

Update on ozone impacts on vegetation: trends and interactions with nitrogen

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44th session TFIAM, 6th May 2015

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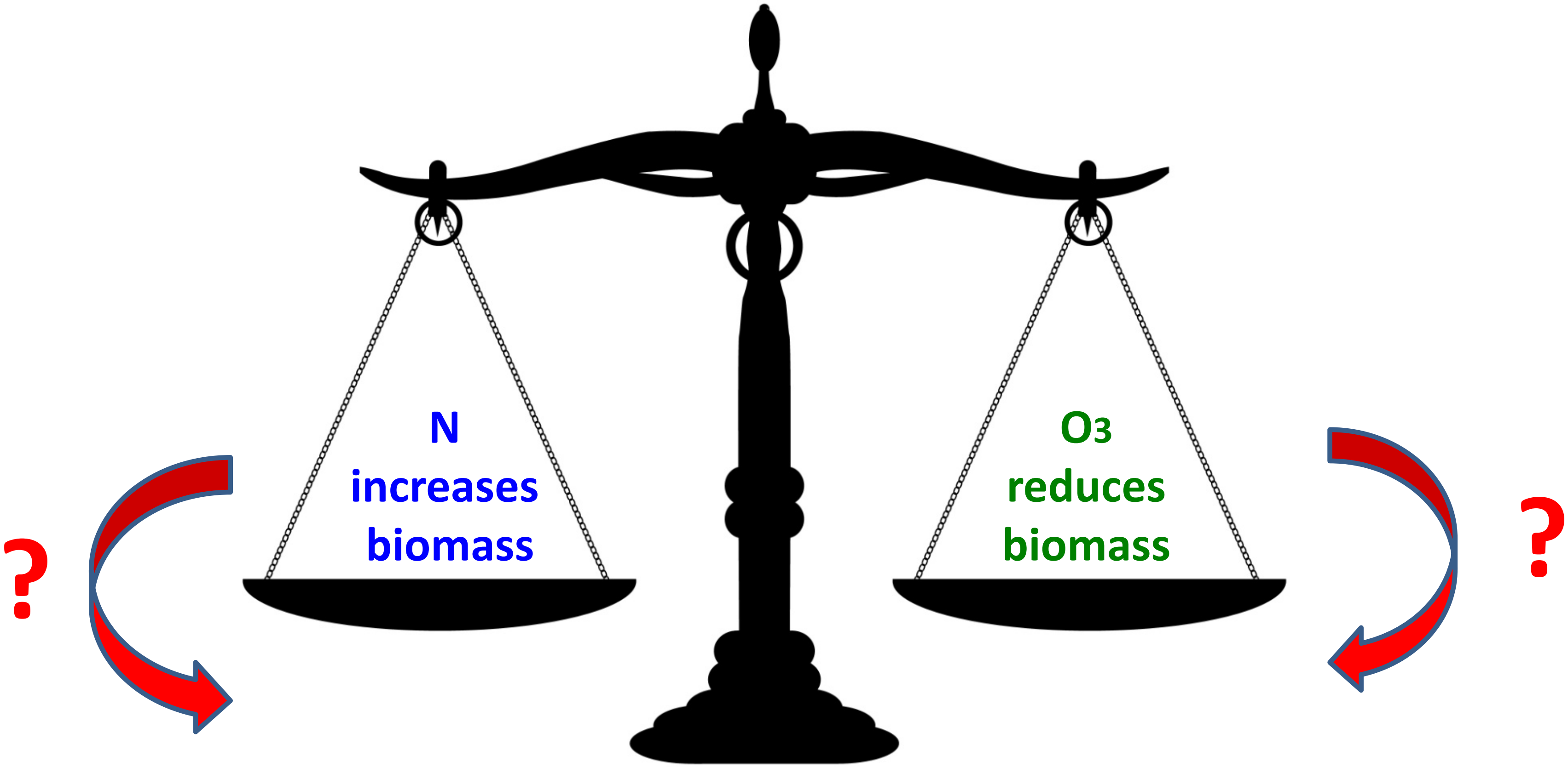
O_3 and N in combination - which way does the balance swing?

