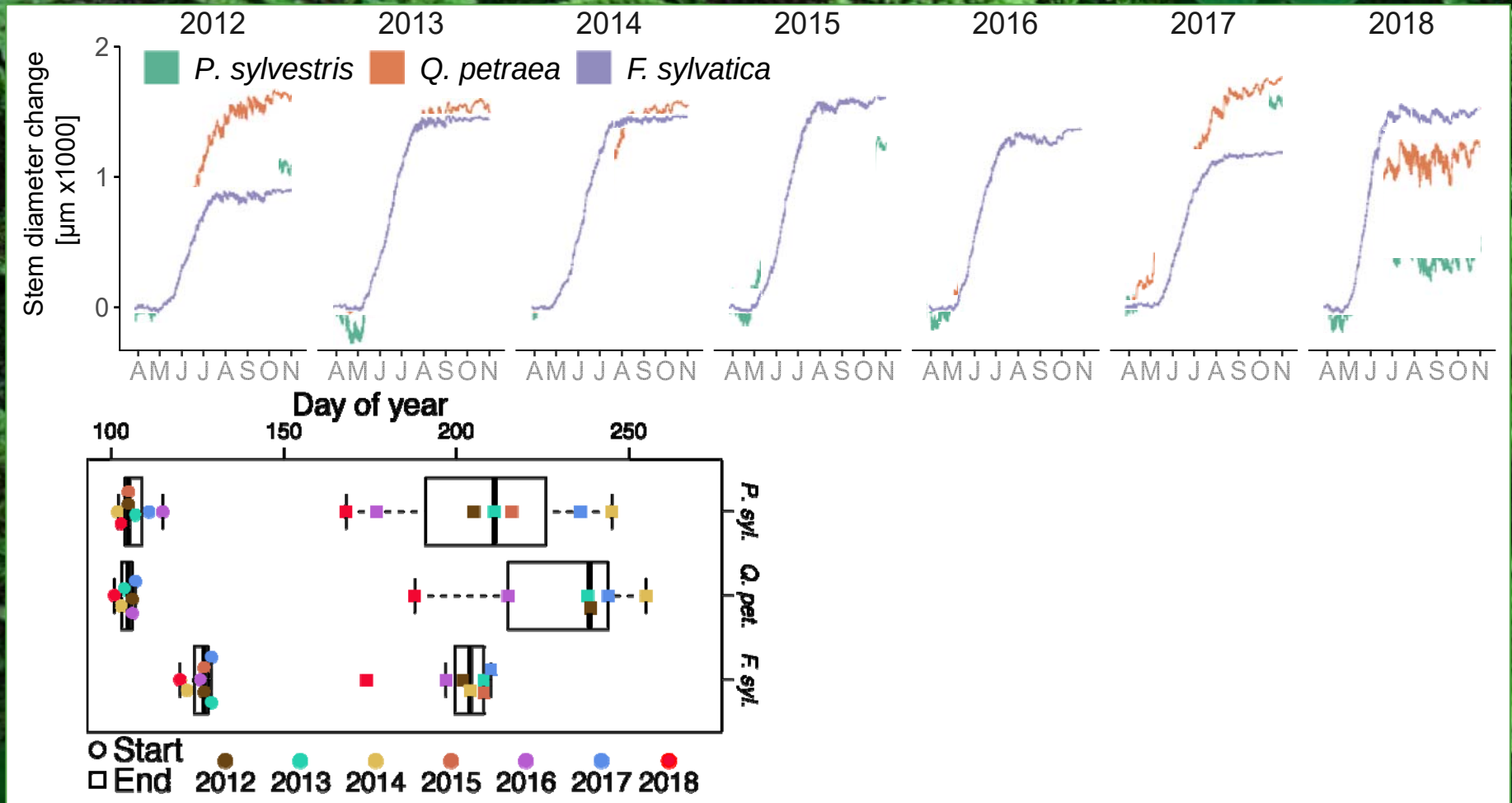

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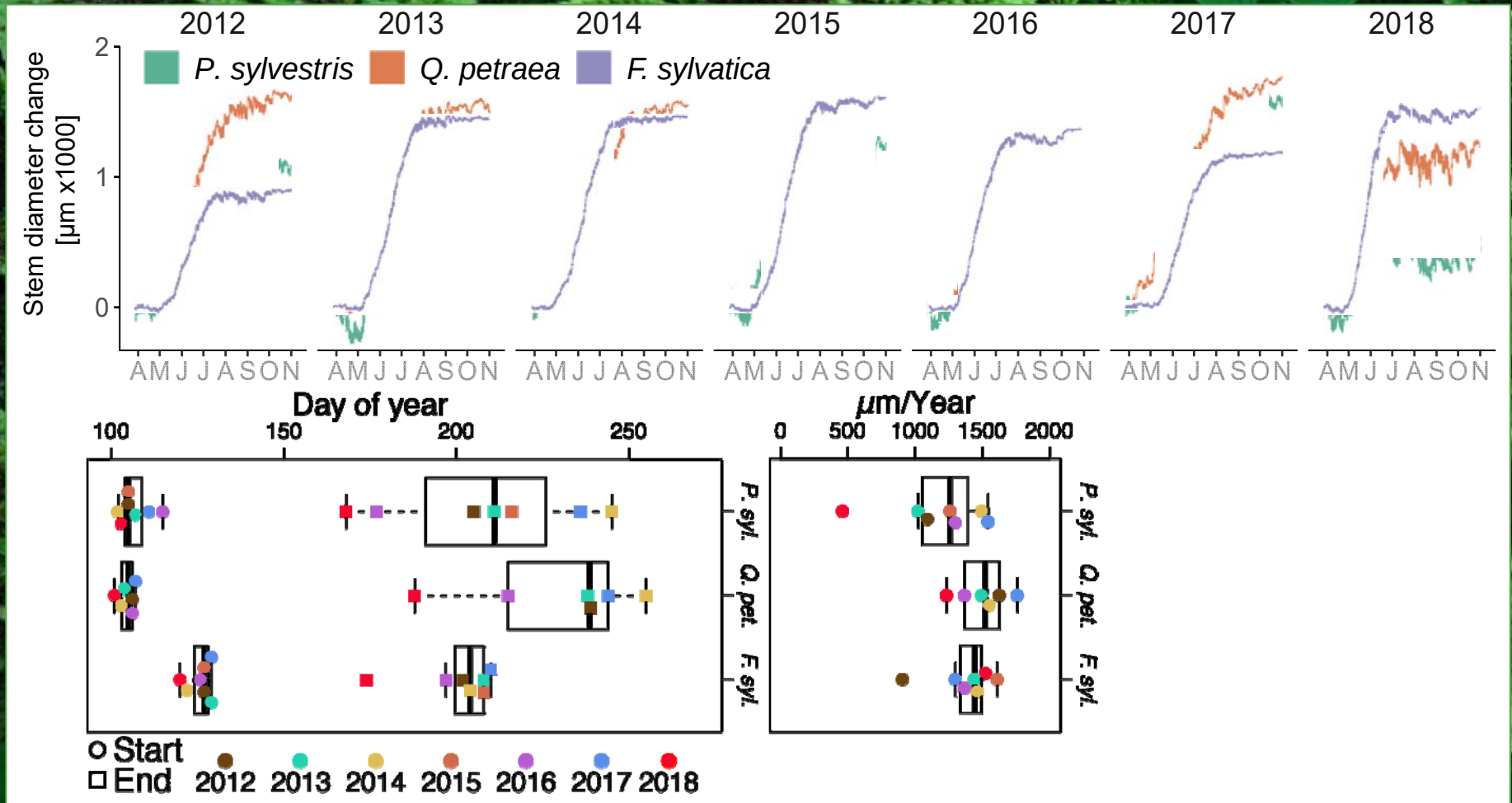

