Forest Research

Impact of N inputs on forest and forest soils biogeochemistry in Great Britain

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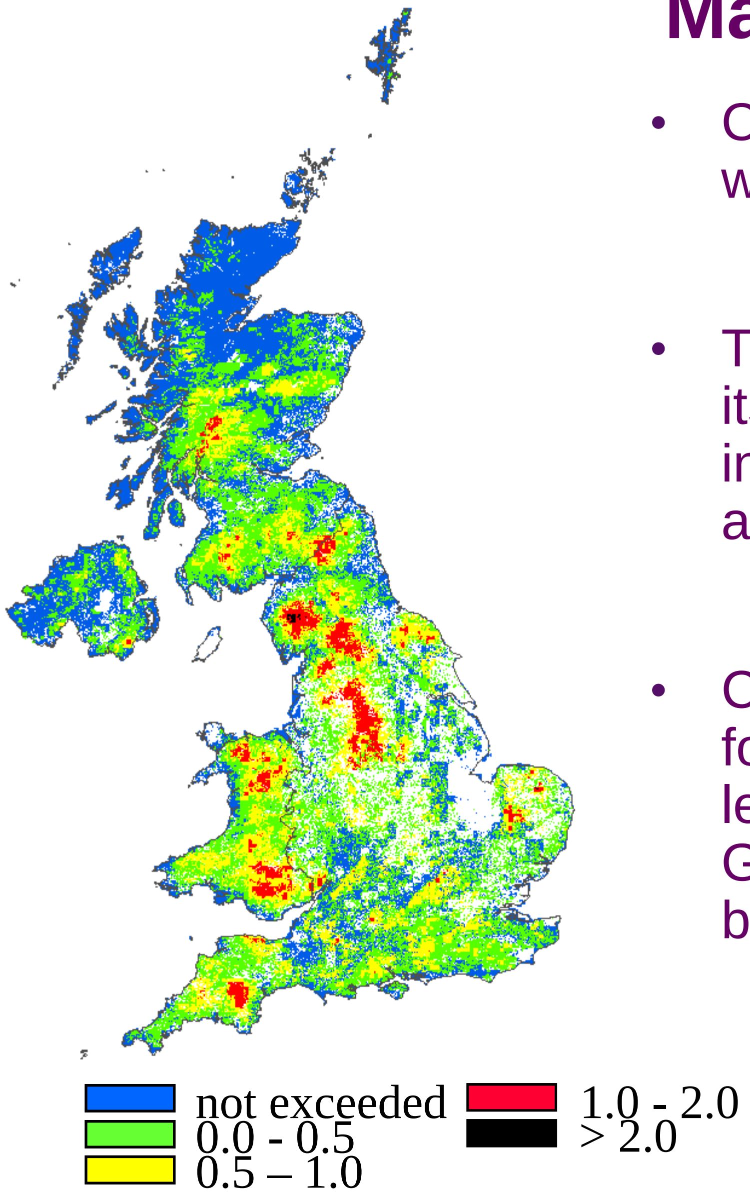
Main Concerns



- Critical N load exceeded in >70% of broadleaf woodland and conifer woodland in the UK,
- The importance of small scale N variability and its impact, e.g. at woodland edges due to the intensity of UK agriculture, farming, road traffic and the fragmented nature of the forests.
- Changes in nitrogen and carbon of forest and forest soils and the possibilities of NO_3 leaching to waters, the implications for forest GHG mitigation potential and the impact on biodiversity.

N inputs affecting forests and soils

- N deposition by local, regional and national sources (intensive farming, agriculture and intensive road system)
- Forest fertilisation (in the past but with long term effects on soil and forest production)
- Other N generated input (such as canopy N generated by biological agents)

This overview includes:

- Small scale impacts of N deposition on soil and forest biochemistry under both broadleaf and conifer stands from N gradients studies (farming and roads)

- Regional differences in N impacts by comparing areas with low and high N deposition

- Long term monitoring of N inputs and outputs and its effects on the forest and soils from the intensive ICP forest monitoring network

- Forest soil N status from extensive national soil survey (BioSoil)

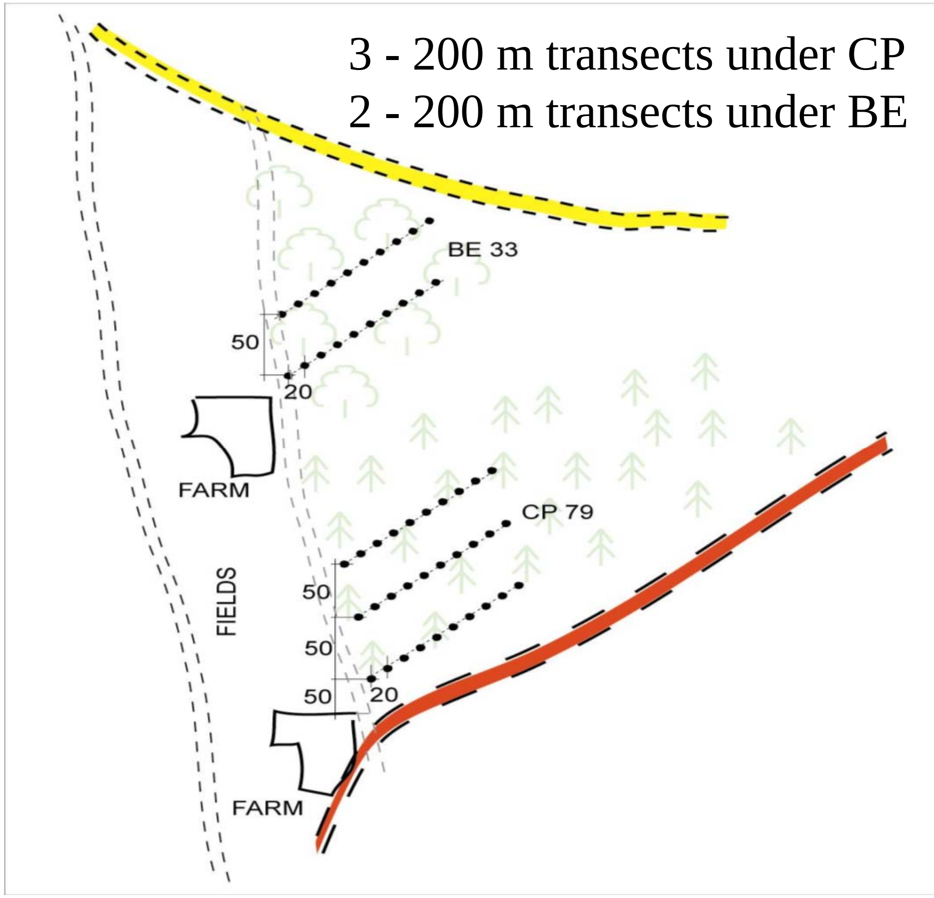
Chicken and pig sheds in Thetford

Experimental transects under Corsican pine and beech stands away from pig and chickens farms

Measurements along transects:

Averaged annual rainfall - 600mm
Sandy soil over chalk

- Air quality (NH_3)
- Rainfall and throughfall chemistry
- Litterfall biomass and chemistry
- Soil solution chemistry
- Litter decomposition
- Foliar chemistry
- Soil chemistry
- Tree growth



