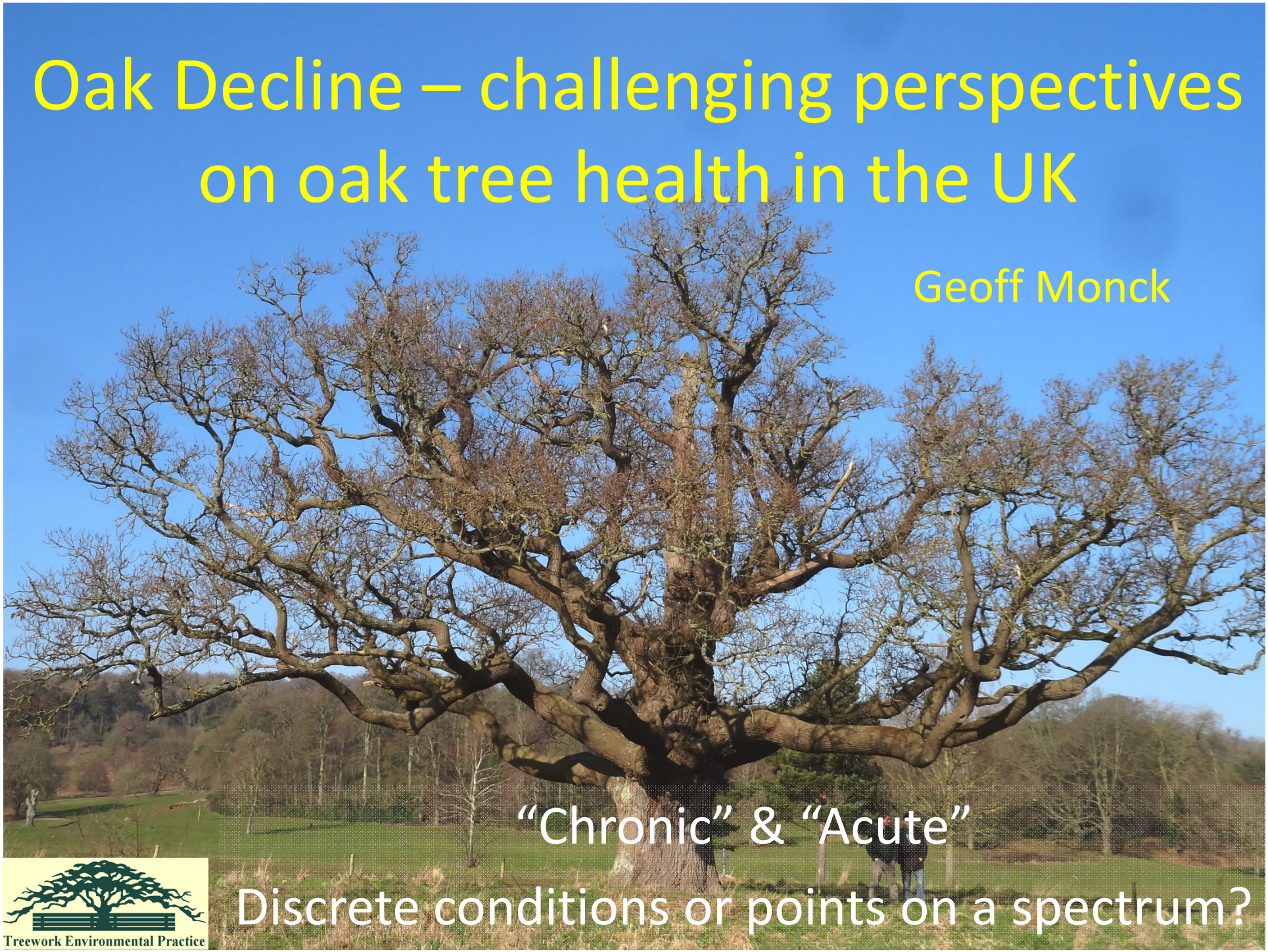
Oak Decline – challenging perspectives on oak tree health in the UK

Geoff Monck



"Chronic" & "Acute"

Discrete conditions or points on a spectrum?

Treework Environmental Practice

What do we mean *Oak Declines*?

- Chronic Oak Decline / Dieback (COD)
- Acute Oak Decline (AOD)







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What do we mean by Acute Oak Decline?






Denman, S. et al . (2014) *A description of the symptoms of Acute Oak Decline in Britain and a comparative review on causes of similar disorders on oak in Europe.* International J. of Forestry

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Historic Perspectives

Episodes of AOD

- 1920s - First widespread episode

  - Tortrix + oak mildew + Armillaria cited.

