Forest Research

Environmental predisposition factors to Oak decline

Elena Vanguelova, Nathan Brown, Sue Benham, Frank Ashwood, Jack Forster, Sandra Denman

Technical Support Unit
Alice Holt biochemical laboratory

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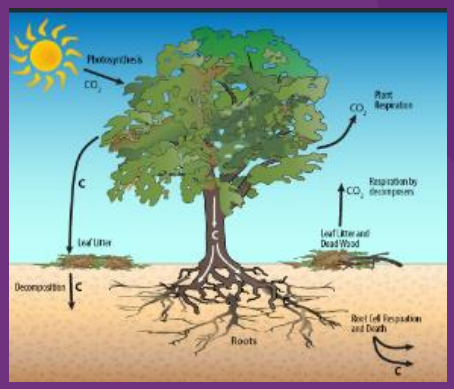
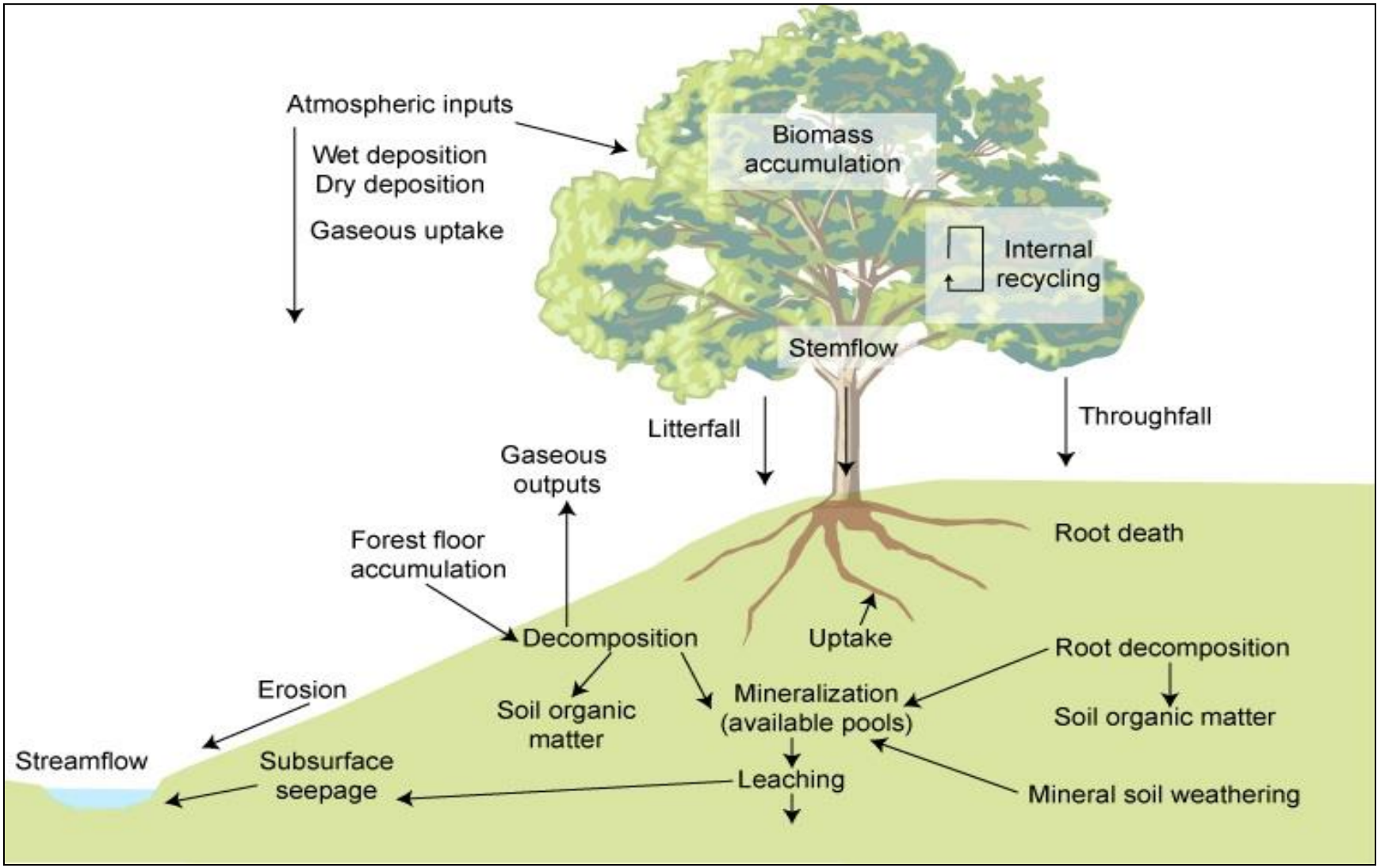
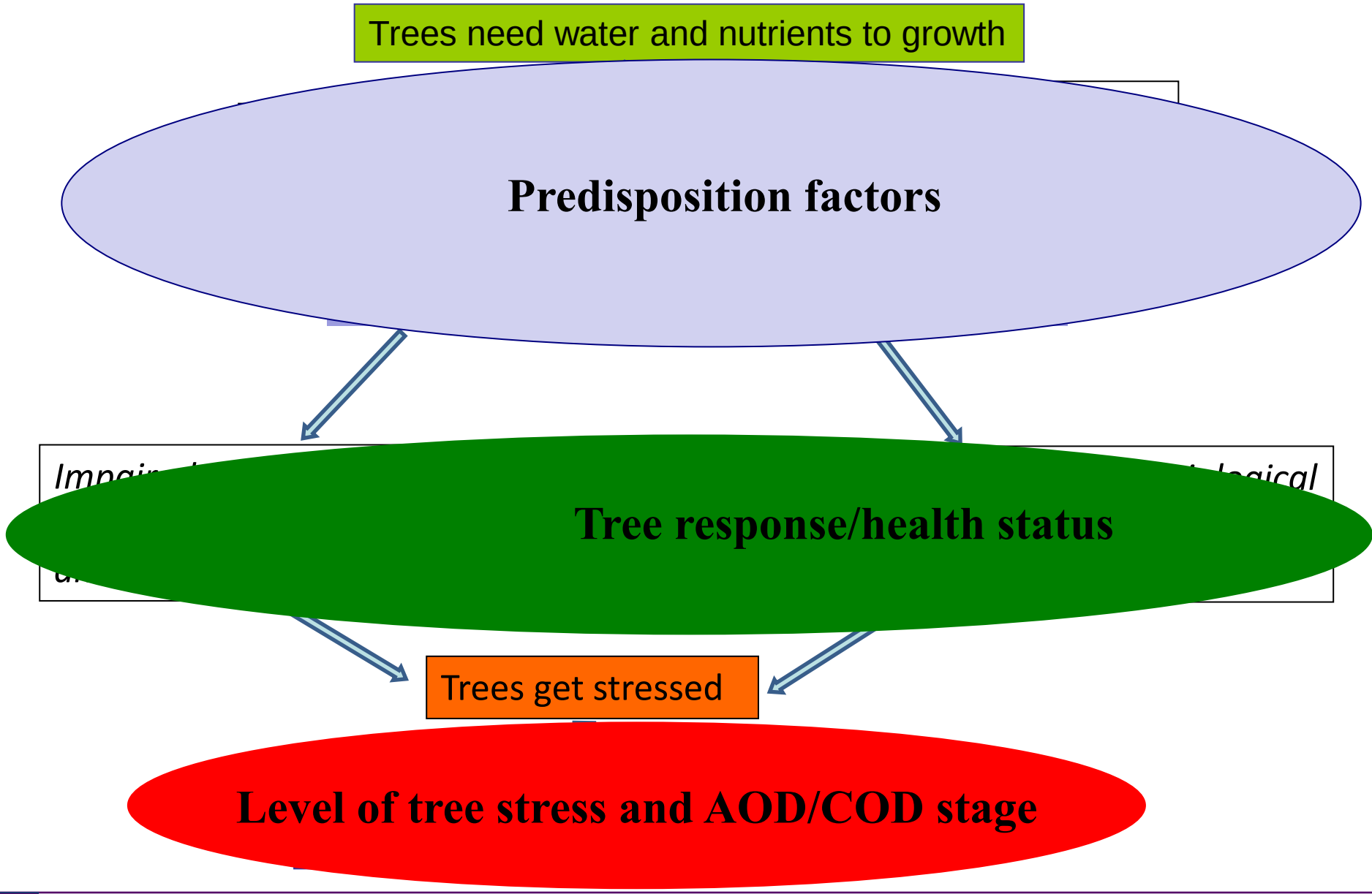