Monitoring at Thetford

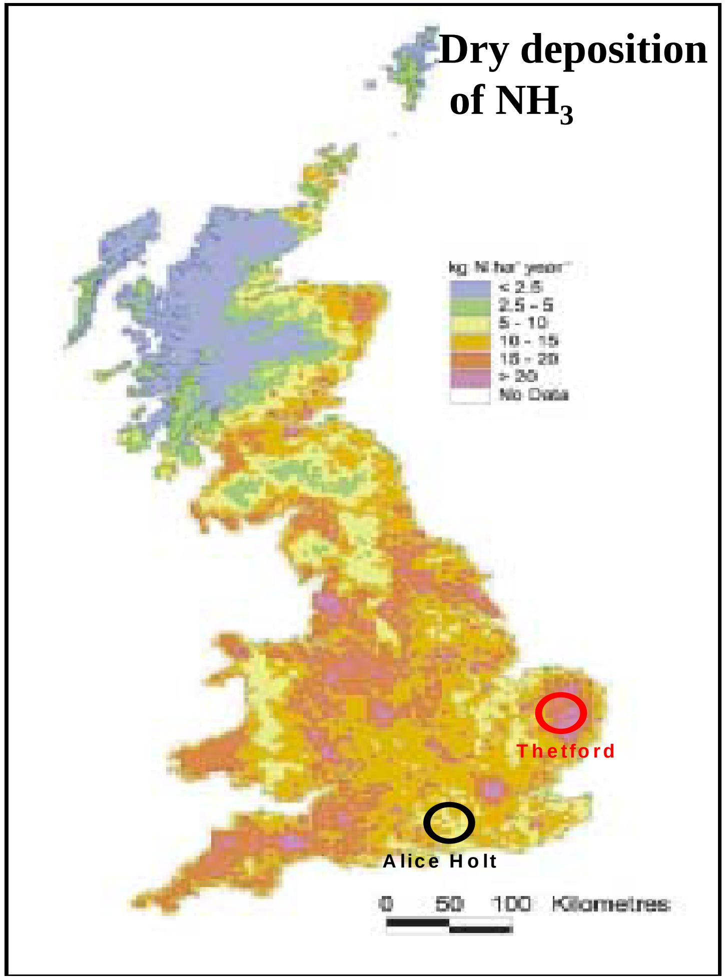




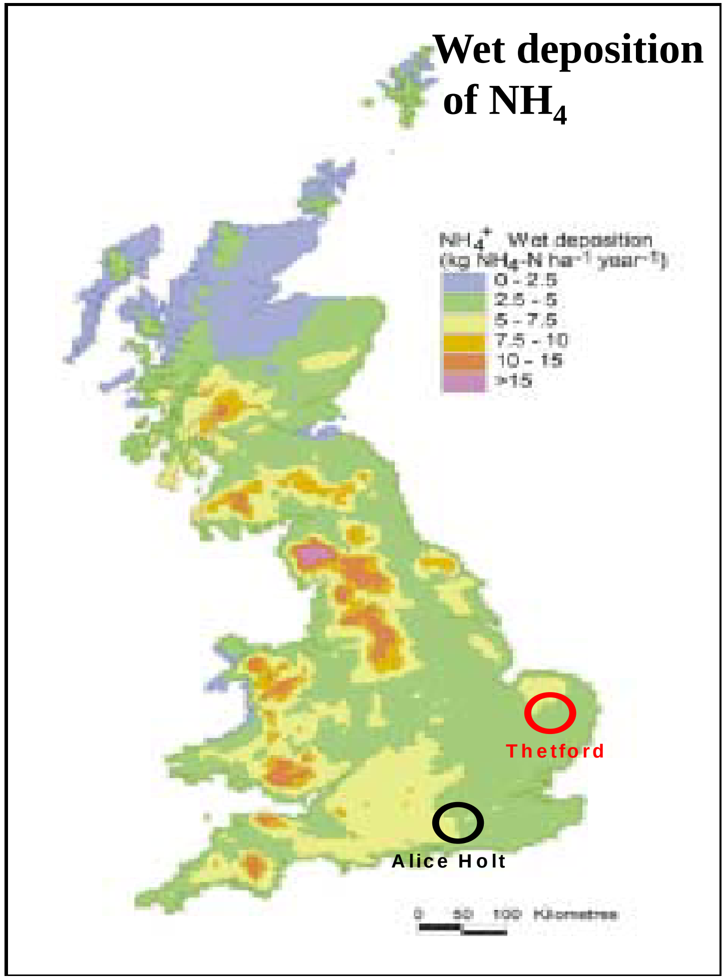



N impacts on soil and forest biochemistry

Gradient and regional studies - at Thetford and Alice Holt forests



Estimated distribution of dry deposition of ammonia to semi-natural vegetation.

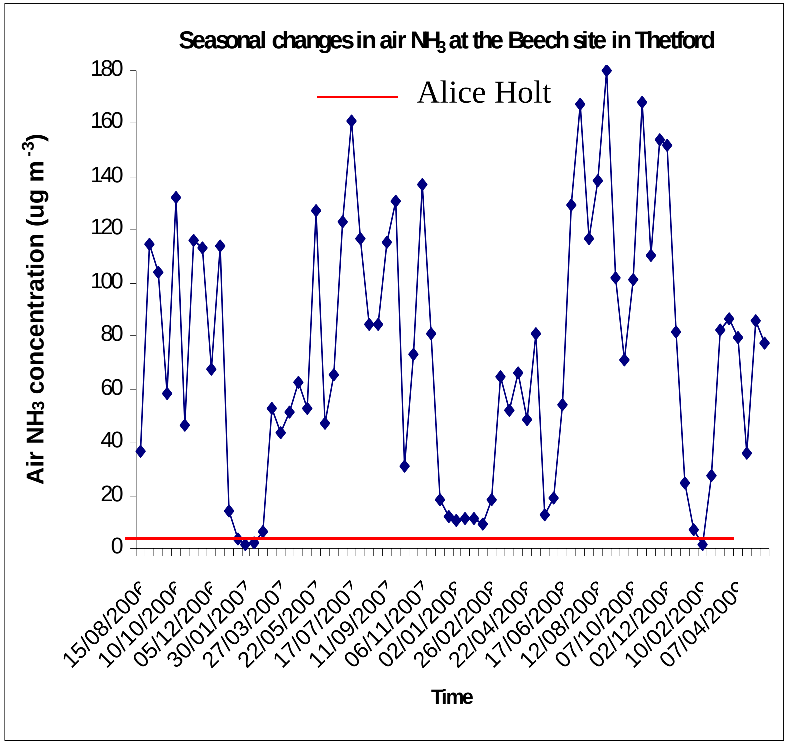


Estimated distribution of wet deposition of ammonium in rain and snow.

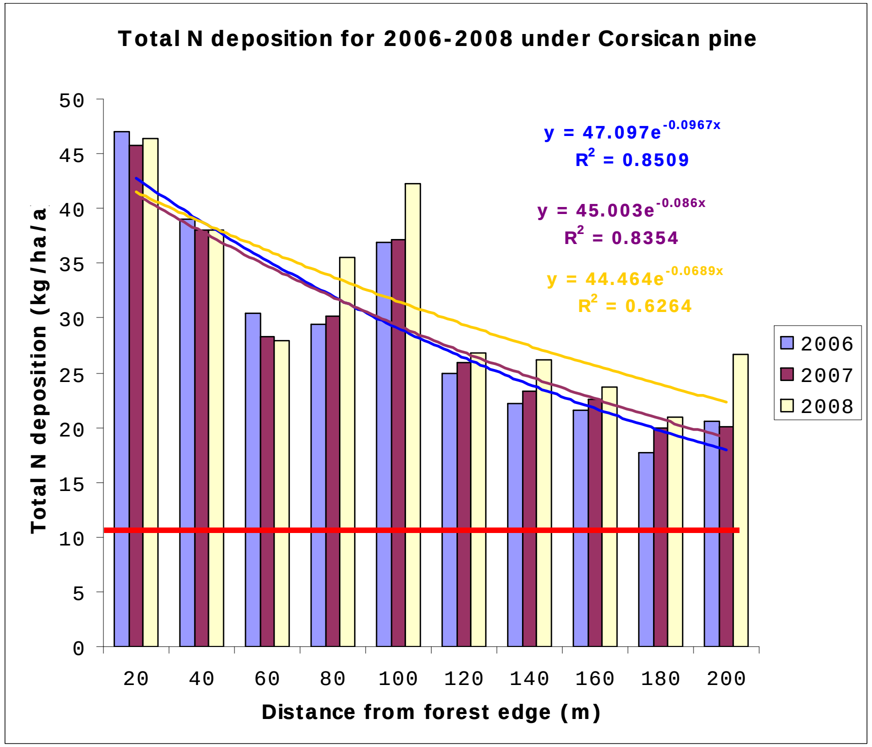
Thetford N deposition 18 to 47 kg/ha/a; Alice Holt 8 to 12 kg/ha/a

