Dendrochronological investigations of Scottish Oak trees and their response to climate and disturbance

Curious12

Global Environmental Change

IAP2-20-114

Overview

Understanding woodland resilience to environmental change requires insights on longer timescales than is currently possible using standard management tools. In recent years, within Scotland, a good knowledge of the impact of past timber exploitation and climate change has been derived for Scots pine using dendrochronological methods (Rydval et al. 2015, 2016, 2017). However, very little is known about the long-term impacts of climate and management on Oak woodlands. Scottish oak woodlands are strongly fragmented with wide ranging ecologies – from the wetter Atlantic realm where oak reaches its northernmost biogeographical limits (Baarda 2005), to the drier lands in the east, including both lowland and upland environments. Although many individual trees in these woodlands are likely 200-300 years in age, it is not known how they responded to the cooler conditions and periods of peak management in the 18th-19th centuries (Smout 2005). It is also unclear how oak trees growing in very different ecological situations may fare in the coming decades (Ray 2008).

This project, using a spatial network of Oak woodlands, aims to undertake a range of dendrochronological analyses necessary to assess the response of oak trees (pedunculate and sessile) to both current and past climate change and examine the influence of different management techniques on growth and resilience. This will enable us to better inform current management strategies for the different regions to increase woodland resilience in the decades to come. As a subsidiary aim, the project will also explore the potential of using stable oxygen isotopes measured from the latewood of oak tree-rings to improve historical dating (Loader et al. 2019) as well as reconstructing past precipitation (Loader et al. 2020).

Methodology

We plan to sample a network of about 20 oak woodland sites across the full species distribution within Scotland including both lowland and upland oak woodlands, the western “cool rainforest” as well as drier sites in the east and south. Further, both semi-natural and old plantation and parkland sites will be targeted.

At each site the following fieldwork protocol will be employed:
1. A brief site ecological assessment will be performed – including an assessment of ground flora assemblages to assess the site ecological types.
2. Quadrat assessment of tree stand density for different tree size cohorts
3. 5mm wood sample cores will be extracted from 30 trees for

Supervisory Team

Rob Wilson
University of St Andrews

Alistair Jump
University of Stirling

Althea Davies
University of St Andrews

Coralie Mills
University of St Andrews

Eileen Tisdall
University of Stirling

Collaborators

Neil Loader
Prifysgol Abertawe
Swansea University

Further Information

for informal enquiries, contact:

Rob Wilson

rjsw@st-andrews.ac.uk

University of St Andrews

Key Words

- Oak
- climate
- disturbance
- management
- resilience

dendrochronological analyses using Swedish increment corers.
4. A further subset of 10mm cores will also be extracted from 5 trees per site for stable isotope analyses.

Lab work:
1. Sample cores will be slowly air dried, mounted, sanded and polished.
2. Ring-width will be measured from scanned images of the samples and crossdated between trees.
3. Experimental measurement of Blue Intensity (Rydval et al. 2014) and earlywood vessel area (Davies and Loader 2020) will also be performed.
4. On a subset of sites, individual latewood increments will be removed from dated cores selected from surveyed forest stands across the network. Cellulose will be extracted for stable isotope analysis. Both carbon and oxygen isotopes will be determined simultaneously by high temperature pyrolysis. Resulting time-series will be calibrated against instrumental climatic data and their spatial coherence assessed with a view to testing their potential as a precision historical dating tool.

Analyses:
1. Site ecological assessment, tree age and recruitment/mortality dynamics
2. Tree-ring data detrending and chronologies developed for comparative analyses.
3. Assessment of periods of non-coherence between sites which may reflect site specific response to disturbance and management
a. Some historical archival work may be employed, if documents exist, to understand / interrogate / interpret the disturbance and management history
4. Disturbance intervention analysis (Druckenbrod et al. 2013) to identify periods of anomalous suppression and release in individual tree records.
5. Climate response and its expression through space and time
6. Utilisation of ring-width, isotopic data, vessel area and blue intensity to create reconstructions of past hydroclimate (likely precipitation).

