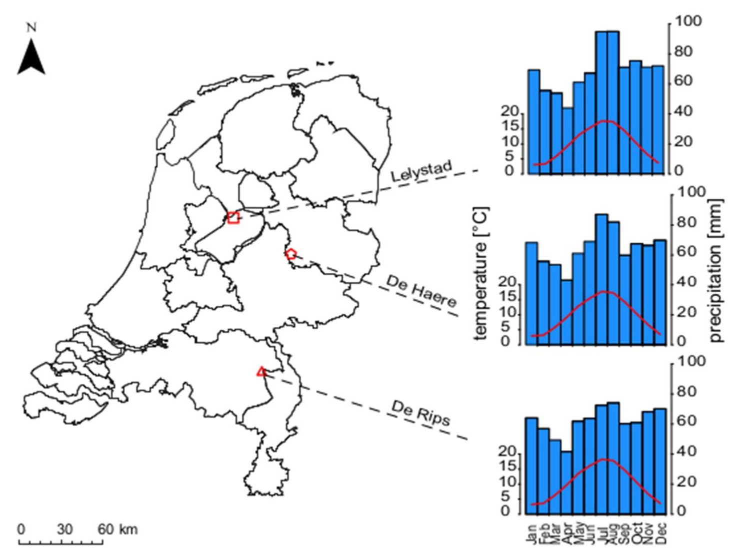
Provenance selection and site conditions determine growth performance of *Quercus robur*

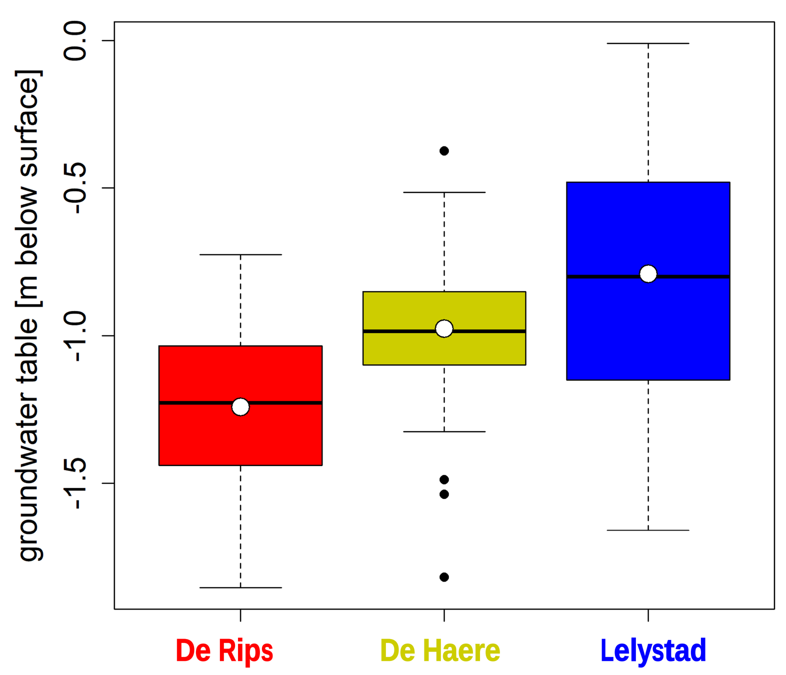
Allan Buras (allan@buras.eu), Ute Sass-Klaassen, Inge Verbeek, Paul Copini

1. Study design

To better understand the effects of site conditions and genotype on growth performance of *Quercus robur* we analysed tree-ring data of 10 dutch provenances represented at 3 dutch oak provenance trials established in 1990. Each provenance-site combination was represented by 10 trees, resulting in tree-ring data from altogether 300 trees. The 3 sites feature rather similar climatic conditions (**A**). However, while Lelystad is characterized by a clay-rich soil and an on average high groundwater table, the sites De Haere and De Rips feature sandy soils and comparably lower groundwater tables (**B**).



