BAC-STOP
STOP BAD BACTERIA ON OAK

# Acute Oak Decline – Predisposition Drivers affect host susceptibility, and disease infection and severity

## Bac-Stop - WP 2 Update

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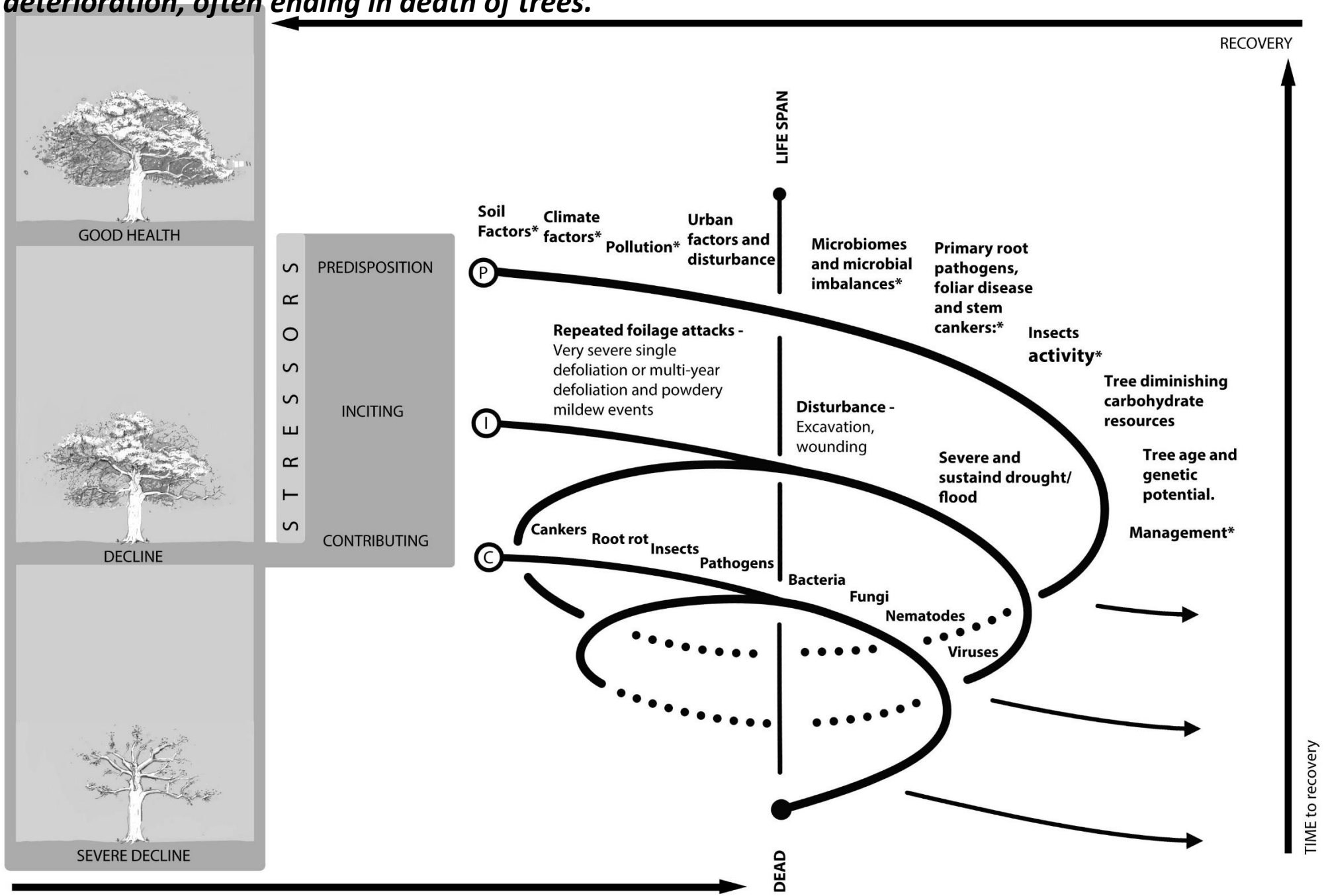
***Decline: Arises from <u>interactions</u> of <u>interchangeable</u>, <u>specifically ordered</u>, abiotic and biotic factors that produce a general deterioration, often ending in death of trees.***




**Decline Diseases are complex having multi-factor causes.**

**Decline disease spiral Model**
**Dynamic disease system**

- **Predisposing**
- **Inciting**
- **Contributing**
- **Time**

**Predisposition places stress on trees weakening them so that they are more vulnerable to P&D**

**Scale is important**

Updated Decline Disease Spiral Model Denman et al. 2022

**Trees need water and nutrients to growth**

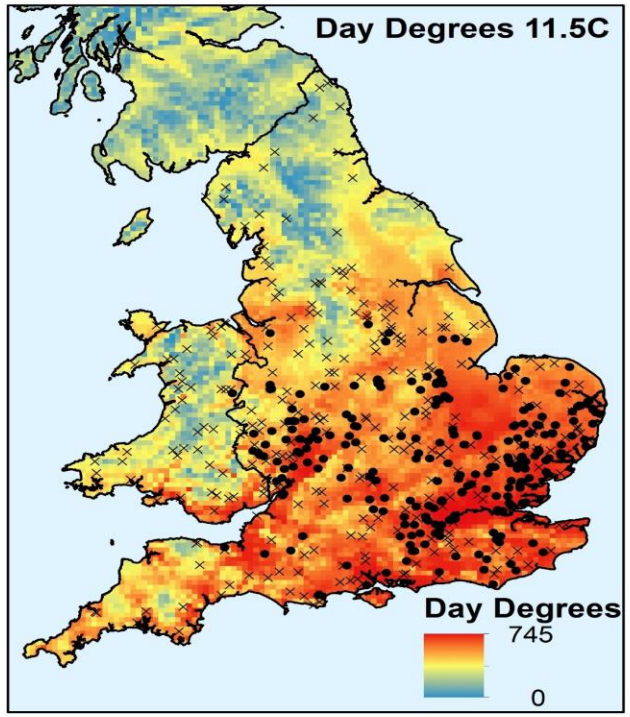
- **Predisposition factors – are linked to water and nutrient availability**
- **Impeded uptake leads to deficiencies**
- **Imbalances**

