Acute Oak Decline: Detecting and understanding the tipping points and feedbacks through soil microbial process indicators

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Acute oak decline (AOD) is a relatively new and specific decline syndrome threatening the native oak species (*Quercus robur* and *Quercus petraea*) in Britain. Opportunistic pathogenic bacteria that are likely widespread in the oak microbiome are widely accepted causal factors for the best-known symptoms, dark bleeds on oak stems, which can lead to crown dieback and tree death, causing much concern among land-owners regarding tree survival.

Acute Decline symptoms on oak trees (Photographs by Sandra Denman and Nathan Brown).

AOD has been widely discussed as fitting a general decline disease model [1] in tree health. This model implies that complex changes in an ecosystem create a threshold whereby a stressed organism changes from a healthy state to a state vulnerable to opportunistic infection and involves an initial role of environmental predisposition in weakening host resilience. AOD occurrence has been shown to be correlated with climate and atmospheric deposition factors which might act in predisposition [2]. However, given that AOD affects individual trees within stands or localised clusters rather than whole stands [3] but climate-and atmospheric-deposition factors act at population scales or larger, it is not possible to explain the distribution of symptomatic trees solely as a function of these large-scale processes.

We know that forest soils are notoriously heterogenous at relevant scale and microbially-mediated biogeochemical processes in soil (i.e.

Decline disease model in tree health (Manion, 1991)

the recycling of plant-available mineral nutrients; decomposition and stabilization of leaf and root litter- derived carbon) are key determinants of plant health, productivity and wider ecosystem function. In previous work, we have shown that soil nutrient status differs between trees with AOD symptoms compared to those without, suggesting that changes in the controlling microbial biogeochemical process rates may either contribute to, or result from, the progression of oak decline and AOD opportunistic infection.

This PhD project therefore **aims to understand the process-level soil microbial biogeochemistry of the AOD condition** and the **relationships between soil biogeochemical processes and tree physiological and environmental drivers**.

The project is in collaboration with Forest Research and will capitalize on existing oak woodland field sites to conduct longitudinal surveys and manipulation experiments to understand temporal dynamics and to resolve cause from effect in the decline disease trajectory. Field-collected samples will be analyzed in the laboratory for both for actual and potential microbial activities through enzyme-specific assays involved in the transformations of carbon, and the key macronutrient elements of N, P and S. Mechanistic modelling will be used to provide further insight into the behavior of the soil-pathogen-oak system, and the potential for oak health-environment feedbacks to soil biogeochemistry.

Training opportunities:
You will receive training in field-based experimental work, field monitoring and associated laboratory analyses of collected samples for soil biogeochemical parameters and microbial activity assays. You will also receive unique training in process-based modelling, research statistical design, statistical models and data management. You will also have opportunity to work with Forest Research on research translation to practical forestry, woodland and forest management and policy.

Student profile:
This project would be suitable for students with a background in Environmental Science, Plant Science, Forestry, (Micro)Biology and/or Ecology. Applicants should preferably hold an MSc in a relevant subject and at minimum an upper 2nd class degree or equivalent.

Funding particulars:
This is a CASE-Studentship supported by Forest Research.

References:
[1] Manion, P. and D. Lachance, Forest decline concepts: An overview, in Forest Decline Concepts, P. Manion and D. Lachance, Editors. 1992, APS Press: St. Paul, Minnesota, USA. p. 181-190.
[2] Brown, N., et al., Predisposition of forests to biotic disturbance: Predicting the distribution of Acute Oak Decline using environmental factors. Forest Ecology and Management, 2018. 407: p. 145-154.
[3] Brown, N., et al., Spatial and temporal patterns in symptom expression within eight woodlands affected by Acute Oak Decline. Forest Ecology and Management, 2016. 360: p. 97-109.

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