


Field-based evidence of ozone impacts on vegetation: an update

Katrina Sharps, Felicity Hayes, Harry Harmens, Gina Mills
Jim Bacon, Karolis Kazlauskis
and the participants of the ICP Vegetation

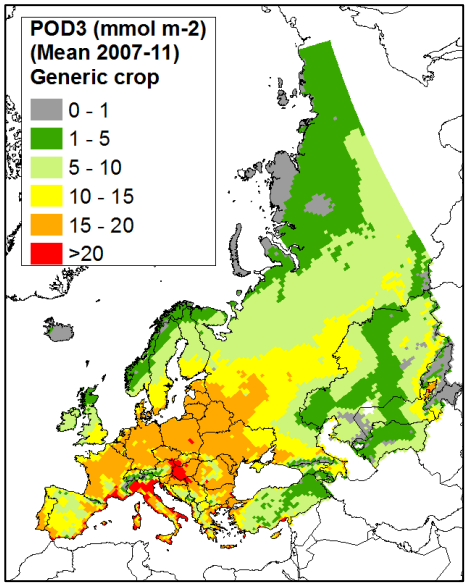
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

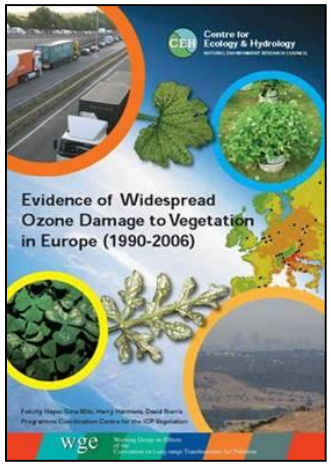
CAPER, 4th-6th April 2016, Bangor

NERC SCIENCE OF THE ENVIRONMENT

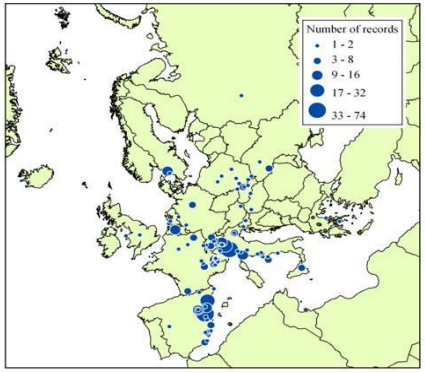
Importance of field-based evidence

- Verify predictions from experiments and models.
- Demonstrate to policy makers that ambient ozone is having an impact.
- Evidence can be used to validate risk maps created using modelled data, e.g. ozone concentration and flux.
- ICP Vegetation 'Evidence Report' in 2007, with >500 records of visible injury from 16 European countries. We present an update of this report.





Hayes et al. 2007

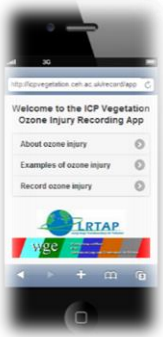


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Sources of evidence

- ICP Vegetation biomonitoring experiments
- Records of visible leaf injury
  - Smart phone App
  - Ozone gardens
  - Published information from surveys and ambient air experimental treatments
  - ICP Forests visible injury records
- Charcoal-filtered vs. non-filtered air experiments
- Epidemiology studies



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Ozone injury App

Recording incidences of leaf ozone injury

Submit photographs of ozone injury

Location on interactive map

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

http://icpvegetation.ceh.ac.uk/record/index

2014/5 App progress

Registrations…..

36 people registered in 2014

33 further registrations in 2015

Primarily in ozone community, but records received from around the world.

Possible obstacles:

Not much ozone damage seen in the field?

No smart phone/lack of phone coverage?
(use online form or complete form and save)

Not out in the field this summer?

Species showing ozone injury (2014/5, App)

1. Beech (*Fagus sylvatica*)
2. Ash (*Fraxinus spp*.)
3. Wayfaring tree (*Viburnum lantana*)
4. Poplar (*Populus* spp.)
5. Black cherry (*Prunus serotina*)
6. Alder (*Alnus* spp.)
7. Common hazel (*Corylus avellana*)
8. Common milkweed (*Asclepias syriaca*)
9. Cutleaf coneflower (*Rudbeckia laciniata*)
10. *Magnolia accuminata*
11. White clover (*Trifolium repens*)
12. Alfalfa (*Medicago sativa*)
13. Wheat (*Triticum* spp.)
14. Tobacco (*Nicotiana tabacum*; Bel W3)
15. French bean (*Phaseolus vulgaris*)
16. Aubergine (*Solanum melongena*)
17. Onion (*Allium cepa*)
18. Lettuce (*Lactuca sativa*)
19. Basil (*Ocimum basilicum*)
20. Raspberry (*Rubus idaeus*)
21. Potato (La Chipper) (*Solanum tuberosum*)