N impacts on soil and forest biochemistry

Air NH_3 at Thetford and Alice Holt



Total N deposition (throughfall) at Thetford and Alice Holt

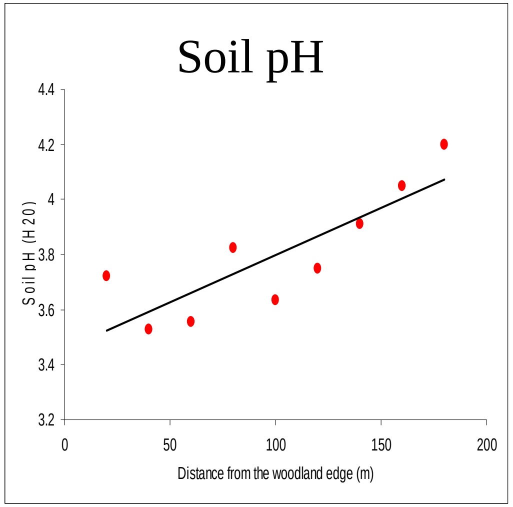


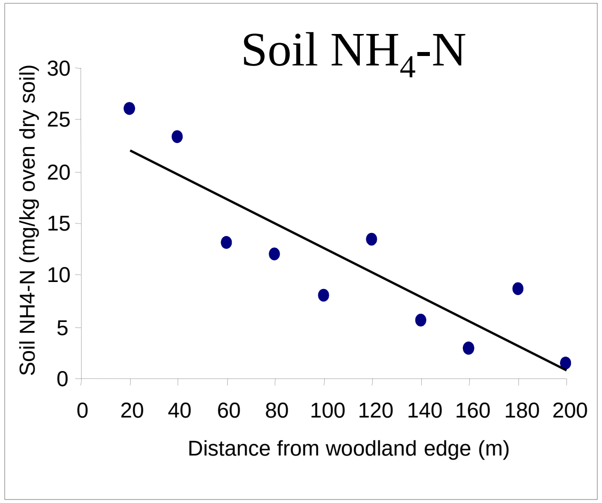
Thetford N deposition 18 to 47 kg/ha/a; Alice Holt 8 to 12 kg/ha/a

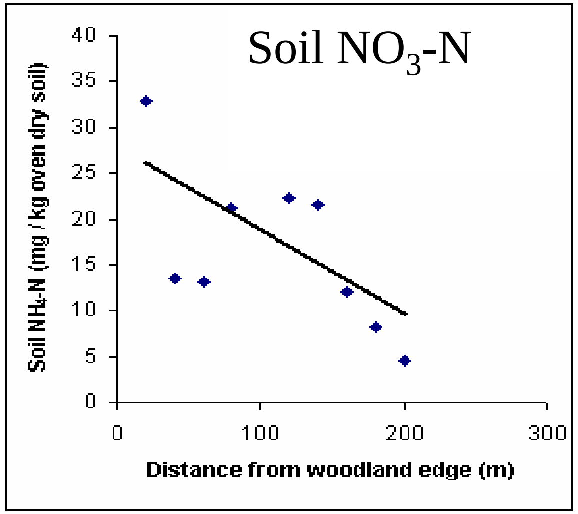
Vanguelova and Pitman, in prep.