- 3 other episodes in 20th century
- Duration of episodes up to 10 years
- ‘Stress factors’ were implicated (e.g. drought)
- Recovery associated with epicormic growth

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The current AOD episode

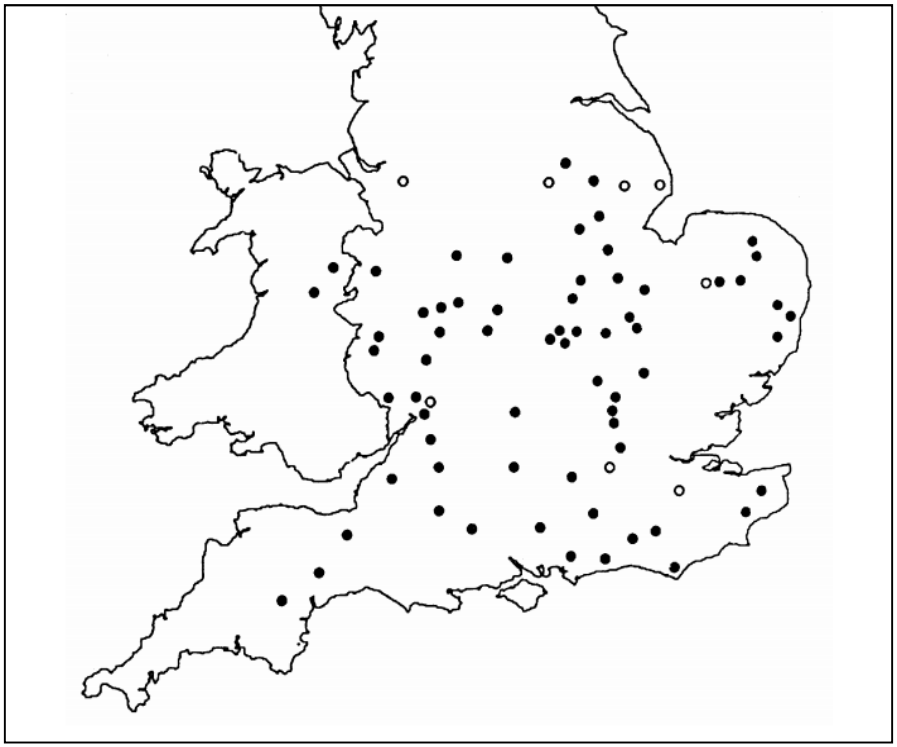
- Main focus of causative study

  Enterobacterial species *Brenneria goodwinii* and *Gibbsiella quercinecans*

- No new lethal bacterial pathogens have been identified that infect and kill whole stands of healthy trees (c.f. *Phytophthora ramorum* v larch)
- Biotic influences (including bacteria) may be ‘stress factor’
- Indications that current AOD event is similarly episodic

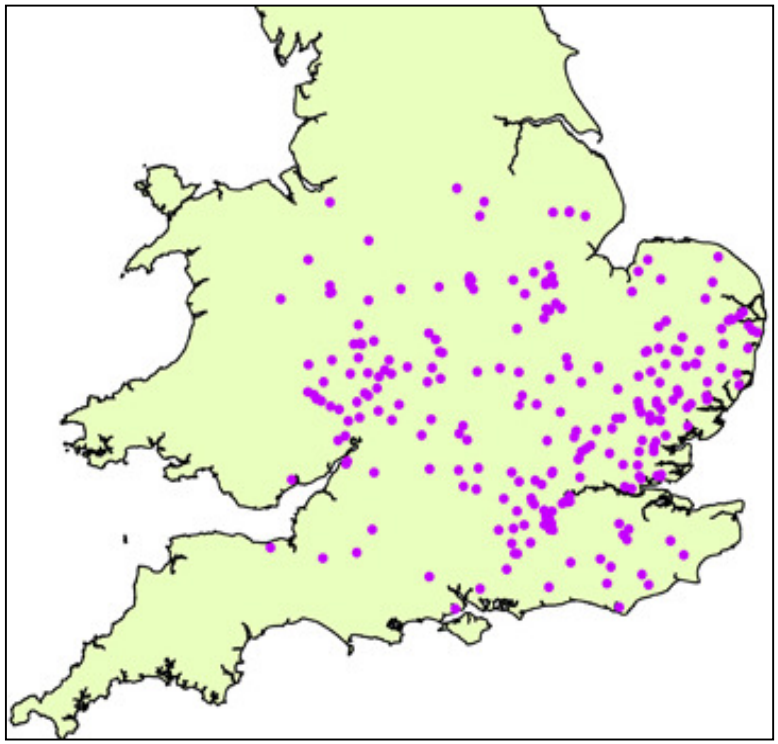
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AOD: distribution of historic and current episodes



