Environmental predisposition factors to acute oak decline in England and Wales

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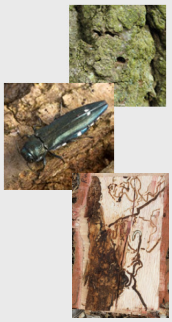
Introduction and Aims

Acute Oak Decline (AOD) affects both native oak species (*Quercus robur* and *Q. petraea*) in England and Wales and is of great concern as oaks represent the largest component of native broadleaf woodland in the United Kingdom.

Affected trees have characteristic stem symptoms, dark coloured liquid weeps from cracks between the bark plates and necrotic lesions are present in the phloem tissue.

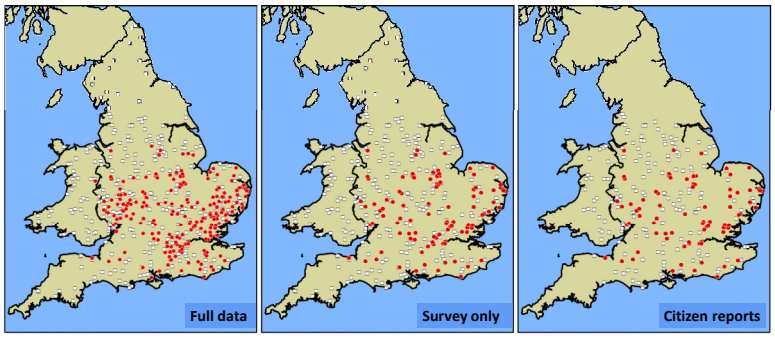
AOD lesions have a high co-occurence with galleries of the two-spotted oak bupretsid (*Agrilus biguttatus*). Necrogenic bacterial species (*Gibbsiella quercinecans* and *Brenneria goodwinii*) are key causal agents of stem lesions. Similar symptoms have been described across Europe.

In this study we investigated if the distribution of AOD is influenced by environmental predisposition factors.



Study sites

In total more than 500 study sites were used. Data from two systematic surveys (presence (red dots) and absence of AOD symptoms (white dots)) were combined with reports from citizens (presence only). Analysis was conducted on the three separate datasets (see below).



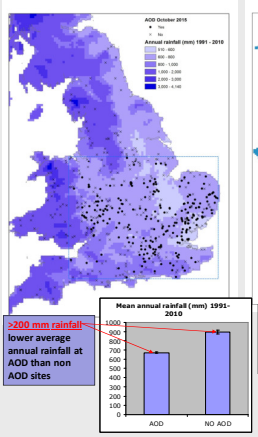
Spatial datasets

Dataset	Description	Source
Climatic parameters	mean air temperature, rainfall, sunshine duration, wind speed, growing season length, growing season degree days	UK Met Office Parry and Hollis (2006)
Day degrees above 11.5 ºC	Calculated in CLIMEX. 11.5 ºC corresponds to estimates of the development thresholds for *A. biguttatus* (Reed et al., 2017), using average monthly temperatures (1971-2000).	UK Met Office
Atmospheric deposition	wet SO_4, dry SO_2/SO_4, wet NH_4, wet NO_3 dry NO_2/NO_3,/HNO_3, dry NH_3/NH_4, total N, cations (Ca+Mg+K) deposition	(CEH, 2006)
National Soil Map 1: 250,000	The soils of England and Wales as described by the English and Welsh Soil Classification system (Avery, 1980).	(Cranfield University, 2004)
National Forest Inventory woodland map	The 2013 woodland area map was used to calculate the area of woodland in each National Soil Map sub-type.	(Forestry Commission 2011)
Hydrology of Soil Types (HOST)	Using the HOST class soils were reclassed as: well drained, seasonally water logged or permanently wet.	(Boorman et. al., 1995)
FC Grant Database	Forestry Commission spatial data of woodland habitat and management supported through grants	(Pyatt, Ray and Fletcher, 2001).

Results

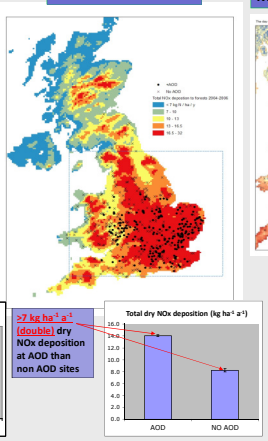
- Analysis of individual climate variables identified many variables that were significantly different between AOD and symptom free sites.
- Logistic regression using GAM (Generalised Additive Mixed) models revealed strongest trends from rainfall, air temperature (day degrees above 11.5°C) and elevation, as well as nitrogen, sulphur and base cation deposition.
- Trends were consistent across all three datasets.
- Spatial Autocorrelation was present in analyses with individual environmental variables, but was not significant in final combined models.
- Soil types that were seasonally waterlogged or had high clay content had a greater proportion of AOD sites, however trends were not significant and require further investigation at site and tree levels.

Rainfall



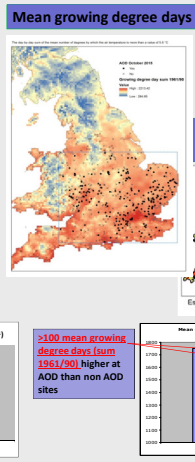
>200 mm rainfall lower average annual rainfall at AOD than non AOD sites

Dry NOx deposition



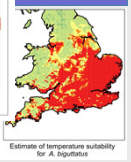
>7 kg ha^{-1} a^{-1} (double) dry NOx deposition at AOD than non AOD sites

Mean growing degree days



>100 mean growing degree days (sum 1961/90) higher at AOD than non AOD sites

Day Degrees >11.5°C



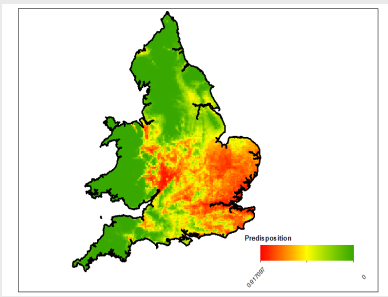
Conclusions

- Extensive survey data relating to the distribution of AOD has enabled significant trends with environmental factors to be detected.
- The correlations with temperature, elevation and rainfall may in part, be attributable to the involvement of *A. biguttatus* in AOD. The distribution of this thermophilic beetle fits closely with that of AOD.
- The results reflect that AOD affected stands are subjected to greater levels of predisposition than those that are healthy, this fits the predisposition model for decline diseases.
- The trends detected in this study are correlative only and detailed field experimentation is the next step to establish the cause and effect mechanisms involved in predisposition.
- Our findings indicate that AOD fits within traditional descriptions of decline and that it should be studied as a system involving multiple factors and different stages of development.
- We plan to establish a research network and use the EU ICP forest extensive and intensive monitoring survey data, to derive information on predisposition factors focussing on oak but also other tree species at both national and European scales.

Healthy Oak

Acute Oak decline

Final model predictions using the full AOD dataset at 1 km square scale



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