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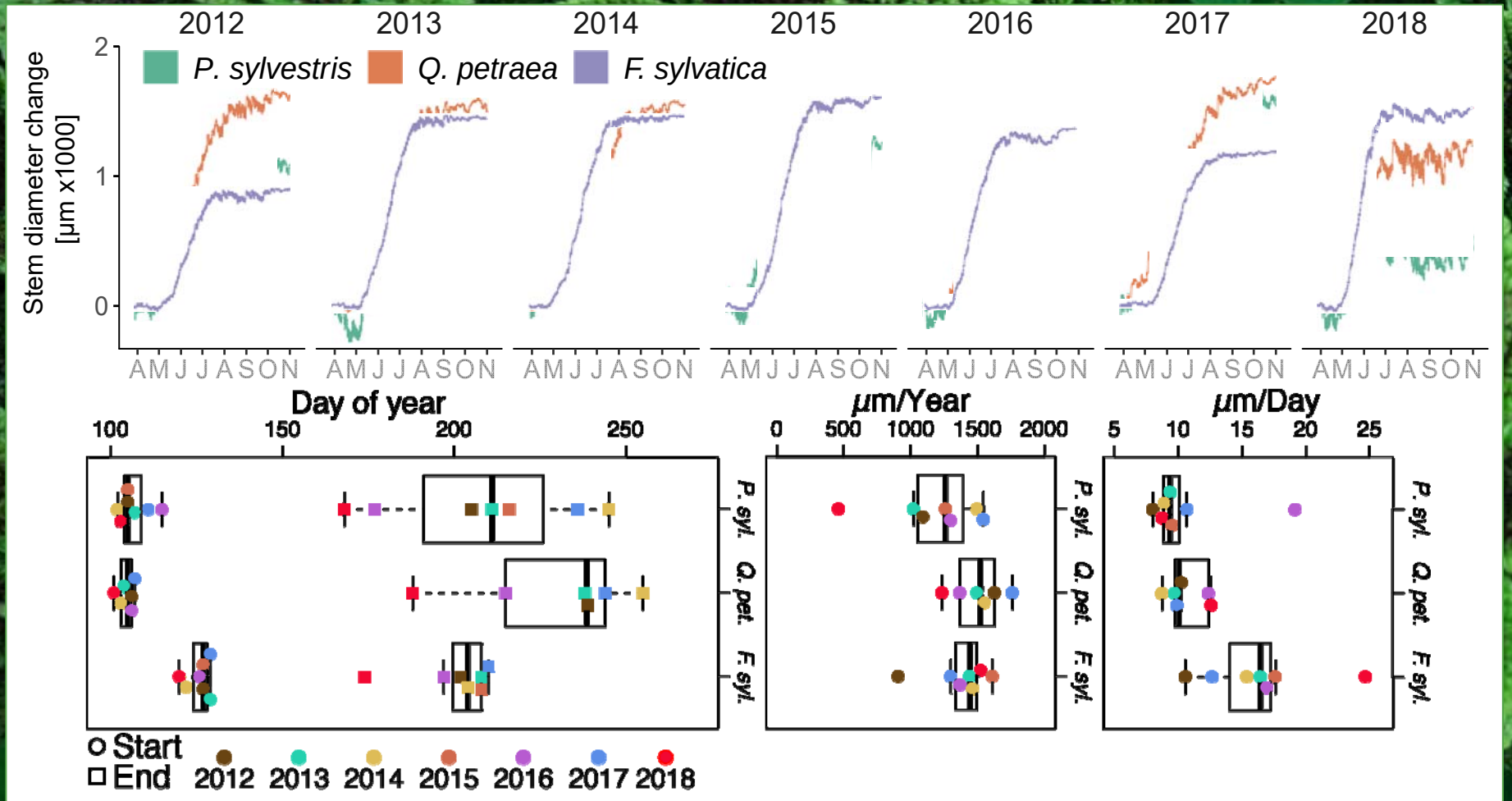

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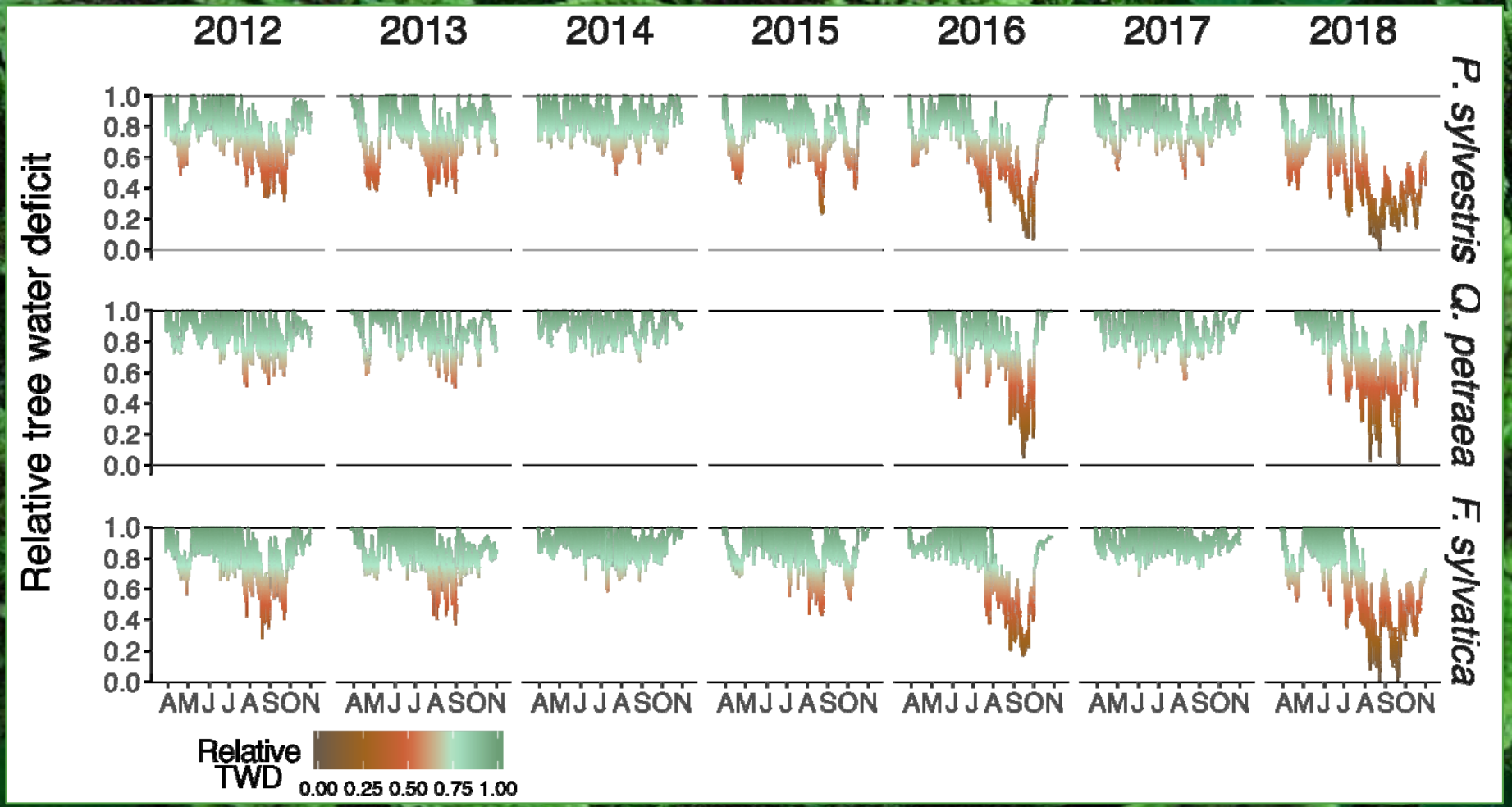
Tree water deficit