1989-1994 episode

Source: Gibbs, 1999

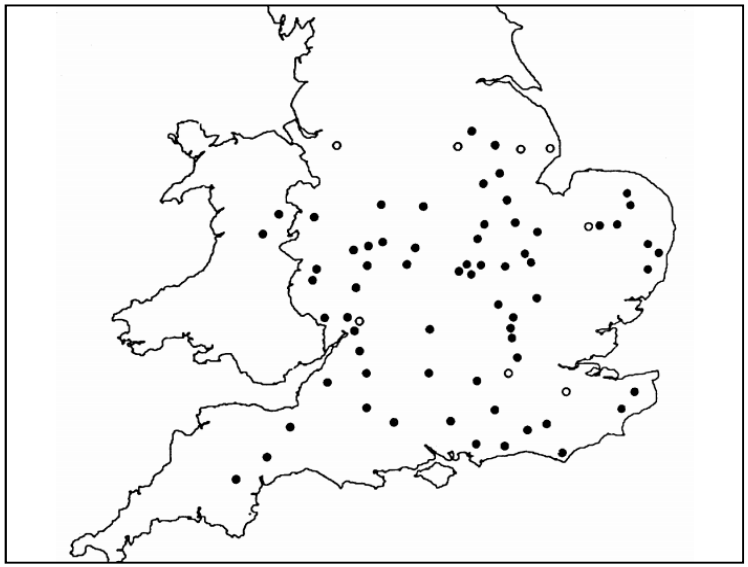


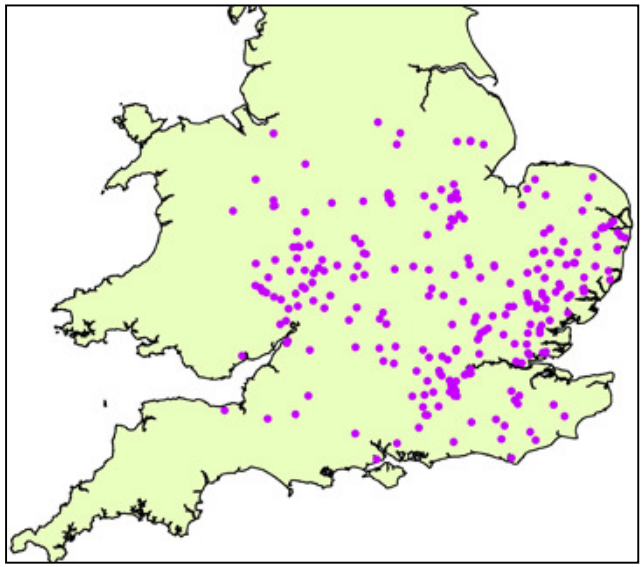
2002-2016 – current episode

Source: Forestry Commission data

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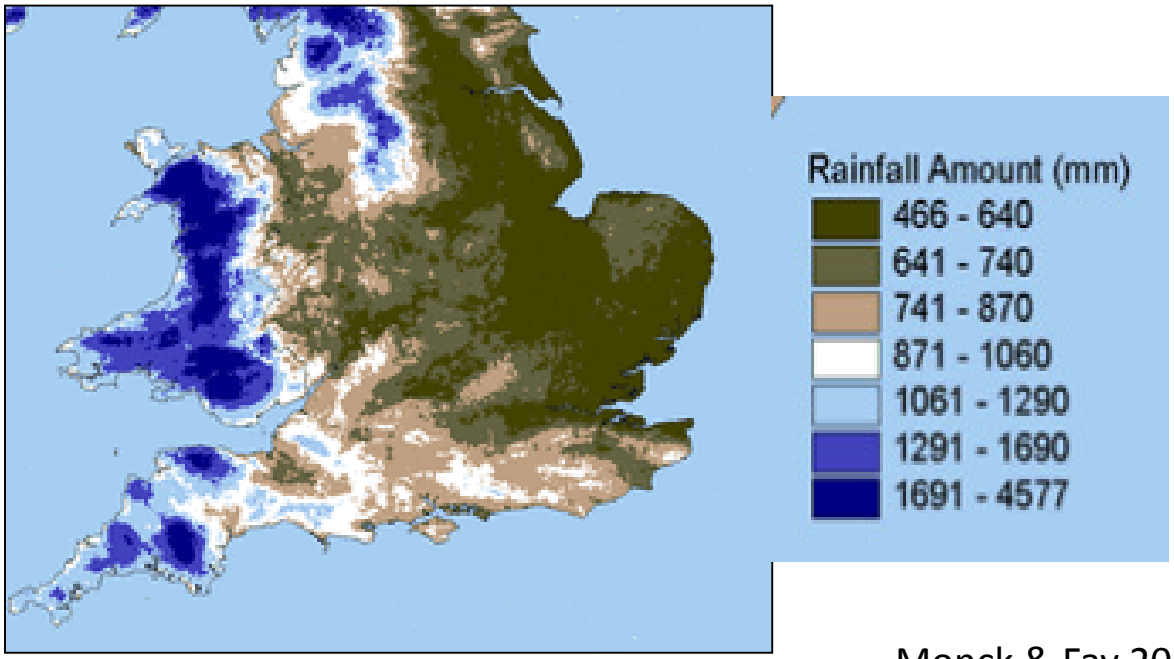
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1971-2000
Average total rainfall

Source: UK Met Office data



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Water stress, AOD-inducing factors

- Negative water potential
- Rainfall and/or soil structure negatively influencing hydrology
- Physically impaired water availability
- Conditions that replicate the effects of drought stress
  - Mildew impairing stomatal function
  - Mycorrhizal degradation
  - Phytopthora sp. & Armilleria sp. – root hair death
  - Polluting effects causing negative osmosis

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Other key supporting evidence that COD and AOD are the same condition

- Dendrochronological data from Europe (Drobyshev et al, 2007; Sohar et al, 2013; Tulik, 2014)
    - Same pattern of rapid decline observed
    - In **every** case initiation of terminal decline correlated to major drought event
    - **WHAT ABOUT THE STEM BLEEDS???**

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Profuse stem bleeding – current episode of AOD