Biogeochemical cycling in forest ecosystems

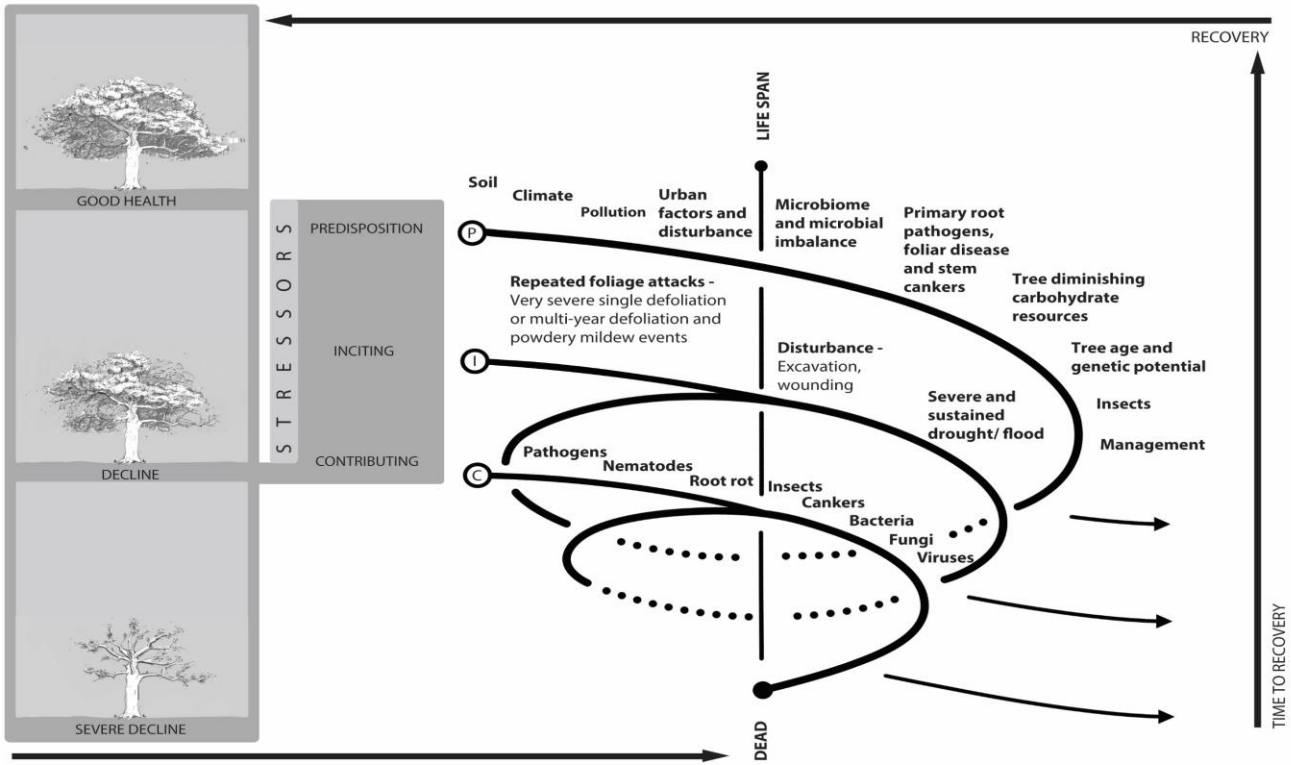
Processes and cycling in Forest Ecosystems