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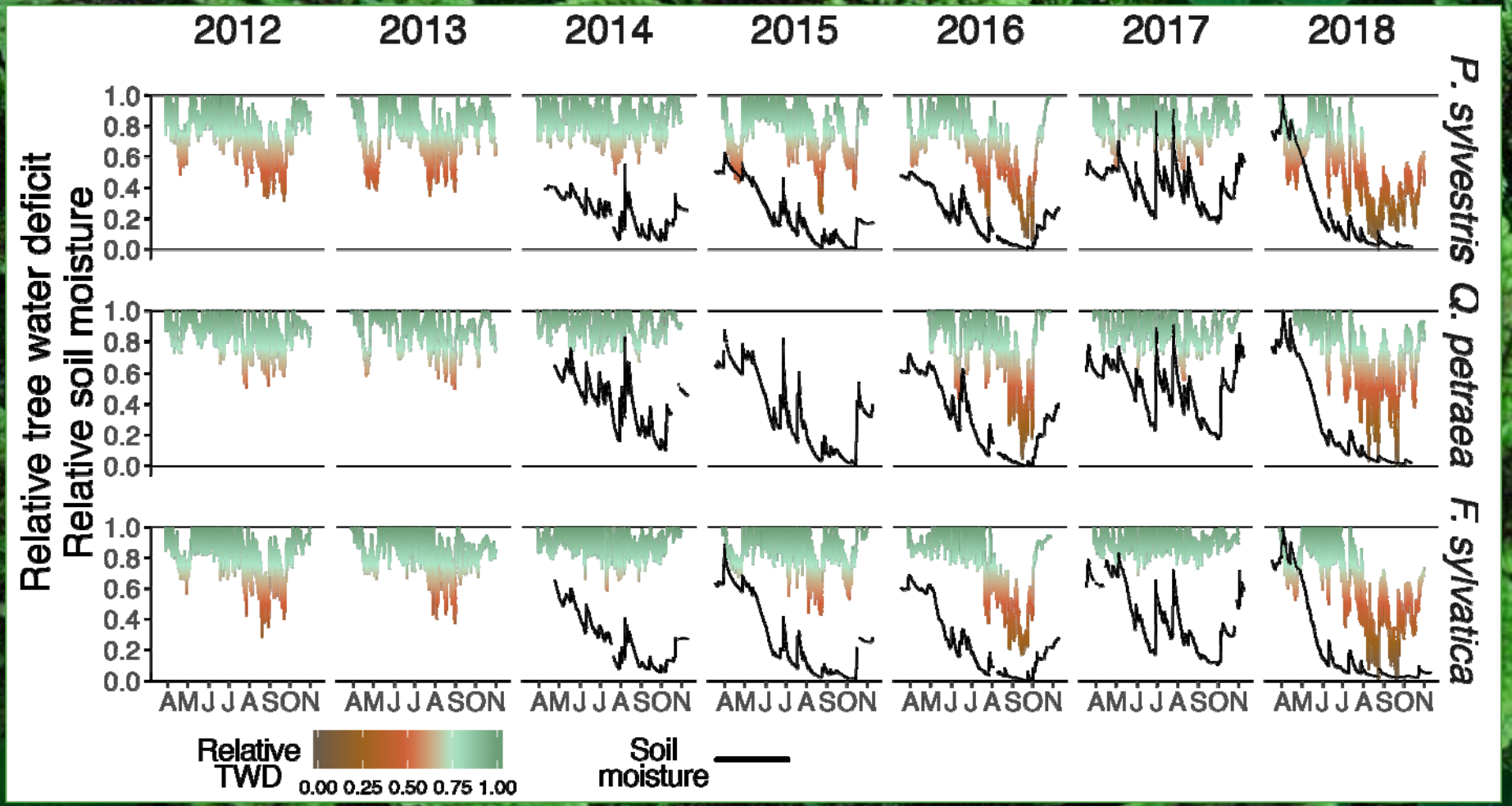
Tree water deficit + soil moisture



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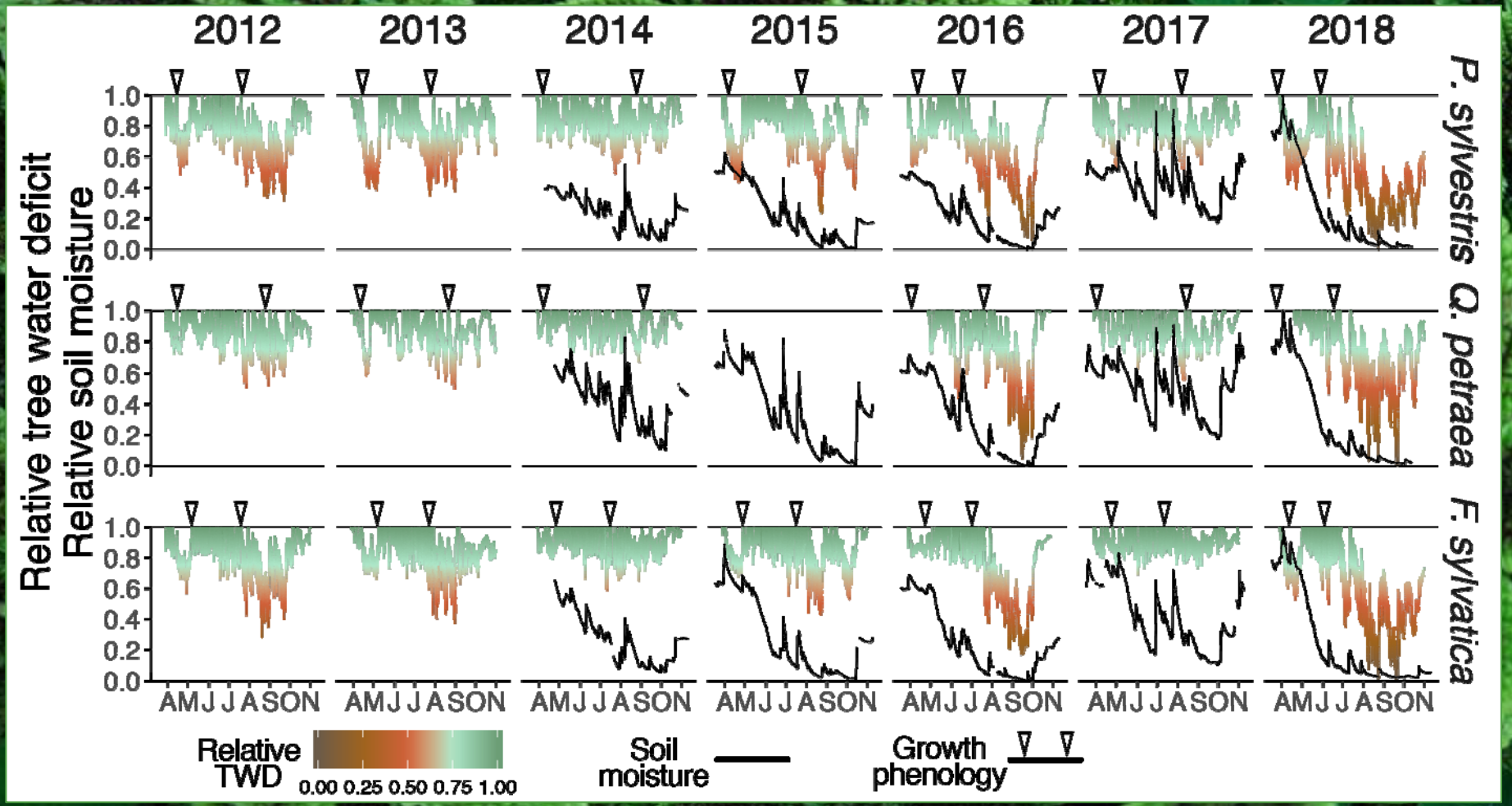
Tree water deficit + soil moisture + growth phenology



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Causal links between tree stem mechanics and the environment

