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 by *Oak Declines*?

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

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What do we mean by Acute Oak Decline (AOD)?




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 sp.* 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)
- Misconception – previously ‘healthy’ trees affected
- Biotic influences (including bacteria) may be ‘stress factor’
- Similarities – previous UK episodes, parallel episodes in Europe

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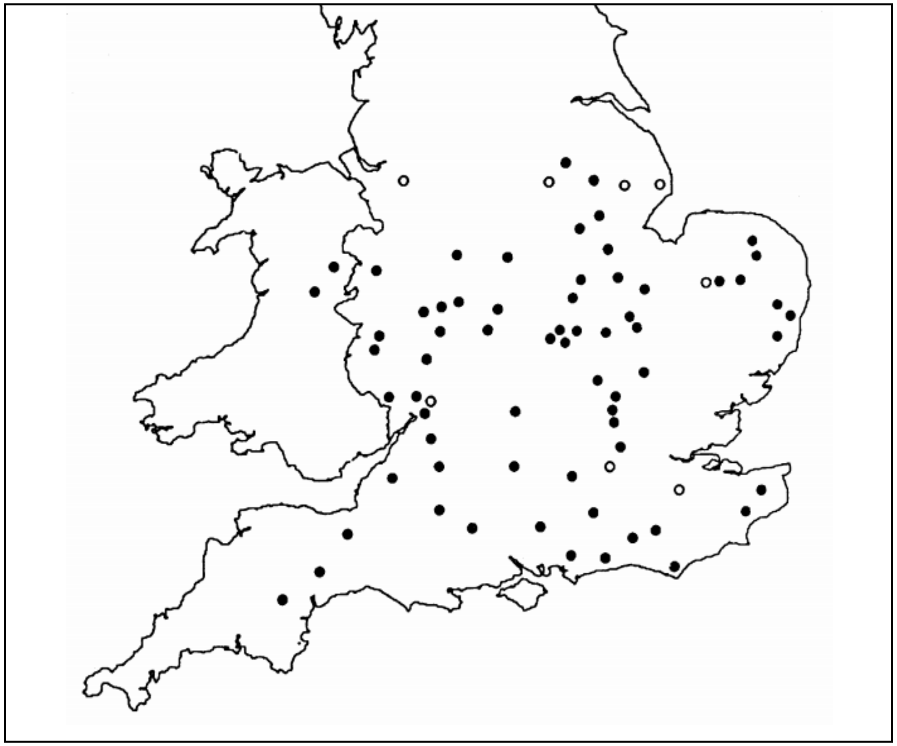
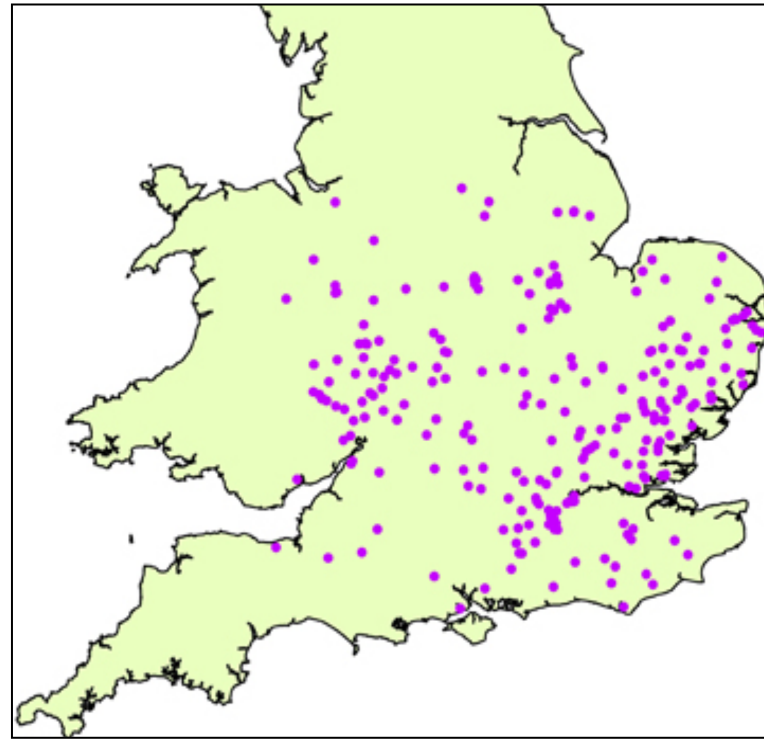
AOD: distribution of historic and current episodes