Project Timeline

Year 1

1. Sep 2021: Late summer fieldwork to sample a couple of sites to allow laboratory training for PhD student over the winter months
2. Winter period: focus on reading and planning (including site identification) for spring/summer 2022 fieldwork.
3. Training in stable isotope methods (Swansea)

Year 2

1. March-September 2022 Ã¢â,¬â€œ fieldwork to sample all 20 oak woodland sites for the project
2. September 2022-Spring 2023 Ã¢â,¬â€œ Lab work to generate site ring-width chronologies
3. Preliminary ring-width analyses to assess stand dynamics, disturbance, climate response etc
4. Use preliminary RW based analyses to identify subset of sites for isotopic measurement
5. Commence development of stable isotope chronologies

Year 3

1. Finalise assessment and analysis of stand dynamics, disturbance, climate response
2. Complete isotopic measurements

Year 3.5

Final analyses to bring all the different data sources together leading towards final write up by the spring of 2025

Training & Skills

Fieldwork methods including tree coring, site ecological assessment.
Laboratory methods including sample preparation, crossdating and the measurement of ring-width, stable isotopes, vessel area and blue intensity.
Analysis methods: Chronology development, modelling (growth and climate) and intervention analysis to identify anonymous trends due to disturbance

References & further reading

Baarda, P., 2005. Atlantic oakwoods in Great Britain: factors influencing their definition, distribution and occurrence. Botanical Journal of Scotland, 57(1-2), pp.1-19.

Davies, D. and Loader, N.J., 2020. An Evaluation of English Oak Earlywood Vessel Area as a Climate Proxy in the UK. Dendrochronologia, p.125777.

Druckenbrod, D.L., Pederson, N., Rentch, J. and Cook, E.R., 2013. A comparison of times series approaches for dendroecological reconstructions of past canopy disturbance events. Forest ecology and management, 302, pp.23-33.

Loader, N.J., Mccarroll, D., Miles, D., Young, G.H., Davies, D. and Ramsey, C.B., 2019. Tree ring dating using oxygen isotopes: a master chronology for central England. Journal of Quaternary Science, 34(6), pp.475-490.

Loader, N.J., Young, G.H., McCarroll, D., Davies, D., Miles, D. and Bronk Ramsey, C., 2020. Summer precipitation for the England and Wales region, 1201Ã¢â‚¬â€œ2000 ce, from stable oxygen isotopes in oak tree rings. Journal of Quaternary Science, 35(6), pp.731-736.

Ray, D., 2008. Impacts of climate change on forestry in ScotlandÃ¢â‚¬â€œa synopsis of spatial modelling research. Forestry Commission Research Note, 101(8).

Rydval, M., Larsson, L.Ãƒâ€¦., McGlynn, L., Gunnarson, B.E., Loader, N.J., Young, G.H. and Wilson, R., 2014. Blue intensity for dendroclimatology: should we have the blues? Experiments from Scotland. Dendrochronologia, 32(3), pp.191-204.

Rydval, M., Druckenbrod, D., Anchukaitis, K.J. and Wilson, R., 2016. Detection and removal of disturbance trends in tree-ring series for dendroclimatology. Canadian Journal of Forest Research, 46(3), pp.387-401.

Rydval, M., Gunnarson, B.E., Loader, N.J., Cook, E.R., Druckenbrod, D.L. and Wilson, R., 2017. Spatial reconstruction of Scottish summer temperatures from tree rings. International Journal of Climatology, 37(3), pp.1540-1556.

Rydval, M., Loader, N.J., Gunnarson, B.E., Druckenbrod, D.L., Linderholm, H.W., Moreton, S.G., Wood, C.V. and Wilson, R., 2017. Reconstructing 800 years of summer temperatures in Scotland from tree rings. Climate Dynamics, 49(9-10), pp.2951-2974.

Smout, T.C., 2005. Oak as a commercial crop in the eighteenth and nineteenth centuries. Botanical Journal of Scotland, 57(1-2), pp.107-114.

Further Information

Prof. Rob Wilson [rjsw@st-andrews.ac.uk] School of Earth and Environmental Sciences
University of St Andrews
St Andrews. FIFE. KY16 9AL
Scotland. U.K.
Tel: 01334 463914