



Ozone and Nitrogen interactions in Birch

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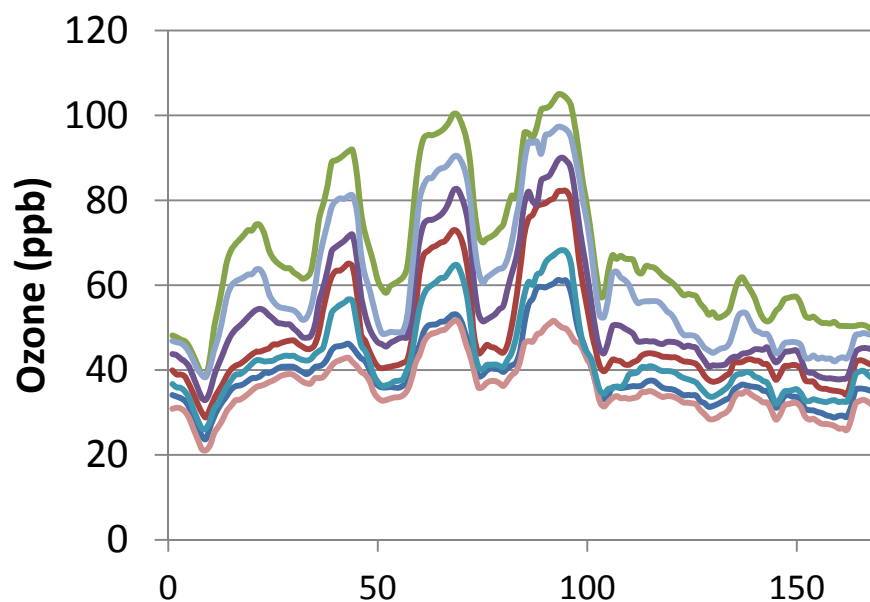
Overview

- ❑ Silver birch (*Betula pendula*) in 7 ozone treatments and 4 nitrogen regimes
- ❑ Ozone exposure May to September 2012 and 2013
- ❑ Quantification of ozone and nitrogen effects on birch
 - ❑ Phenology
 - ❑ Leaf-level effects on photosynthesis and g_s
 - ❑ Tree-level effects on NEE
 - ❑ Biomass
 - ❑ Nitrogen cycling
- ❑ Does nitrogen influence the response to ozone?
- ❑ Does ozone reduce the impact of added nitrogen?



Experiment set-up

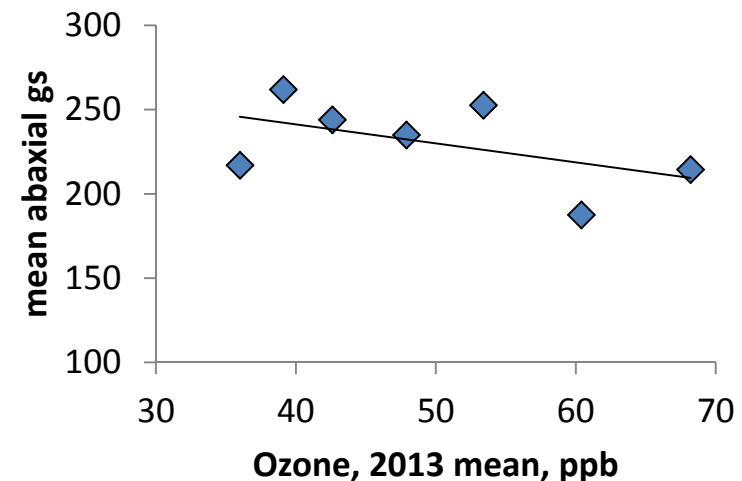
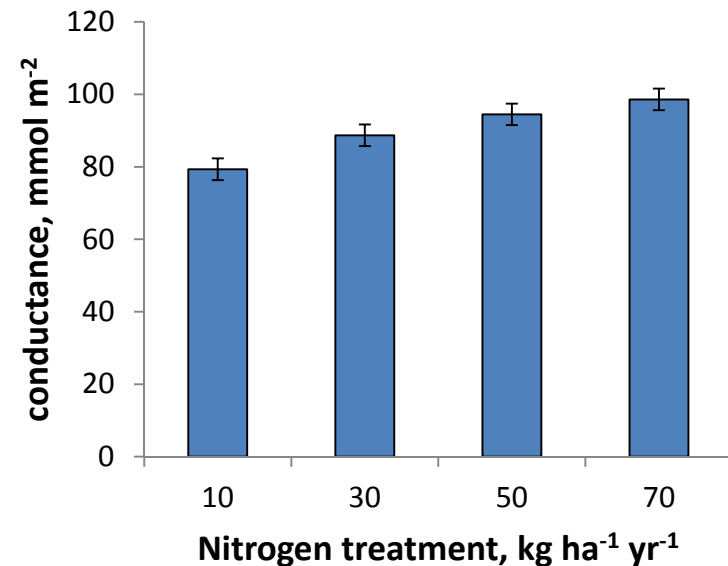
- ❑ Ozone treatments with seasonal mean ozone concentrations from **31 ppb to 68 ppb**. Using an episodic ozone profile repeated each week
- ❑ **10, 30, 50 and 70 kg N ha⁻¹ year⁻¹** ammonium nitrate, + constant micronutrients (applied weekly during growing season, monthly during winter)