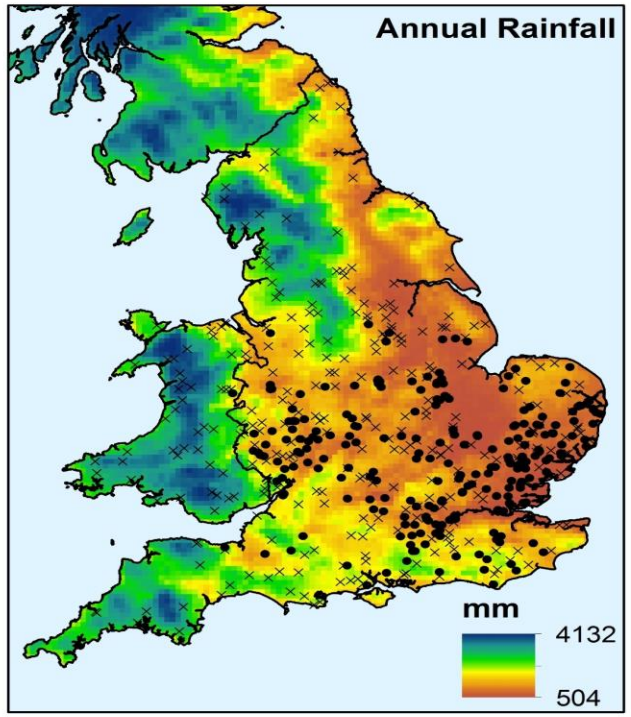
**Tree response affects their health status**

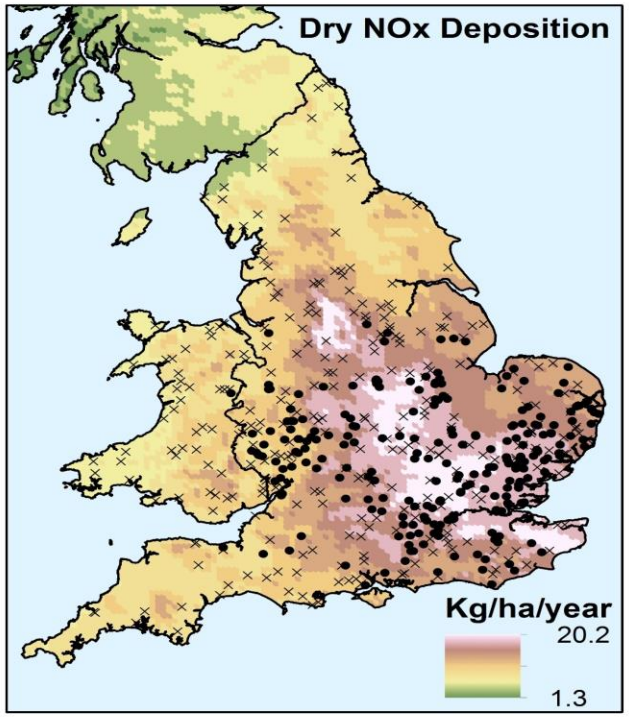
**Trees become stressed**

**Increased risk of pests and diseases - AOD/COD**

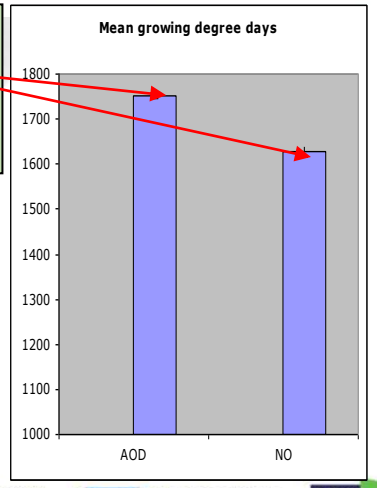
# Predisposition factors associated with AOD  Landscape Scale



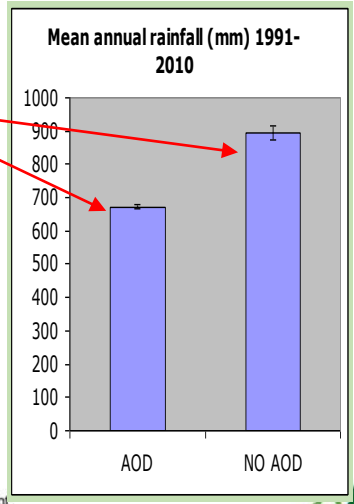



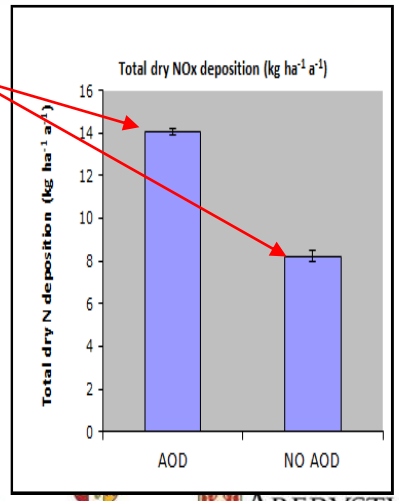

**>100 days difference** (>11.5 C (sum 1961/90)




**>200mm rainfall difference** average annual rainfall (1991-2010)




**(~7kg/ha/a) difference** dry N deposition




## Significant correlations between AOD occurrence and:

- Warm areas
- Dry areas prone to drought
- High nitrogen
- Low dry sulphur

# Soil as a predisposing factor at site specific scale and the links between soil and trees (roots and foliage)

Ten study sites: 7*AOD and 3*COD

10 healthy and 10 symptomatic paired trees were chosen = 20 trees – used across all work packages

For each tree, 5 soils and 5 root samples were taken with soil cylindrical core (8 cm diameter, 15 cm depth)