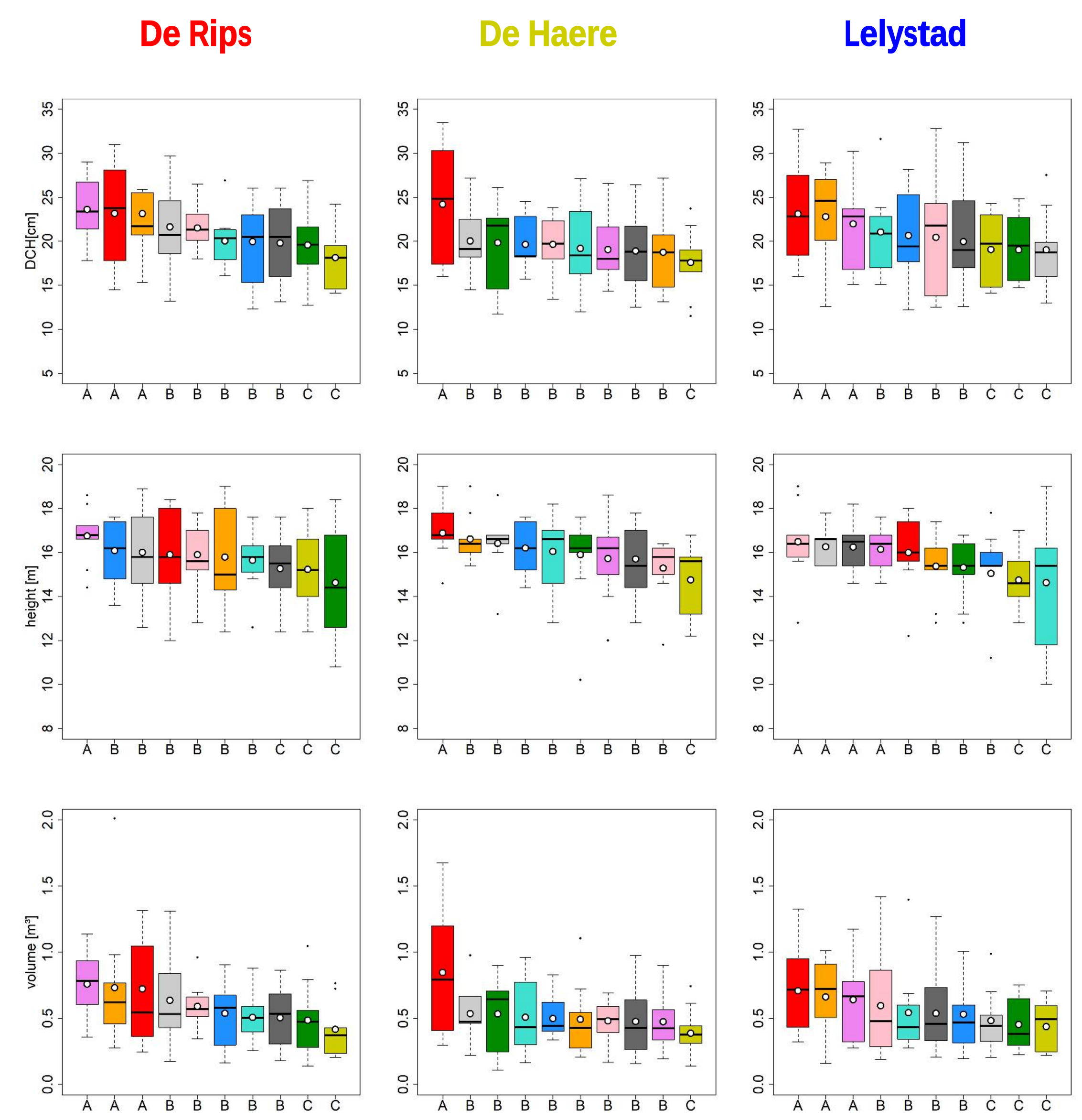
A: Location and climate of the three different oak provenance trials studied.