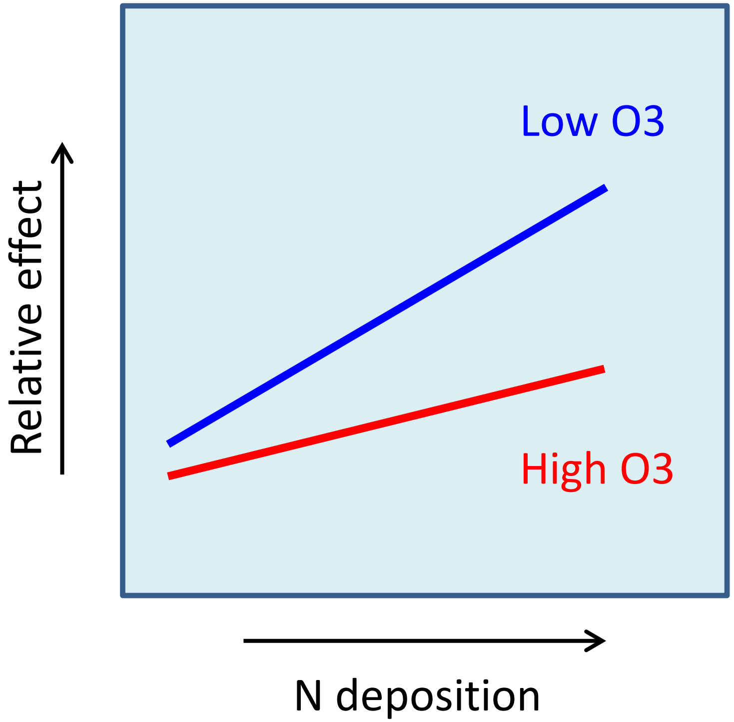


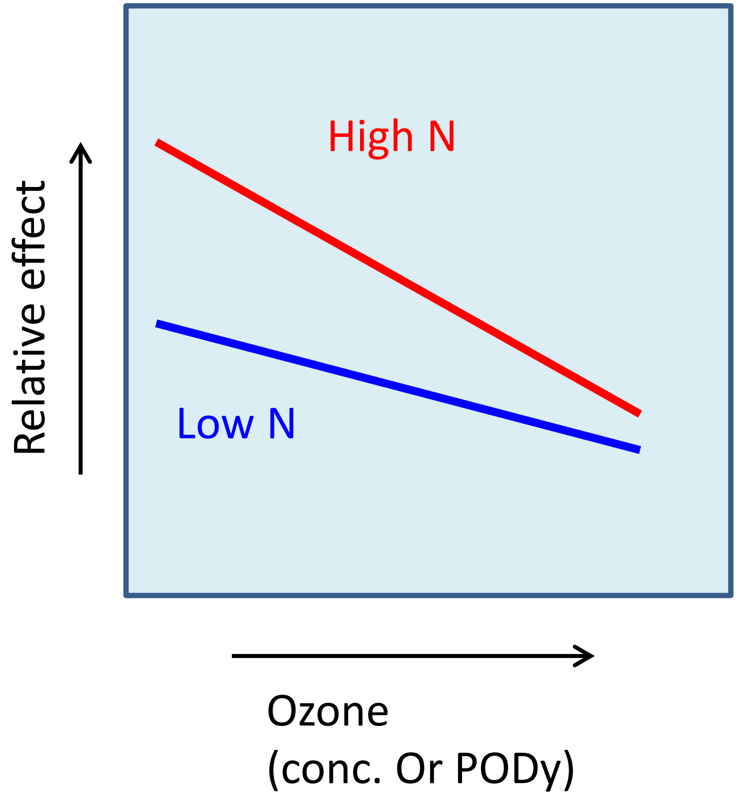
Depending on perspective...

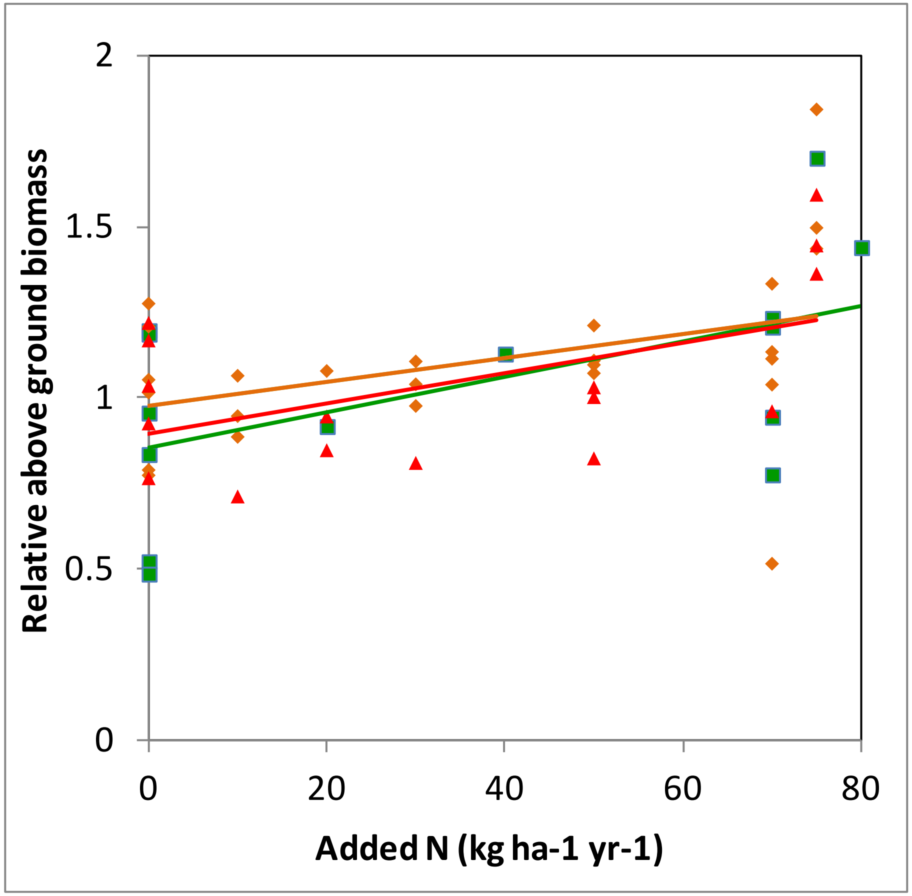
Does high ozone negate the growth enhancing effect of N?

or

Does N dep. make plants more sensitive to ozone?







< 35 ppb, “MFR”

40 – 55 ppb O3, “CLE”

60 – 95 ppb, no O3 controls (“NoC”)