Soil pH, NH_4-N, NO_3-N in Thetford's gradients

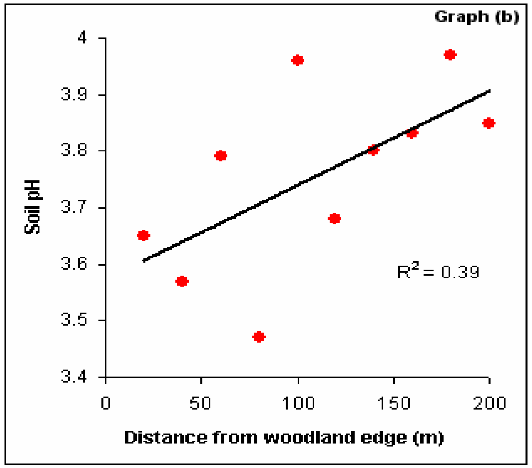
Corsican pine

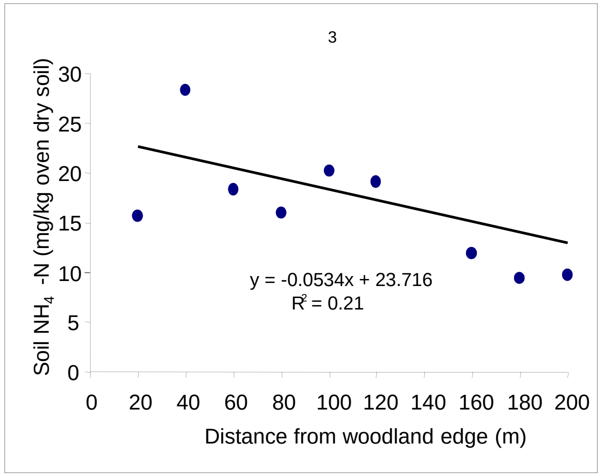


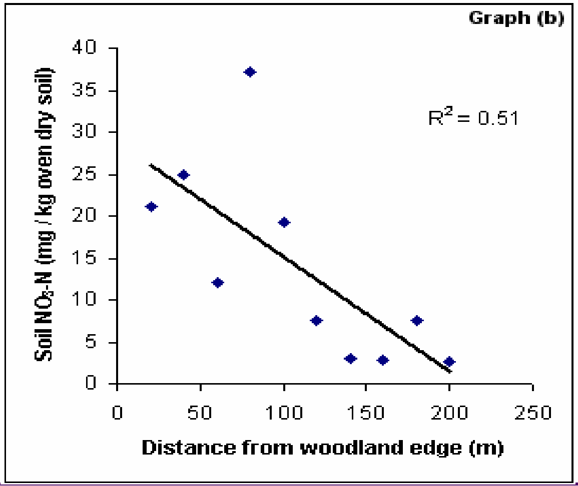




Beech

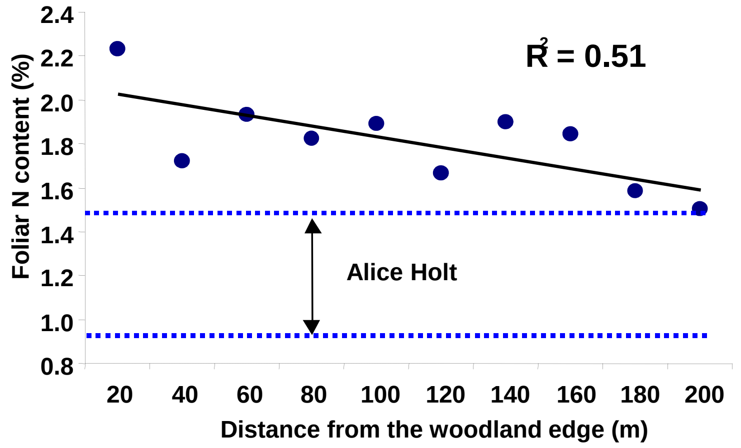




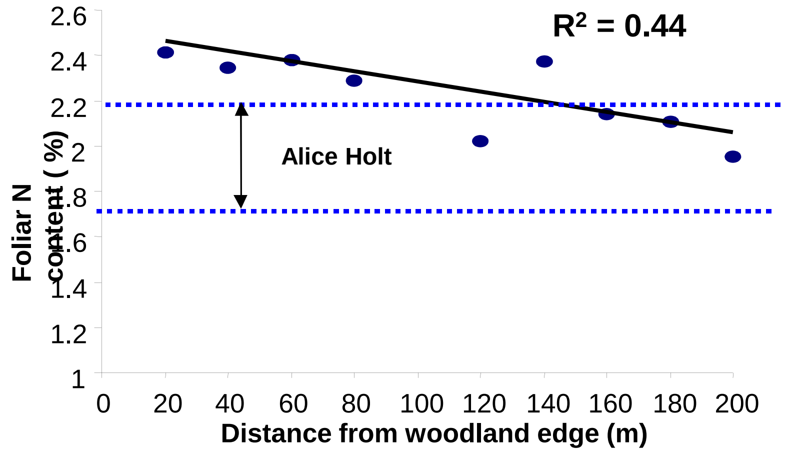


Foliar N in Corsican pine and beech at Thetford and Alice Holt forest

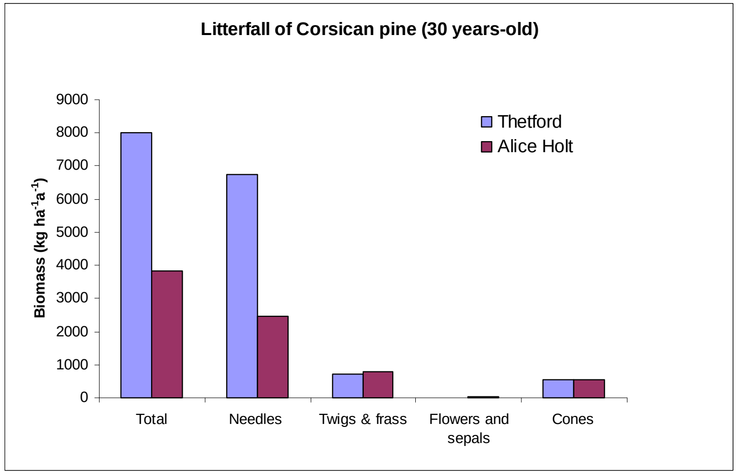
Corsican pine

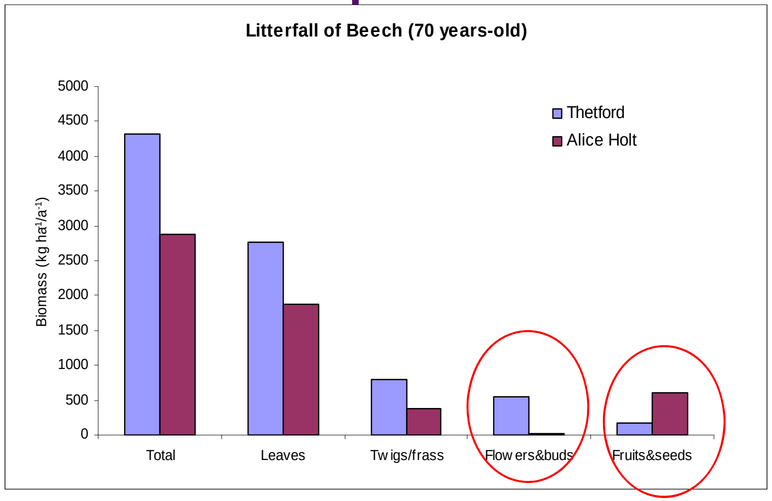


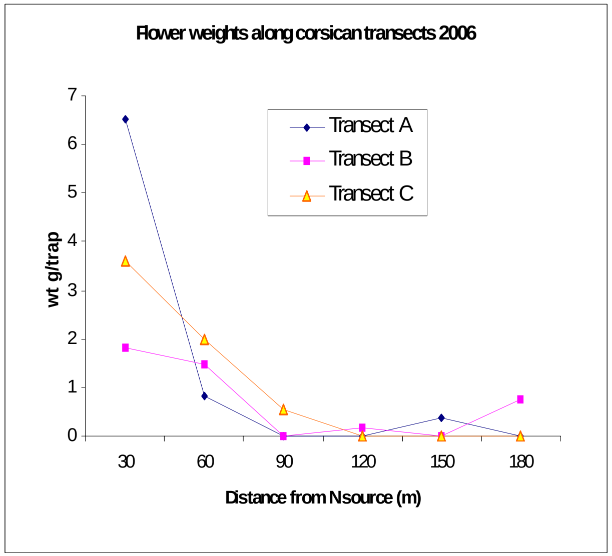
Beech

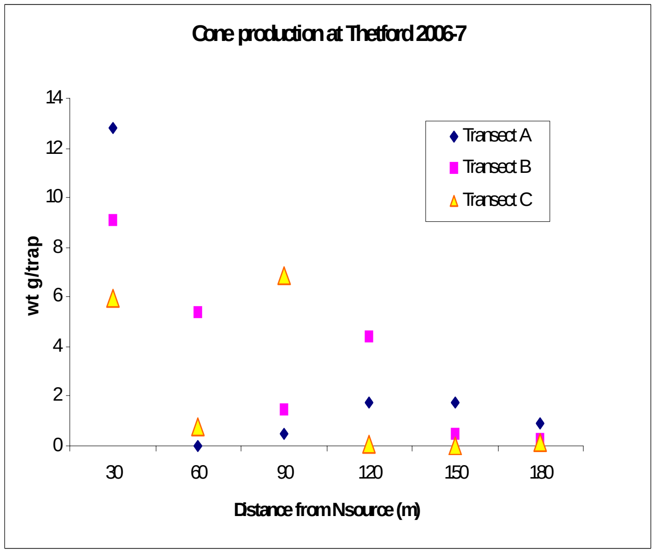


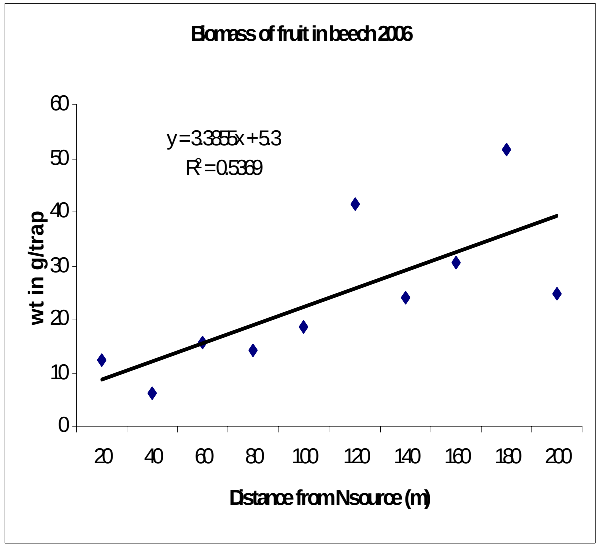
Litterfall biomass at Thetford and Alice Holt Corsican pine and Beech forests

