

OZONE EFFECTS ON THE BIOMASS, NODULATION AND NITROGENASE ACTIVITY OF CLOVER CULTIVARS

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How do you make a cow?

Amongst other things, 1kg of beef needs roughly:

- 460 L drinking water
- 43kg grain/hay
- 46,000 L water to make the feed
- 25g of N per kg of meat
- 700kg cow ~ 17.5kg N

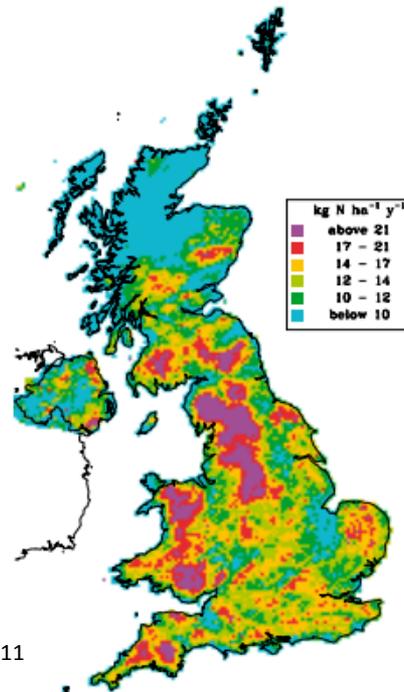
This N must be obtained from the pasture forage

? + ? =



A temperate pasture may require $>100\text{kg}/\text{ha}^{-1} \text{yr}^{-1}$ of N input to meet the demands of grazing livestock.

- Some will be deposited (UK total N deposits $<10\text{kg} - >21\text{kg}/\text{ha} \text{yr}^{-1}$)
- Applied in fertilisers
- Obtained via clover (*Trifolium* spp.)



Clovers are legumes (Fabaceae)

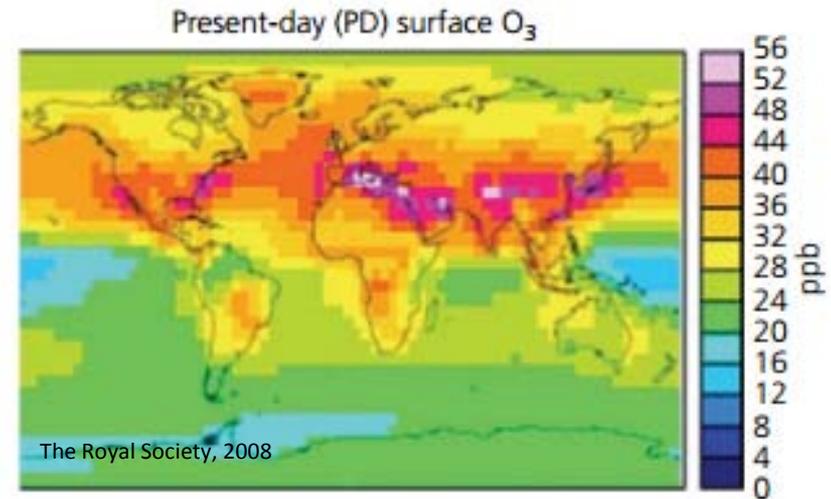
- Bare symbioses with N-fixing rhizobia in organs called root nodules in N-limited conditions.
- Legumes are the primary source of protein for a substantial proportion of human population.
- Importance of legumes in agriculture known for millennia



White clover root nodules

Ozone concentrations have increased since pre-industrial era

- Ground level ozone most damaging air pollutant
- Causes multi-billion \$ losses annually in a range of important arable crops.
- Further increases predicted during cause of this century