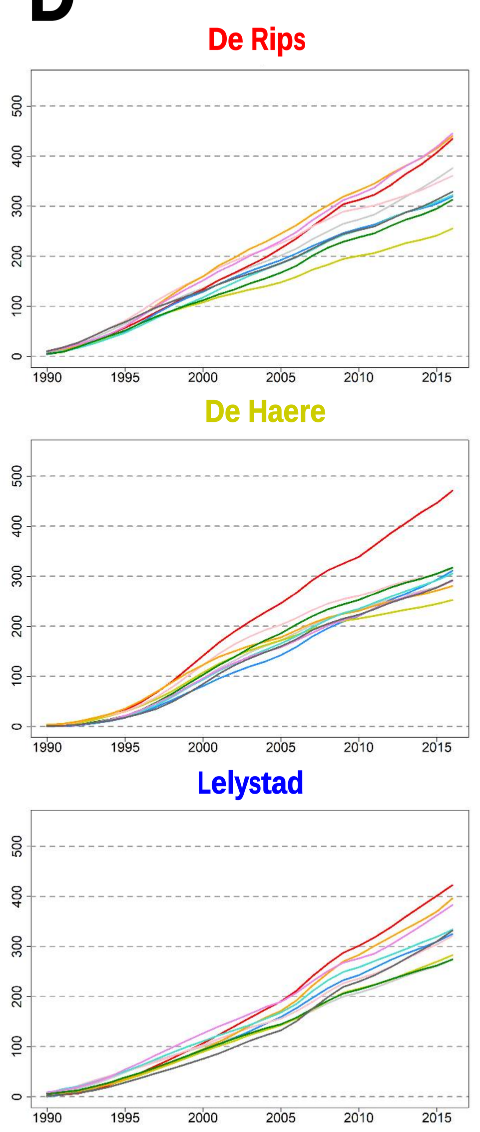
B: Groundwater tables at the study sites. Groundwater tables differ significantly among sites according to pairwise Wilcoxon rank-sum test.

2. Insights

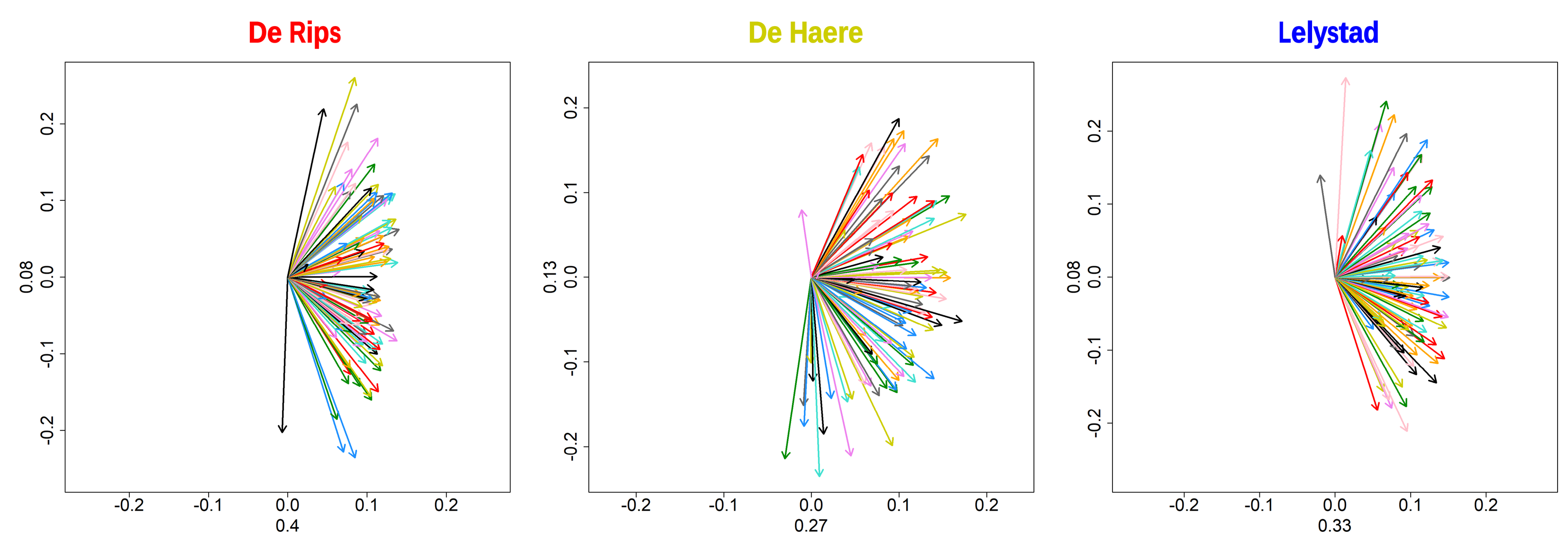
Genotype effects: At each site, we found clear differences among provenances regarding tree stature (**C**) and annual wood production (**D**). Specific provenances performed superior (e.g. red in C and D) or inferior (olive-green) in all sites. Using Principal Component Gradient Analysis (Buras et al., 2016) we could not identify provenance-specific high-frequency growth patterns (**E**).