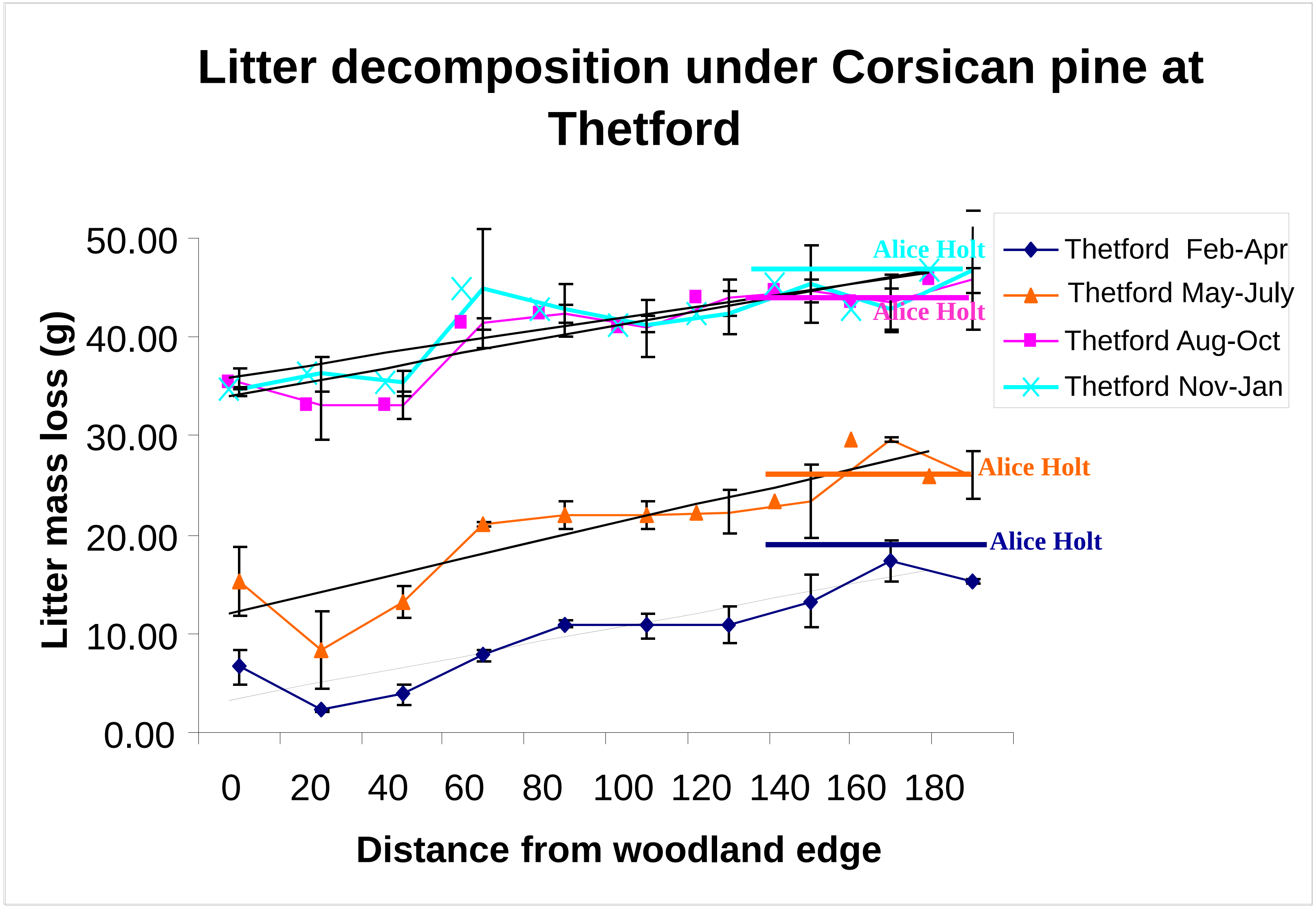




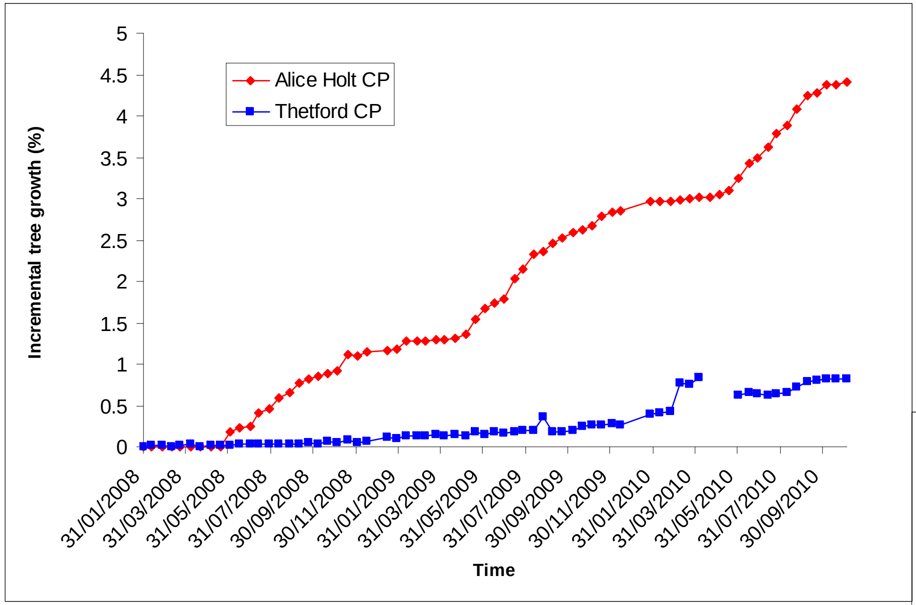


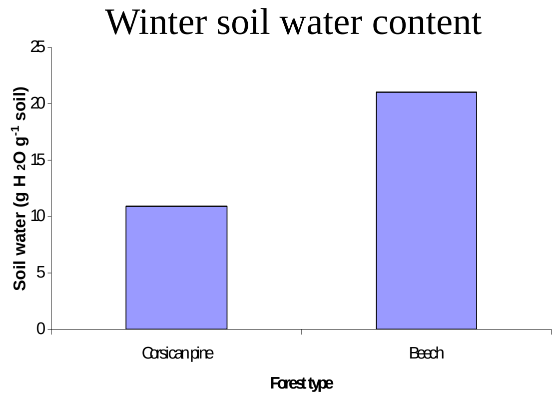




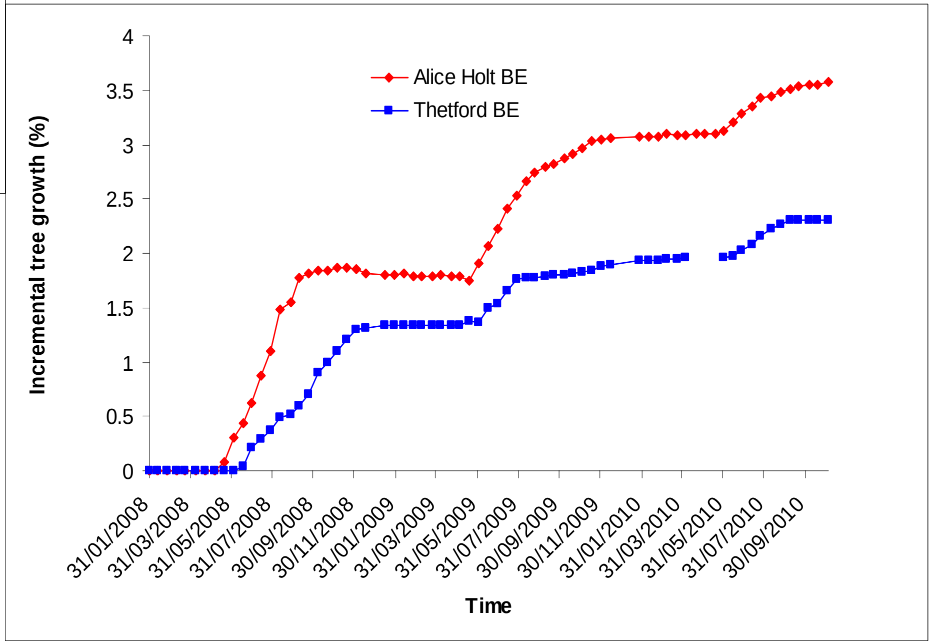

Litter decomposition under Corsican pine at Thetford
Litter mass loss (g)
50.00
40.00
30.00
20.00
10.00
0.00
0
20
40
60
80
100
120
140
160
180
Distance from woodland edge
Thetford Feb-Apr
Thetford May-July
Thetford Aug-Oct
Thetford Nov-Jan
Alice Holt
Alice Holt
Alice Holt
Alice Holt