Predisposition factors for tree stress



Decline disease spiral model



Soil

Compaction.

Low moisture holding capacity.

Poor soil drainage Fluctuating water table.

Soil acidity.

Poor fertility.

Nutrient imbalances.

Climate

Low rainfall.

High temperatures.

Flooding.

Extreme events.

Frosts.

Sustained stong wind.

Pollution

Excess atmospheric and soil pollutants (e.g. nitrous oxides).

Imbalances of nutrients (e.g. P- shortage).

Microbiome and microbial imbalance

Rhizosphere soil – imbalances in bioconversion of nutrients (e.g. Nitrifying microbes).

Disruption to biotransfer of nutrients (e.g. Mycorrhizae).

Disruption to protective and growth promoting activities.

Primary root pathogens, foliar disease and stem cankers

Buttress root rots (e.g. *Phytophthora , Gynmopus, Armillaria*).

Feeder root rots (e.g. *Phytophthora, Pythium, Ilyonectria*)

Foliar – Powdery mildew - repeated outbreaks.

Insects

Repeated Insect attacks by defoliators and live-bark boring beetles.

Management

Stock on land.

Planting density.

Thinning.

Mixtures.

Social pressures (e.g. foot fall, pathways).

An updated Manion 1981 Decline disease spiral model (Denman et al., 2022)

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Are there identifiable predisposition drivers in oak declines in the UK?

Hypotheses:

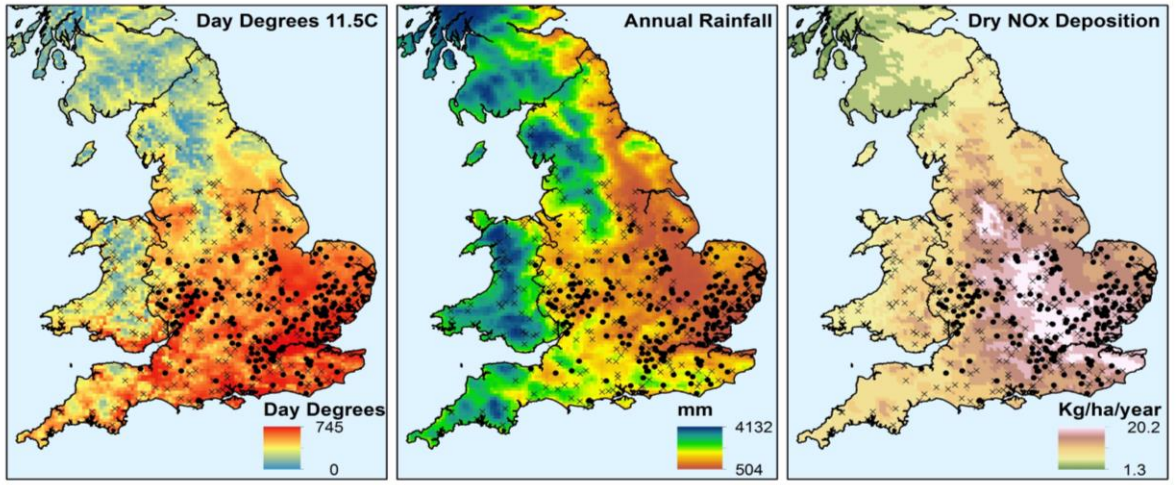
1. **There are identifiable environmental predisposition drivers associated with AOD and COD**

2. **Predisposition factors vary at different scales (national, site, tree scales) and tree condition (AOD/COD)**

3. **Altered and impaired tree nutrient uptake is linked with soil conditions and poor root development**

Predisposition factors at national scale

AOD distribution maps and spatial datasets used

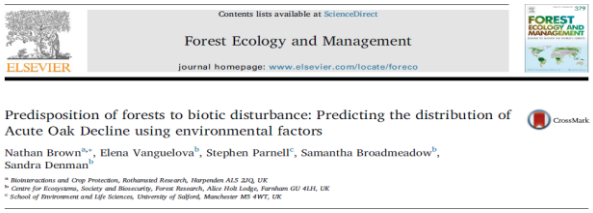


Dataset	Resolution	Source
Climatic parameters	5 km x 5 km grid	UK Met Office Parry and Hollis (2006)
Day degrees above 11.5 °C	5 km x 5 km grid	Average max and min monthly temp (1971-2000) UK Met Office
Atmospheric deposition	5 km x 5 km grid	(CEH, 2006)
National Soil Map 1: 25,000	Polygon shapefile	(Cranfield University, 2004)
NFI woodland map	Polygon shapefile	(FC 2011)
Hydrology of Soil Types (HOST)	Polygon shapefile	(Boorman et. al., 1995)
Ecological Site Classification for forestry (ESC)	Woodland habitat and management map	(Pyatt, Ray and Fletcher, 2001).