C: Diameter at coring height (DCH), tree height, and tree volume pooled by provenance (colors) and site (left, center, right panels). Letters indicate group association according to pairwise Wilcoxon rank-sum test. Panels D and E use the same color coding.

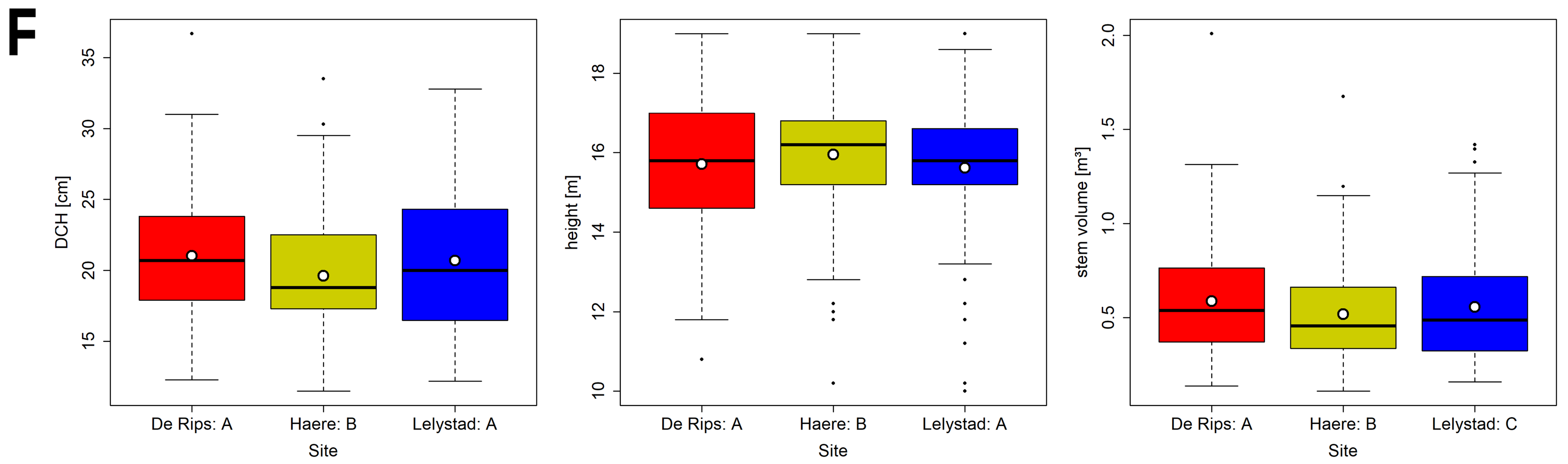


D: Cumulative basal area time-series for each provenance at each site.

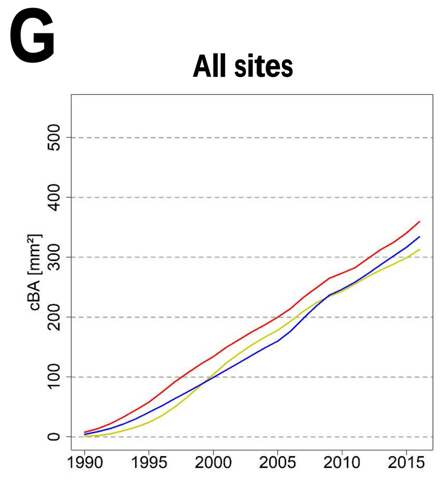


E: PCGA-loadings colored according to provenances for each site. The lack of color-wise clusters of loadings suggests no existence of provenance specific high-frequency growth signals.