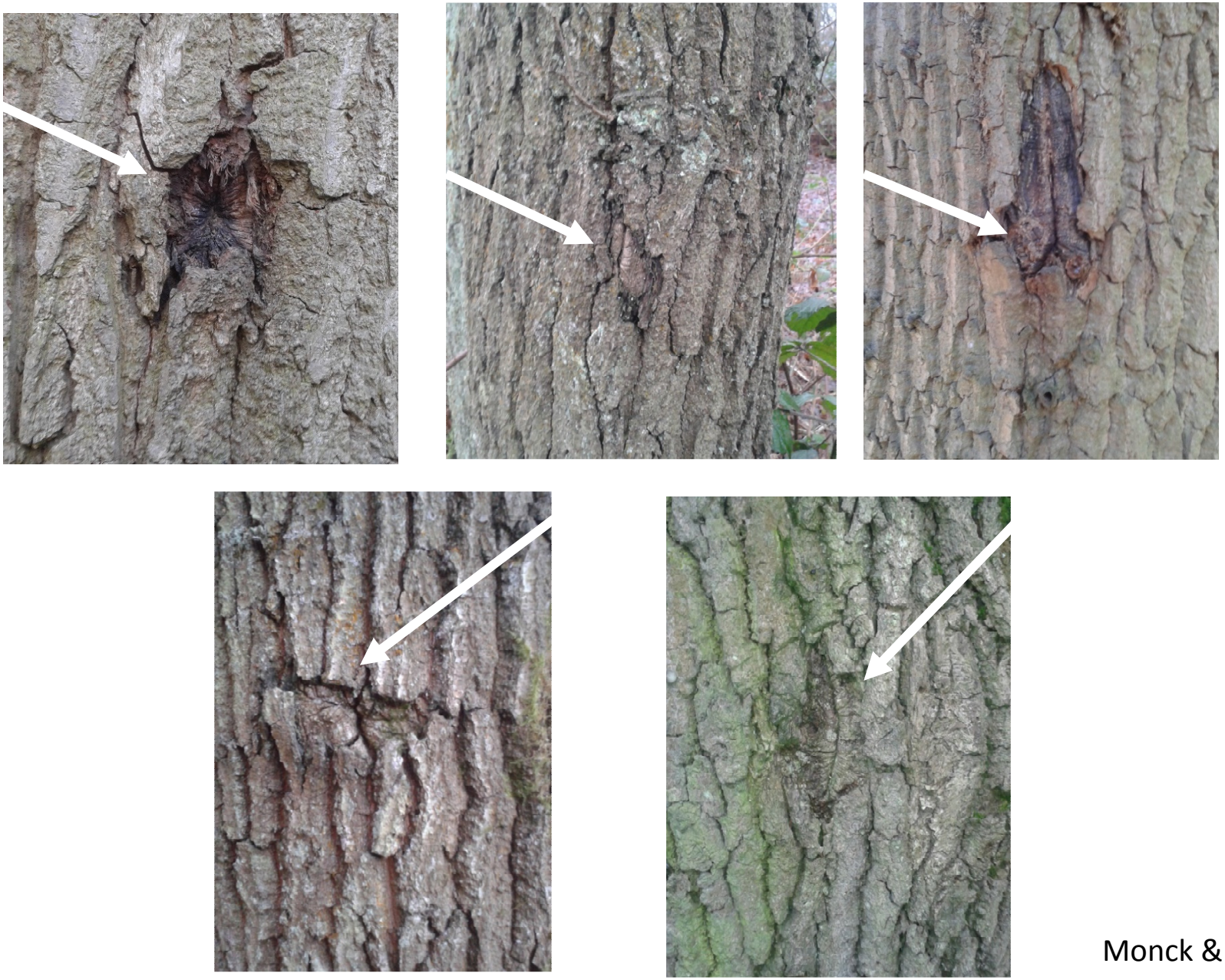
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Stem bleeds on an oak in Richmond Park during the previous 1989-94 episode (Gibbs 1999) – testing for Phytopthora sp. and Armillaria sp. negative

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Partially occluded stem bleeds in oak populations (Guildford)



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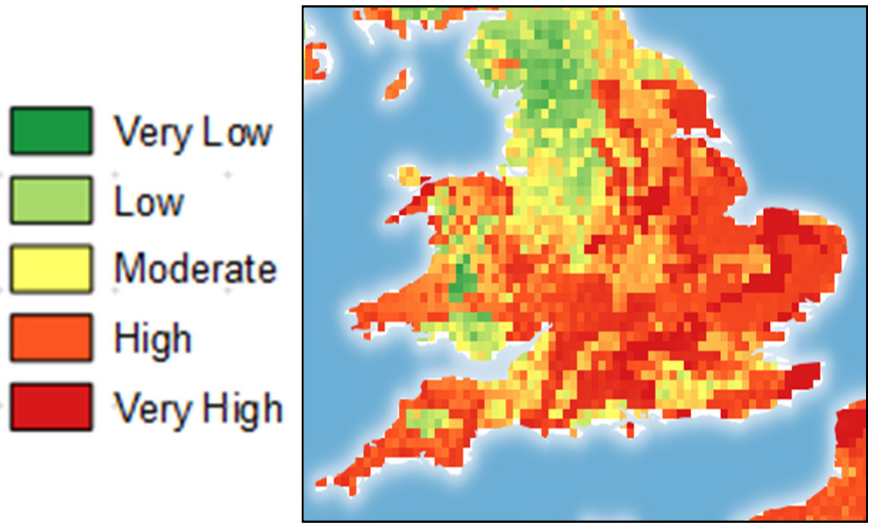
Episodic decline history