- **GAM – generalised additive mixed models revealed <u>AOD occurs in</u>:**

- ***Warmer areas***
- ***Low rainfall areas***
- ***Low elevations areas***
- ***High nitrogen deposition***
- ***Low sulphur deposition***

Brown et al., 2018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Predisposition of forests to biotic disturbance: Predicting the distribution of Acute Oak Decline using environmental factors

Nathan Brown[a,*], Elena Vanguelova[b], Stephen Parnell[c], Samantha Broadmeadow[b], Sandra Denman[b]

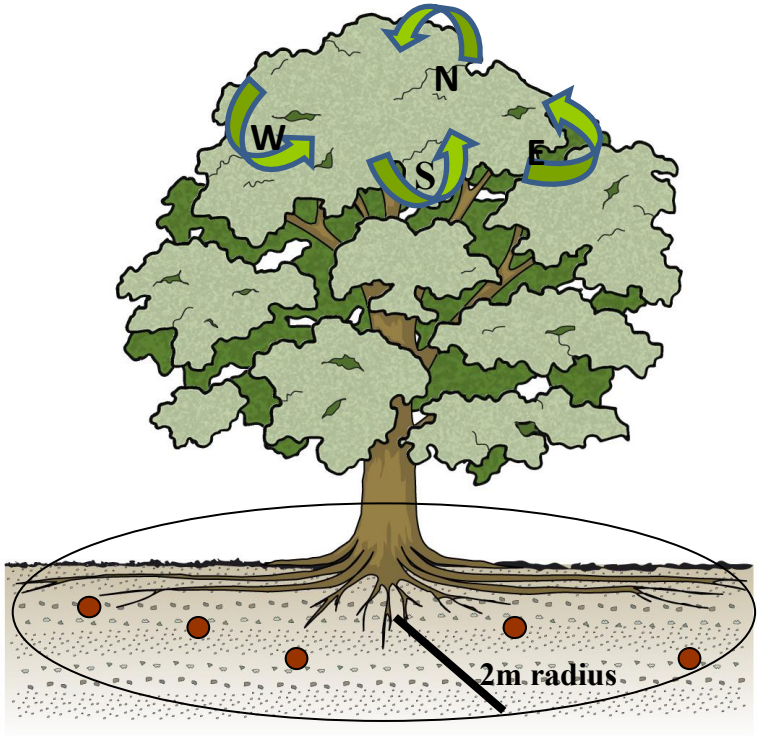
[a] Biointeractions and Crop Protection, Rothamsted Research, Harpenden AL5 2JQ, UK
[b] Centre for Ecosystems, Society and Biosecurity, Forest Research, Alice Holt Lodge, Farnham GU 4LH, UK
[c] School of Environment and Life Sciences, University of Salford, Manchester M5 4WT, UK