Above-ground biomass

<u>Significance</u>

N effect: $p<0.01$

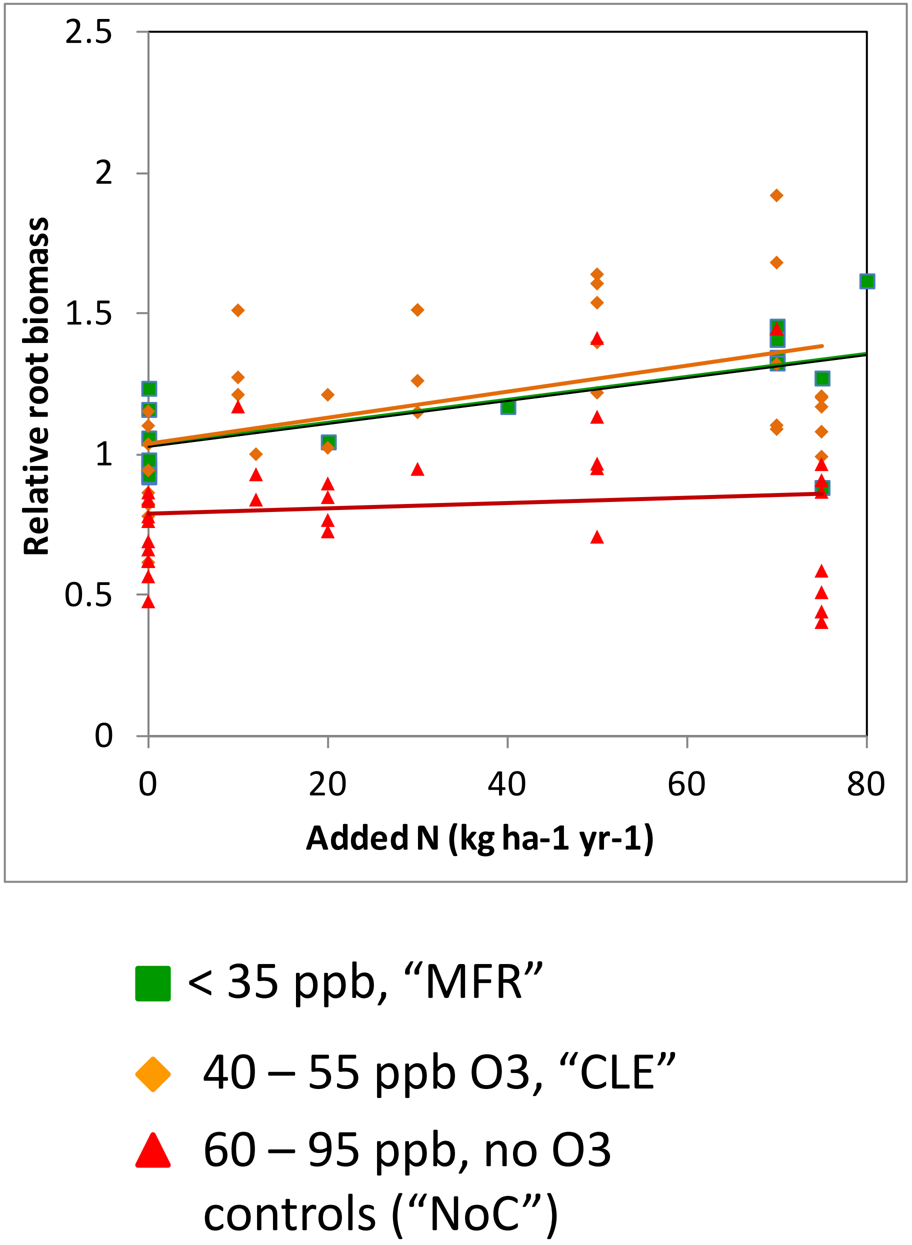
O3 effect: ns

N x O3: ns

Data sources

Sources:	Species:
Gerosa et al. (in prep)	*Quercus robur; Carpinus betulus*
Hayes et al. (in prep)	*Betula pendula*
Thomas et al. 2005	*Picea abies*
Wyness et al. 2011	*Ranunculis acris*
Yamaguchi et al. 2007	*Fagus crenata*

Mills et al., submitted



Root biomass

Significance

N effect: $p<0.01$

O3 effect: $p <0.01$

N x O3: ns ($p=0.16$)

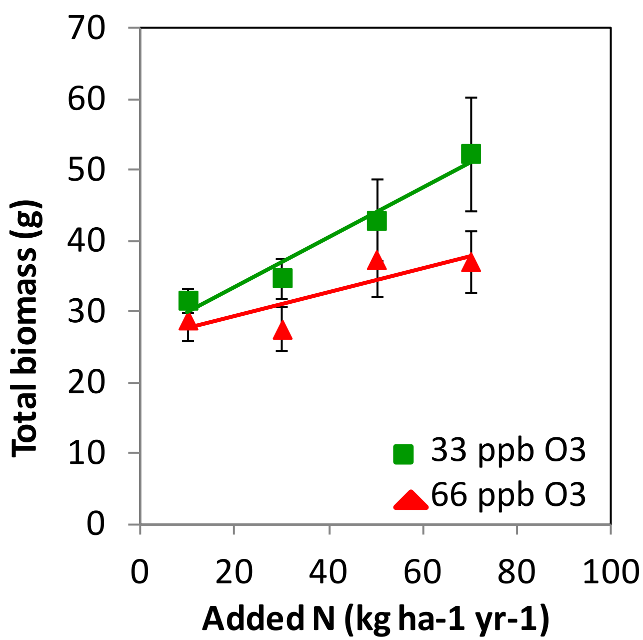
* Strong hint for loss of beneficial effect of N at high O3

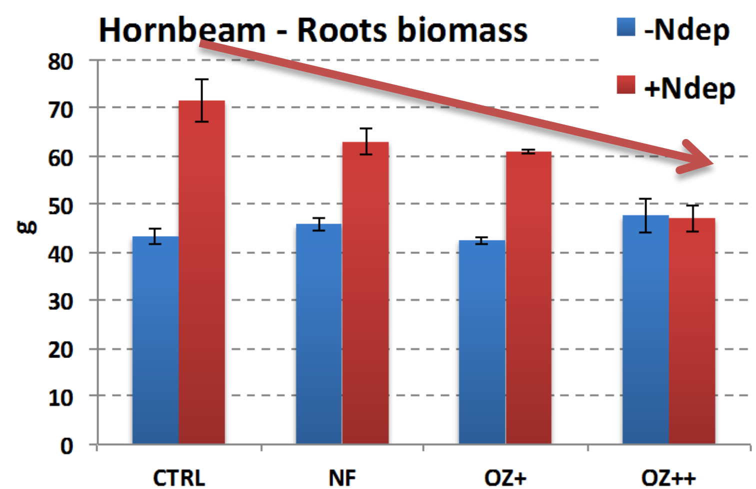
Data sources

Sources:	Species:
Gerosa et al. (in prep)	*Quercus robur; Carpinus betulus*
Hayes et al. (in prep)	*Betula pendula*
Jones et al. 2010	*Carex arenaria*
Thomas et al. 2005	*Picea abies*
Watanabe et al. 2008	*Castanopsis siebaldii*
Wyness et al. 2011	*Ranunculis acris*
Yamaguchi et al. 2007	*Fagus crenata*