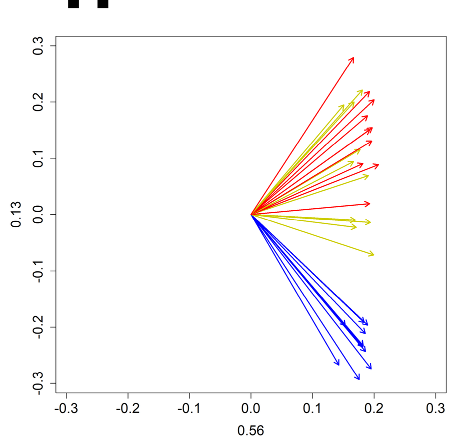
Site effects: Wood production differed more among provenances at a given site than between sites (**C** vs. **F** and **D** vs. **G**). In general, the average absolute wood production was comparably high at all sites. PCGA identified a clear grouping of De Rips and De Haere which were clearly separated from Lelystad (**H**). Chronologies of detrended ring-widths indicated no strong impact of the severe drought in 2003 but a site-specific response to a late-frost event in 2010 (**I**). Climate correlation analyses indicated a tendency towards early-season drought-stress at De Rips and De Haere, as represented by negative effects of previous June temperature and positive effects of previous year water availability index SPEI (**J**). In contrast Lelystad featured a negative correlation with previous August, which however was not reflected in SPEI. Concluding, it seems that oaks growing at sites with sandy soil texture and lower groundwater tables (De Rips and De Haere) might be more affected by early-season drought than those growing at clay-rich sites with high groundwater table (Lelystad). Whether the observed patterns are more pronounced for old-grown trees in comparison to the yet young trees studied here (25 years) remains to be studied. These findings are supported by similar effects of soil conditions on growth variability of Norway spruce (Rehschuh et al., 2017).



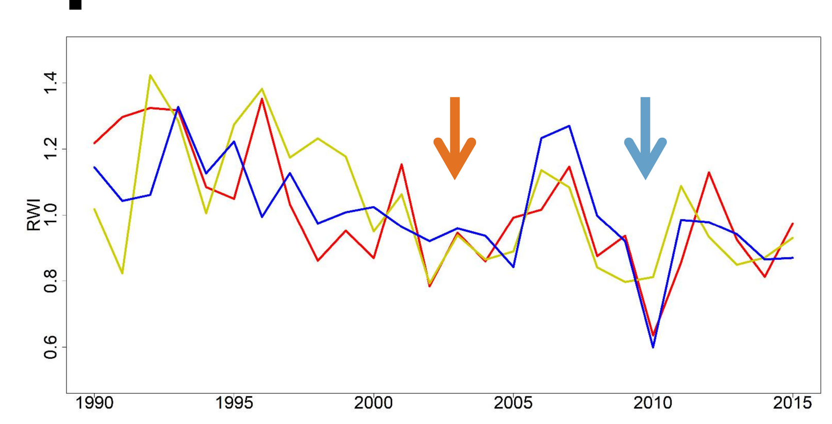
F: Diameter at coring height, tree height, and tree volume differ marginally significant between sites. Letters A, B, C refer to grouping according to pairwise Wilcoxon rank-sum test. The site-specific color code is also used in G, H, I, and J.