Oak Health Monitoring Sites

Cronic Oak decline sites

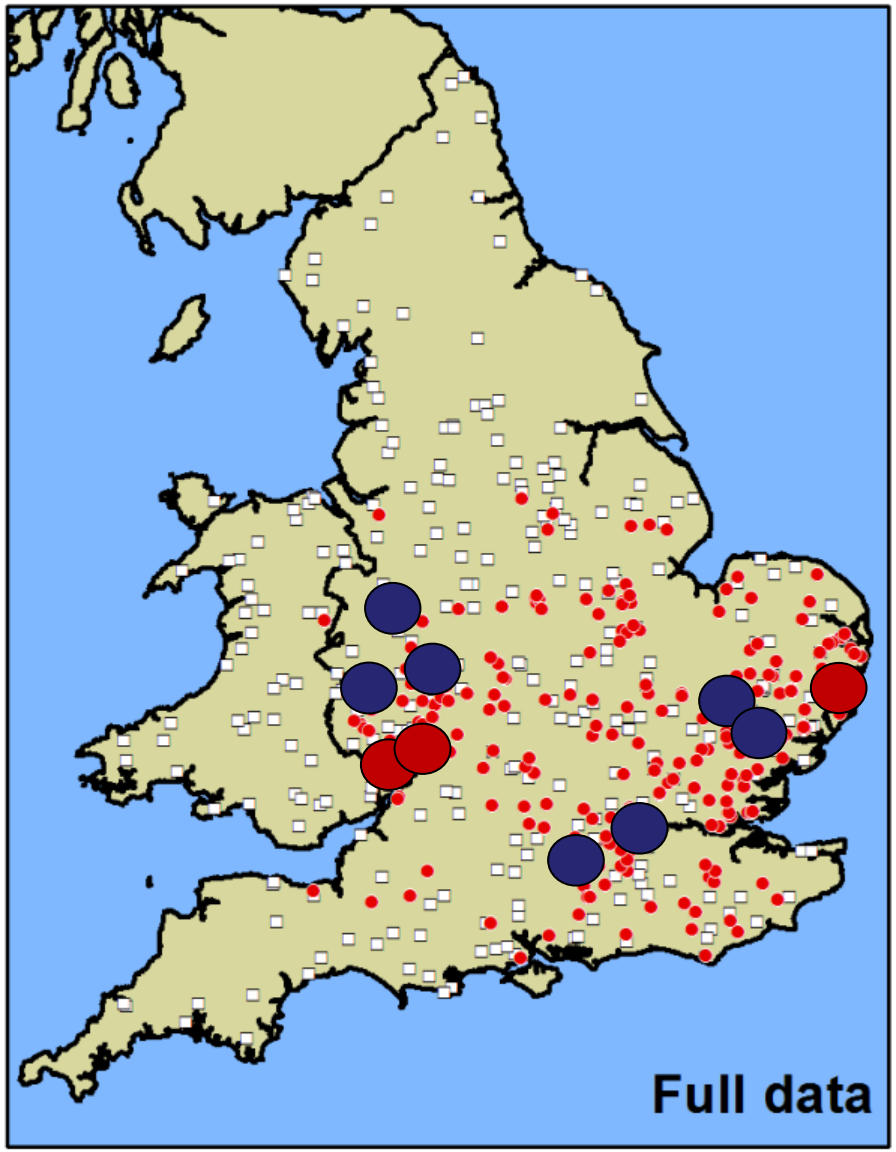
Acute/Chronic Oak decline sites

Foliar sampling – 4 cardinal directions



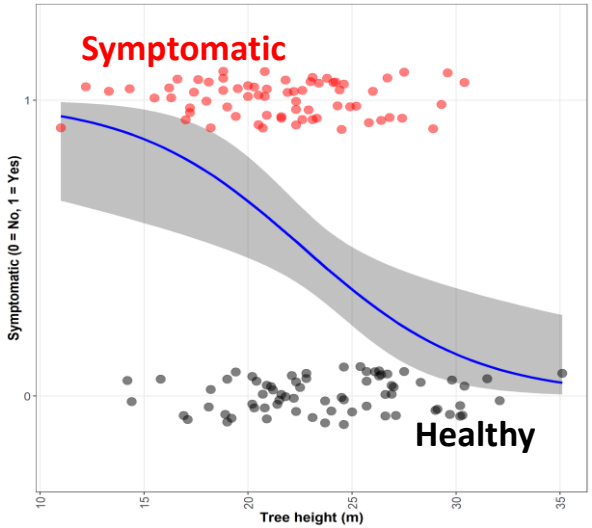
Soil and root sampling – 5 points per tree

Foliar/roots/soil analysis of >50 chemical and physiological parameters measured

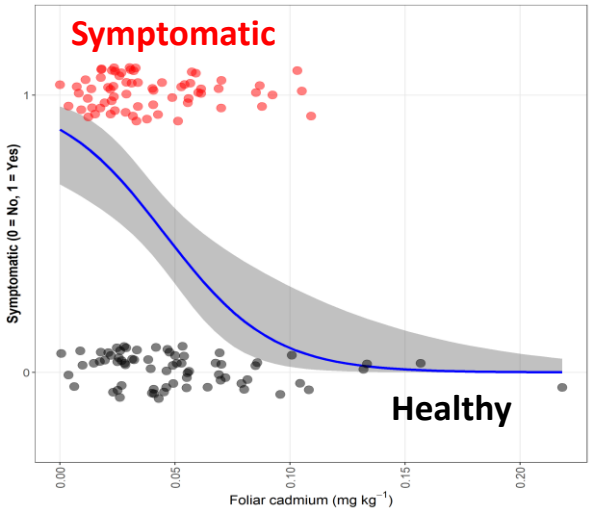


Overall patterns across sites

Increases in tree height, root phosphorous were associated with a decreased probability of trees being symptomatic (either AOD or COD).



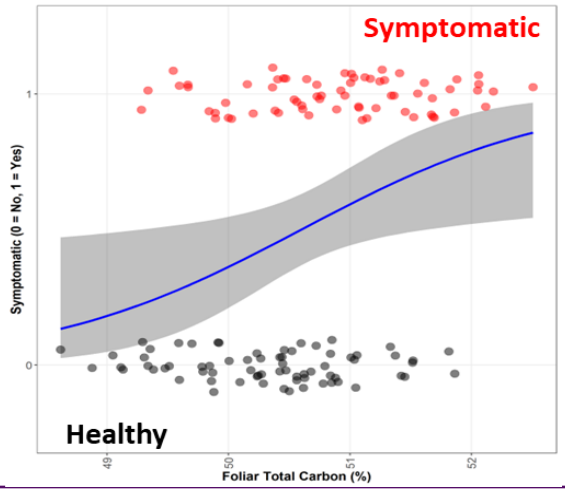
Tree height ✓



Root phosphorous ✓

Increases in foliar carbon contents were associated with an increased probability of trees being symptomatic (either AOD or COD)