Ozone effects on pasture

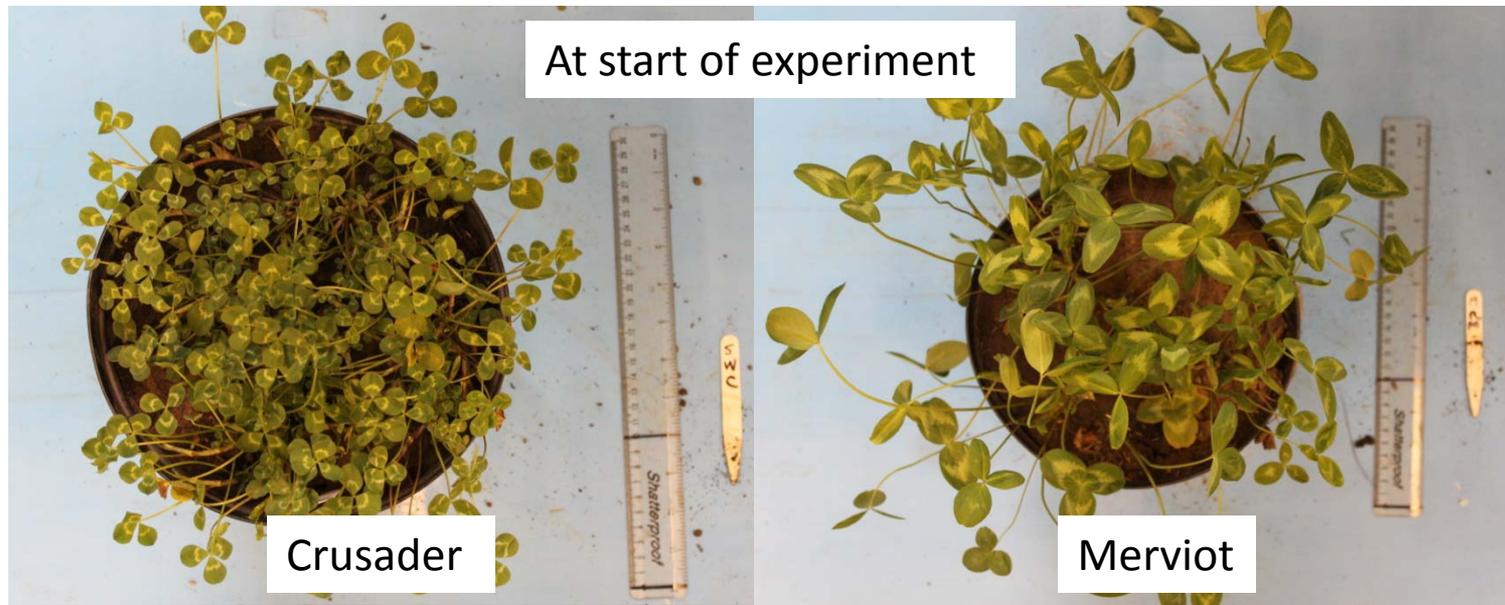
- Numerous studies show ozone may affect reductions in composition yield, & forage quality in temperate pasture



- Ozone shown to reduce nodulation/fixation in number of legumes
- Modern cultivars of clover