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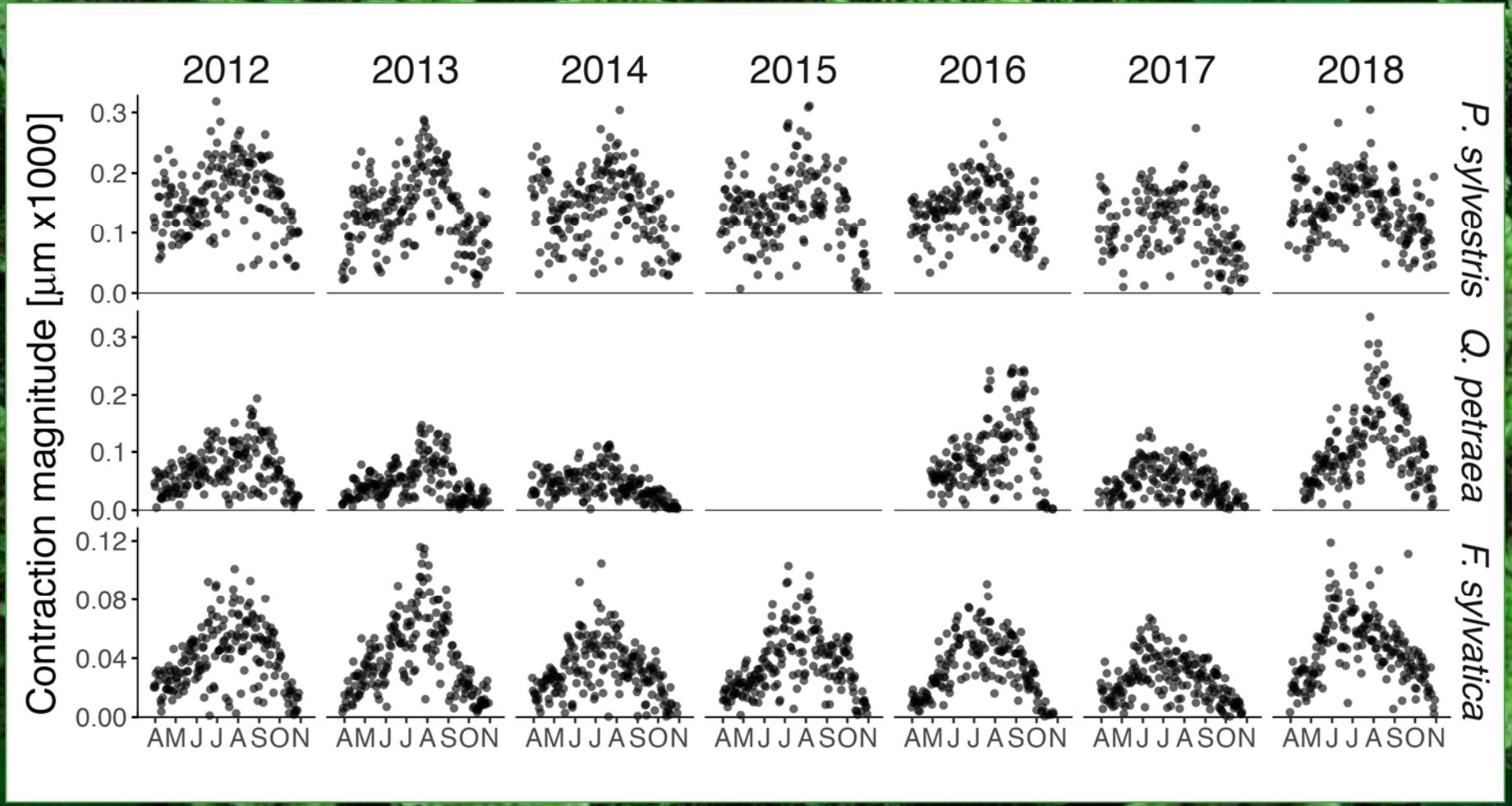
Diurnal stem dynamics – tree stem shrinkage



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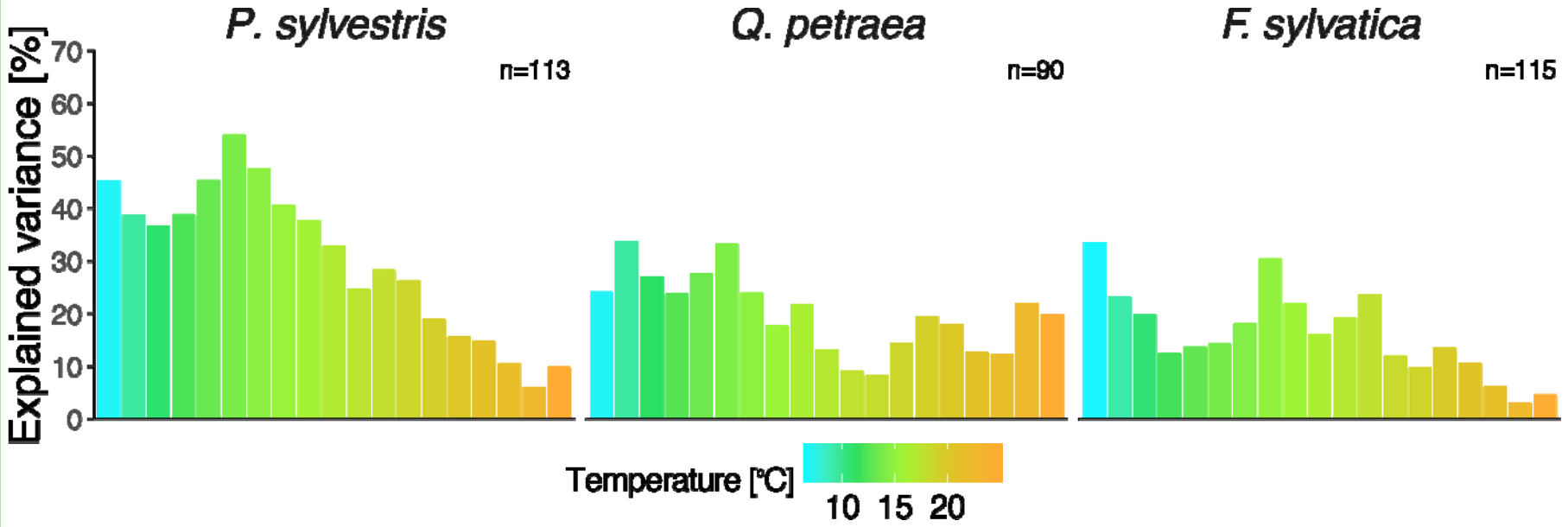
Causal links between tree stem mechanics and the environment

PLS regression model: Contraction magnitude ~ TEMP + RAD + VPD + RH + PPT
Subset condition: **Temperature**



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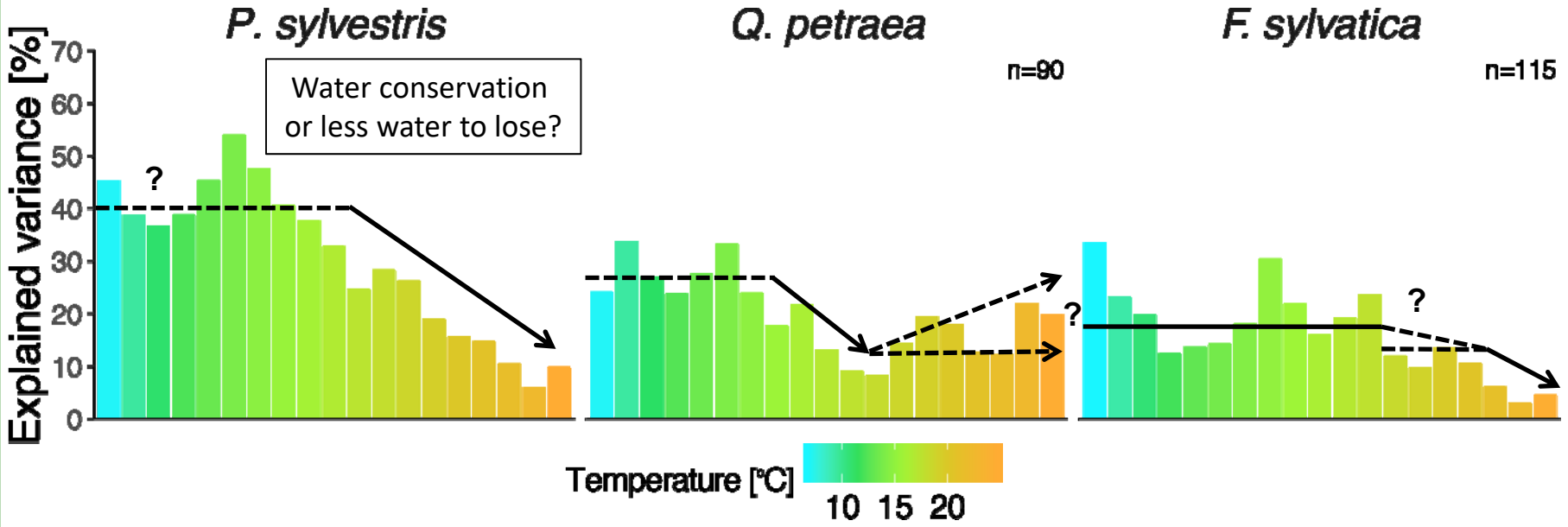