Weekly profile 2013 (actual data)

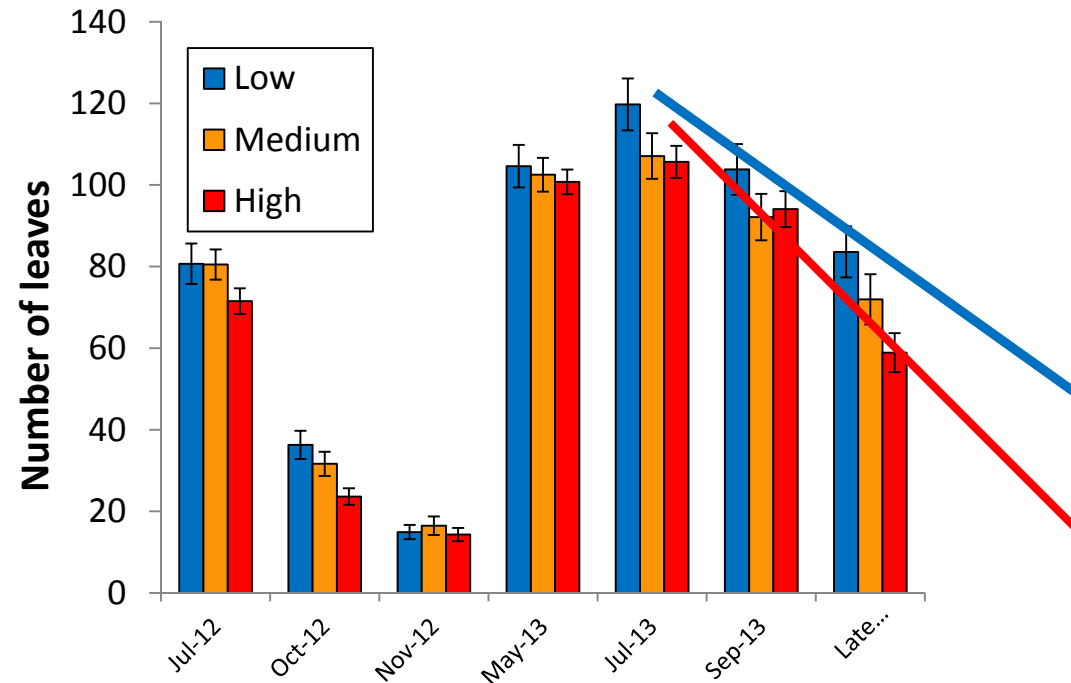
Nitrogen increases ozone uptake

- ❑ Leaves from the highest nitrogen treatment had **elevated stomatal conductance (~15%)** and **elevated chlorophyll content**
- ❑ The DO₃SE model (models fluxes of ozone into a leaf based on climatic and other variables) can include the effect of N on g_{\max}
- ❑ This gave a better fit of the tree size data compared to when using a single model
- ❑ Decreased g_s with increased O₃ (in optimum climatic conditions)