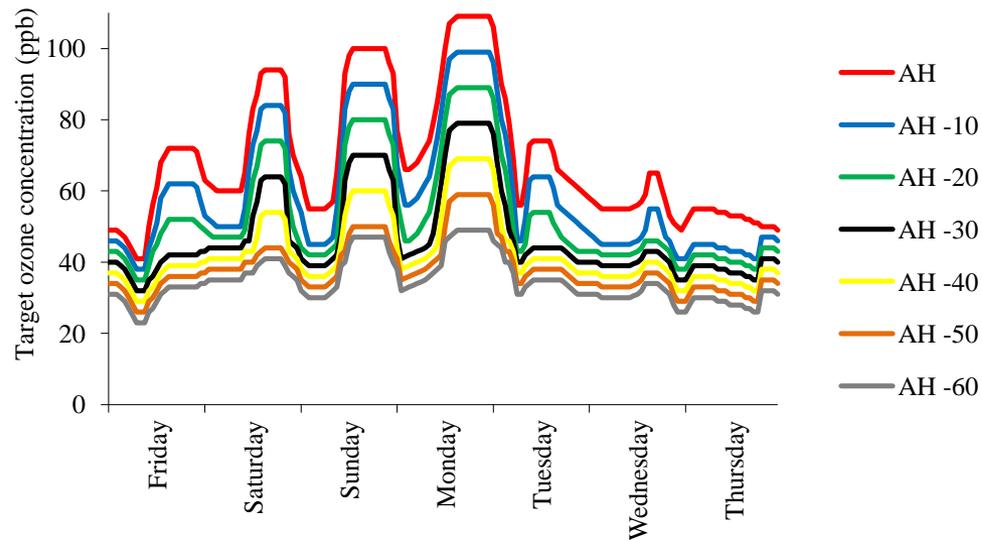
Solardome study

- Studies based at the CEH solardome facility (nr Bangor)
- Test of modern clover cultivars recommended for general use in grazed pasture (British Grassland Society, 2012).
- White clover (*Trifolium repens* cv. Crusader)
- Red Clover (*Trifolium pratense* cv. Merviot)



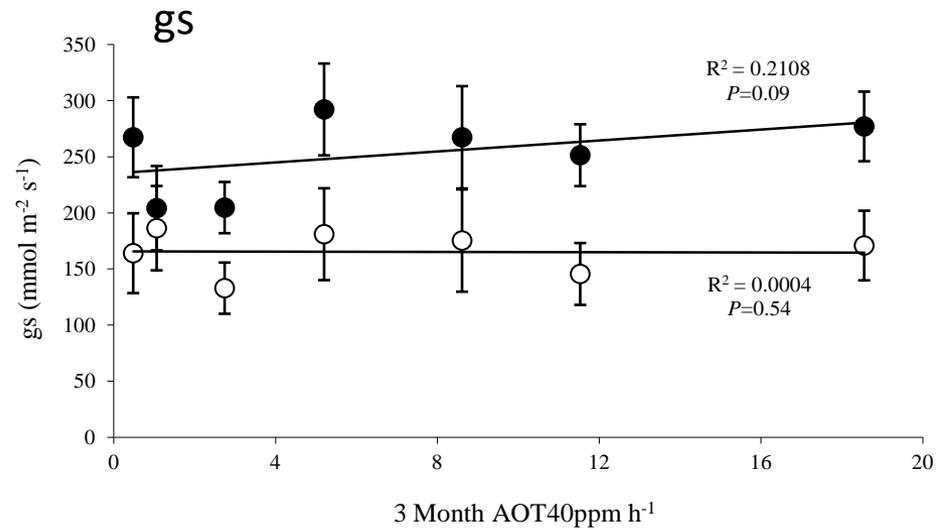
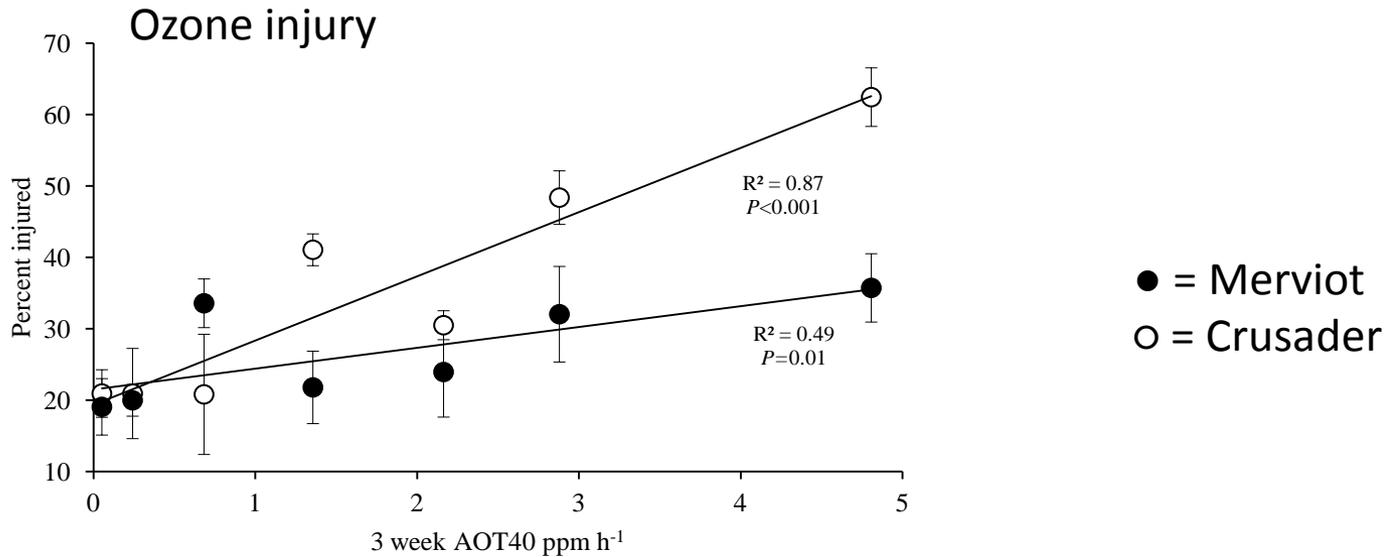
Broad aim to quantify physiological impacts on the cultivars.