Tree annual growth at Alice Holt and Thetford forests



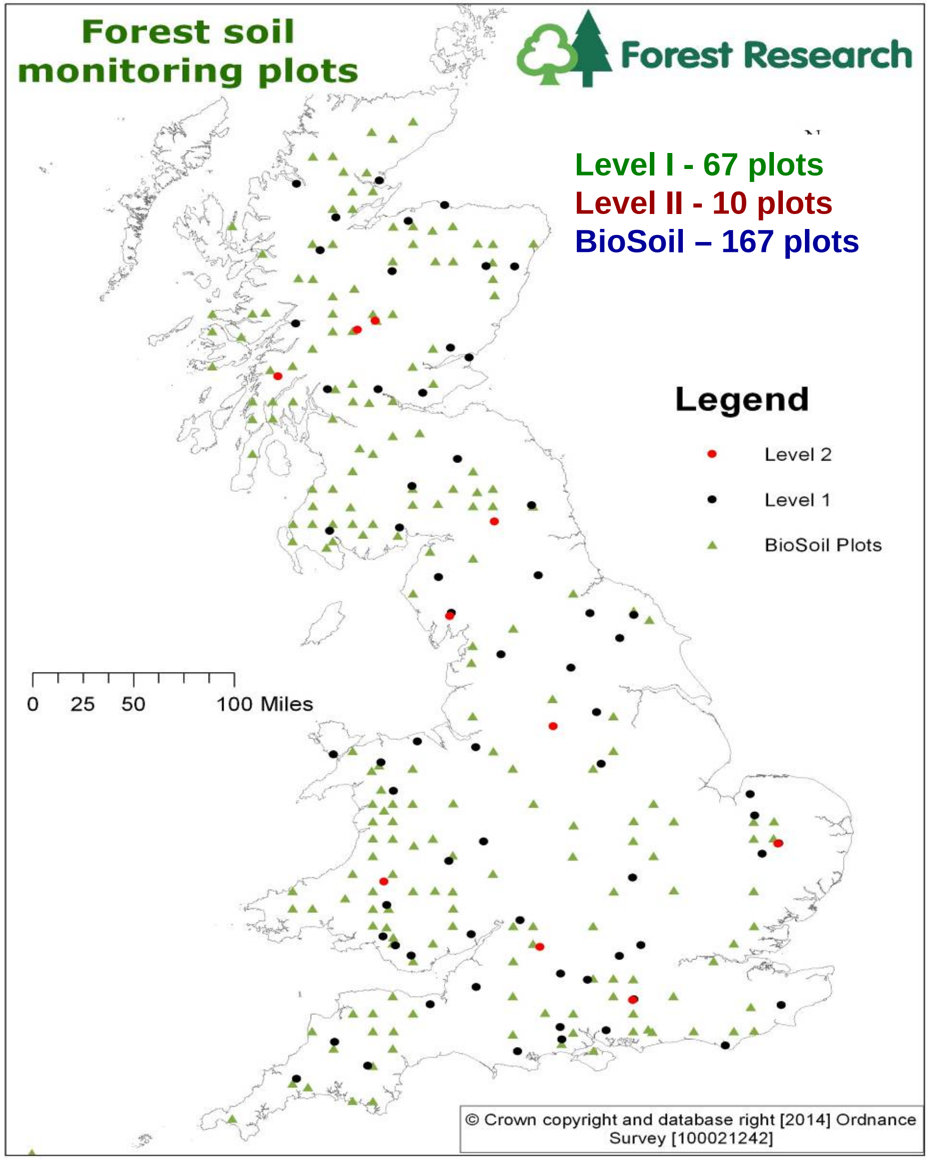


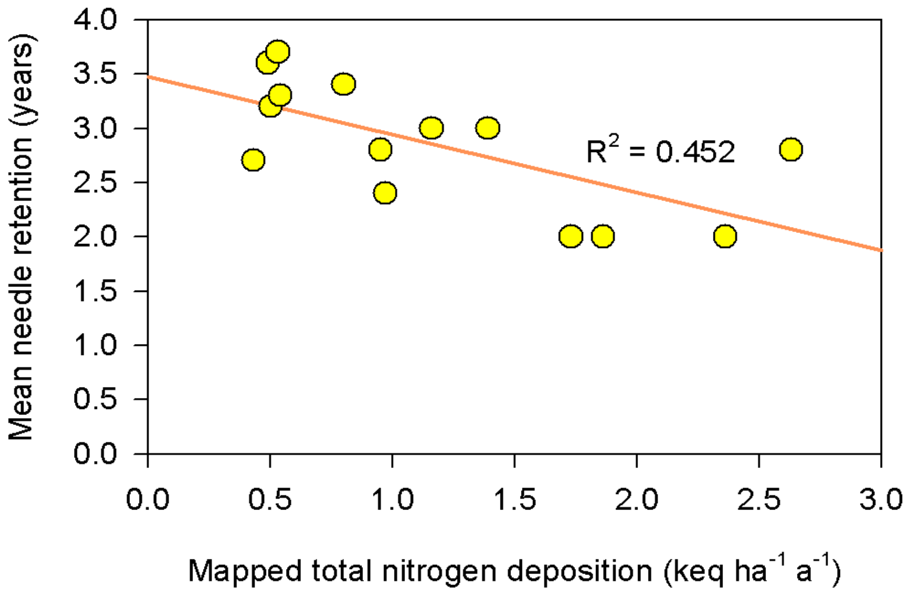
Does N exacerbate the drought impact on tree growth?

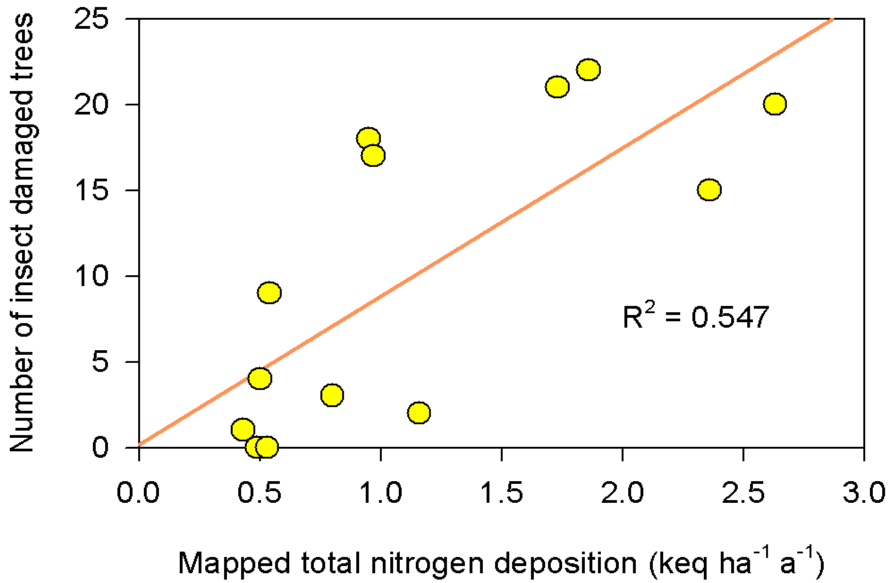


Vanguelova and Pitman, in prep.

Extensive and Intensive ICP forest monitoring networks





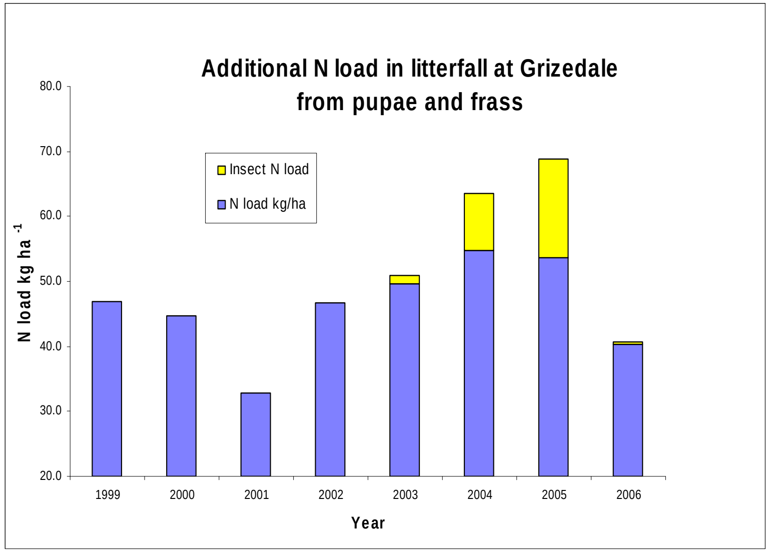


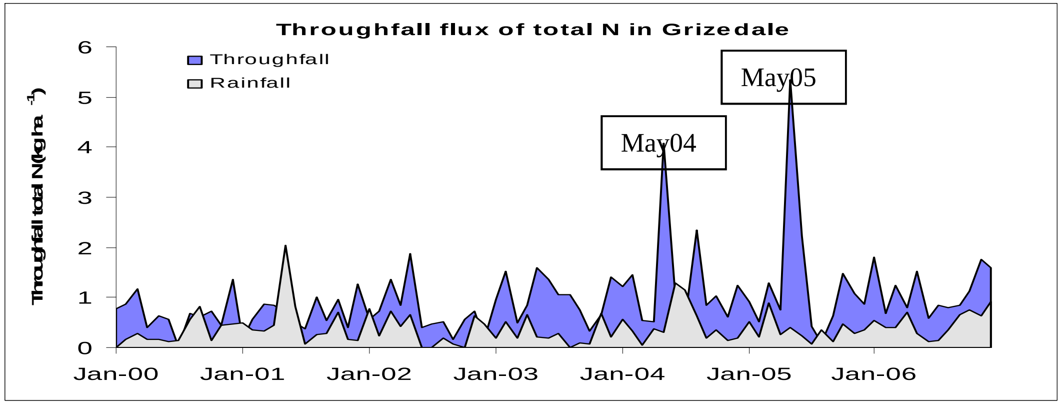
Observed relationships between forest condition and nitrogen deposition (Level I)