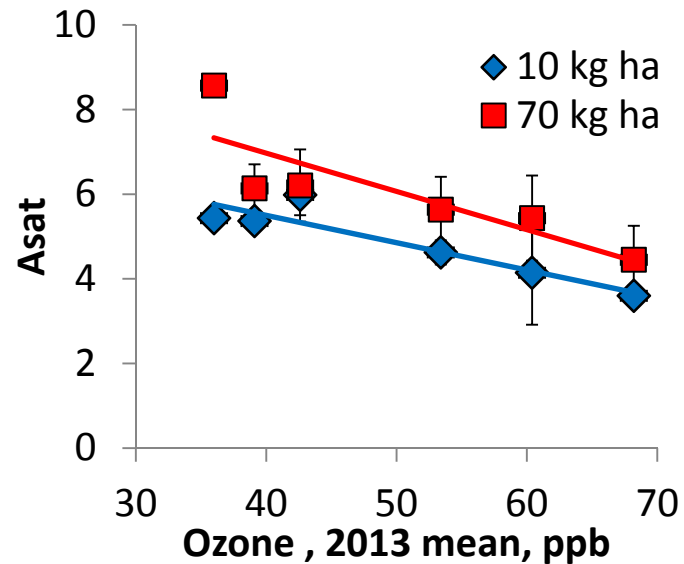
Premature leaf senescence with elevated ozone

Effect of increased ozone on leaf count in birch

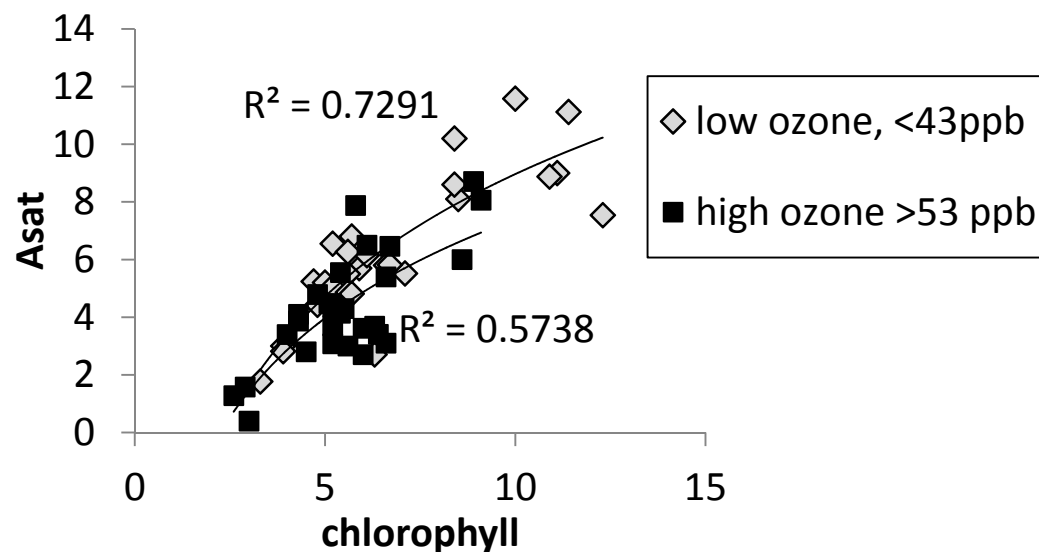


- More leaves with increased nitrogen
- Fewer leaves with elevated ozone
- Earlier leaf loss with elevated ozone (ozone * time interaction, $p < 0.01$)