- Plants exposed in to 7 ozone scenarios (with a unique scenario per dome).
- Scenarios based on a profile recorded at Aston Hill monitoring station (Flintshire, UK).
- 6 replicates per scenario; exposed for 12 weeks

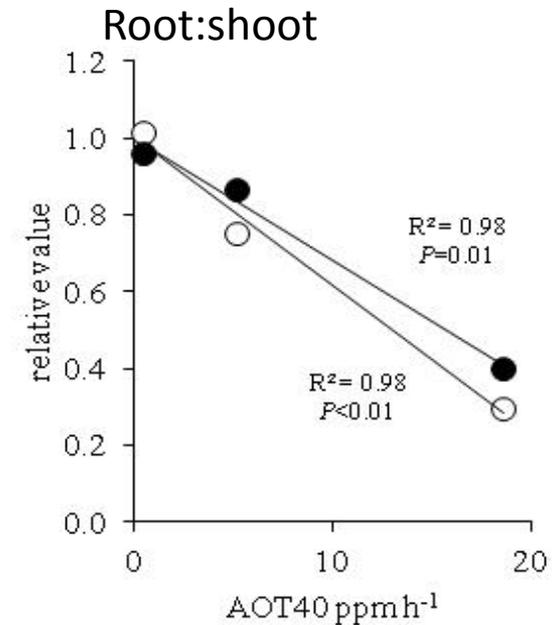
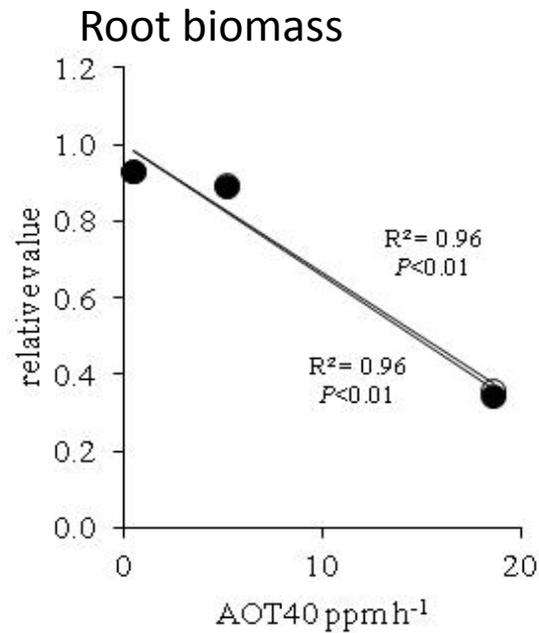
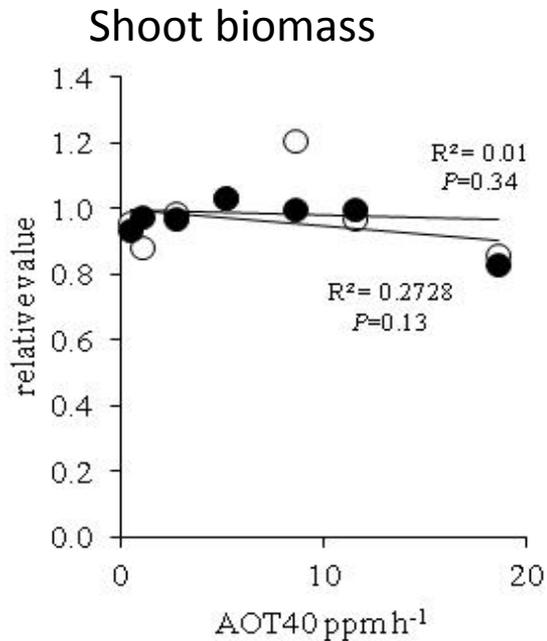