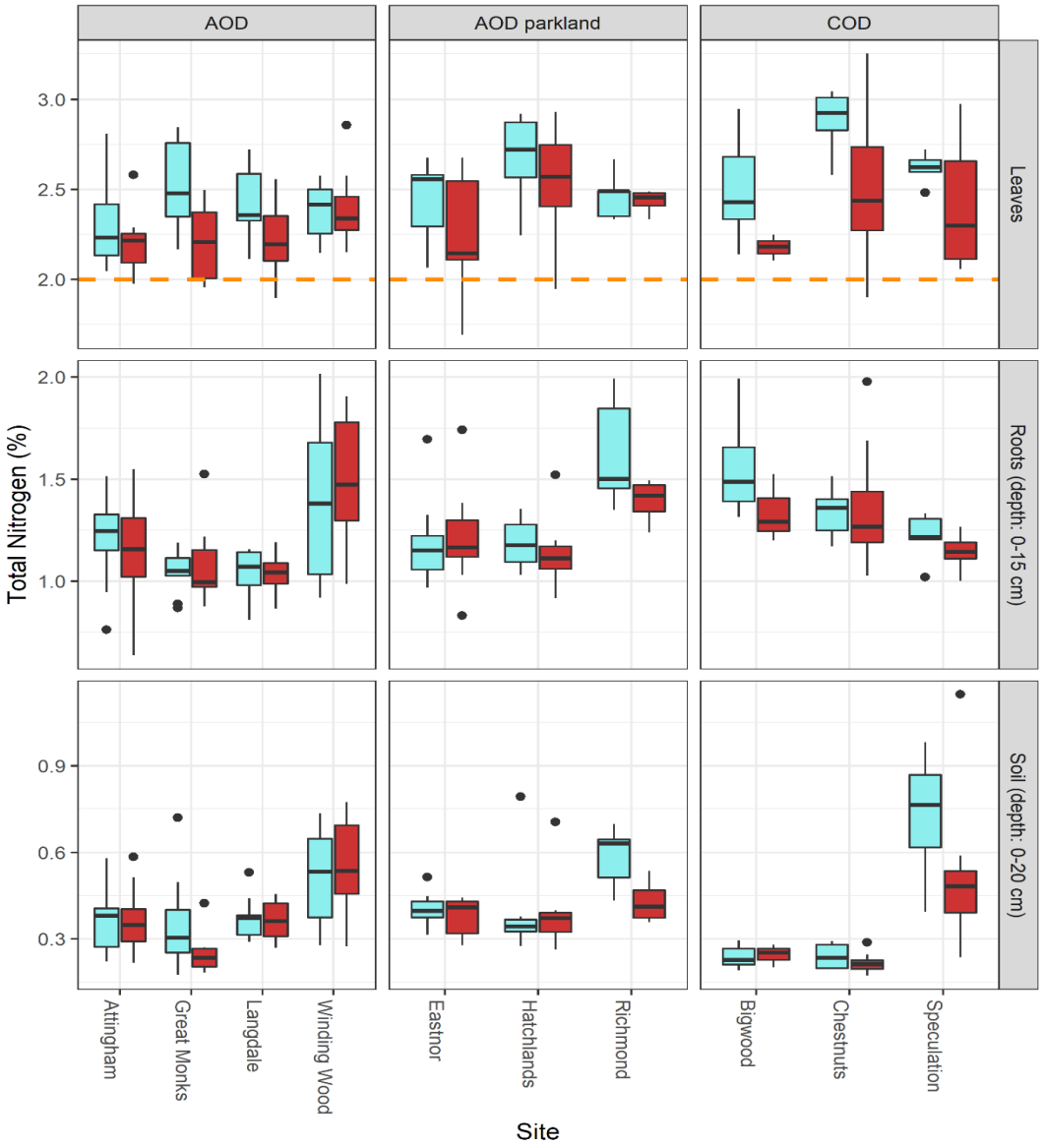
Foliar carbon content ✓



Higher foliar carbon content

- ***Stress tolerant strategy*** **of trees to abiotic stresses and better resistance to herbivory.**
- **Greater investment in structural or non structural compounds (e.g. lignin, tannins) to ensure longer leaf life and more productivity over the longer term.**