Asat vs ozone

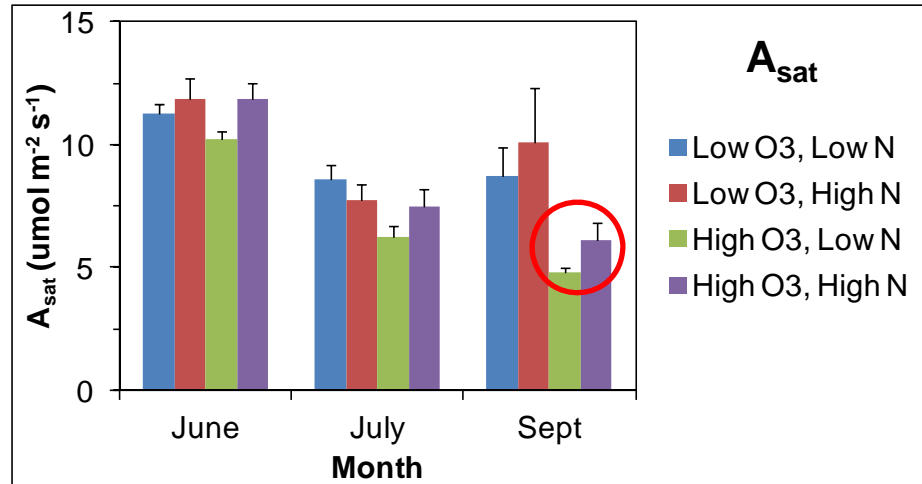


- Asat decreased with increasing ozone
- Asat increased with increasing nitrogen

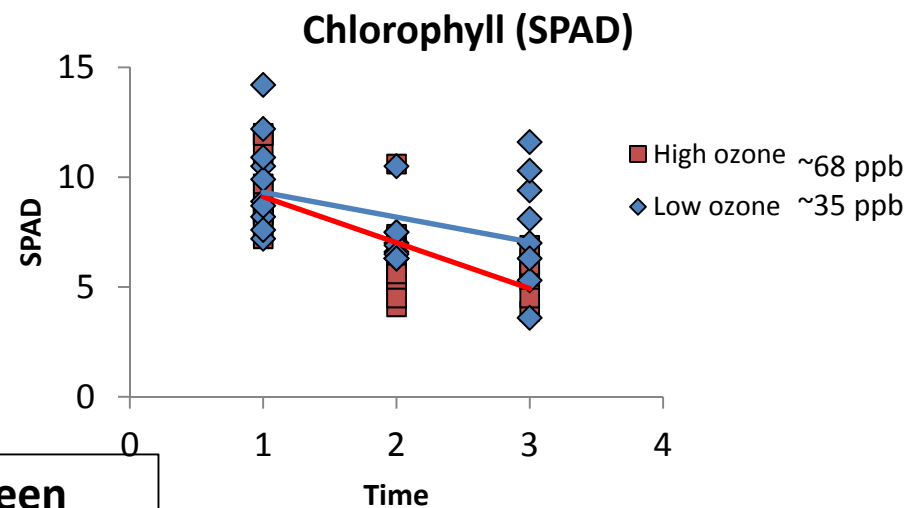
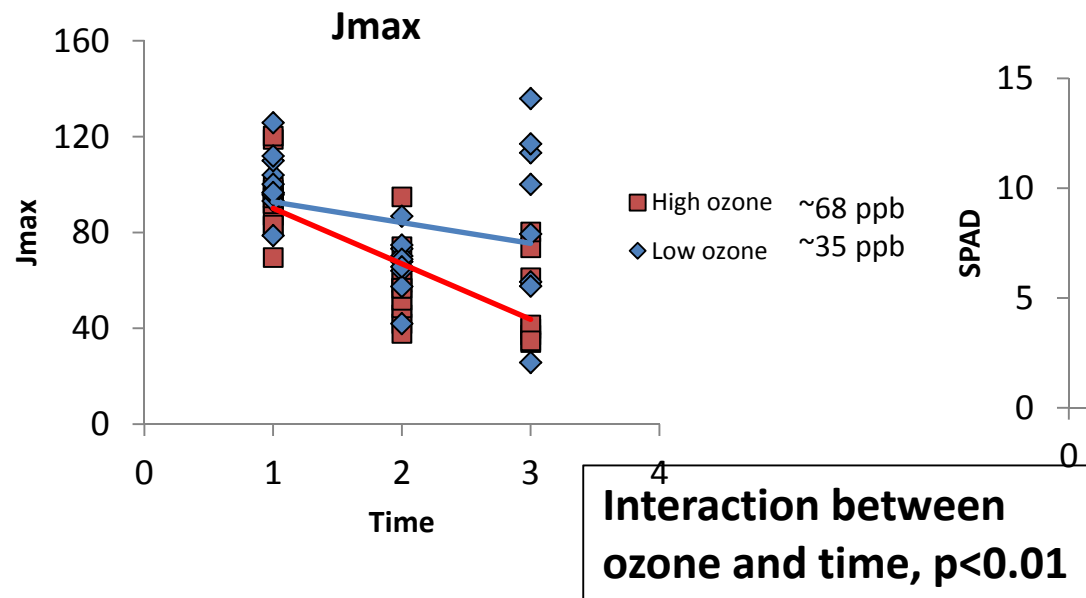


- Asat was related to chlorophyll content
- Same response function at low and high ozone (and low and high nitrogen)