Ozone injury and stomatal conductance (gs)

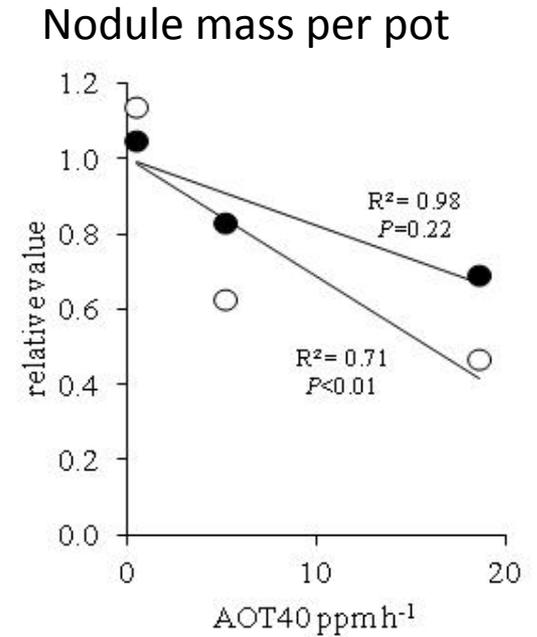
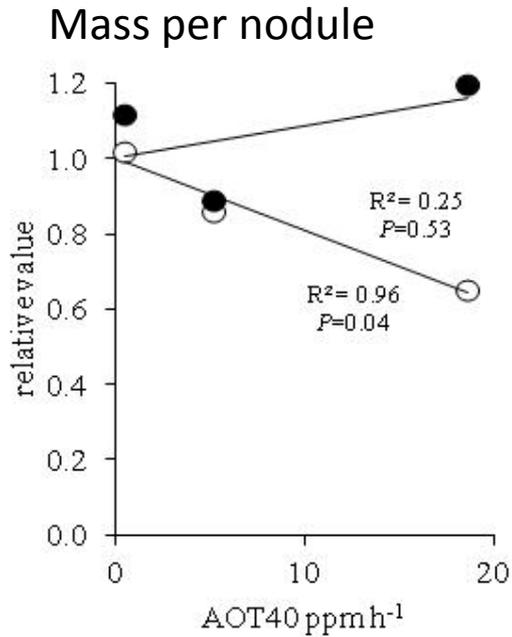
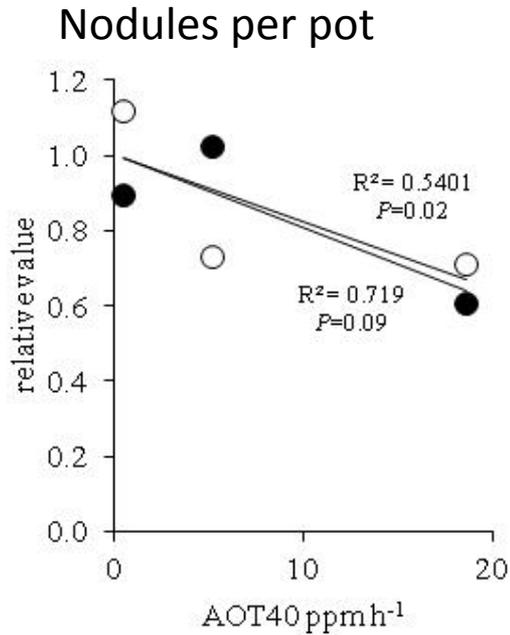