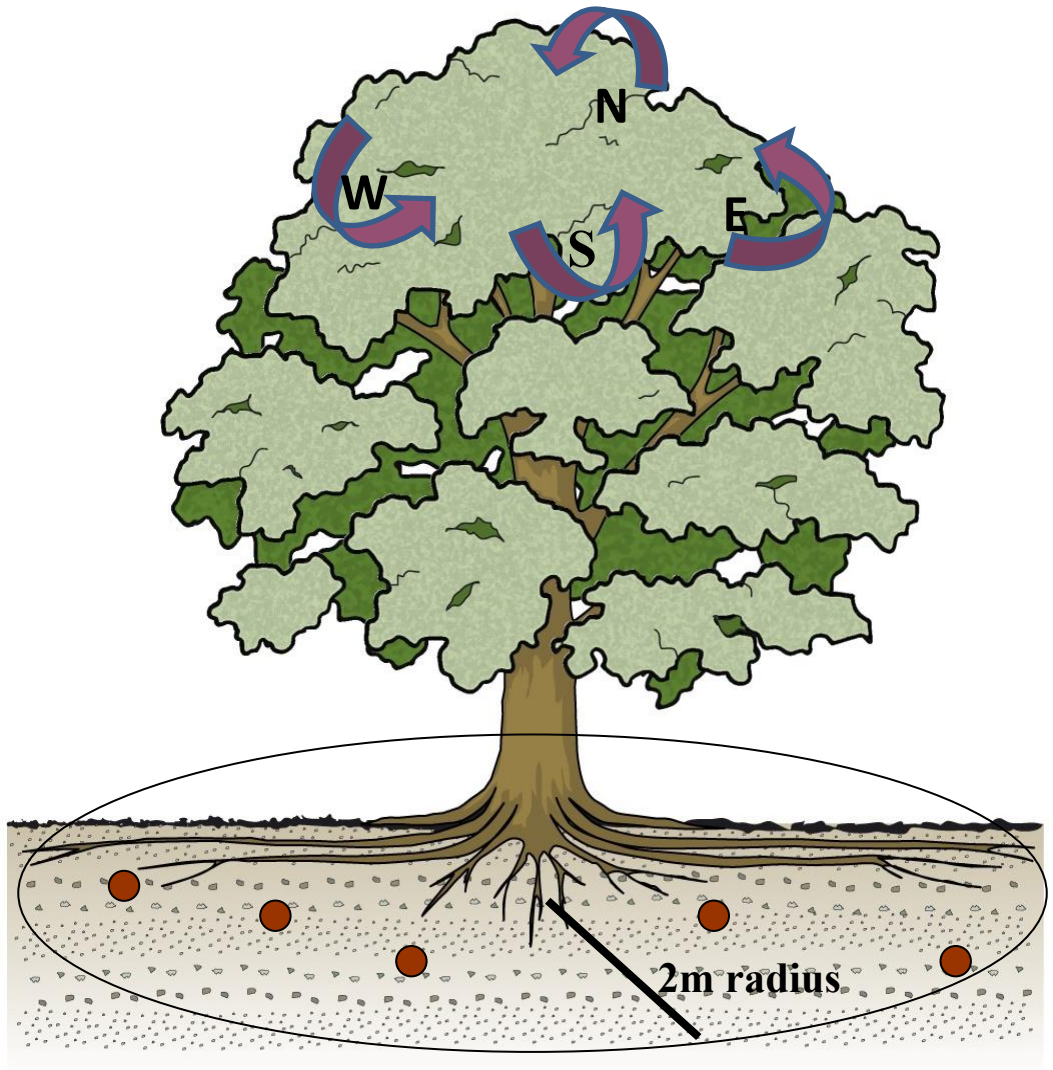
Each root sample split to mineral soil of 0-15-15-30 cm depth

Each soil sample split to humus layer and mineral soil of 0-20, 20-40, 40-80 cm depth

The same 20 trees in each site had foliar sampling and analyses

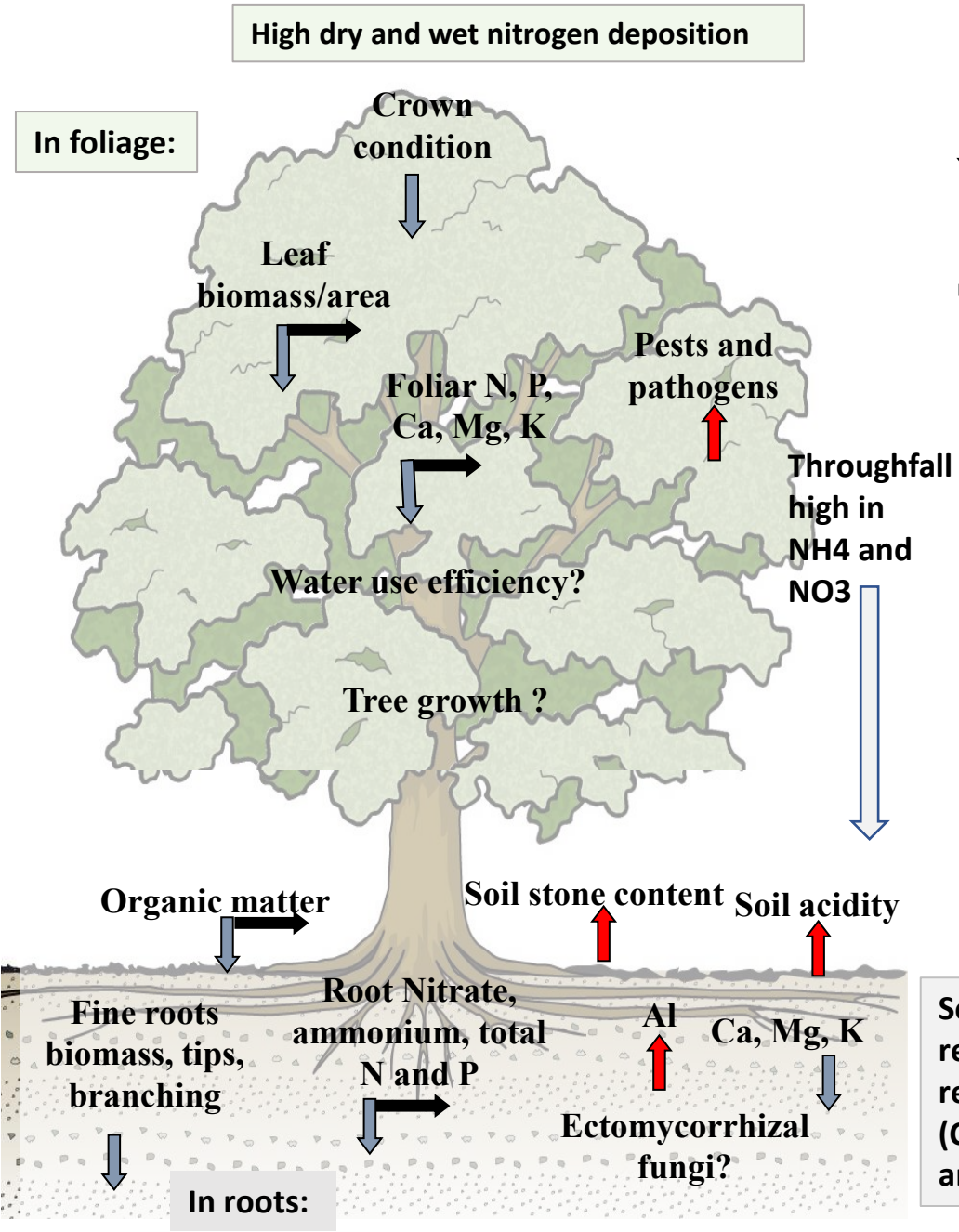
All chemical analyses carried out in FR's biogeochemical laboratory at Alice Holt