Kennedy and Freer- Smith, 2000

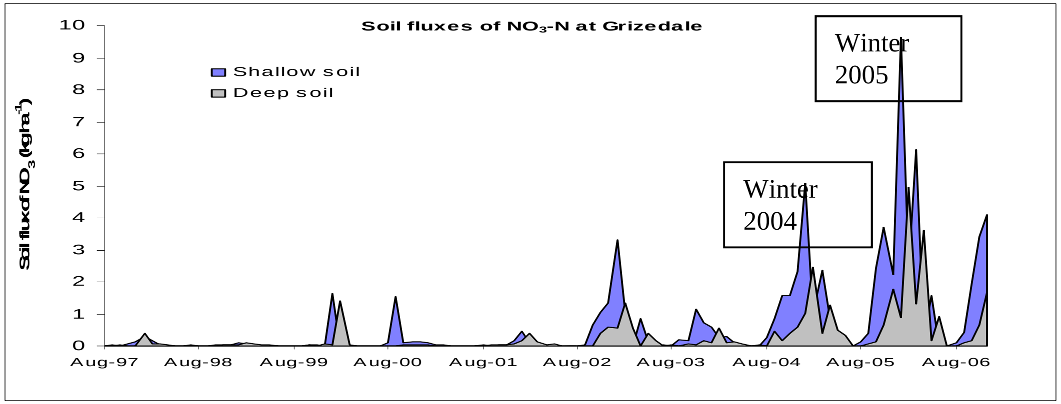
Biological N inputs (Level II)

Tortrix viridana





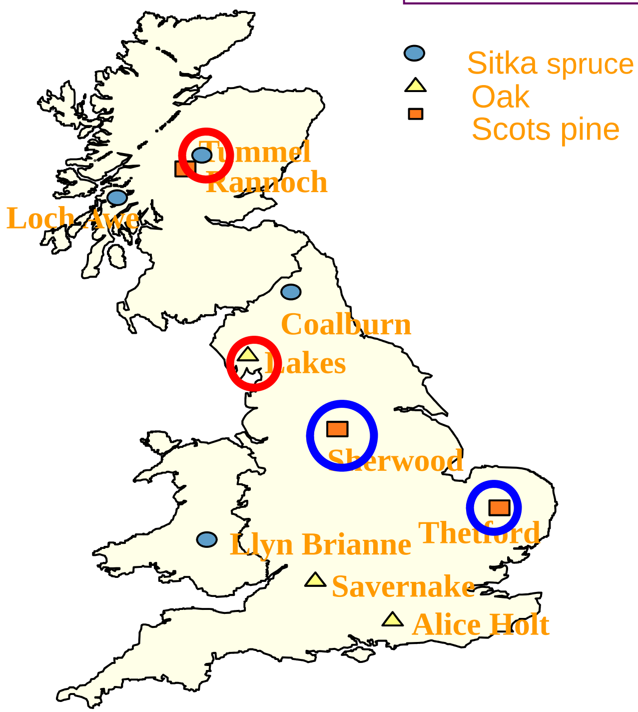
Operophtera brumata

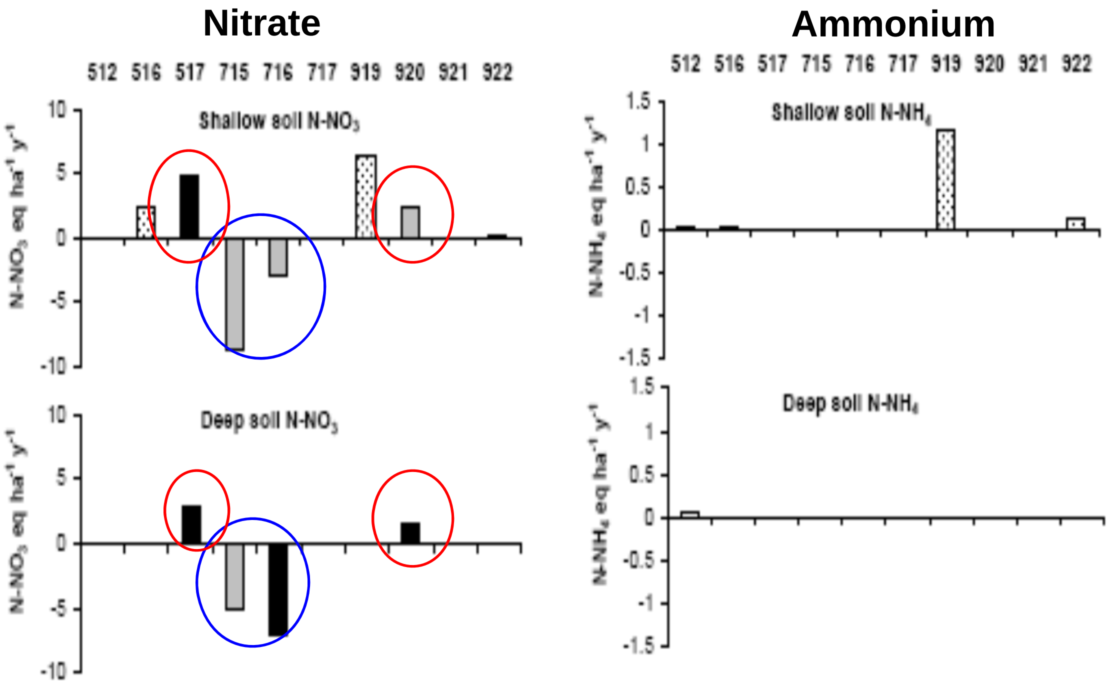


Pitman et al., 2010

N impacts on soil and forest biochemistry

Changes in soil solution NO_3 and NH_4 in 9 Level II sites (1994-2006)

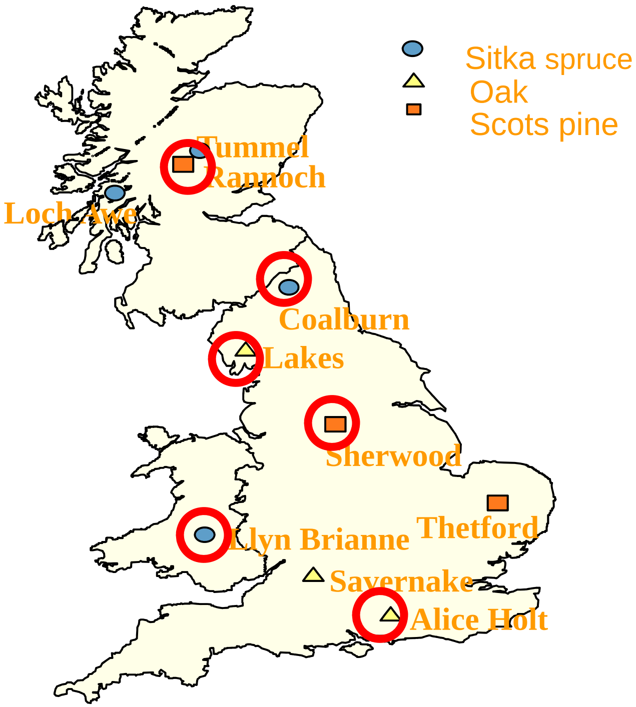




- **Decrease in soil solution NO_3 only at sites with N deposition or overall acidic pollution decline**
- **NO_3 concentrations in the soils are very dependent on water cycling at the sites, e.g. build up or leaching**
- **No changes in soil solution NH_4 were observed in time although NH_4 in deposition has declined**

Vanguelova et al, 2010

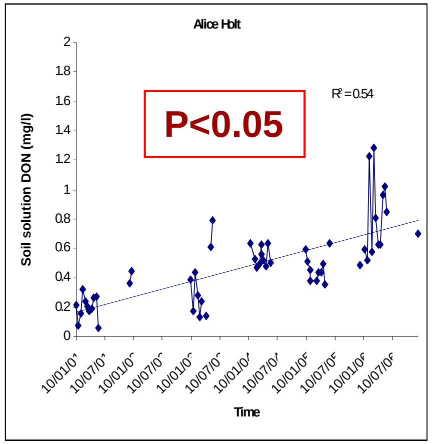
DON increase in soil solution - in response to higher DON input and or accumulation, recovery from acidity and increased microbial activity?