Shoot and Root biomass



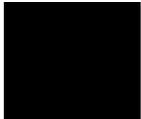
● = Merviot
○ = Crusader

Nodule biomass

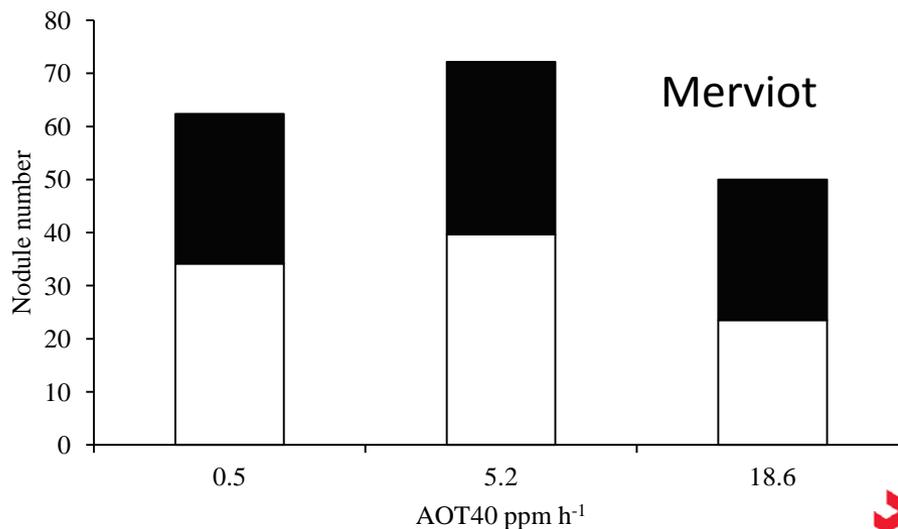
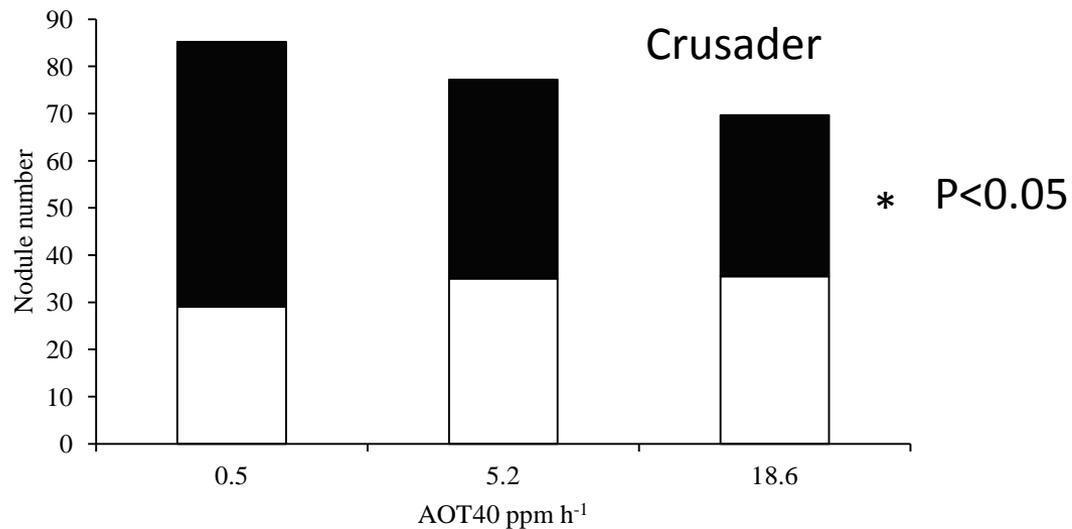