*Foliar sampling – 4 cardinal directions*




*Soil and root sampling – 5 points per tree*

## Acidity driven scenario:




## Acidity driven Healthy vs AOD trees

**Significant differences – in AOD trees:**

- Soil acidification
- Al toxicity to roots
- Cation (Ca, Mg, K) depletion
- Higher stone content
- *Lower* root density, biomass, tips, branching
- *Lower* carbon and water holding capacity
- *Lower* specific leaf area but similar biomass
- *Lower* tree uptake of N, P, Ca, Mg and K

# AOD Developing Model

Soil acidification causes release of Al ions and reduces cations availability (Ca, Mg and K) by exchange and leaching processes → Al toxicity inhibits feeder roots growth causing low capability of trees for nutrient uptake → Reduced nutrient availability in soil and reduced root growth can significantly reduce tree nutrient uptake and tree growth

# Bac-Stop Project WP 2

## Predisposition at the tree specific scale

## Field trial

***Drought and nutrient stress predisposition drivers***

**Effects on host growth and metabolism**

**Effects on AOD establishment and severity**

**<u>Hypothesis</u>: AOD is more likely to establish, develop more rapidly and be more severe in stressed or weakened trees**

***The primary aim of the experiment was to determine the effects of drought and nutrient deprivation on AOD establishment and development***

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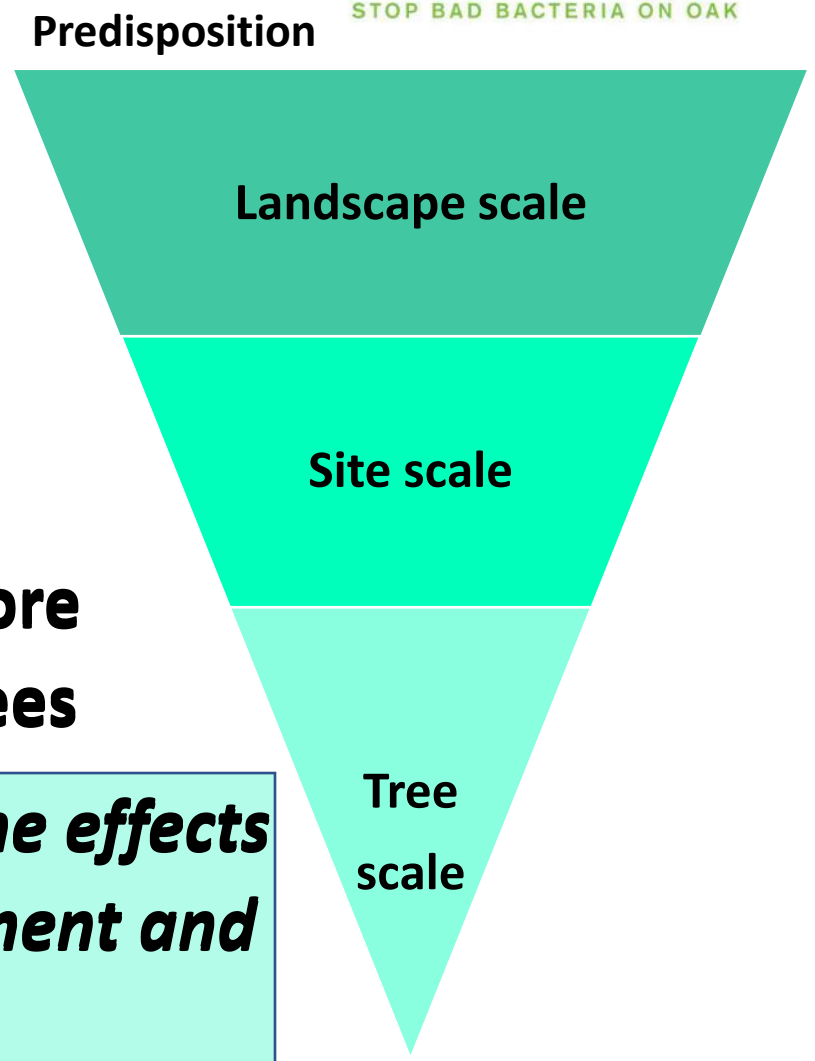


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## Secondary aims were to determine:

- The effects of drought and nutrient deprivation on tree growth, metabolism, and the microbiome
- AOD can develop on healthy trees
- AOD can establish without wounding
- AOD can develop without the presence of *Agrilus* larvae
- Specific biochemical molecules (elicitors) cause the upregulation of damaging bacterial genes.