Mills et al., submitted

- This signal is stronger when only considering high conc/depositions





- Silver birch, CEH expts

Hayes et al., ECLAIRE, unpublished

- Hornbeam, UNICATT expts

Gerosa et al., ECLAIRE, unpublished

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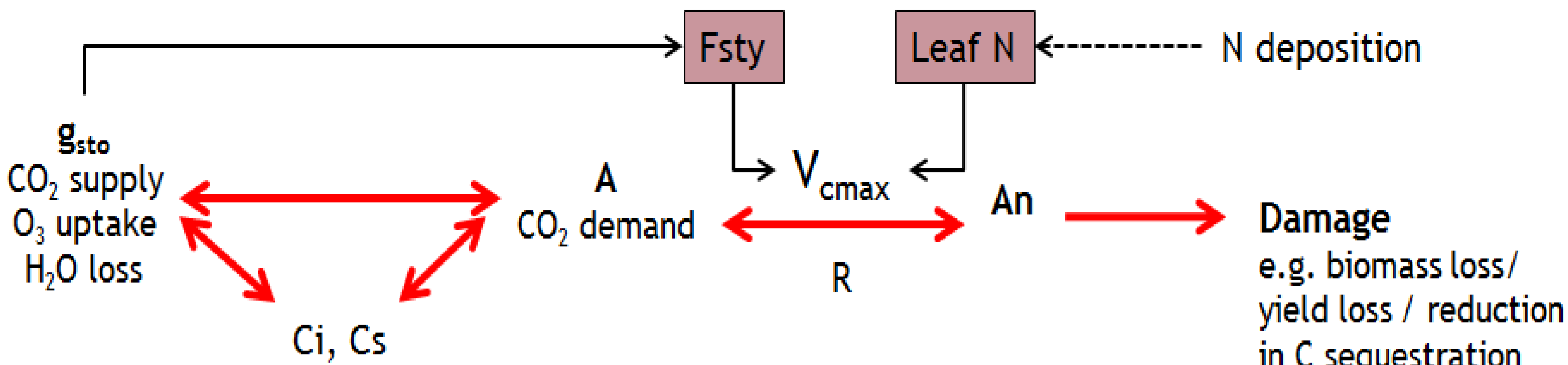
Development of DO_3SE for impact assessment

Integrating effects of O_3, N, H_2O, CO_2 and climate

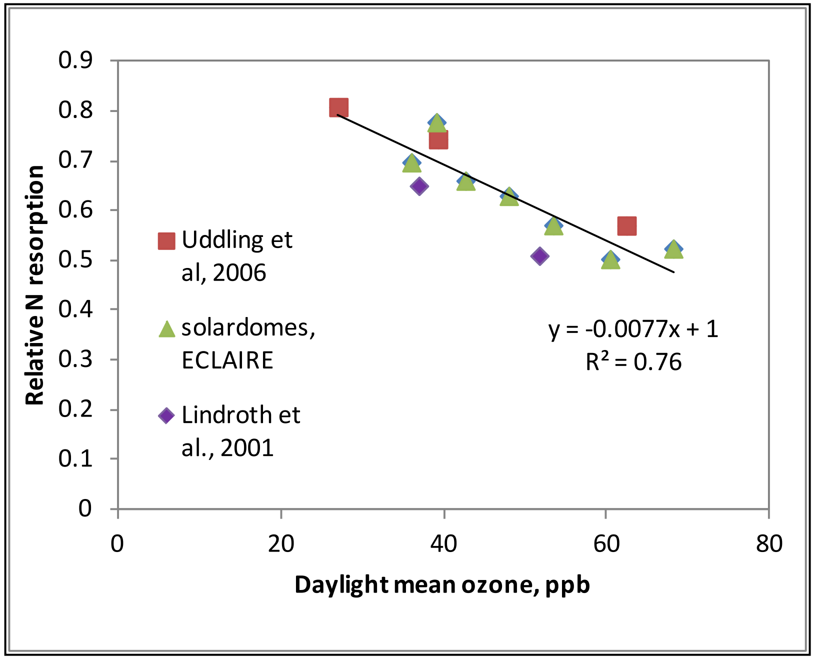
- Penman Monteith H_2O balance
- Coupled A_n-g_{sto} model (based on Farquhar et al., 1980 and Ball-Berry, 1987)
- Leaf N effect incorporated through V_{cmax}



- **By altering V_{cmax} to simulate variations in leaf N, it is possible to assess effect of N deposition on O_3 uptake.**

O_3 changes litter quality

Resorption of N from leaves prior to leaf fall



Karlsson, Hayes, et al., unpublished

- At higher ozone concentrations, less of the leaf N is transported back into the tree before the leaves fall
- Implications for soil processes
- Ecosystem scale model MADOC: Ozone included for first time to assess combined impact with N on net primary productivity (NPP) and nitrate leaching (*Rowe, Hayes et al.*)

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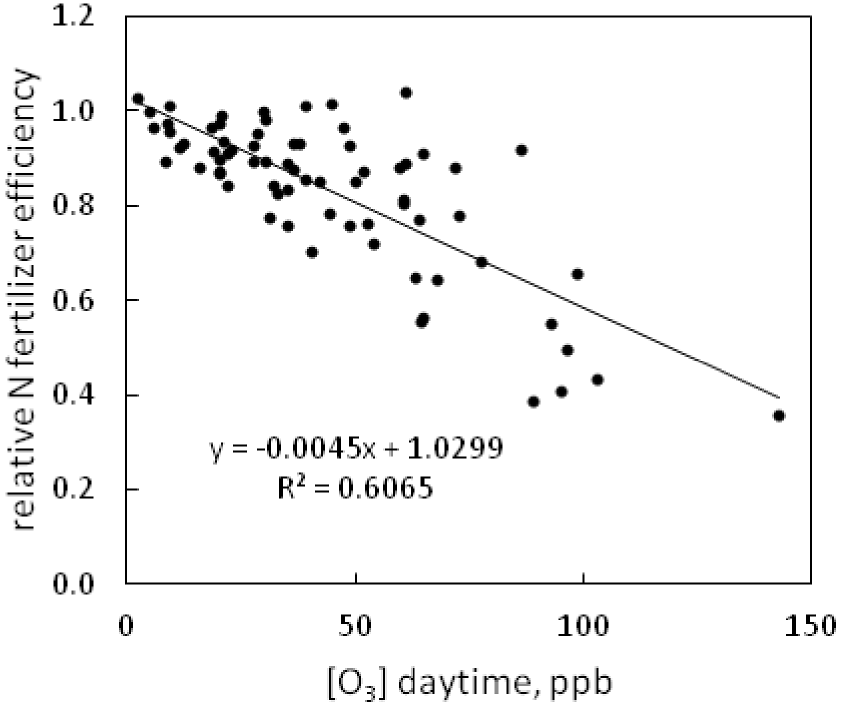
Ozone reduces N fertilizer use efficiency

Broberg and Pleijel, unpublished



- Ozone reduces the yield of wheat
- It also reduces the efficiency of conversion of soil N into seed protein N
- Counteracting the reduced yield with added N fertilizer may lead to added environmental pollution due to reduced efficiency of N conversion

*Based on data from 21 experiments

* Also available as a POD_6 -relationship

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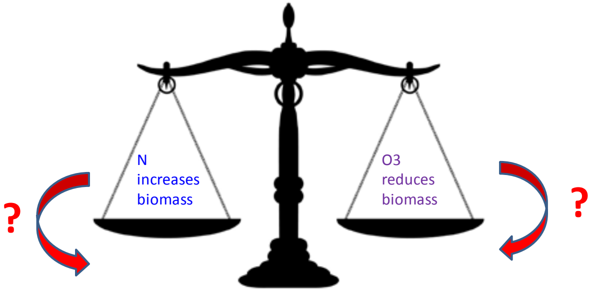