- = Merviot
- = Crusader

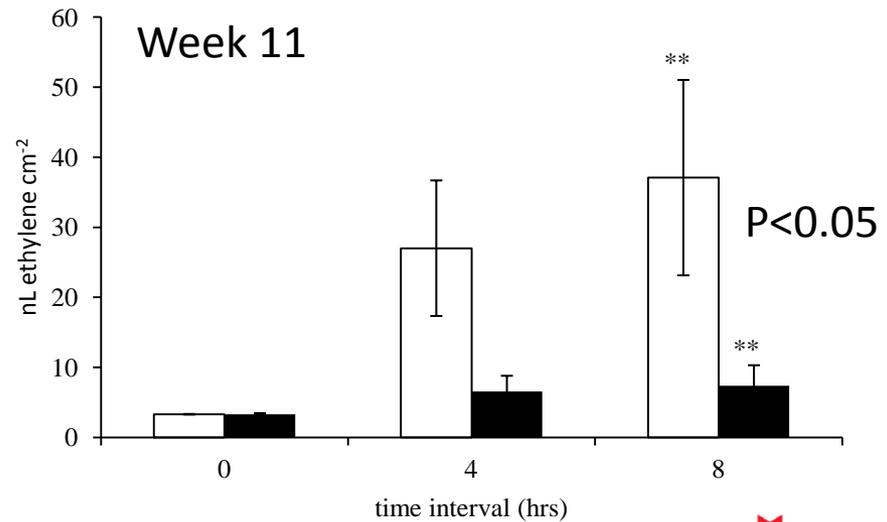
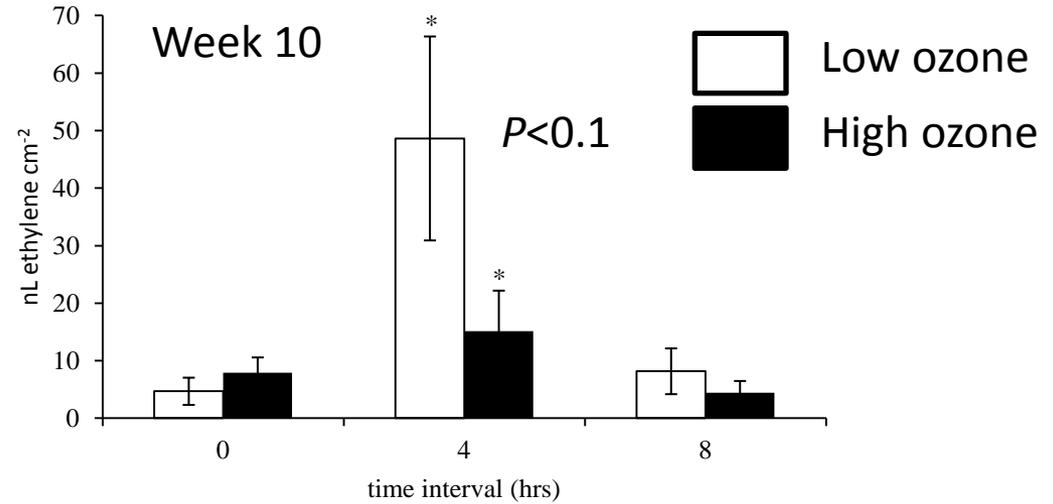
Nodule size

 Nodules
0.7->1.5mm

 Nodules
<0.1mm-0.7mm



In-situ nitrogenase activity (Acetylene reduction assays)