1989-1994 episode

Source: Gibbs, 1999



2002-2016 – current episode

Source: Forestry Commission data

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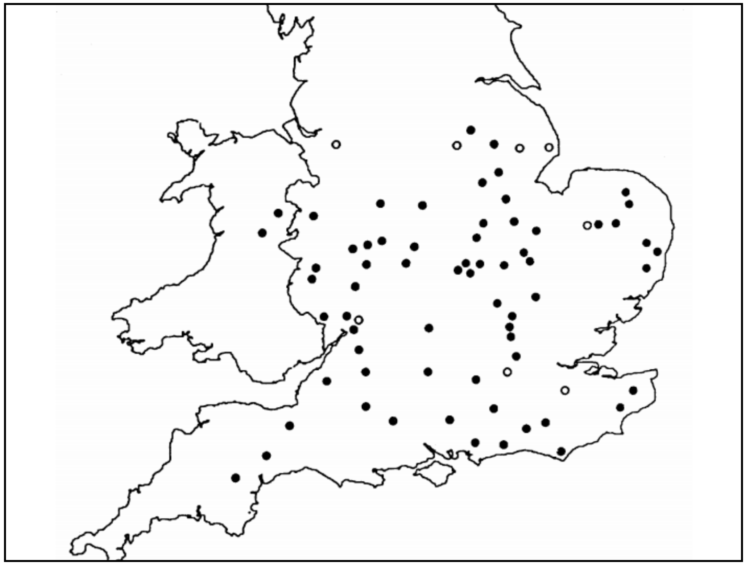
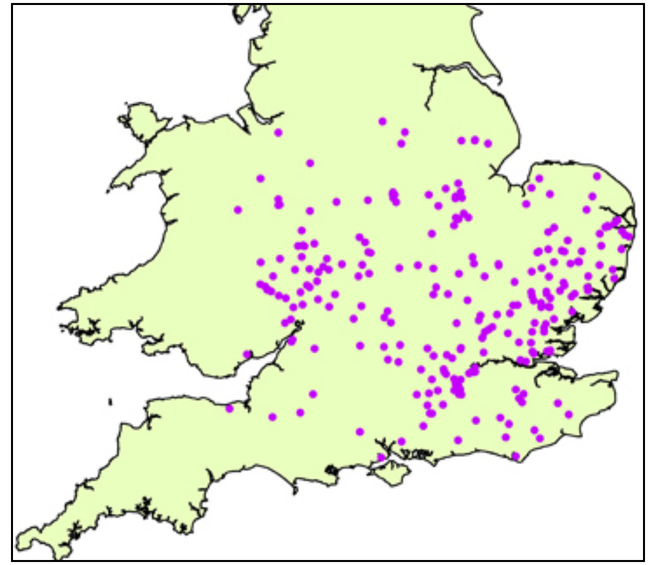
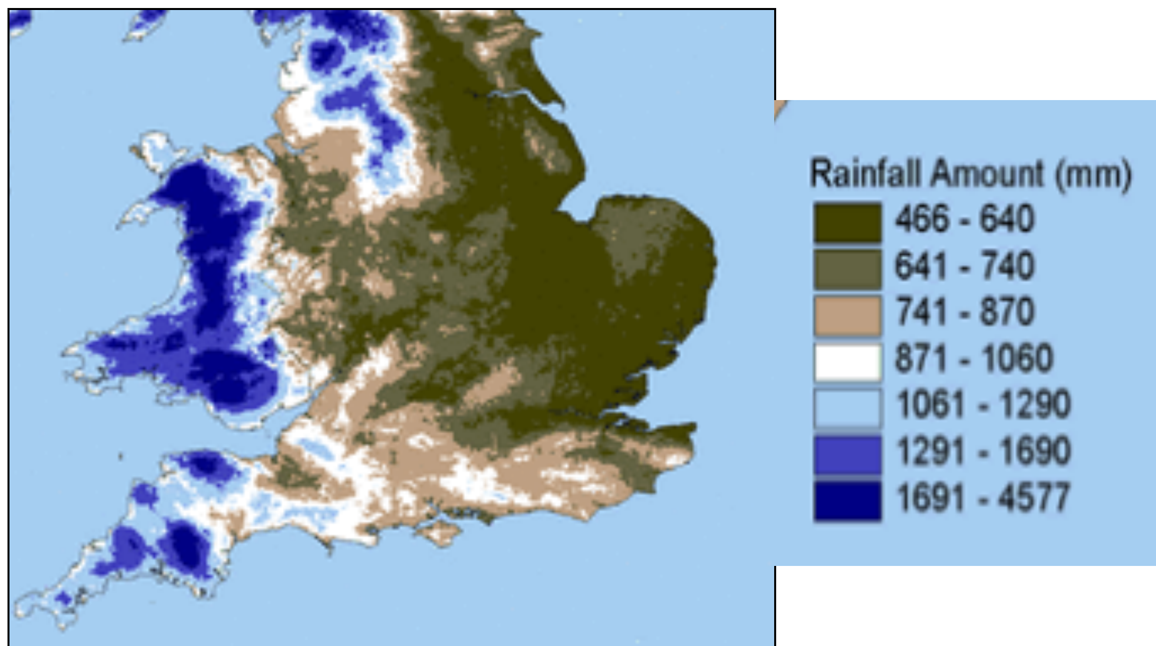