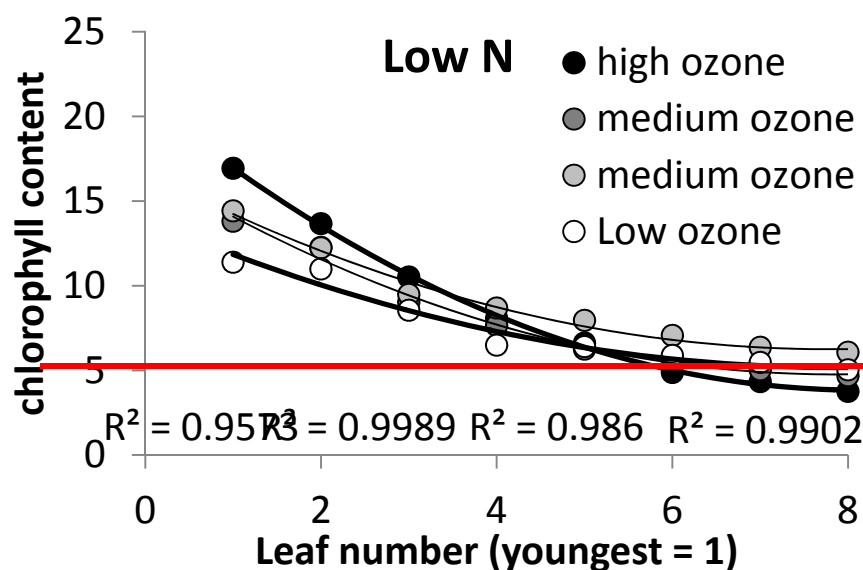
Photosynthesis vs time



- High ozone reduced A_{sat} and chlorophyll index late in season
- Stomatal conductance (light saturated) also reduced with high ozone late in the season
- Tendency to higher chlorophyll index and A_{sat} at high N

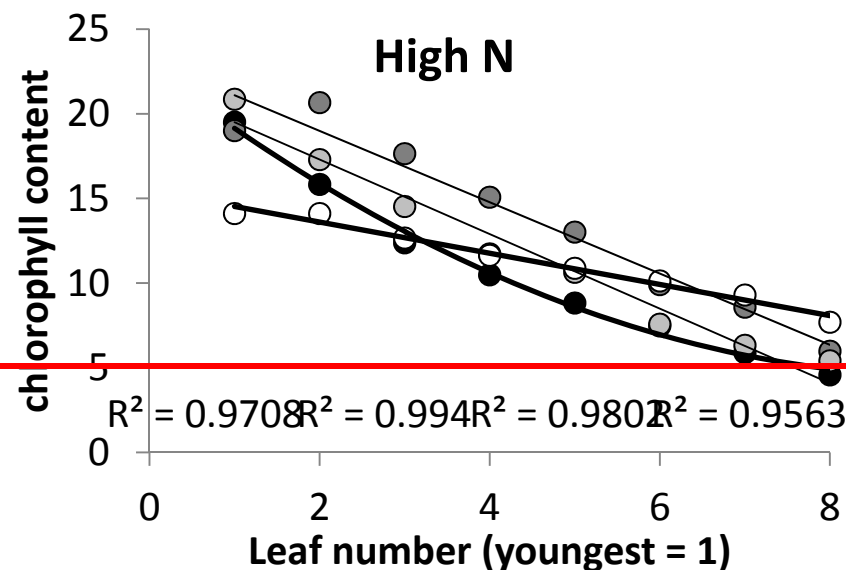


Chlorophyll content (4th September)