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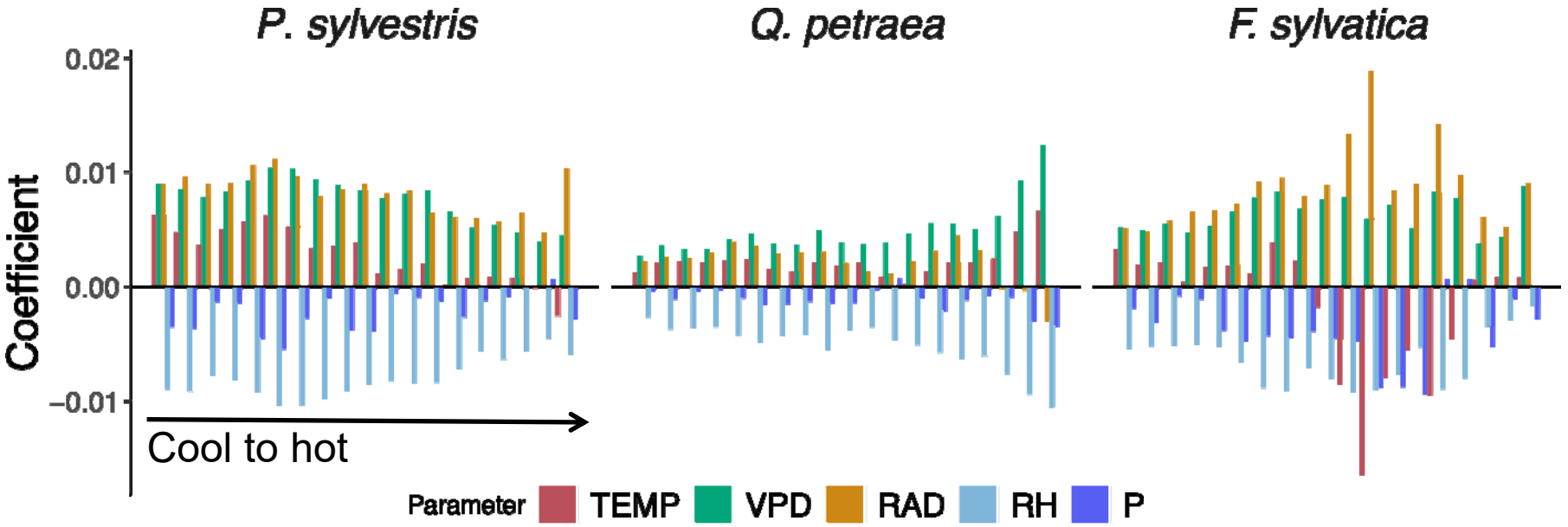

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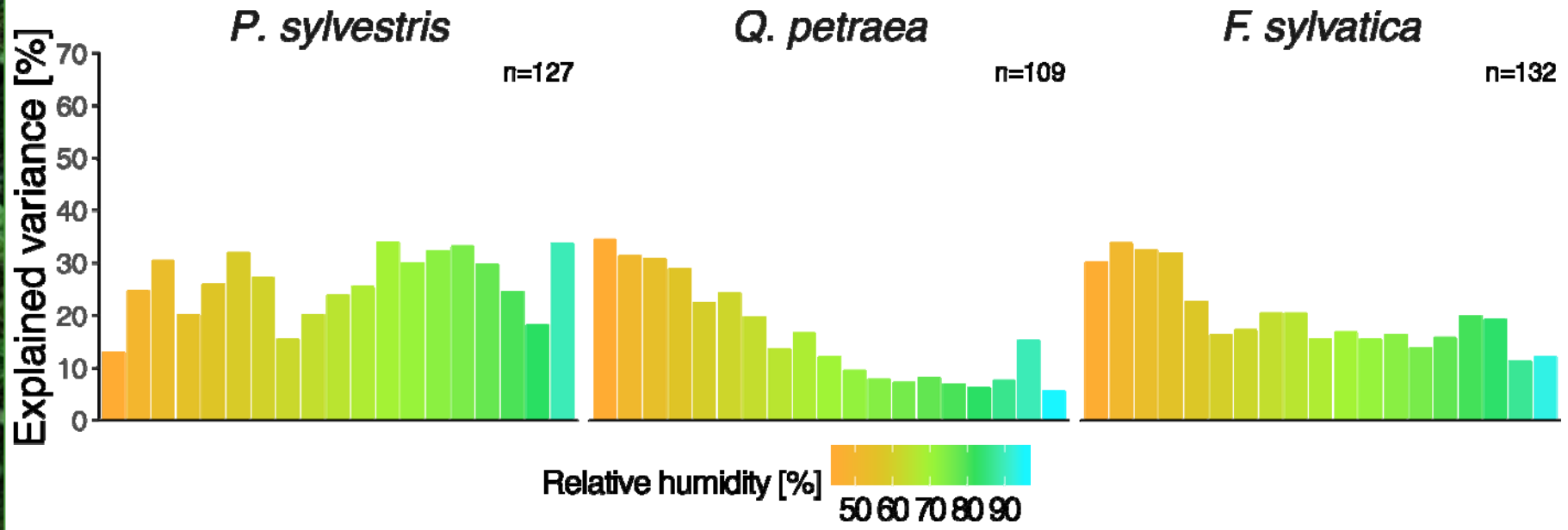
PLS regression model: Contraction magnitude ~ TEMP + RAD + VPD + RH + PPT
Subset condition: **Relative humidity**



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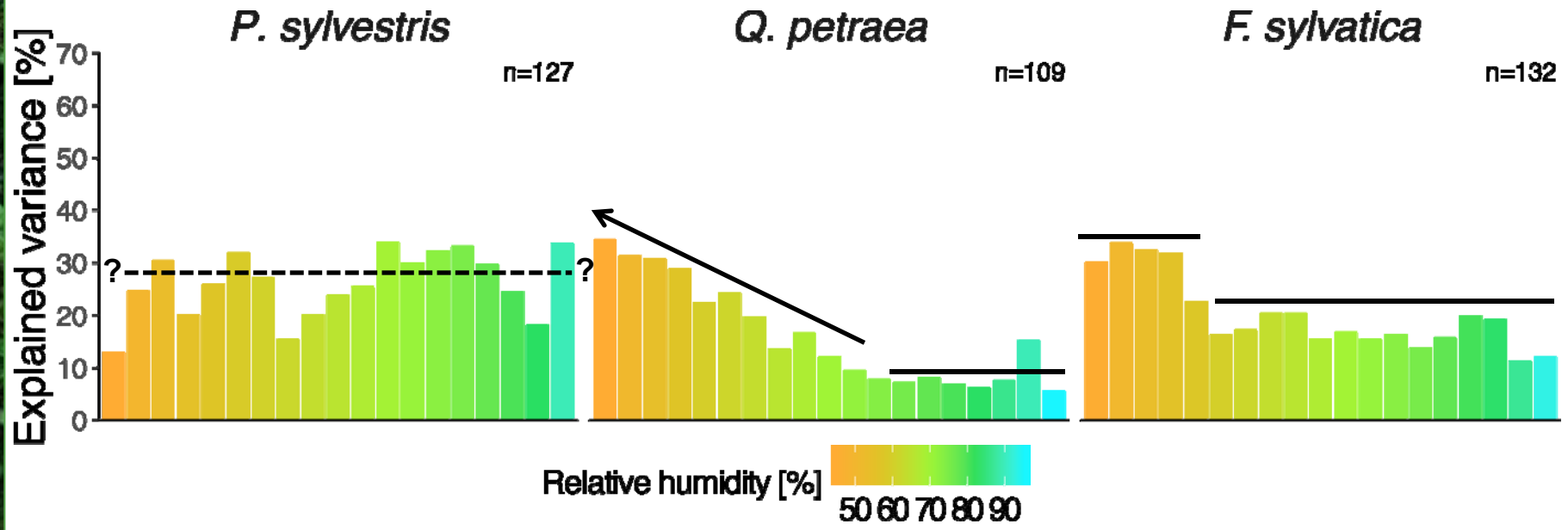