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**The Experiment comprised:**

**3 environmental treatments:**

- **Control**
- **Drought**
- **Ringbarking as a proxy for water and nutrient deprivation stress**

6 blocks; 8 trees per treatment per block

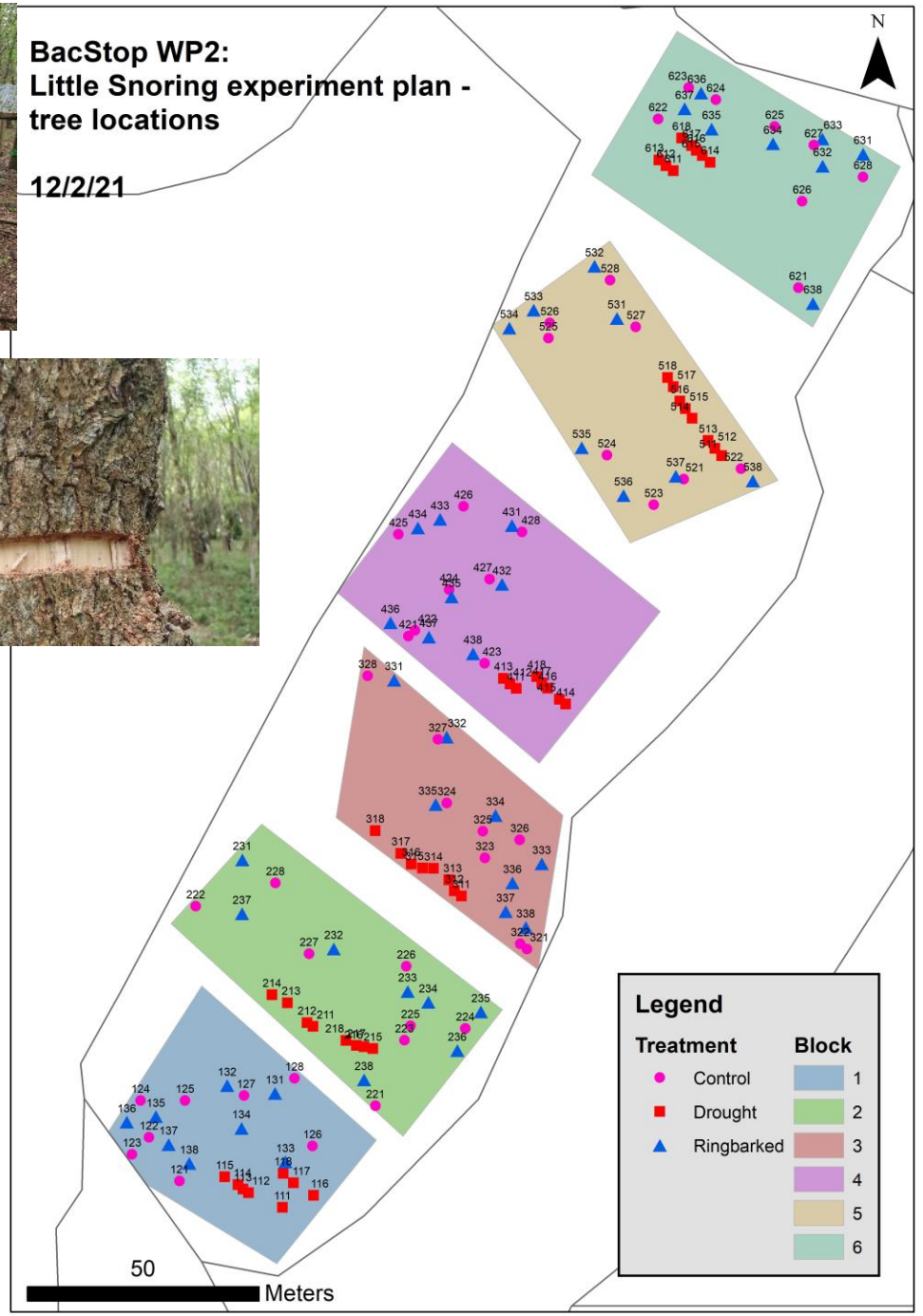
**The biological treatments applied to the trees included various combinations of wounding, bacteria and beetle larvae**

| Treatment # | Wound | Bacteria | *Agrilus* eggs | Name |
|---|---|---|---|---|
| 1 | *Absent* | *Absent* | *Absent* | NW Control |
| 2 | *Present* | *Absent* | *Absent* | W Control |
| 3 | *Absent* | *Absent* | *Present* | NW-Ag |
| 4 | *Present* | *Absent* | *Present* | W-Ag |
| 5 | *Absent* | *Present* | *Absent* | NW Bacteria |
| 6 | *Present* | *Present* | *Absent* | W Bacteria |
| 7 | *Absent* | *Present* | *Present* | NW Ag+B |
| 8 | *Present* | *Present* | *Present* | W Ag+B |

**Is drought predisposition essential for AOD development?**

**Can *Agrilus* attack a healthy tree?**

**Can AOD develop without a wound?**



# Parameters measured

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- Disease severity on trees
- Host responses to environmental and biological factors
  - TreeTalkers - continuous measurements of host physiological response and tree nutrient status
  - Metabolomics – impacts on tree chemistry and metabolism
  - Transcriptomics – show tree genes responding to the treatments
  - Microbiome – microbial community composition
- Environmental Conditions
  - Data loggers – continuous soil temperature, moisture
  - Soil nutrient and physical status