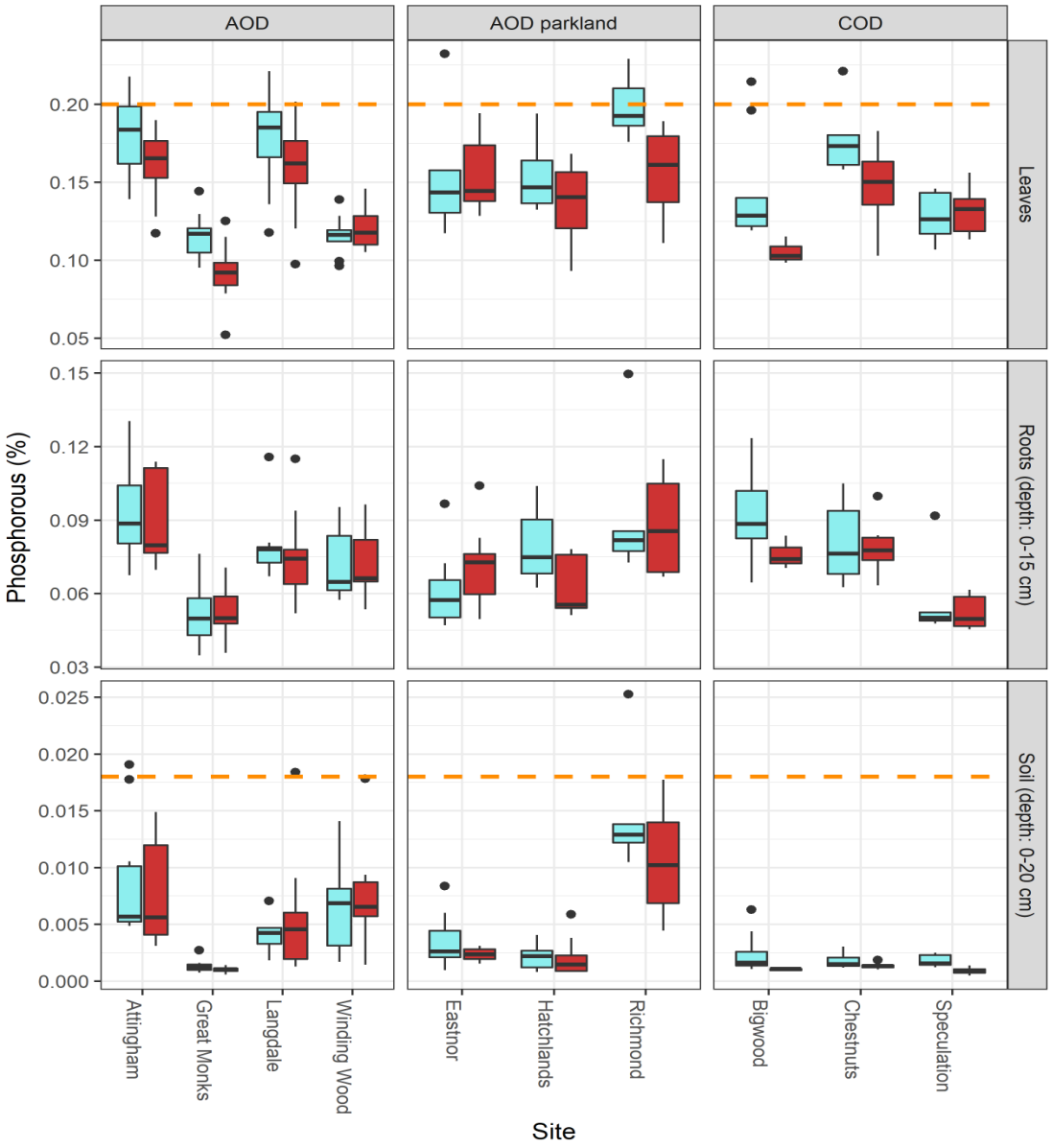
Site specific patterns – Nitrogen



Nitrogen

- Lower N uptake at COD sites linked to lower N in roots and soils
- All AOD and COD sites foliar N levels higher than thresholds of N limitations, but some very high than optimal level suggesting even N saturation
- N, P and K make 75% of mineral nutrients in plants

Site specific patterns – Phosphorous



Phosphorous

- Lower P uptake at many AOD and COD sites linked to lower P in roots and soils
- All AOD and COD sites foliar P levels lower than thresholds of P limitations, so P deficiency across all sites

Status
Non-symptomatic
Symptomatic

- Soil P availability very low and under the critical thresholds for P uptake
- N, P and K make 75% of mineral nutrients in plants

Across COD site patterns

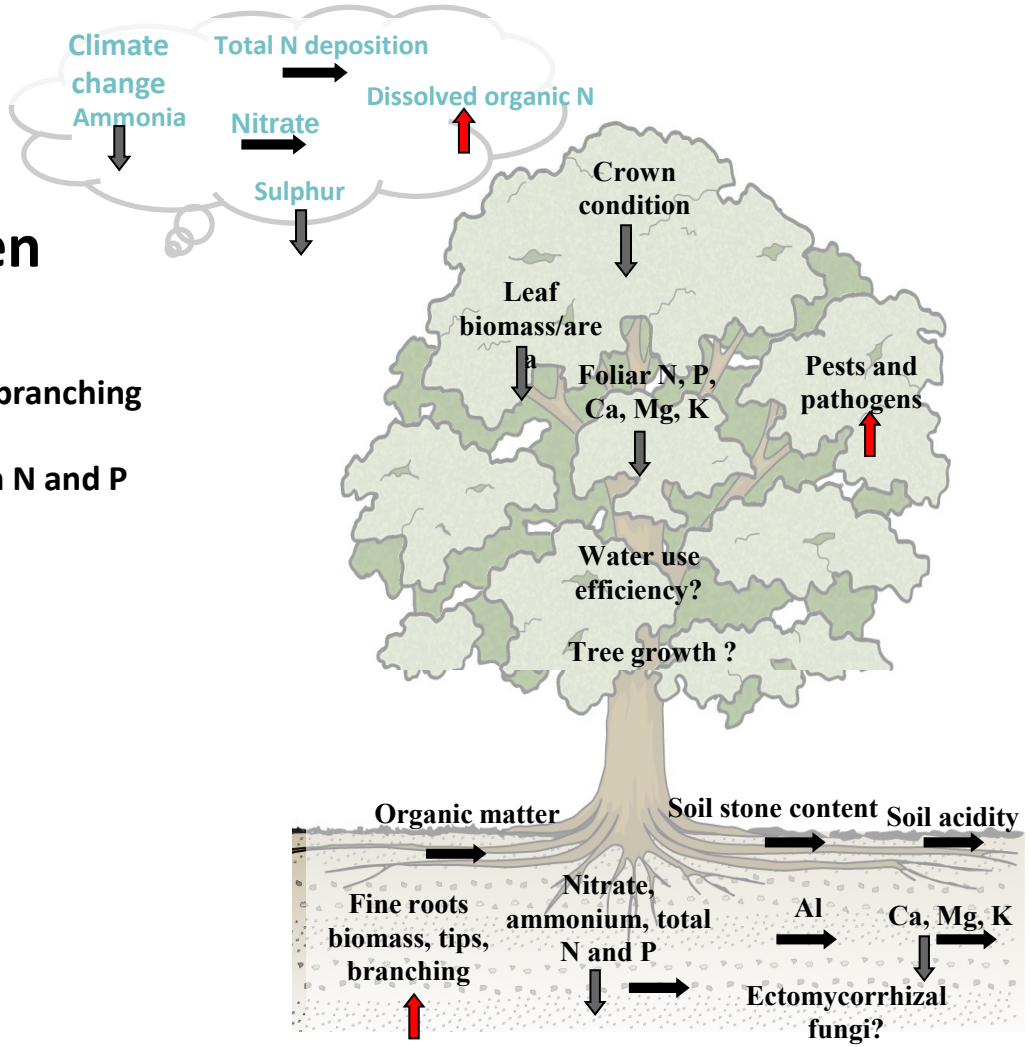
First scenario: N, P driven

- Lower soil N,P and K (in some cases)
- Higher fine root biomass, density, tips, branching
- Lower leaf area and biomass
- Lower uptake of N, P, Ca, Mg and K with N and P in deficiency levels