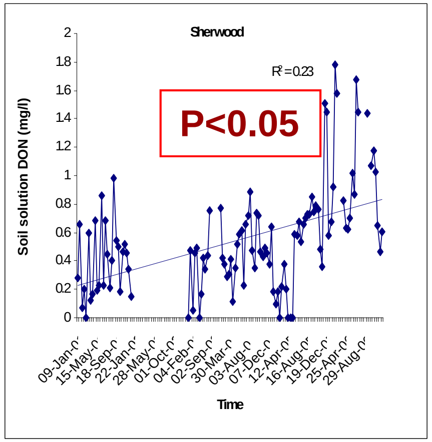


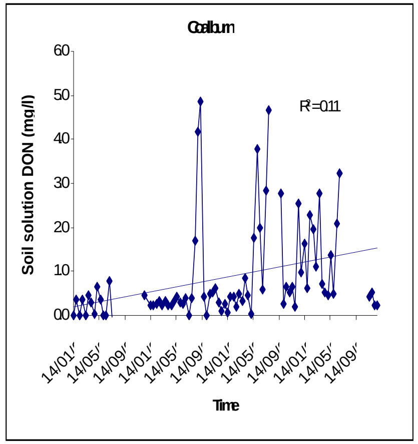
Oak sites

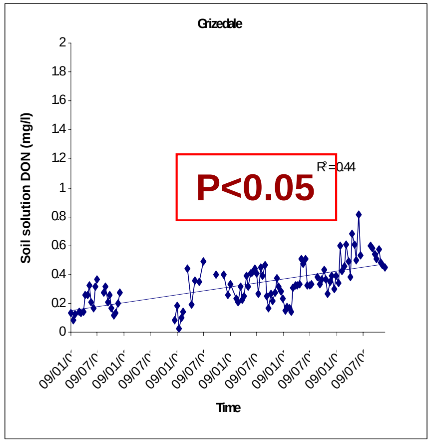
Scots pine sites

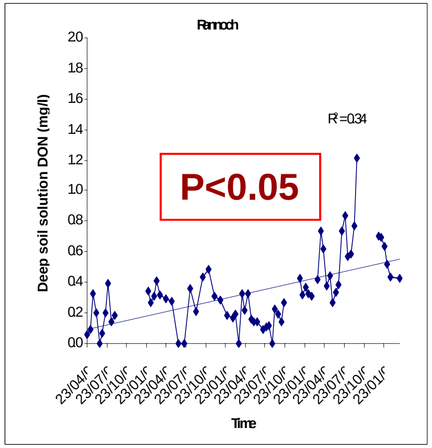
Sitka spruce sites

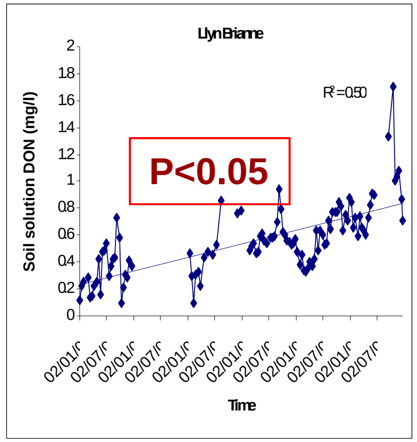












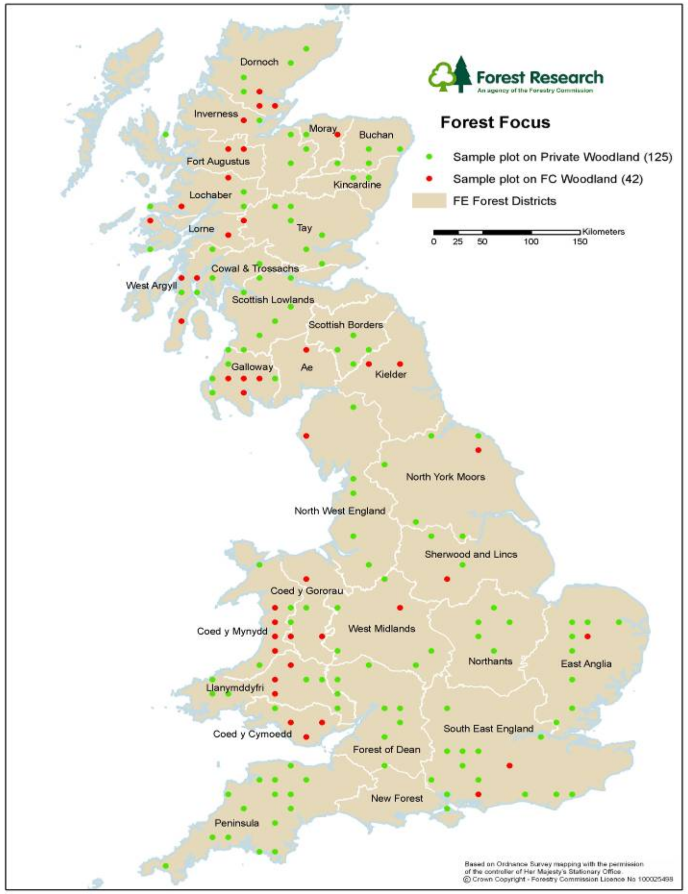
Possible causes:

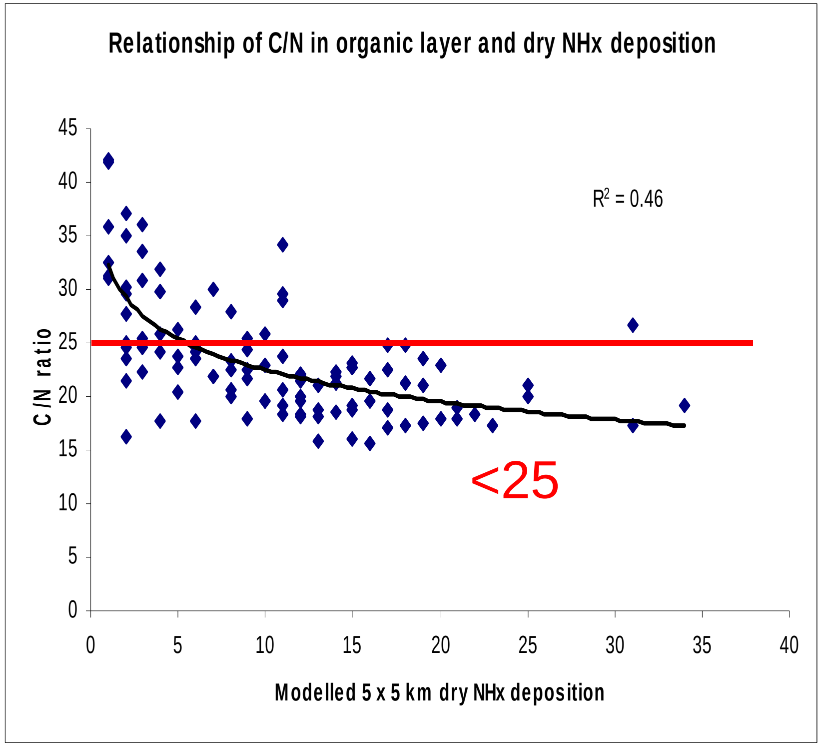
1) soil pollution recovery
2) increased microbial activity,
3) increased soil temperature
4) Increase in soil N accumulation

Vanguelova et al, 2010

N impacts on soil and forest biochemistry

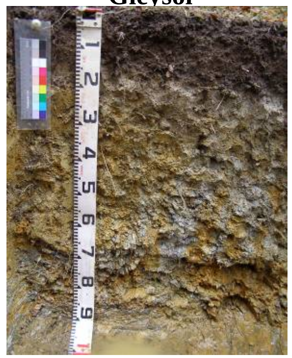
UK BioSoil plot locations - 167 plots





Podzol

Gleysol



Histosol

Some conclusions

- Concerns over the local effects of excess nitrogen deposition and its forms remain and need to be taken into account in forest design plans around intensive farming in order to help N abatement but also to reduce the impact on the environment (forest, soils and waters).
- The importance of biological generated N should not be overlooked when considering N deposition impacts on soil processes and forest C balance.
- Long term trend analysis suggest significant increase in DON in rainfall, throughfall and soil solution in most of the UK Level II forest sites. The source of this organic dissolved nitrogen in rainfall is uncertain.
- Some preliminary results suggest that UK forest soils have accumulated N during the past 15-20 years and the likelihood for this N to be released are yet to be determined

- Forest Management Practices can override or mitigate these responses!!!

Thanks to:

BioSoil:
Malcolm Reeves,
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Andrew Hipkin
Gordon Hudson
Tanja Sanders

Intensive Monitoring
Sue Benham
Andy Moffat
Dave Durrant
Peter Crow
Paul Taylor

References:

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