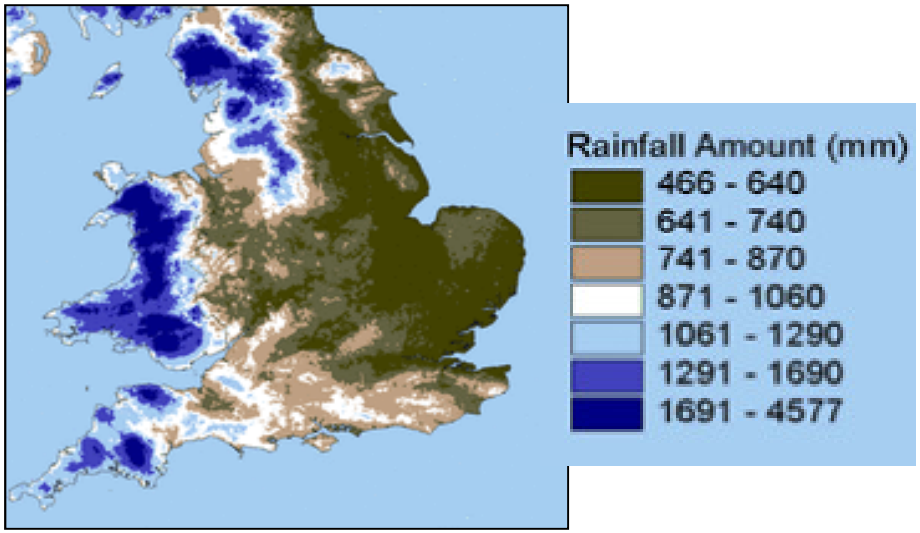
Occluded stem bleeds point to past events



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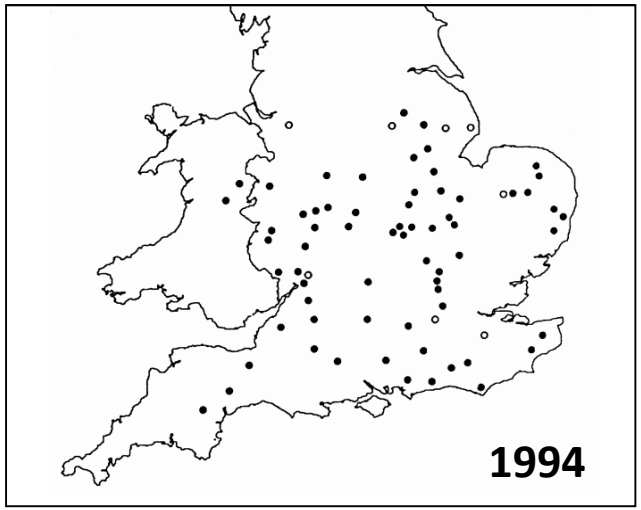
Epidemiological patterns
Potential indicators of underlying cause

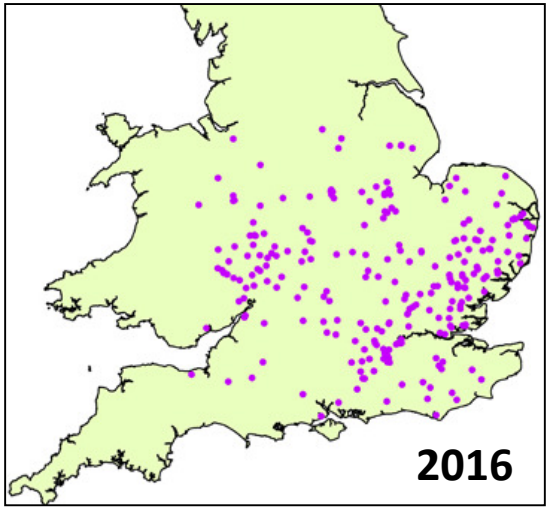




Potential threats to soil biodiversity 2016

Global Soil Biodiversity Maps, associated to the Global Soil Biodiversity Atlas, European Soil Data Centre, Joint Research Centre of the European Commission. June 2016





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The soil ecosystem

- Complex relationships - soil microbes & tree roots
- Trees drive rhizosphere microbial communities
  - Root exudates (carbohydrates, proteins & hormones)
- Complex feed-back loops
  - Tripartite (leaf endophyte – tree – rhizosphere)
- Microbial community compositions driven by root exudates suppress soil-borne pathogens
- Conduit for communication between trees

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Harmful impacts upon soil biology

- High N & P Impacts
  - Impaired mycorrhizal function
  - Impaired mycorrhizal root colonisation
  - De-coupling effects
- Increased N & P inputs alter mycorrhizal communities
  - Loss of low nutrient adapted & highly mutualistic species
  - Dominated by less mutualistic generalist species
- Impaired mycorrhizal soil networks
  - inhibit nutrient & water absorption
- Impaired drought resistance & pathogen defence