1971-2000
Average total
rainfall

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
  - Oak mildew impairing stomatal function
  - *Phytophthora sp*., *Armillaria sp*., *Collybia fusipes* - root hair death
  - Polluting effects causing negative osmosis
  - Mycorrhizal degradation

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Other key supporting evidence that COD and AOD result from the same underlying 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???**
  - Common to COD & AOD
  - Colonisation by bacteria may increase extent and incidence
  - No correlation - severity of bleeds & crown condition

(Denman, 2014; Royal Parks Study - Monck & Fay 2017)

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Profuse stem bleeding – current episode of AOD

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

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Partially occluded stem bleeds in oak populations (Guildford)

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Episodic decline history

Visually transient, long occluded stem bleeds point to past events

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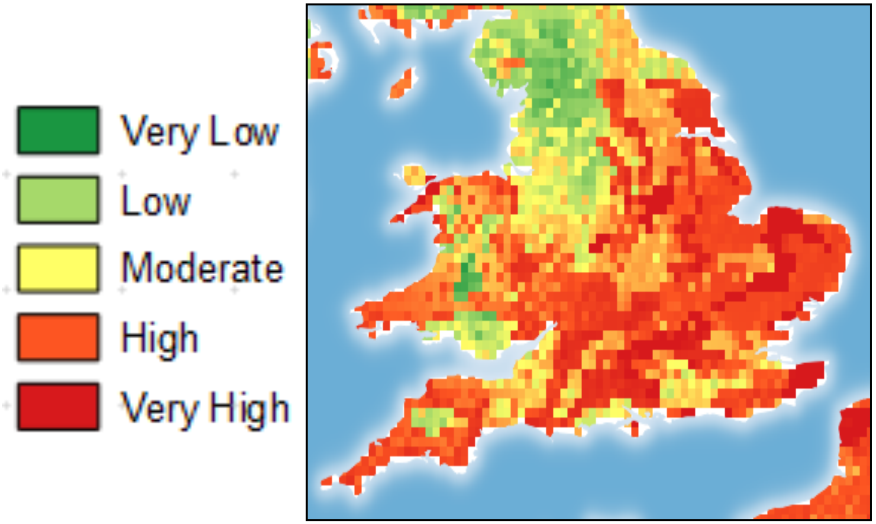
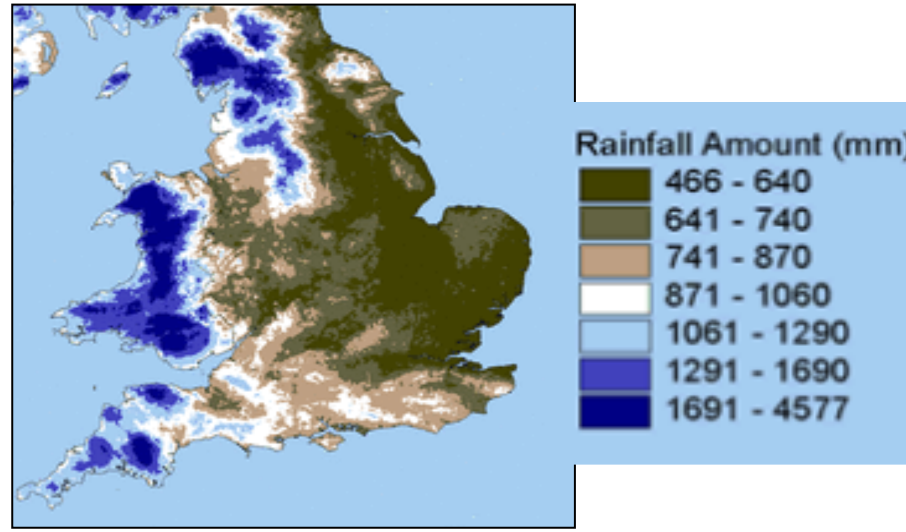