O_3 and N interactions: Summary

- Clear evidence of separate effects of N and O_3 on many processes of importance for ecosystems including C allocation, N use efficiency, N fixation, and soil processes

- Direction of interactions depends on the process and relative concentrations of O_3 and N, for example stimulation of photosynthesis by increasing N did not occur at higher O_3

- At highest ranges of N and O_3 expected in Europe:
  - O_3 reduces growth enhancing effects of high N (e.g. roots)
  - Relative effects of O_3 are greater at higher than at lower N

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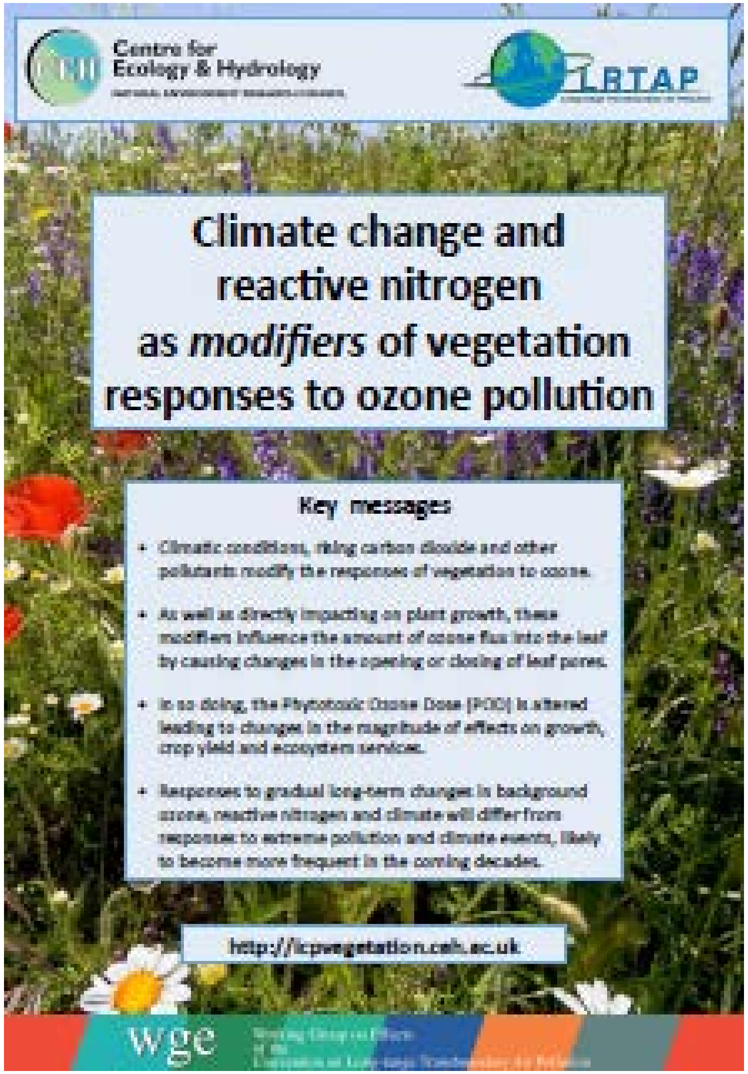
N and CC as modifiers of ozone impacts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LRTAP

Climate change and reactive nitrogen as *modifiers* of vegetation responses to ozone pollution

Key messages

- Climatic conditions, rising carbon dioxide and other pollutants modify the responses of vegetation to ozone.
- As well as directly impacting on plant growth, these modifiers influence the amount of ozone flux into the leaf by causing changes in the opening or closing of leaf pores.
- In so doing, the Phytotoxic Ozone Dose (POD) is altered leading to changes in the magnitude of effects on growth, crop yield and ecosystem services.
- Responses to gradual long-term changes in background ozone, reactive nitrogen and climate will differ from responses to extreme pollution and climate events, likely to become more frequent in the coming decades.