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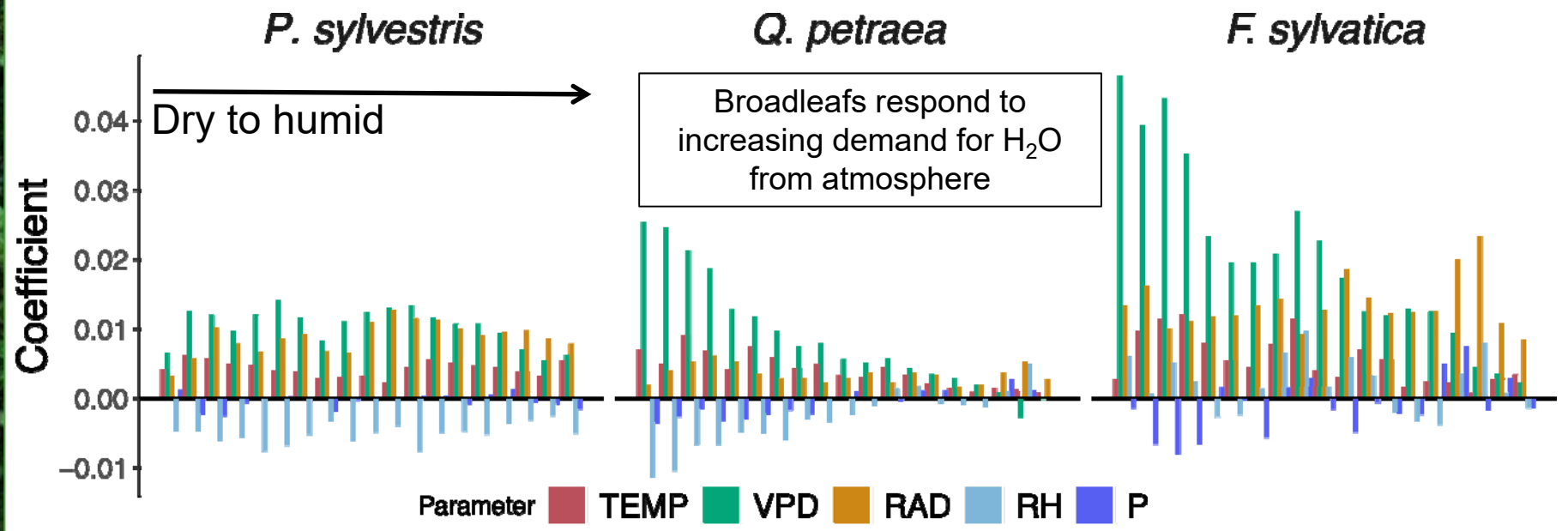

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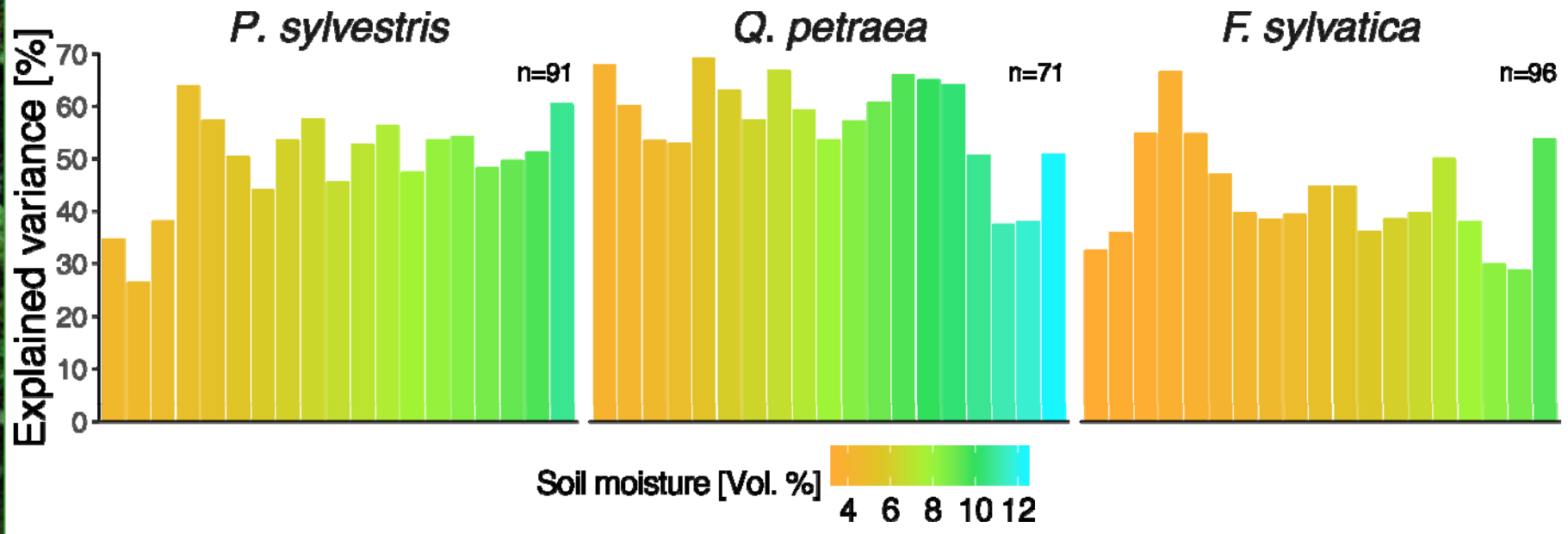

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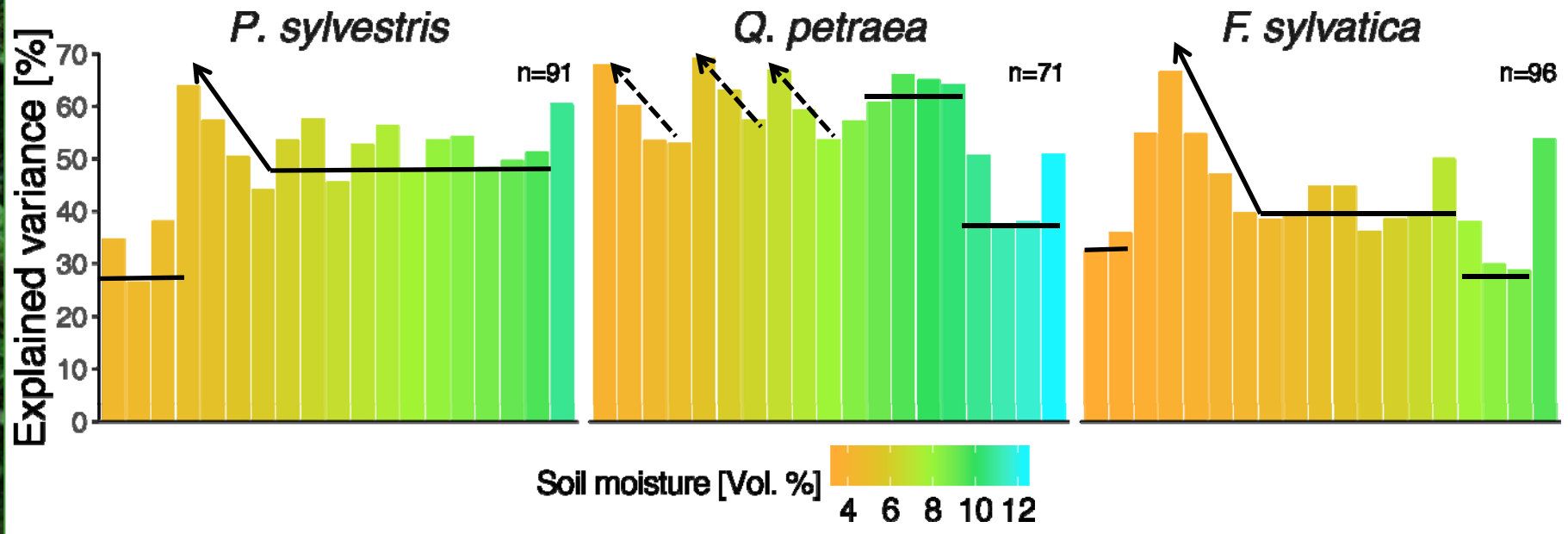
Causal links between tree stem mechanics and the environment