Curved response functions
Preferential allocation to new leaves

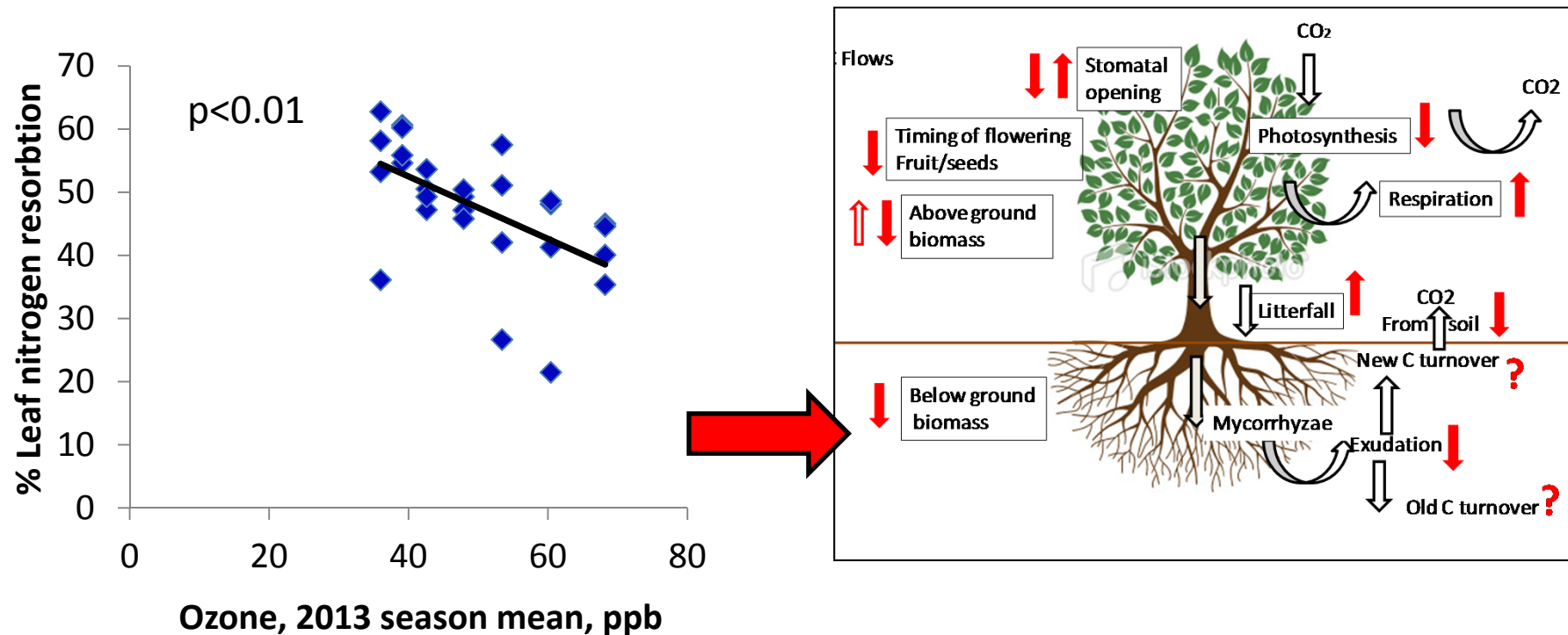
Old leaves are not functional
(no older leaves on branch)



Linear response functions
No preferential allocation
Except at high ozone

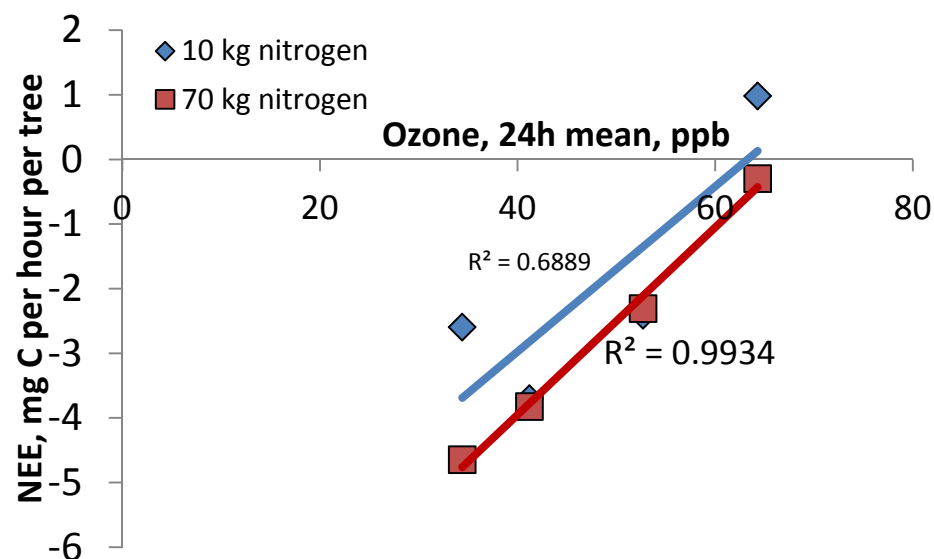
Old leaves are not functional with
high ozone
(older leaves on branch except at
high ozone)