http://icpvegetation.ceh.ac.uk

wge

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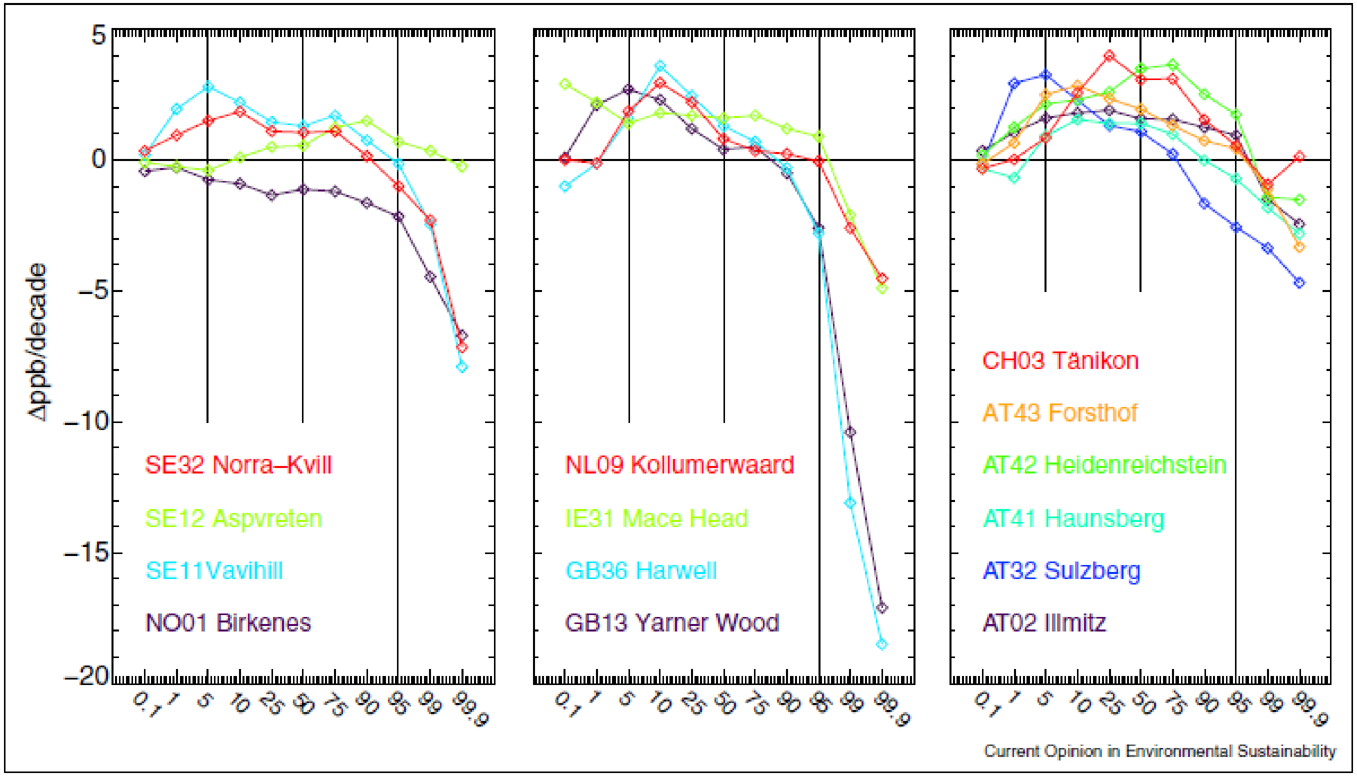
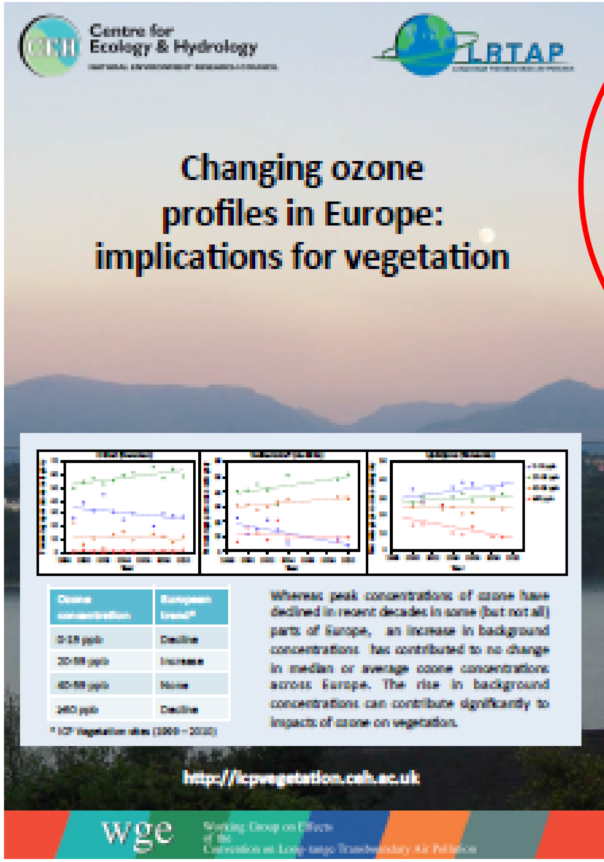
EMEP stations (Torseth et al., 2012. Simpson et al., 2014)



Change mean annual percentiles 1990-1999 to 2000-2009

- ❑ Decrease highest ozone levels and a corresponding increase low levels in the UK, the Netherlands and some other sites
- ❑ No trends in Switzerland or Austria
- ❑ Cause rise background ozone not fully understood, neither is the lack of trends

Changing ozone profiles (1999 – 2010)



Ozone concentration	European trend	Sites showing European trend
0-19 ppb	**Decline**	Tervuren (BE), Seibersdorf (AT)
20-39 ppb	**Increase**	Östad (SE), Ascot (GB), Tervuren (BE), Giessen (DE)
40-59 ppb	None	All, except increase in Seibersdorf (AT)
≥60 ppb	**Decline**	Ljubljana (SI)

- Background concentrations rising, peak concentration declining (but site specific)
- Abatement of precursors at global scale needed

Country	Site	24 hr mean	Daylight mean	Night mean	Daily max	Daily min	AOT40[a]	POD_3 IAM[b]
Belgium	Tervuren	None	None	Increase	None	Increase	None	None
Slovenia	Ljubljana	None	None	None	Decline	None	Decline	None
European mean		**None**	**None**	**Increase**	**None**	**Increase**	**None**	**None**

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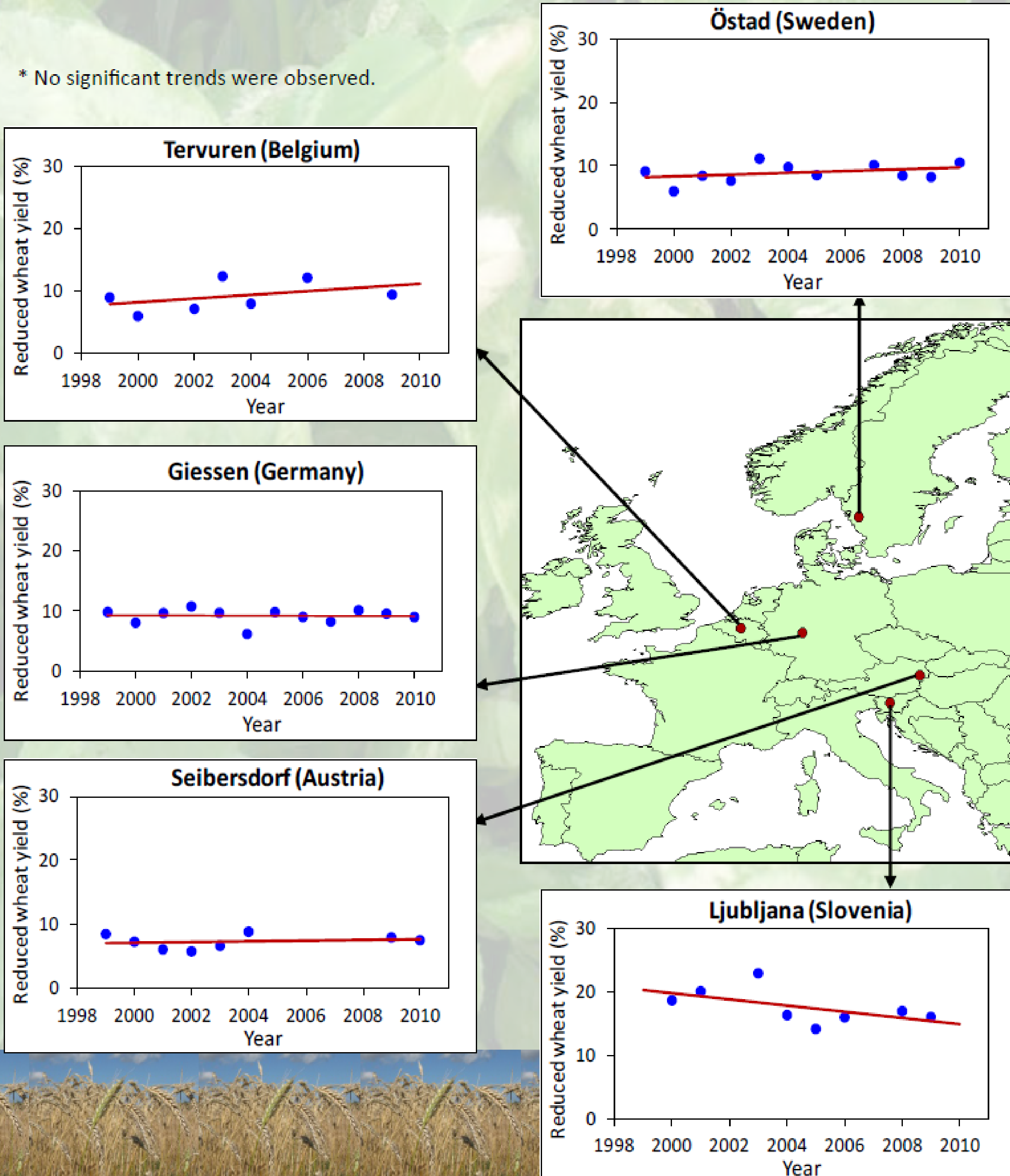
No significant trends in reduced wheat yield (POD_3IAM)*