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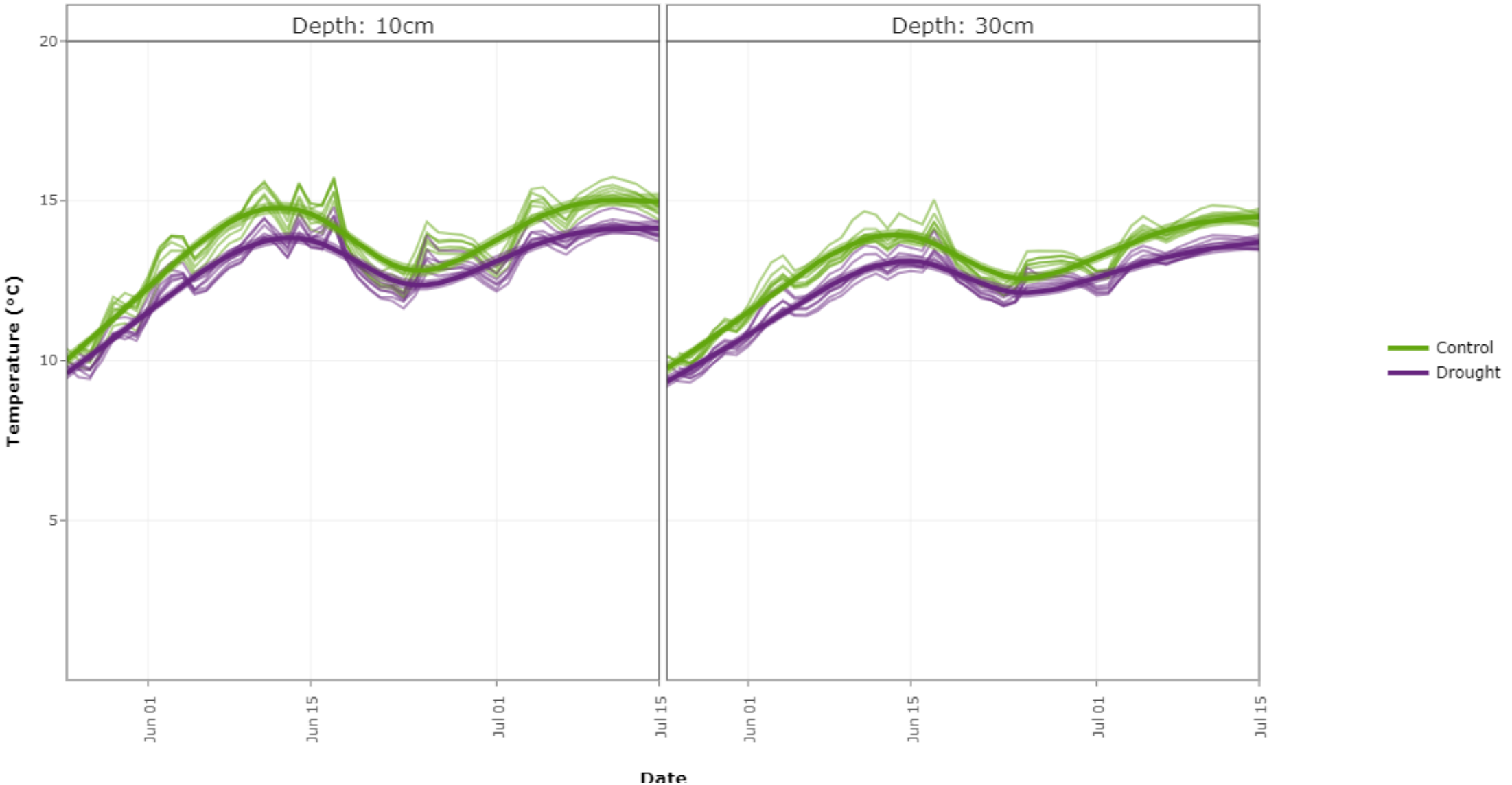