Litter cycling – senesced leaves



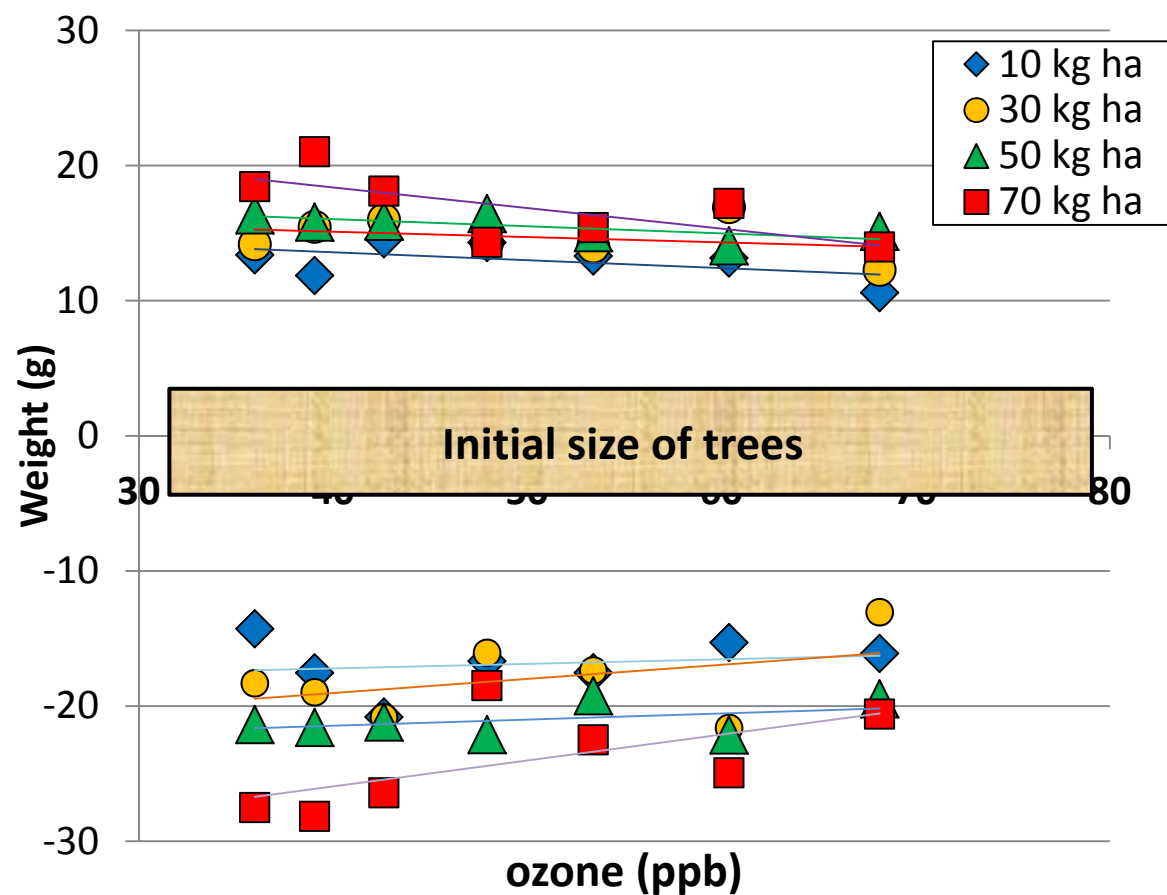
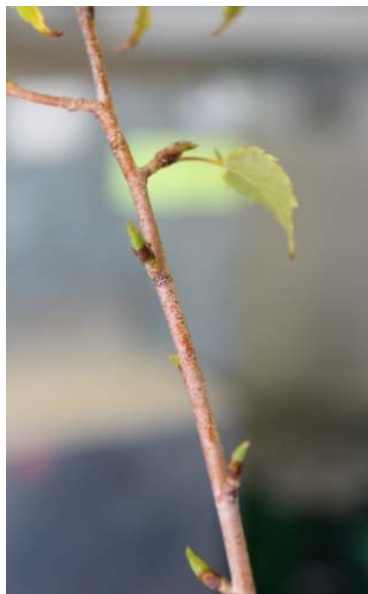
- In higher ozone, leaves are lost from trees before all N is re-absorbed.
- Higher N content of leaf litter - potential effects on soil processes