* No significant trends were observed.

* Assuming no soil water limitation

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New Smart phone App

Recording incidences of leaf ozone injury

Submit photographs of ozone injury

Location on interactive map

Purpose:

(1) Quantify extent of damage in changing profile

(2) Validate risk maps

2015: Protocol developed for recording ozone injury

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Pilot study 2014: ozone experts

- 20 records submitted (36 people registered):
  - **Europe**: UK, Northern Italy, Switzerland
  - **USA**: Boulder & St Louis (**ozone gardens**), Rocky Mountains NP
  - **Asia**: China (Beijing)

- Limited submissions due to low stomatal ozone fluxes (e.g. wet and cold, hot and dry – short growing season), experts not out in the field?

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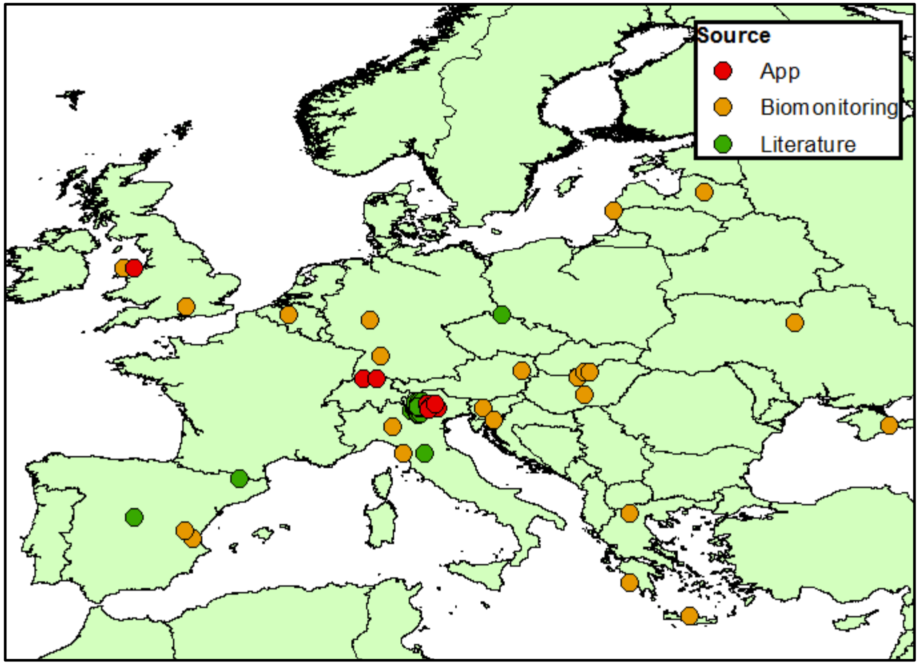
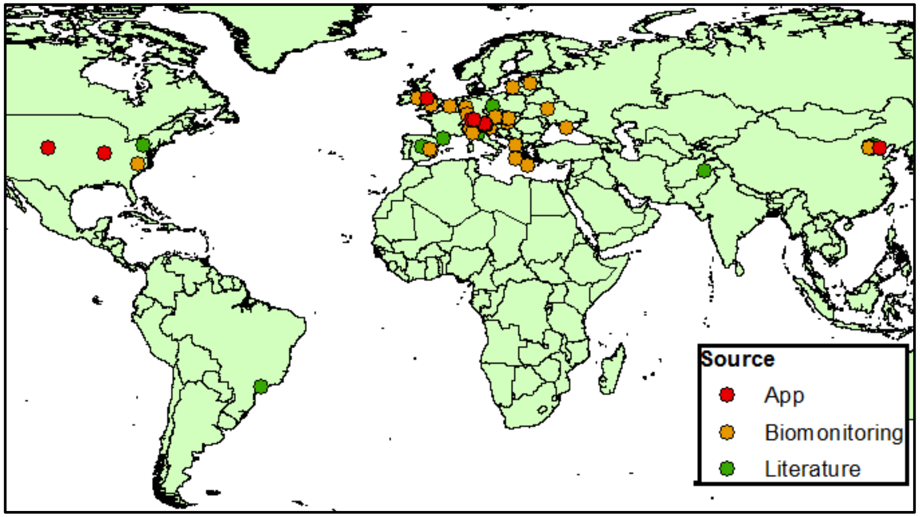
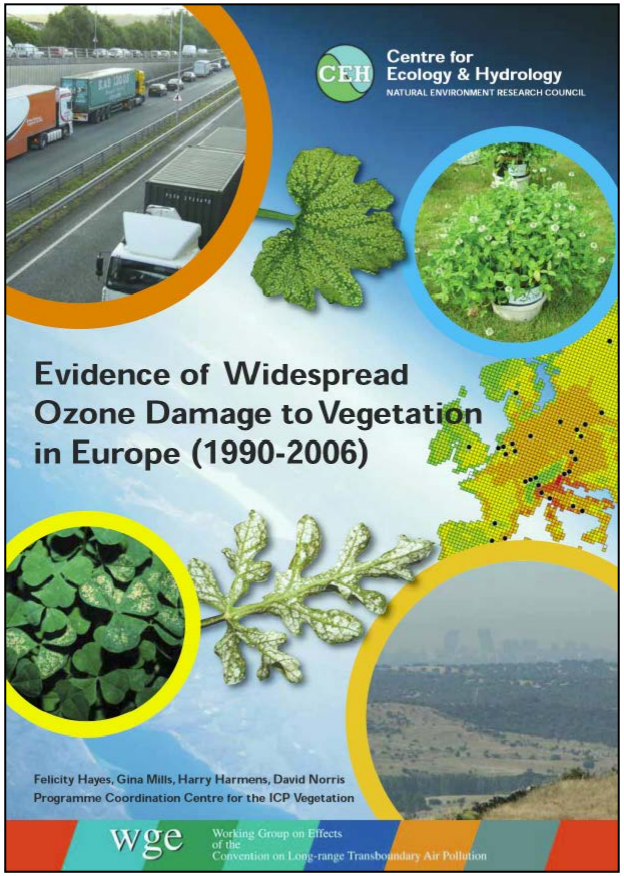
Further field-based evidence ozone impacts