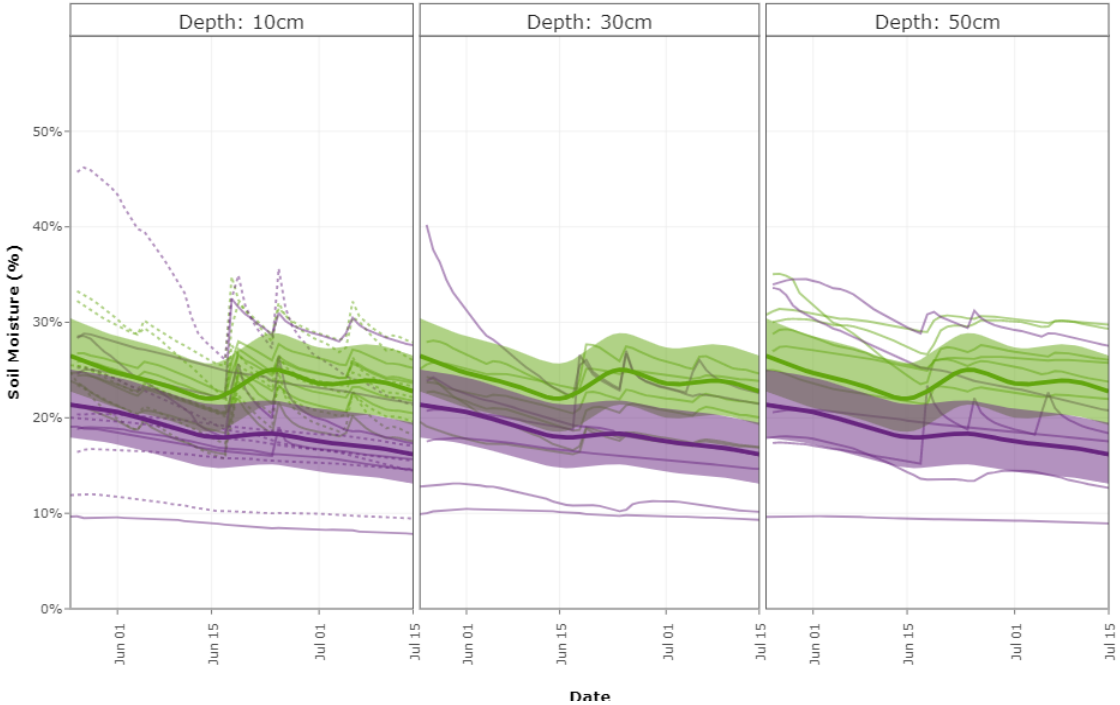
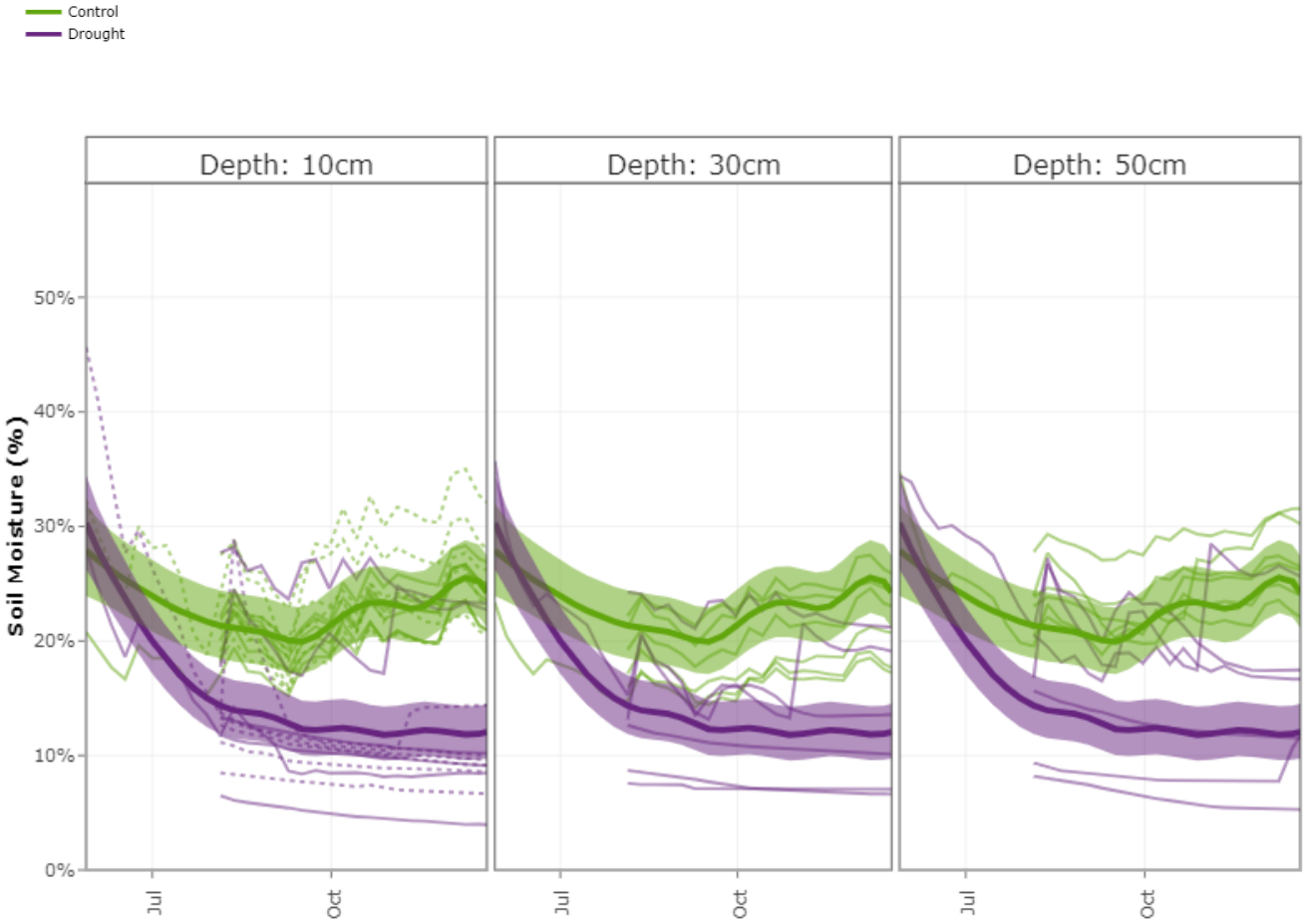