Sites exhibiting these patterns are:

1. Chestnut
2. Big wood
3. Speculation

All are COD sites



Across AOD site patterns

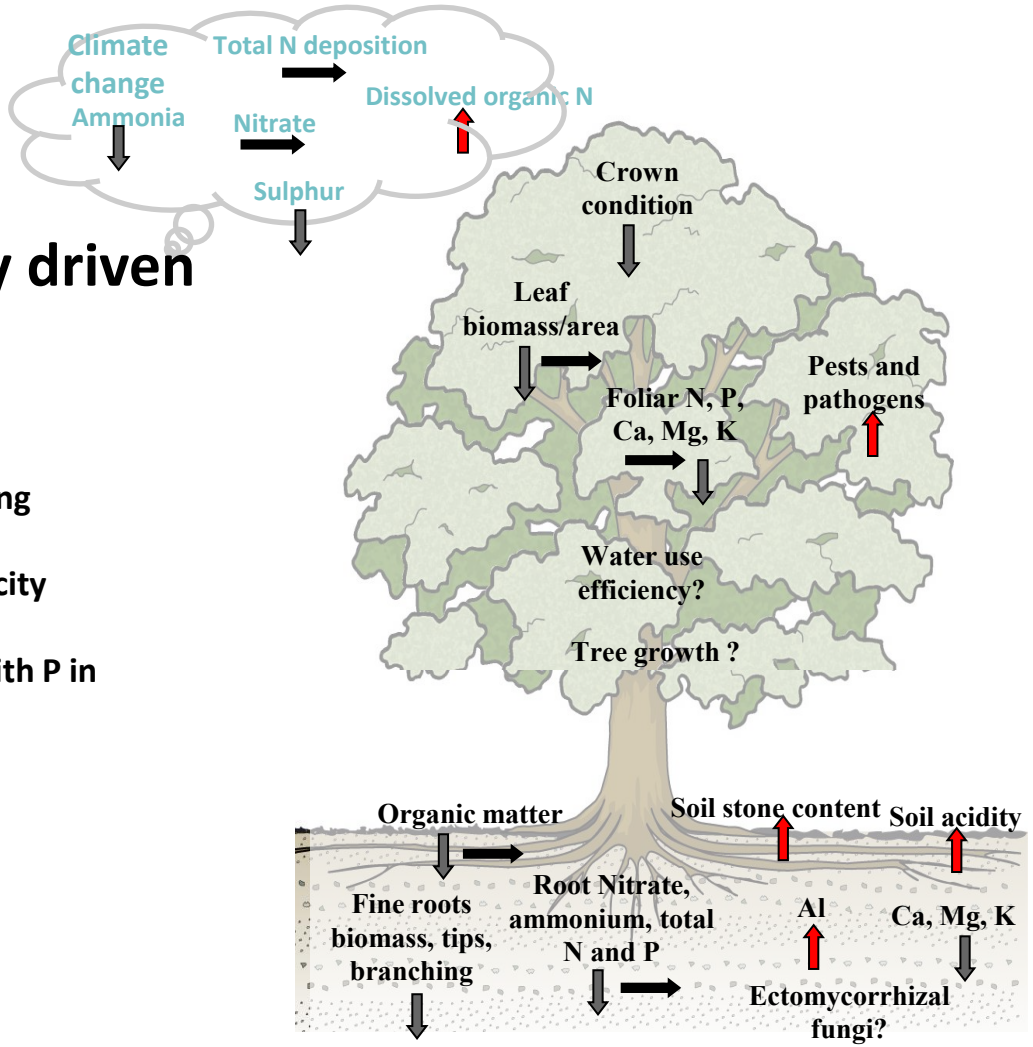
Second scenario: acidity driven

Soil acidification
Cation (Ca ,Mg, K) depletion
Aluminium toxicity to roots
Lower root density, biomass, tips, branching
Higher stone content
Lower soil carbon and water holding capacity
Lower specific leaf area
Lower tree uptake of N, P, Ca, Mg and K with P in deficiency levels

Sites exhibiting these patterns are:

1. **Great Monks wood**
2. **Attingham park**
3. **Winding Wood**
4. **Langdale**

All are AOD sites!



Conclusions

1. Identifiable environmental predisposition drivers associated with AOD and COD ✓
2. Predisposition factors vary at different scales (national, site, tree scales) and tree condition (AOD/COD) ✓
   - National scale - warmer, drier areas at lower elevations with high N and low S levels. Drought effects need testing under controlled conditions (current BacStop project).
   - Across all specific sites – AOD and COD trees have been under external environmental stress and they show complex tolerance mechanisms to accommodate such stress suggesting that Oak trees have some plasticity to changes in the wider environment. Tipping points of when abiotic stress give way to biotic influence needs to be investigated.
   - Site specific scale – two scenarios emerging related to soil acidity and nitrogen and phosphorous deficiency associated with different Oak declines (AOD or COD).
3. Impaired tree nutrient uptake in AOD, COD trees is linked with soil conditions and poor root development ✓
   - Particularly for N, P, soil acidity but also for Ca, Mg and K
   - More cause and effect studies are required related to potential environmental and soil drivers

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Thank you!

Elena Vanguelova
elena.vanguelova@forestresearch.gov.uk