PLS regression model: Contraction magnitude ~ TEMP + RAD + VPD + RH + PPT
Subset condition: **Soil moisture**



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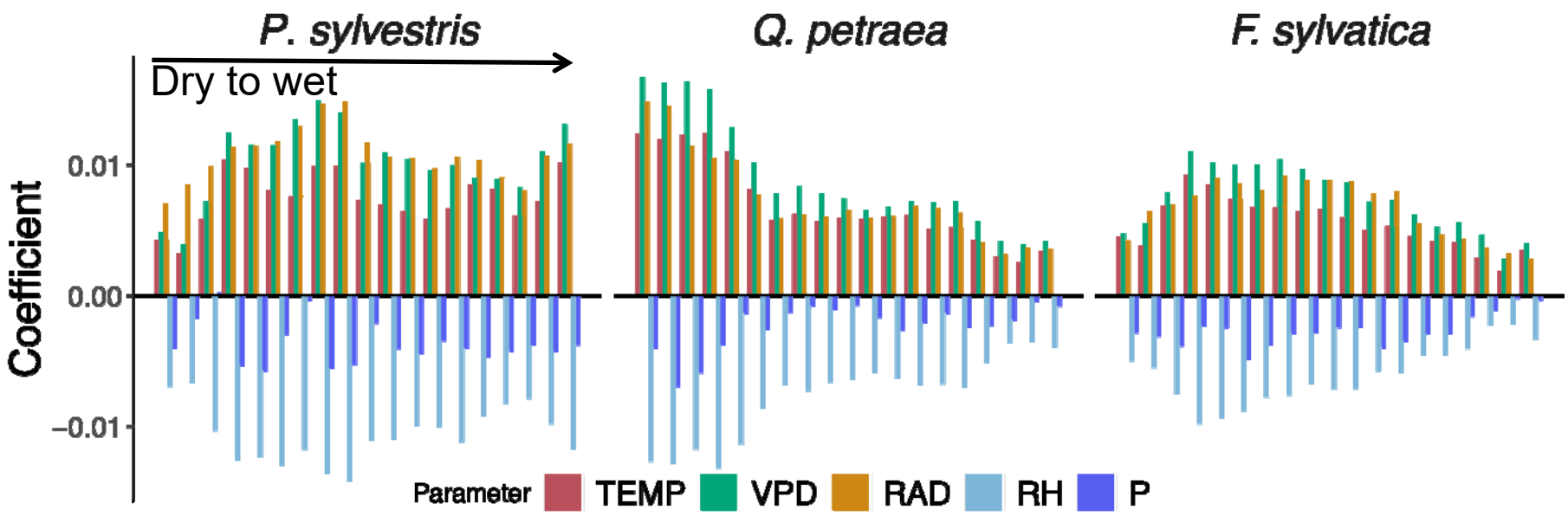

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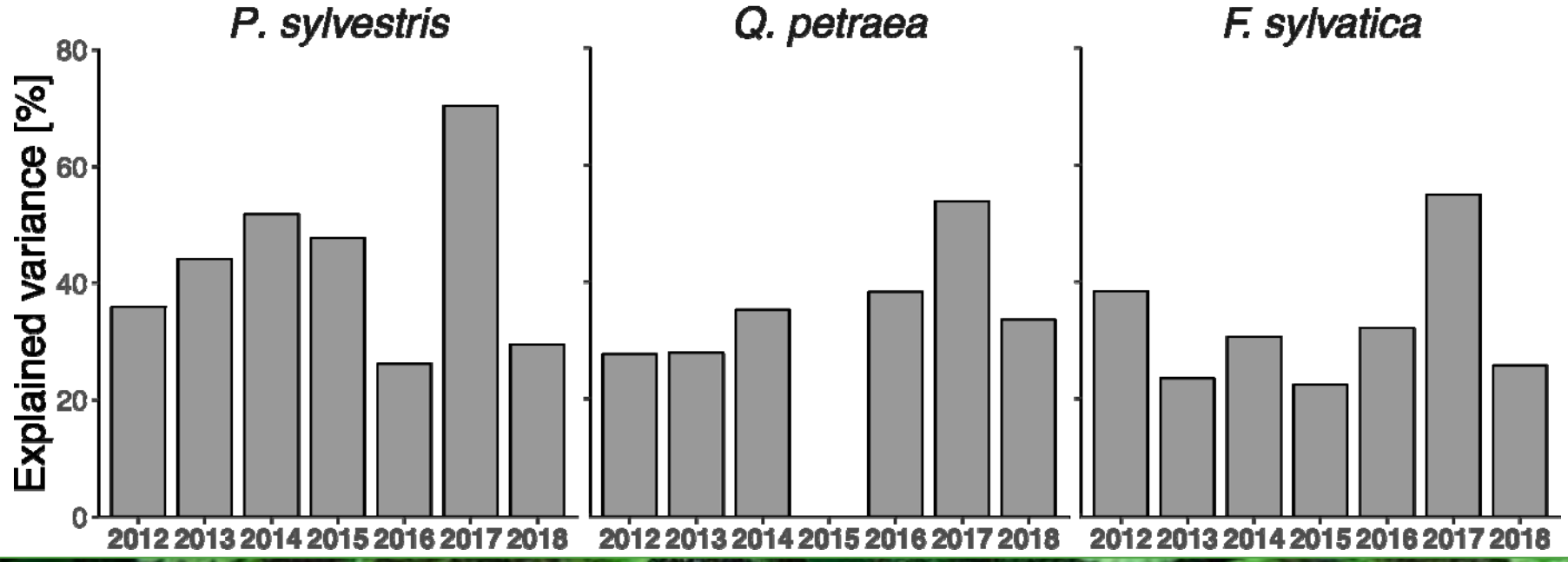
Subset condition: **Year**



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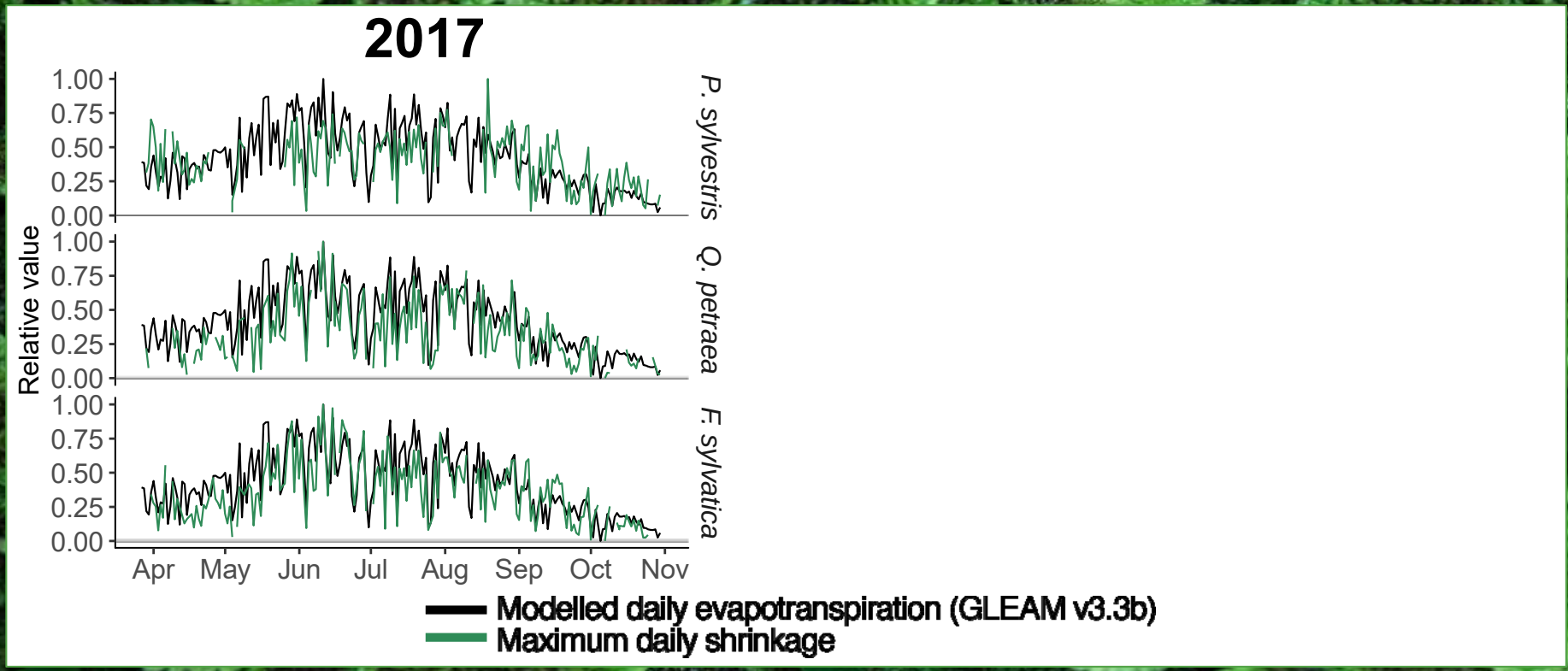
Daily tree stem shrinkage vs. modelled evapotranspiration