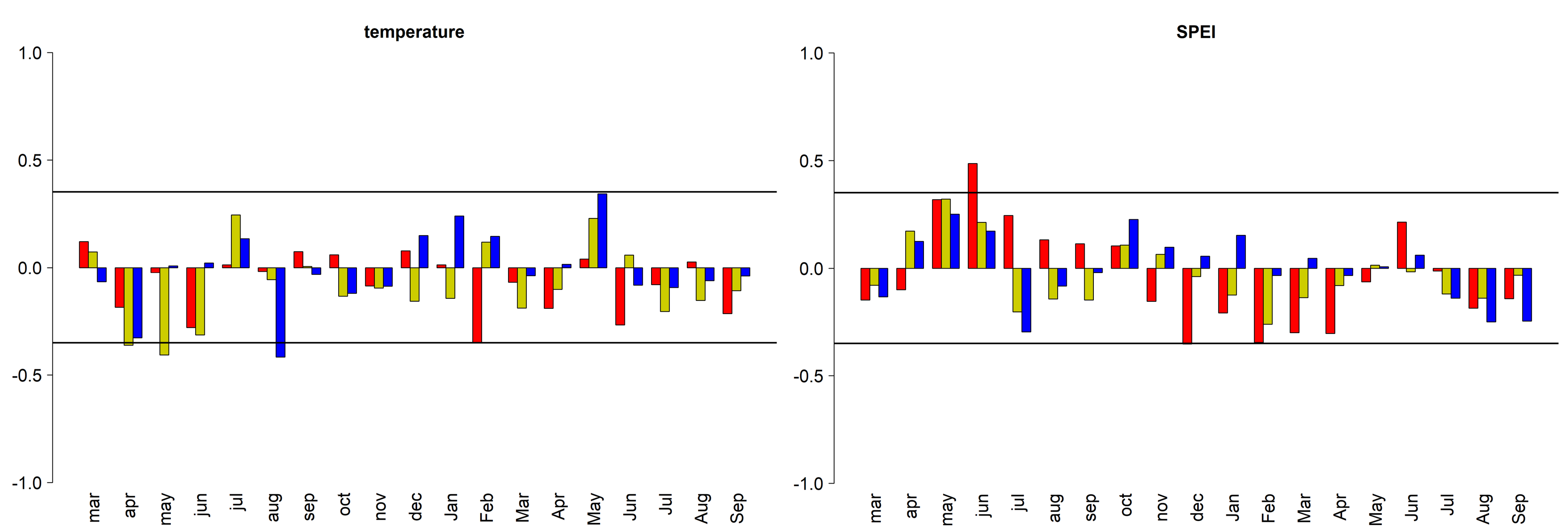
G: Cumulative basal area time-series for each site.



H: PCGA-loadings colored according to sites. Loadings from De Rips and De Haere form a cluster distinct from Lelystad.



I: Site-chronologies of pre-whitened ring-width data for each site. The growth decline in 2010 refers to a late-frost event in May (blue arrow). Please also note the lack of a negative pointer year in 2003, i.e. a strong drought-event in the Netherlands (orange arrow).



J: Climate-growth correlations of pre-whitened site chronologies with monthly temperature and the SPEI – an index for water availability. Please note the tendency towards negative temperature impact and positive water availability impact in De Rips and De Haere in June of the year prior to ring-formation which was not observed for Lelystad, which however featured a negative response to previous year August temperature.

3. Key messages

I. Genotype determined absolute growth and tree stature of pedunculate oak across sites.

II. Site-specific soil conditions governed high-frequency growth variability of pedunculate oak.

→ **Site conditions are an important factor to consider when evaluating provenance trials regarding their ability to cope with climate extremes such as heat and drought.**

(see also Klisz et al., 2019)

Cited references:

Buras *et al.*, 2016: Tuning the Voices of a Choir: Detecting Ecological Gradients in Time-Series Populations. *PLOS ONE* **11,** e0158346.

Rehschuh *et al.*, 2017: Soil properties affect thr drought susceptibility of Norway spruce. *Dendrochronologia* **45**, 81-89.

Klisz *et al.*, 2019: Limitations at the limit? Diminishing of genetic effects in Norway Spruce provenance trials. *Frontiers in Plant Science* **10,** 306.

Acknowledgements:

This study was supported by the Stilte-Stichting Landgoed Den Bosch. We thank the Centre for Genetic Resources, The Netherlands (CGN) and State Forestry Service (staatsbosbeheer) for permission using the provenance trials.