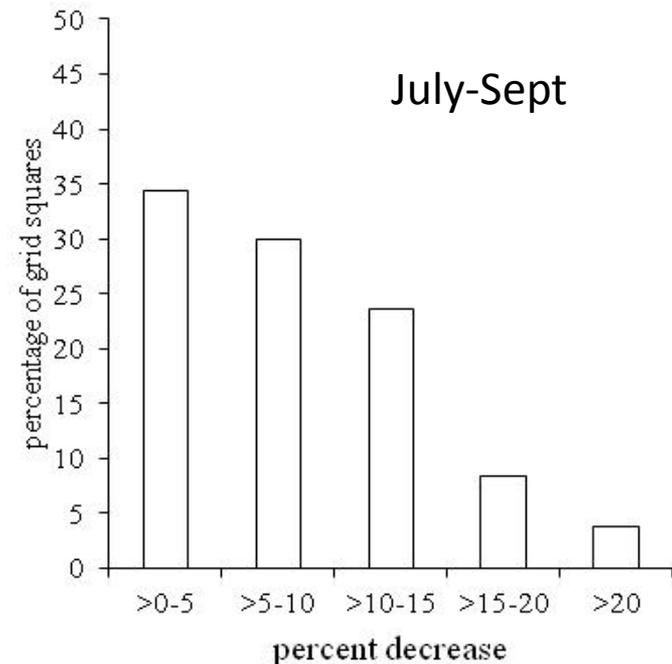
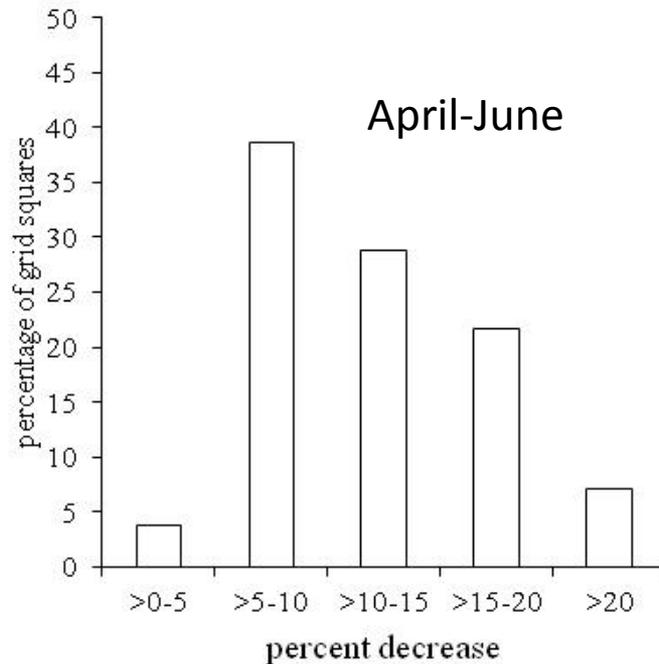


What does this mean for the UK?

Using 10 x 10km grid square and AOT40 values for pasture-growing areas of the UK*, in a high ozone year (2006), there was potentially :

April – June : a mean 12% reduction in nodule mass

July – September: a mean 8% reduction in nodule mass



* Data from Mhairi Coyle, in Mills *et al.*, 2011, O3 and food security in the UK report for Defra

Summary and conclusions

- Systemic reductions in below ground biomass and nodulation, and reduction in nitrogenase activity.
- Perhaps arising from a reduction in the translocation of assimilate.
- Continuing increases in the level of ozone may cause lasting declines in pasture fertility and productivity.



This growing season.....

- Mixed community of high sugar Ryegrass ('AberMagic') and Crusader
- 6 O₃ treatments +/-Intermittent drought
- Sequential harvests and nitrogen fixation assays (= 220 pots!).
- Paper close to submission

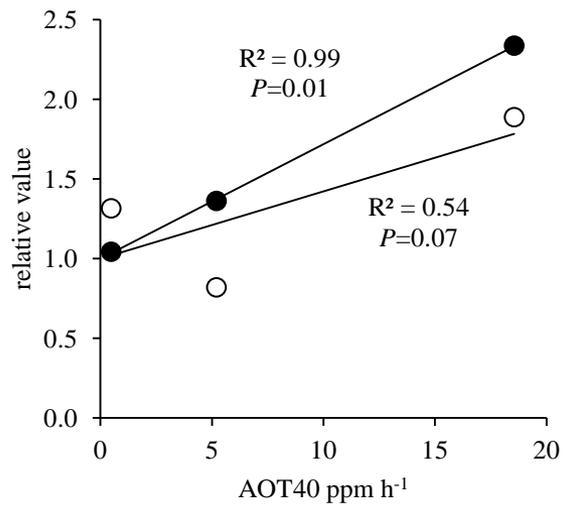


Acknowledgements

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Nodules g⁻¹



Nodule mass g⁻¹