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Photographs: K. Nara, in The Ectomycorrhizal Picture Book (http://www.edu.k.u-tokyo.ac.jp/nara_lab/home/ectomycorrhizas) Monck & Fay 2017

Our attempt to understand oak decline

- Can we understand oak decline without understanding adverse factors affecting resilience that have a basis in the soil?
- Conventional study has been based on above ground symptomology & potential pathogens
- Only very recently has soil and rooting environment been considered
- 2010 Royal Parks AOD study to test organic amendments to symptomatic trees
- Assessing crown response and soil biology and chemistry

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The Royal Parks Study

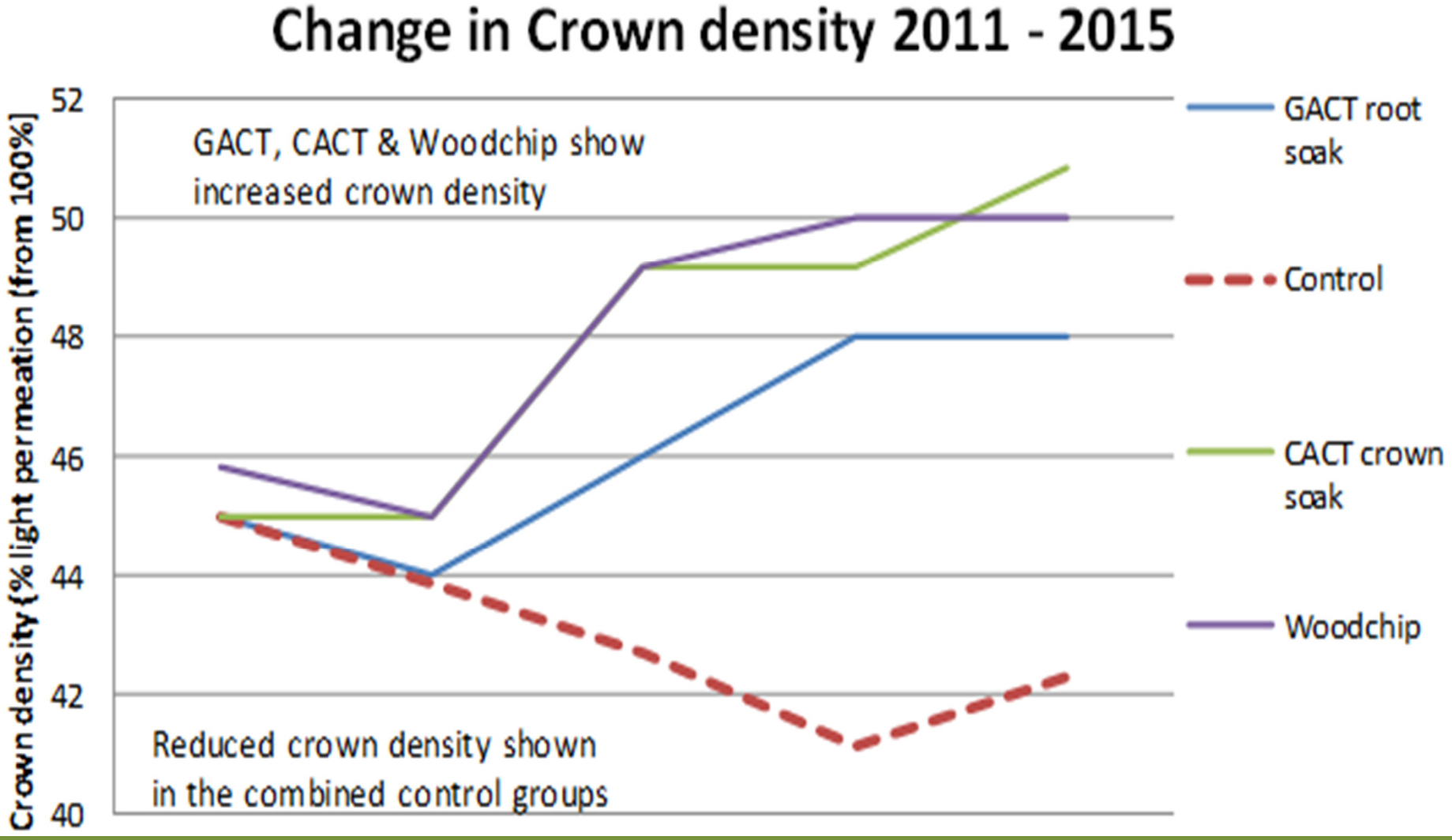
- Richmond and Bushy Parks, London
- 5 study groups
  - 2 x control
  - 1 x **G**round application (root soak) of **A**erated **C**ompost **T**ea (**GACT**)
  - 1 x foliar application (**C**rown soak) of **A**erated **C**ompost **T**ea (**CACT**)
  - 1 x application of **Woodchip** mulch to rooting zone
- Innes system – crown density
- Also recorded
  - Mildew
  - Defoliation

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Royal Parks AOD study

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Mean crown density reduction (%) for treatment groups