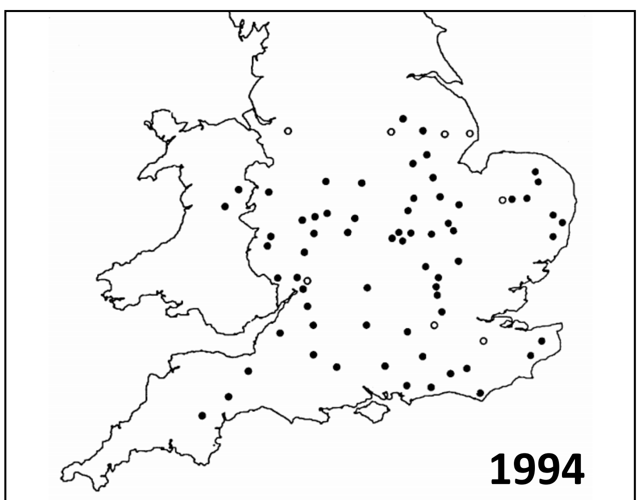
Epidemiological patterns
Potential indicators of underlying cause

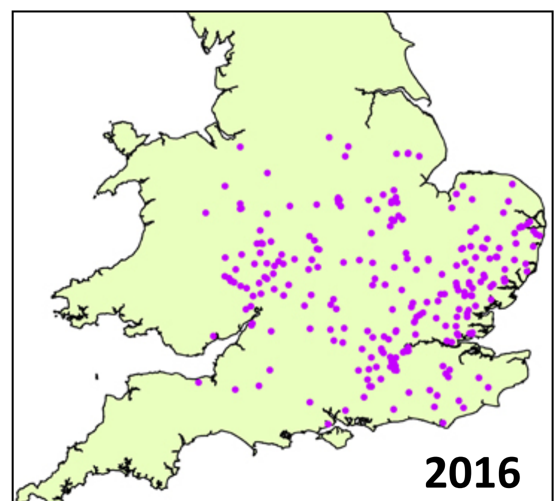


Potential threats to soil biodiversity 2016

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 tree/soil/microbe ecosystem

- Complex relationships - soil microbes & tree roots
- Trees drive rhizosphere microbial communities
  - Root exudates (carbohydrates, proteins & hormones)
- Complex feed-back loops

  (Rudrappa et al, 2008; Kumar et al, 2012; Novas et al, 2011)
  - 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

Implications for our understanding of plant pathology

- Tree(s) / soil / microbe – interconnected superorganism
- Tree health reflects that of whole biotic system
- Conventional models of plant/disease interactions of limited use
  - Based on premise of tree as a discrete unit
  - Assume uncompromised microbial element
  - 'Koch's Postulate' - inappropriate

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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
- Soil and rooting environment only recently 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 (2011-2015)

- 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
  - Stem bleeds
  - Oak Jewel beetle exit holes