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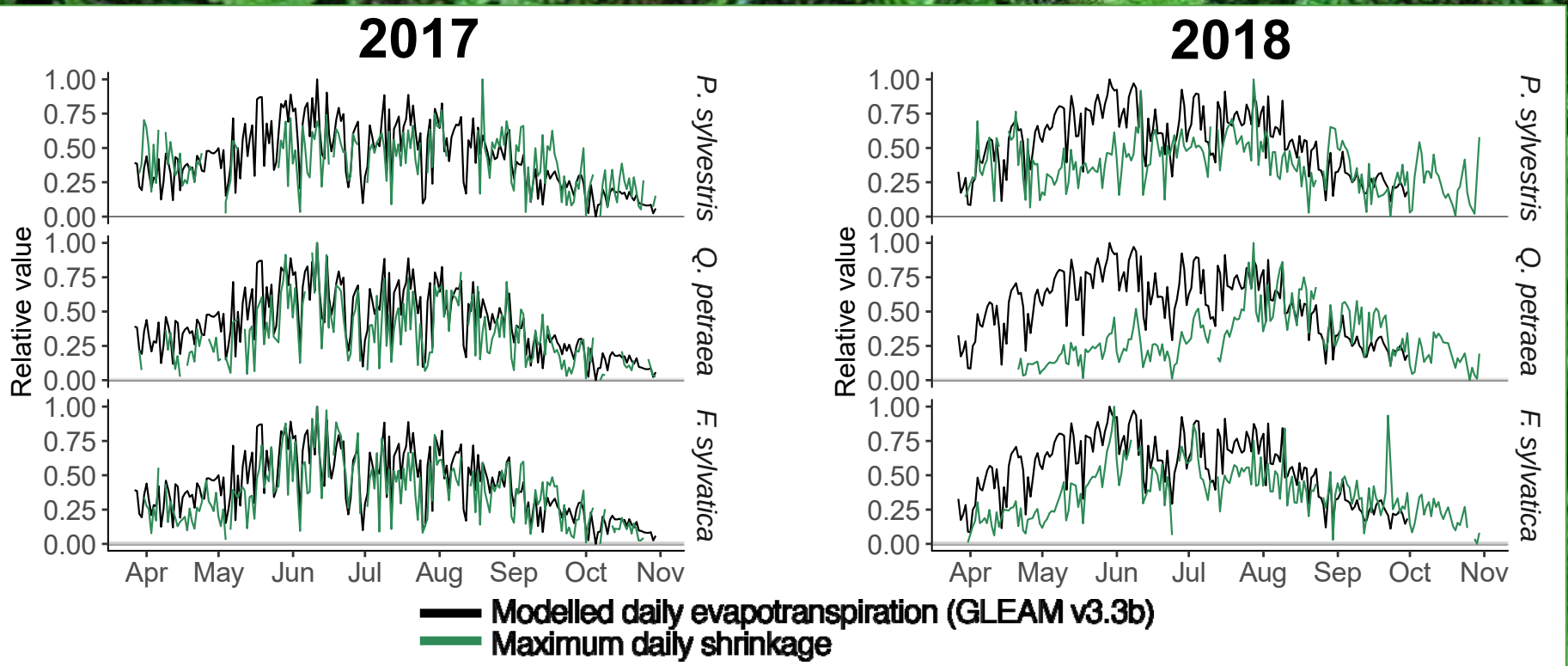

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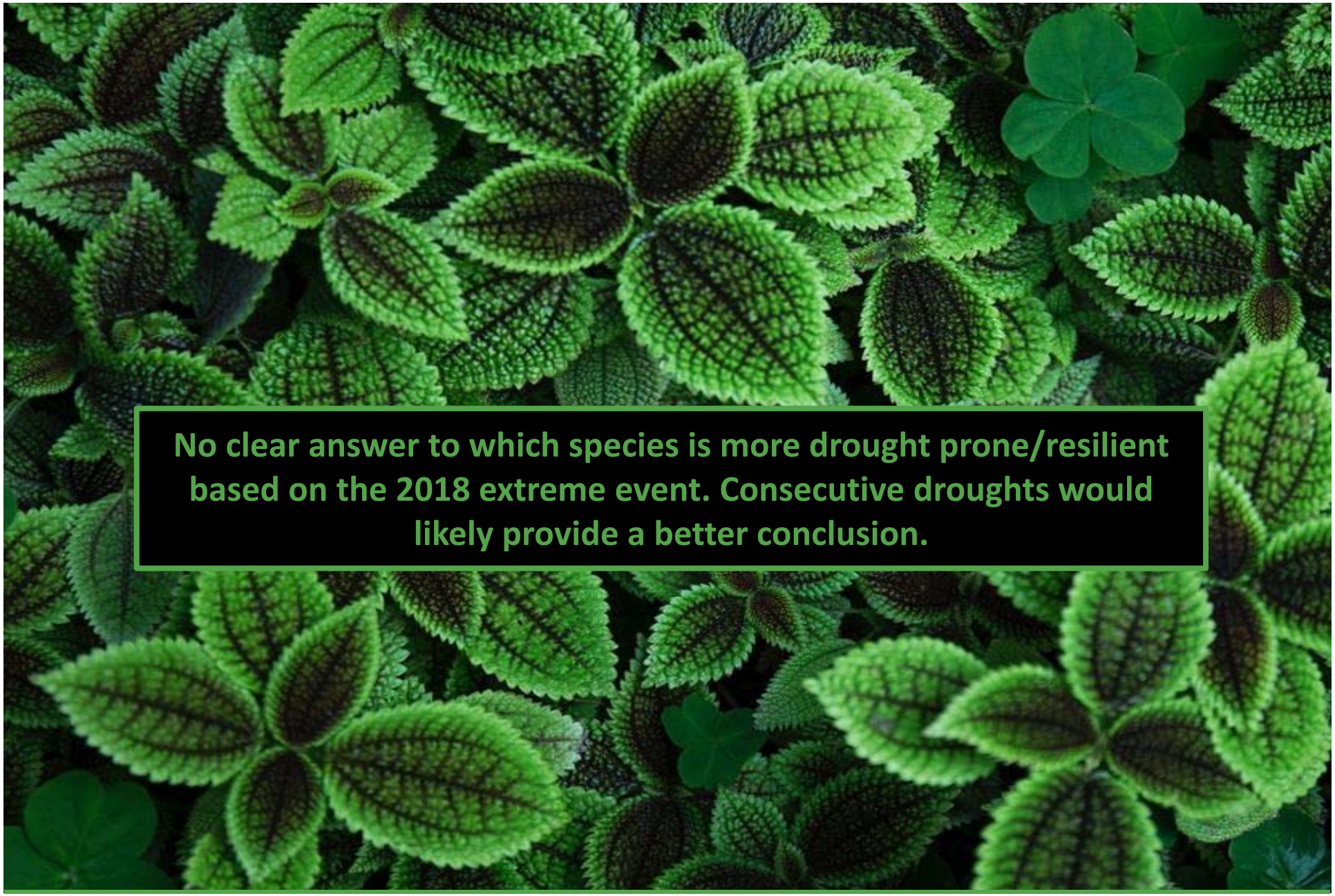

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