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Results & hypothesis

- GACT and woodchip application to rooting zone:
  - reintroduce live mycorrhizal fungi and spores, and beneficial bacteria
  - Reintroduce humic acids

- Woodchip mulch application increases short-term OM, reduce pH, alters B/F ratio, improves moisture retention

- Enhanced function of mycorrhizal network between trees

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Compost tea foliar application treatment group
(T4217)

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70% reduction crown density



45% reduction crown density



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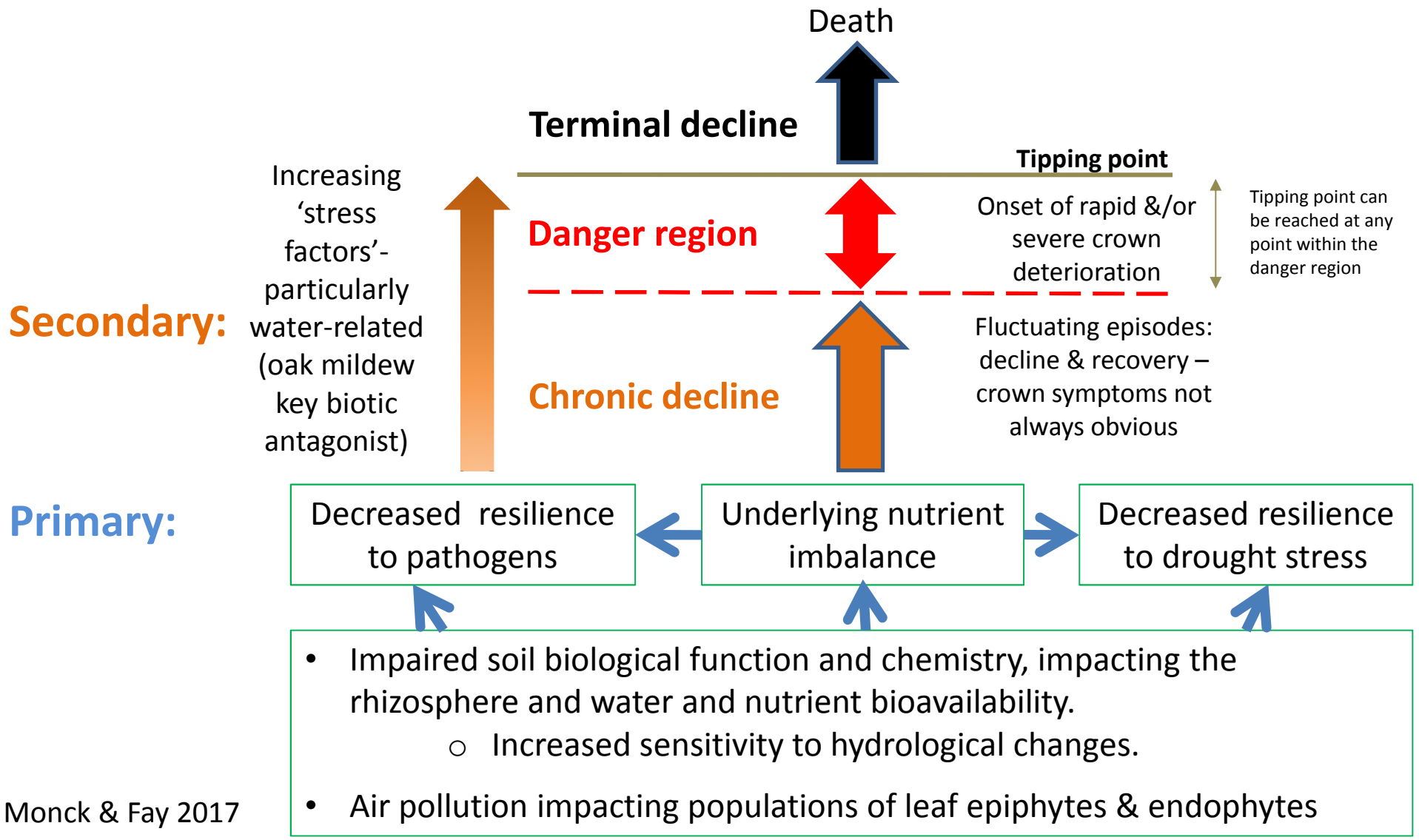
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Compost tea foliar application
Hypothesised beneficial effects

1. Antagonistic effects on oak mildew
2. Absorption of nutrients through leaves
   - Micronutrients
   - Humic acids
   - Work in Germany by Thomas & Bùttner (1998)
3. Presence of beneficial microbes on the leaf surface may serve to influence root exudates thus having an effect on the rhizosphere

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Hypothesis: Model of Oak Decline



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Implications for ancient & veteran trees (AVTs)
& associated biodiversity

- Other tree species may also be negatively affected by compromised soil ecosystem
  - beech, lime, sycamore, horse chestnut, sweet chestnut, ash, etc?
- AVT oaks less affected than younger age classes
  - Beneath AT roots, soils with greater continuity & biodiversity
  - Longstanding associations with mycorrhizal communities
    - Conserve low nutrient adapted (disappearing) mycorrhizal species
- AVT management – conservation of soil ecosystem biodiversity
- Serious implications for future AVT recruitment from younger age classes