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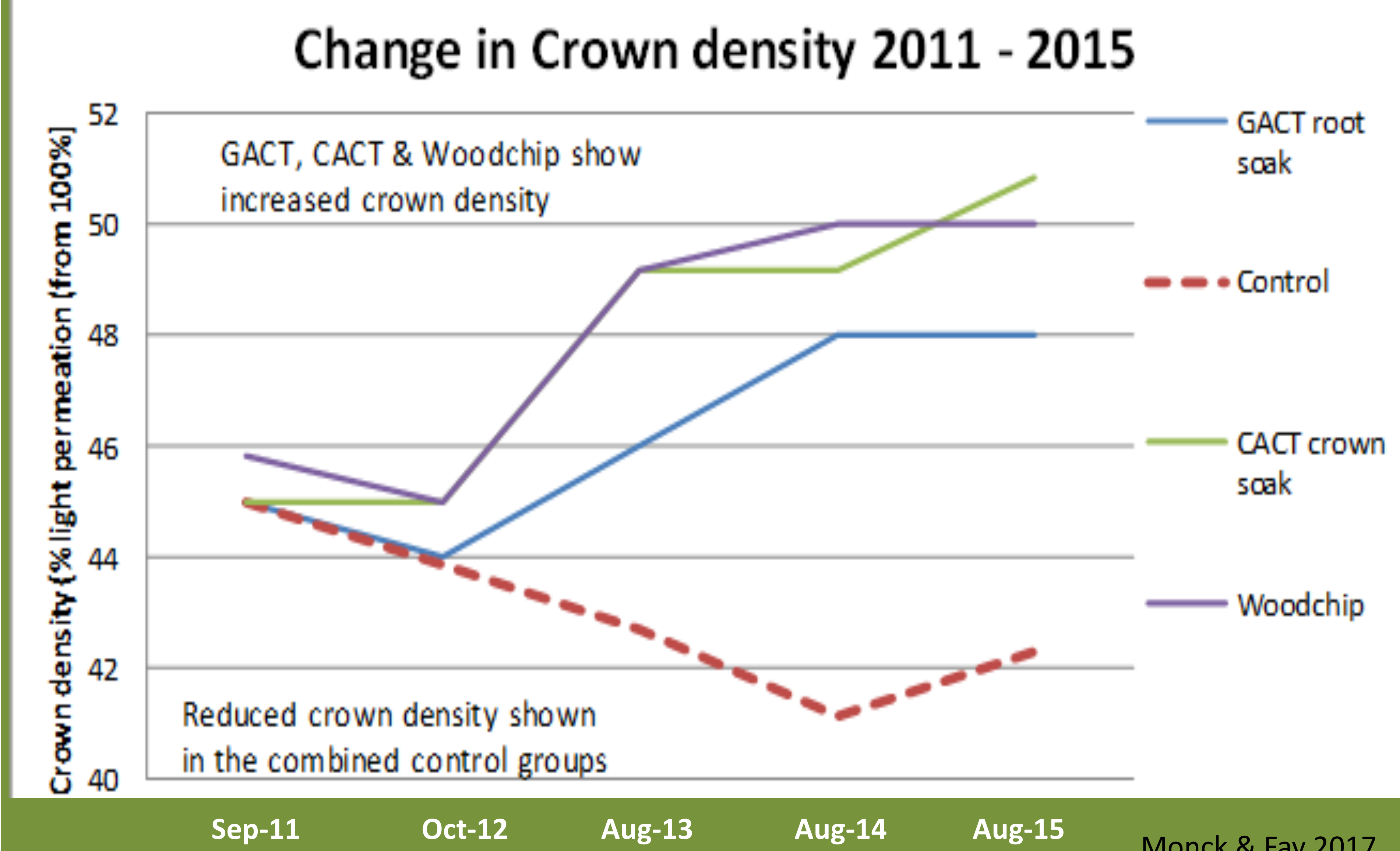
Royal Parks AOD study

Mean change in crown density (%) 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
  - Fertilise with micronutrients
- 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) (both photos taken late August)

70% reduction crown density

45% reduction crown density

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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 leaf epiphytes and endophytes may influence root exudations