Net Ecosystem Exchange



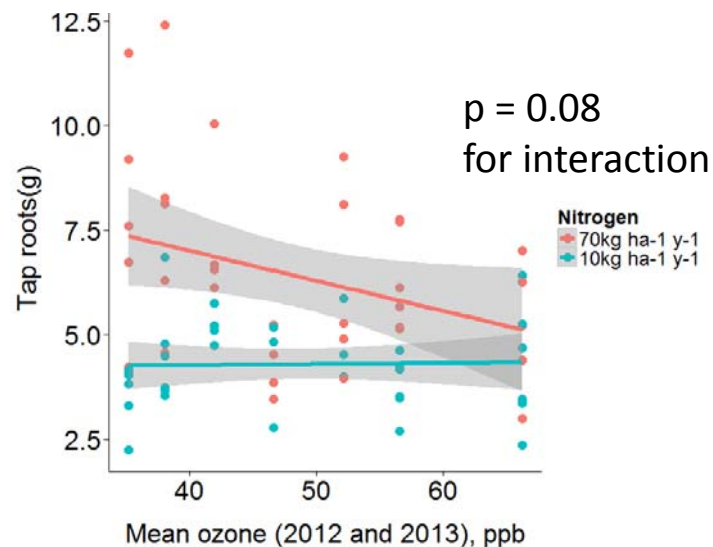
- ☐ Reduced NEE with increasing ozone
- ☐ Increased NEE with increasing nitrogen
- ☐ Effects were related to leaf number
- ☐ No interaction between ozone and nitrogen

Biomass (not including leaves)



Large effects on roots

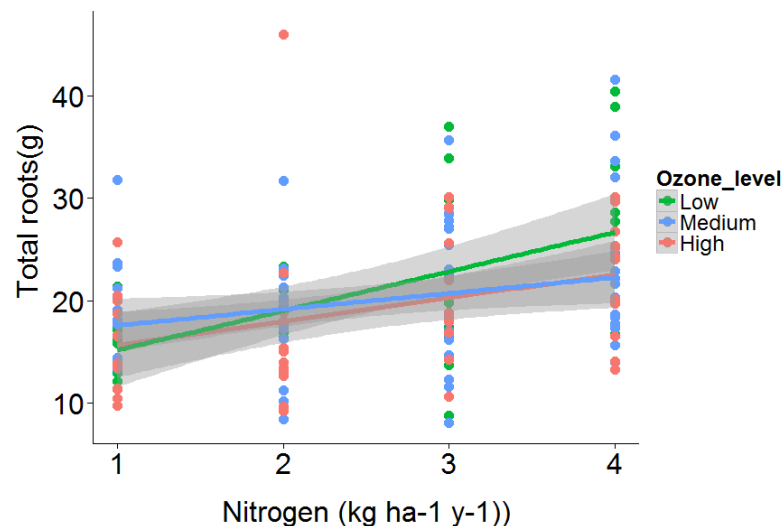
Tap root weight



Coarse roots (and tap roots and fine roots) showed larger differences between N treatments at low ozone

The proportion of fine roots remained constant

Total roots



Nitrogen increased total root biomass ($p < 0.01$)

Ozone may be lessening the response to increased nitrogen

Photographic summary

High N



Low ozone → high ozone

Low N



Low ozone → high ozone

Gradients visible in:
Tree height (photos are the same scale)
Leaf number

New facility and ozone x N experiment



FAZE: O₃ Field release system under development at Bangor



- Sand-dune cores have been collected from NW UK coastal sites across a nitrogen deposition gradient (range: 5 to 26 kg N ha y⁻¹)



- To be exposed to ambient ozone, and ambient + 20 and ambient +40 ppb ozone in FAZE

Summary

- ☐ Does nitrogen influence the response to ozone?
- ☐ Does ozone reduce the impact of added nitrogen?
- ☐ Significant effects of both ozone and nitrogen were found on birch
- ☐ Some indications that elevated ozone may lessen the response to increased nitrogen
- ☐ Linear relationship between 'response' and mean ozone concentration, and 'response' and nitrogen treatment (no 'threshold' for effects)
- ☐ Some 'interactions' between ozone and nitrogen may be indirect e.g. via changing phenology
- ☐ Ozone and nitrogen may be acting in different ways and on different timescales