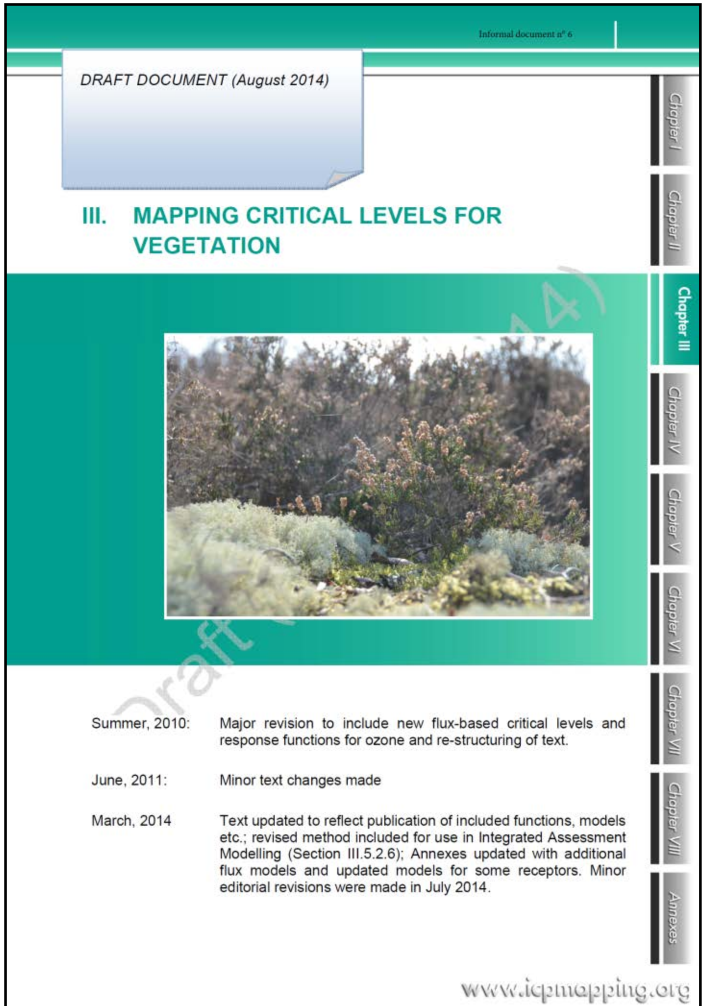


Post 2006 data

Hayes et al., 2007



Chapter 3 Mapping Manual: Critical levels


Informal document n° 6

DRAFT DOCUMENT (August 2014)

III. MAPPING CRITICAL LEVELS FOR VEGETATION

Summer, 2010:	Major revision to include new flux-based critical levels and response functions for ozone and re-structuring of text.
June, 2011:	Minor text changes made
March, 2014	Text updated to reflect publication of included functions, models etc.; revised method included for use in Integrated Assessment Modelling (Section III.5.2.6); Annexes updated with additional flux models and updated models for some receptors. Minor editorial revisions were made in July 2014.

Chapter I
Chapter II
Chapter III
Chapter IV
Chapter V
Chapter VI
Chapter VII
Chapter VIII
Annexes

www.icpmapping.org

http://icpvegetation.ceh.ac.uk

Minor updates:

- ❑ Update critical levels for tomato yield and quality (González-Fernández et al., 2014. Environmental Pollution).
- ❑ Simple soil moisture index included in EMEP modelling and mapping (Simpson et al., 2012)
- ❑ Autumn 2016, Spain: ozone CL workshop.
- ❑ Five working groups to prepare background documents:
  Methodology; Evidence; Crops; Trees; Grasslands

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International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

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Welcome to ICP Vegetation

The International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

The ICP Vegetation was established in 1987 under the United Nation Economic Commission for Europe (UNECE) ***Convention on Long-Range Transboundary Air Pollution (LRTAP)***. The ICP Vegetation is an international research programme investigating the impacts of air pollutants on crops and (semi-)natural vegetation and reports to the ***Working Group on Effects (WGE)***. The programme focuses on the following air pollution problems: impacts of ozone pollution on vegetation and the atmospheric deposition of heavy metals and nitrogen to vegetation. In addition, the ICP Vegetation is taking into consideration impacts of pollutant mixtures (e.g. ozone and nitrogen), consequences for biodiversity and the modifying influence of climate change on the impacts of air pollutants on vegetation. The results of studies conducted by the ICP Vegetation are used in assessments of the current, and predictions of the future, state of the environment. Thirty five Parties to the LRTAP Convention participate in the programme.

The programme is led by the UK, has its Programme Coordination Centre at the ***Centre for Ecology and Hydrology - Bangor*** and is funded by the ***Department for Environment Food and Rural Affairs***(Defra).

News

New reports/brochures:

- Annual report 2012/13 now available
- Ozone pollution: Impacts on ecosystem services and biodiversity
- Heavy metals and nitrogen in mosses: European survey 2010/11
- Benefits of air pollution control for biodiversity and ecosystem services (WGE full report and brochure)

27th ICP Vegetation Task Force Meeting, 28-30 Jan 2014, Paris, France

Thank you very much for your attention!

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