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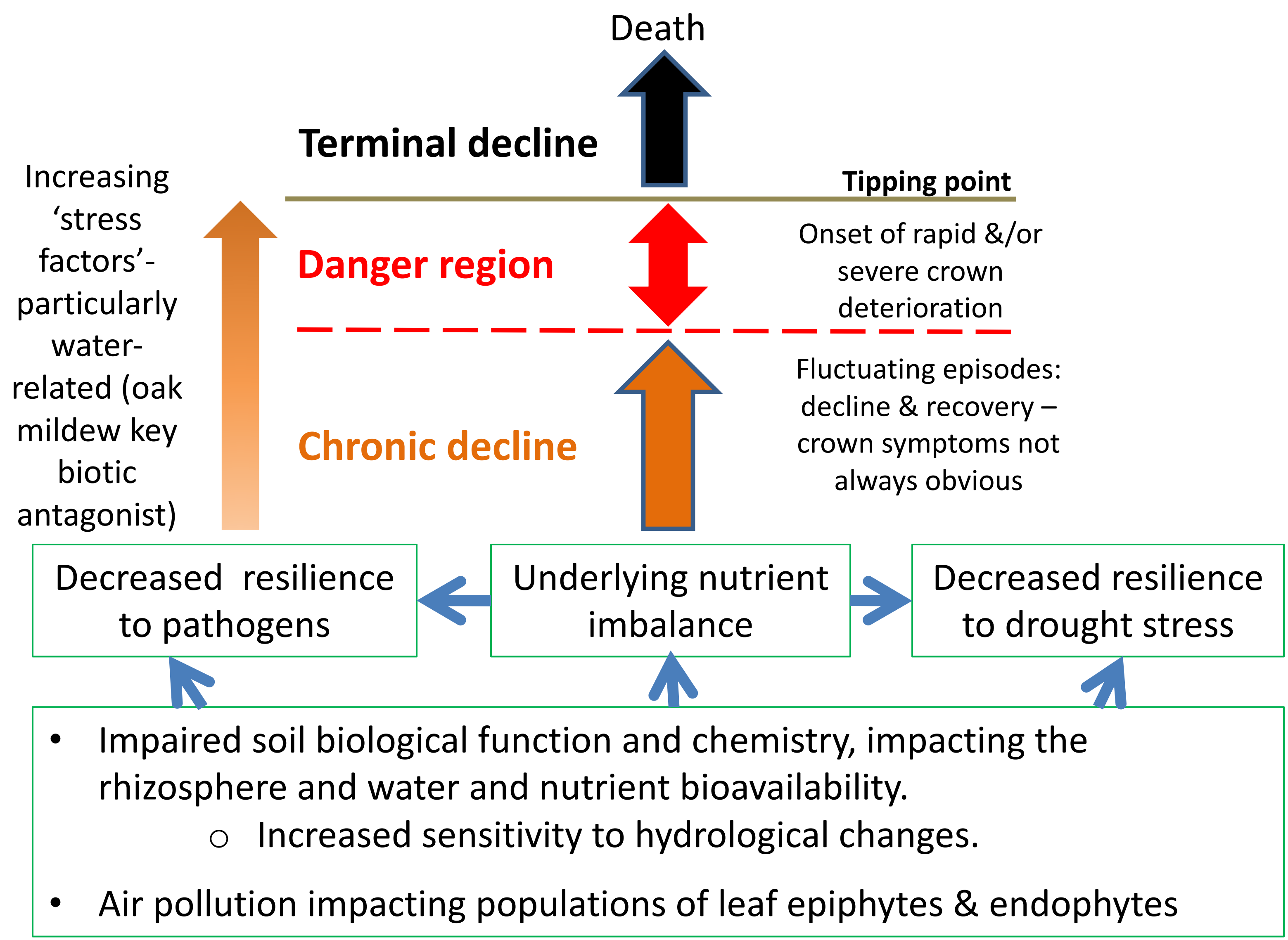
Hypothesis: Model of Oak Decline

Secondary:

Primary:



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Implications for population sustainability
& associated biodiversity

- Other tree species also likely to be negatively affected by compromised soil ecosystem
  - lime, sycamore, beech, horse chestnut, alder, ash, elm, sweet chestnut, etc?
- Ancient and veteran (AVT) oaks less affected than younger age classes
  - Beneath AVT roots, soils with greater continuity & biodiversity
    - Confer resilience upon host
  - 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
  – Related to species
- **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
  – Other tree species
- **What role do leaf epiphytes & endophytes play in disease suppression and expression?**
- **Understand population dynamics, mortality rates & sustainability**

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