**Soil Temperature Data Jun-Jul 2021**




**WP2 Field trial soil moisture data May2021-July2021**




**WP2 Field trial soil moisture data July2021 –Nov 2021**

# Non-Wound *Agrilus* only treatments

Mark inoculation spot on trees with white marker & surface disinfest

Apply tubes to non-wound treatments

Examine egg cases, apply to non-wound treatments;

Put protective seal on

# Non-Wound bacteria only treatments

Prepare inoculum in mobile lab ensure correct concentration of bacterial cells

Apply tubes to non-wound treatments

Using pipettes apply set volumes to tubes on trees

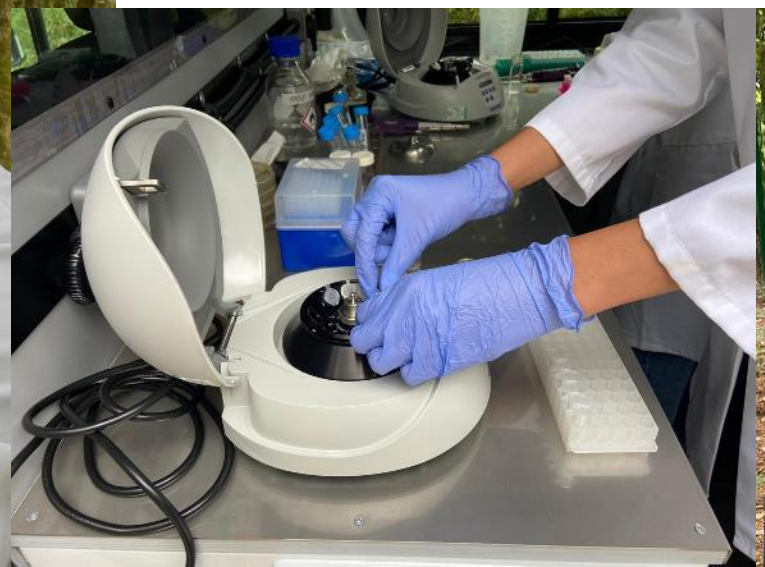
Put protective seal on

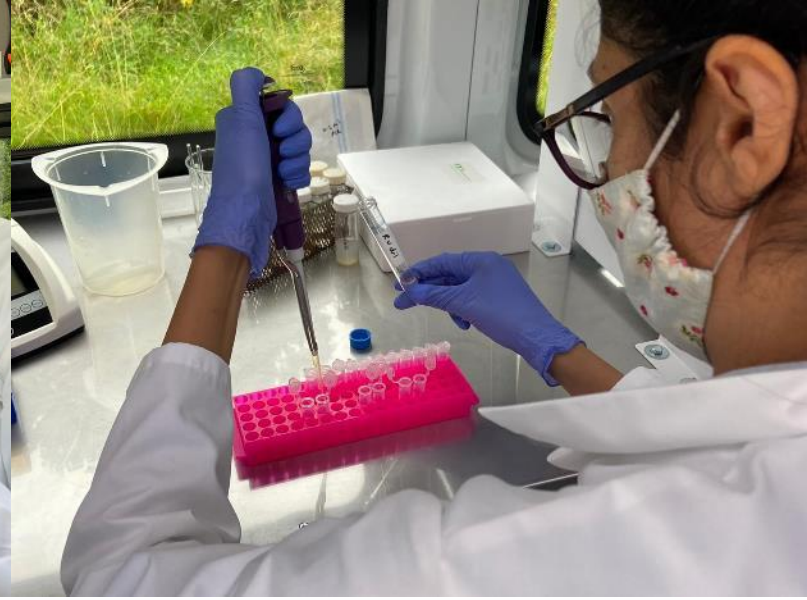

# Wound treatments

Mark inoculation spot on trees with white marker & surface disinfest

Wound trees with cork borer and apply tubes to tree stem with silicon plugs

*Agrilus*: Examine egg cases, apply to wound treatments;
Bacteria: Using pipettes apply to tubes
Both: Apply bacteria on day 1 leave overnight, on day 2 apply *Agrilus*
Put protective seal on



## Monitor trees and possibly repeat next year


## ***Mid-term assessment: Callus assessment as an indicator of tree energy status***

**Scoring Scale**

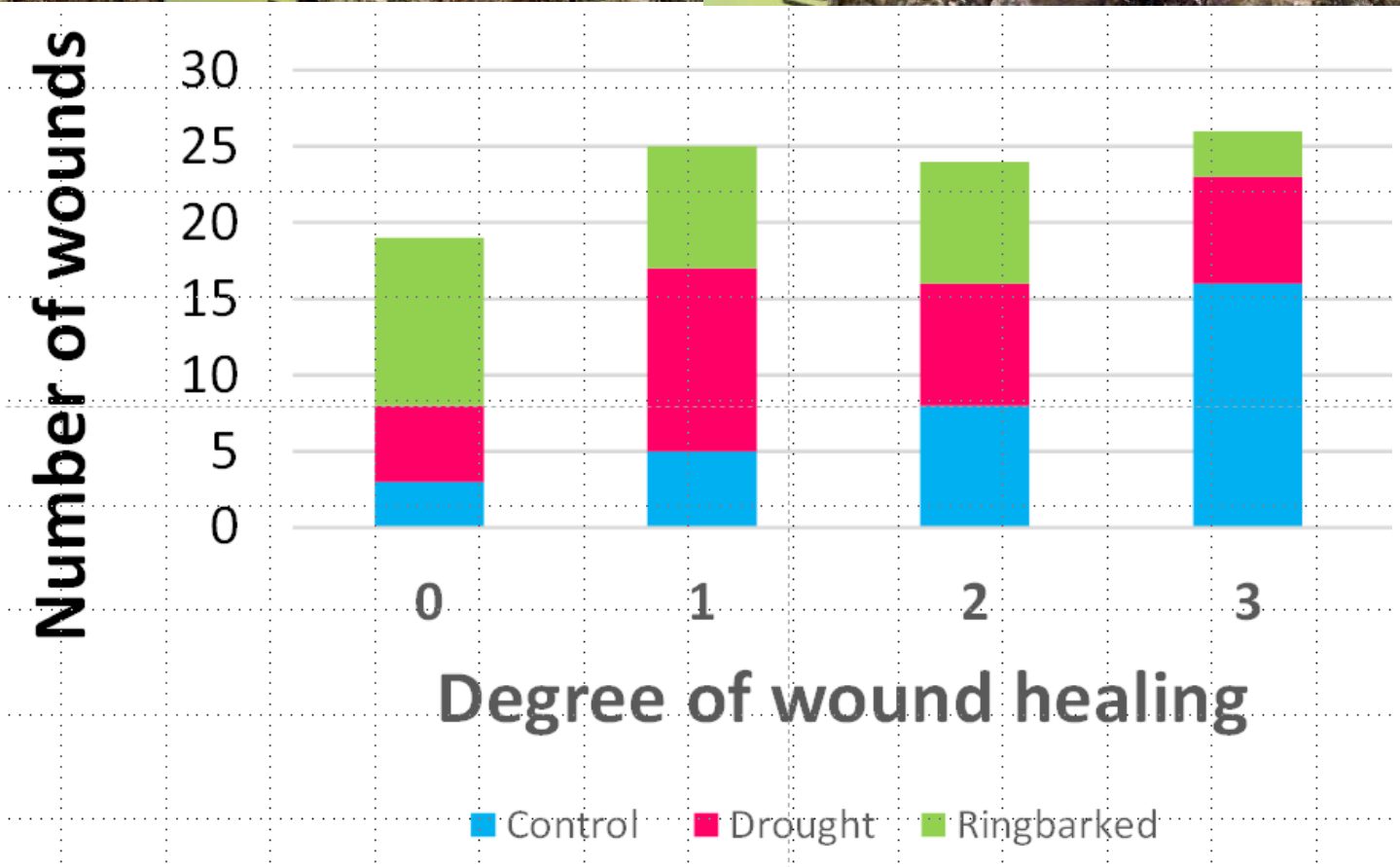
**0 = No healing**

**1 = < ¼ of the wound has healed**

**2 = ¼ - ¾ of the wound has healed**

**3 = > ¾ of the wound has healed**

**4 = Wound fully healed**



# Concluding statements

- Tree-Time! Research takes a long time
- Sustained investment in research is yielding results on correlations between environmental predisposition drivers and AOD occurrence
- Existing models are being updated and new models are developing
- Research takes courage and persistence
- Thanks to the amazing team and thanks to all our stakeholders for their fantastic support –
- You are all helping secure a future for our oak trees

# Thank you

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