PROJECT INFORMATION

Project title:	**Assessment of weather typologies and remote sensing data to explain and predict acorn production in *Quercus robur* and *Quercus petreae***
Project ID:	232
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PROJECT DESCRIPTION

Motivation

Weather is thought to be a key proximate factor in mast seeding, in part due to its ability to act as a large-scale synchroniser of masting events (Norton and Kelly 1988; Bogdziewicz et al. 2017, 2021). Current studies on the influence of the weather on masting species' reproduction give varied, and occasionally contradictory results, with differing species-specific responses to the same weather events (García-Mozo et al. 2007; Bisi et al. 2016; Koenig et al. 2016; Bogdziewicz et al. 2019). The differing reactions to weather cues and resulting seed production reported in the literature may in part come from between-species variation in their life history and reproductive cycles (Pérez-Ramos et al. 2015; Bogdziewicz et al. 2019), but may also come from reactions to weather cues changing depending on the climate (Masaki et al. 2008; Poncet et al. 2009; Mooney et al. 2011), or the stage of the reproductive cycle the tree is in when the weather cue occurs (Buechling et al. 2016; Allen et al. 2017). Species-specific studies considering the interaction of the environment at each stage of a masting species reproduction are now required. Due to the complexity of interacting factors, one promising avenue for research is to use Principal component and K-means clustering applied to temporal datasets (as used in Addy et al. 2021). This method takes intra-annual weather patterns and uses them to create distinct yearly categories. This approach may be able to define the weather typologies most likely to result in a masting year. It may generate predictions on how climate change will impact masting and represents our best chance forecasting masting behaviour will change in the future.

Research objective

This research will generate annual weather typologies to be applied to long-term data on acorn production. We will determine if this method of categorisation can be used to i) explain past and predict future masting events, ii) be used to predict how masting will be affected by future anthropogenic climate change and iii) assess if there are continental scale differences within the same species. Other analytical approaches will also be applied.

Research methods

Study system

Oaks serve as an important umbrella species for biodiversity in the UK. The two UK native oak species, Quercus robur L. and Quercus petreae (Matt.) Liebl. have been recorded to support 2300 species of birds, bryophytes, fungi, invertebrates, lichen and mammals (Mitchell et al. 2019). Other ecosystem services that oak forests provide include, climate regulation, biomass production, water supply, purification and flood defence (Bauhus et al. 2010; Brockerhoff et al. 2013; Thompson et al. 2014; Sing et al. 2015). UK oaks will mast on average around every 4-7 years, requiring long term data sets to be able to appropriately study their reproduction.

Procurement of acorn crop data

Some acorn production data has already been acquired on the regional and population scale from Forestry England, UK. We have permission to access the records of a UK based seed producer (Forestart, Shropshire), this shall enable us to clarify if low numbers of acorns recorded in Forestry England's data are a result of poor acorn crop and not lack of collection effort. The ICP Forests data will be vital to ensure suitable numbers of independent UK replicates, as well as granting between-country comparison.

Procurement of Environmental data:

In addition to the meteorological data offered from the ICP Forests database, long-term weather station data from the UK Meteorological Office shall be obtained from the most applicable weather stations for each set of acorn production data. If further data is needed for sites outside the UK, then we can obtain this from the country specific meteorological organisation's long-term databases.

Changes in canopy cover have been shown to give some level of predictive power for masting events (Camarero et al. 2010), and should be considered in parallel to weather variables when attempting to predict mast events. The Normalized Difference Vegetation Index will be obtained from ESA's open-source Sentinel-2 or LANDSAT database. This can then be paired to the location of the acorn production data. NASA's open-source data also includes measures of global terrestrial evapotranspiration and leaf area index (LAI). Further data on soil and woodland characteristics shall be obtained from online sources (e.g., soilscapes).

Statistical analysis

The study shall use Principal component and K-means clustering (as used in Addy et al. 2021) applied to temporal datasets of weather patterns and acorn production. The analysis shall also include remote sensing data of canopy growth as well as consideration to other abiotic factors such as forest age, forest health and soil condition etc. Principal component analysis is an exploratory analysis used to define the most important sources of variation within complex systems (Wold et al. 1987). To appropriately group the results from the Principal Component Analysis into annual categories we shall use a k-means clustering procedure (Hartigan and Wong 1979). Other analytical approaches will also be applied. All such statistical analyses shall be performed using R v 3.6.1 (R Core Team 2019).

Timescale

The project shall begin in Summer 2021, with model building and analysis taking place over Winter 2021/22. The project shall conclude at the latest March 2024 where I shall have completed my PhD project.

Expected outcomes

The outcome of our study will enable prediction of masting events, enabling more efficient use of resources to collect acorns for conservation or seed orchards. Further understanding of the mechanistic drivers behind oak masting will improve the predictive power as to how climate change could shape UK and EU oak forests, and hint at best practices or management approaches to adopt to limit the potential damage of climate change on oak health.

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