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Research urgently required

- **Using metagenomics, establish baseline parameters of 'healthy' / 'unhealthy' soil community assemblages**
  - Related to soil type, chemistry & structure variables
  - Related to tree age-class
- **Are AVT oaks acting as conservation reservoirs for disappearing mycorrhizal species?**
  - Comparative study of rhizosphere microbiology
  - Healthy AVT oaks v declining oaks on the same site
- **What role do leaf endophytes play in disease suppression and expression?**

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National strategy
Basis for the focus of resources

- **The importance of survey**
  - we need to know what we have
  - what condition it is in
  - understand population dynamics, mortality rates & sustainability

- **Define criteria for assessing soil conditions**
  - based on research outcomes

- **Identify ultimate subset of key populations that are growing in favourable soils**

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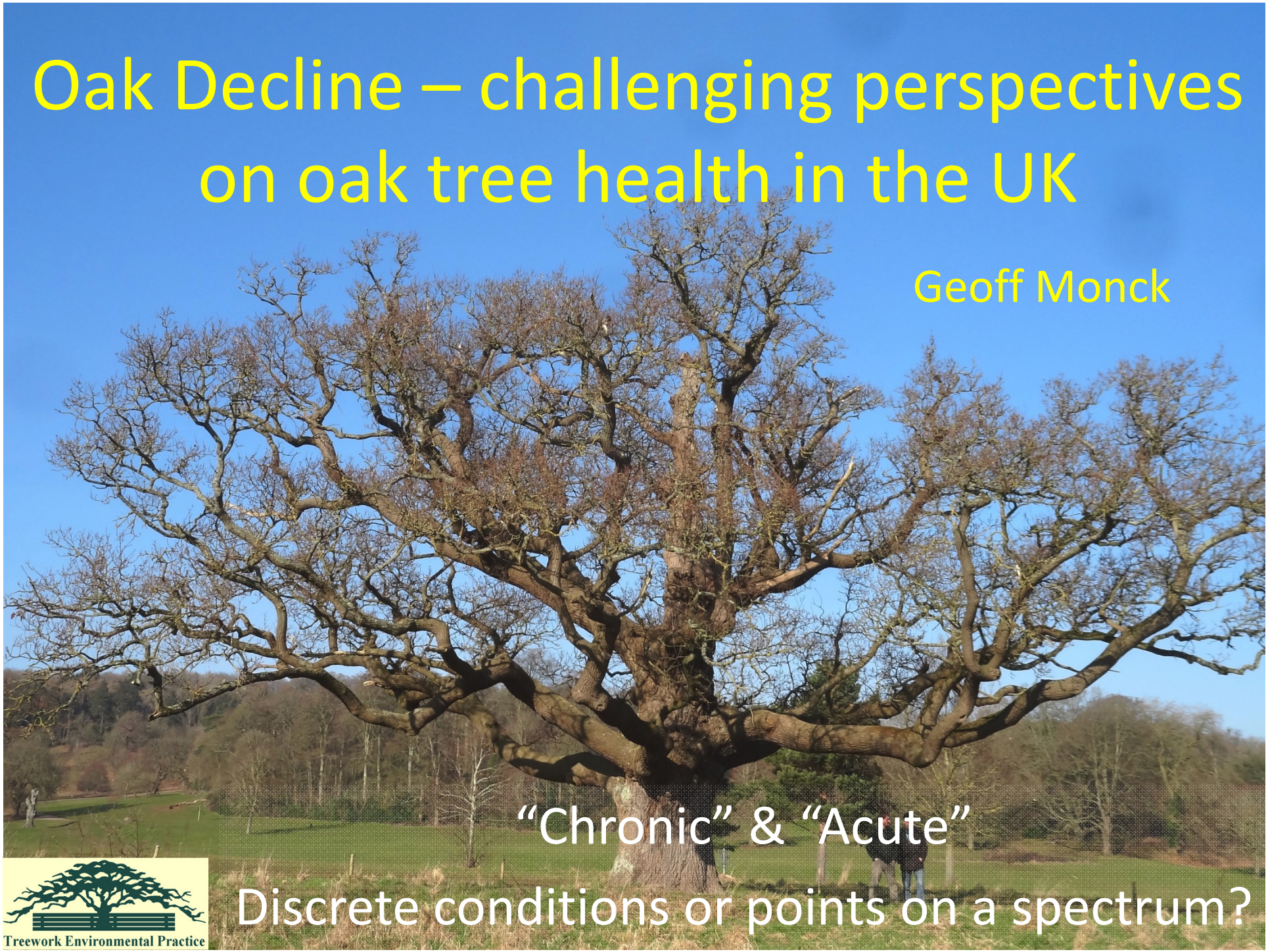
Oak AVT management strategy

- **Objectives don't change:**
  - Manage for tree longevity
  - Manage for continuity of habitat
- **Define management prescriptions & priorities**
  - Understand prevailing soil conditions on site
  - Management to restore soil to 'good health'
    - AVTs **and** future AVTs
  - Management to ensure bridging habitat - veteranisation
  - Review responses in context of treatment and population assessment and re-prioritise accordingly

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