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

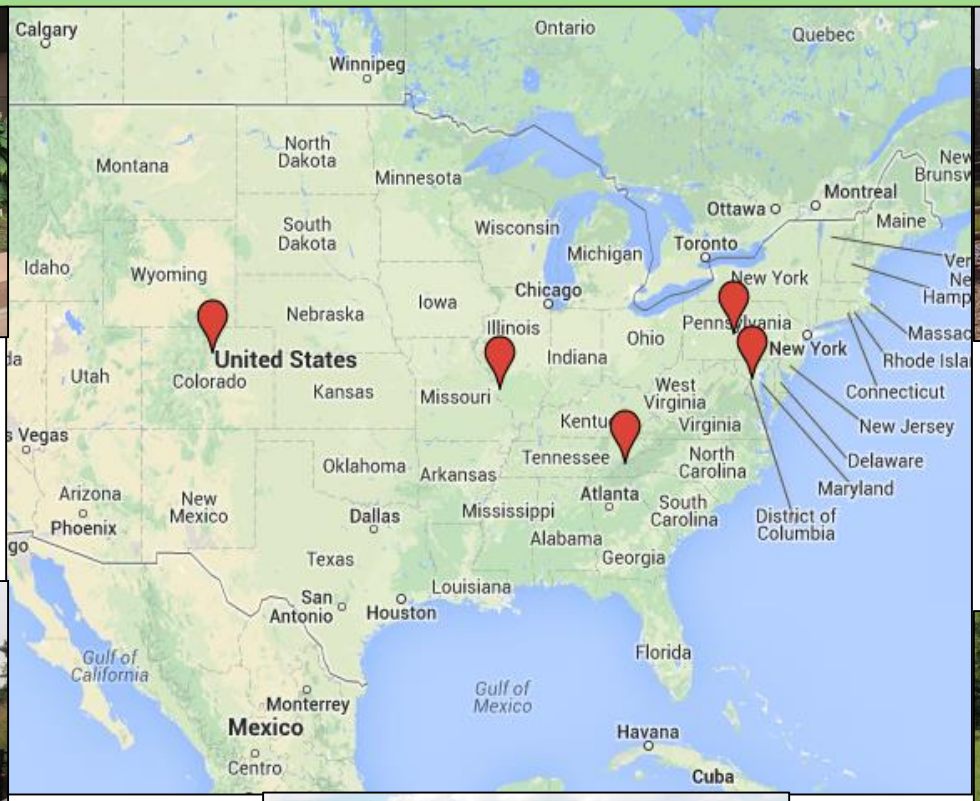

Gina Mills, white clover, Milan, July 2015


Kelley Belina, French bean, USA, July 2015


Sabine Braun, beech, Switzerland, Aug 2015

USA Ozone Bio-indicator Gardens

Boulder, Colorado



Penn State University

St Louis University

Great Smoky Mountains NP

NASA Goddard Research Station, Maryland

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Ozone injury recording protocol

Recording the presence/absence of ozone injury using the smart-phone App or online recording form

Experimental Protocol

ICP Vegetation*, 2015

CONTACT: ICP Vegetation Programme Coordination Centre, Centre for Ecology & Hydrology, Environment Centre Wales, Deiniol Road, Bangor, Gwynedd, LL57 2UW, United Kingdom.

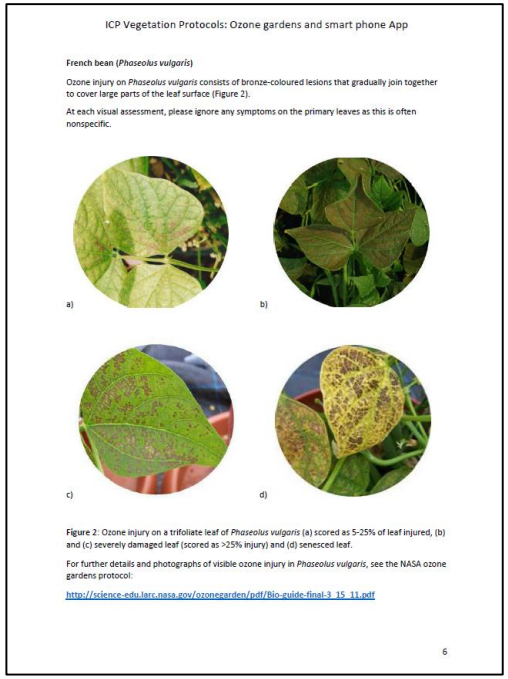
Telephone: +44 (0) 1248 374500

Email: fhay@ceh.ac.uk; katshar@ceh.ac.uk

Website: http://icpvegetation.ceh.ac.uk

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

- Use of the ozone App
- Ozone gardens



ICP Vegetation Protocols: Ozone gardens and smart phone App

French bean (*Phaseolus vulgaris*)

Ozone injury on *Phaseolus vulgaris* consists of bronze-coloured lesions that gradually join together to cover large parts of the leaf surface (Figure 2).

At each visual assessment, please ignore any symptoms on the primary leaves as this is often nonspecific.

a) b) c) d)

Figure 2: Ozone injury on a trifoliate leaf of *Phaseolus vulgaris* (a) scored as 5-25% of leaf injured, (b) and (c) severely damaged leaf (scored as >25% injury) and (d) senesced leaf.

For further details and photographs of visible ozone injury in *Phaseolus vulgaris*, see the NASA ozone gardens protocol:

http://science-edu.larc.nasa.gov/ozonegarden/pdf/Bio-guide-final-3_15_11.pdf

6

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

http://icpvegetation.ceh.ac.uk/manuals/

NERC SCIENCE OF THE ENVIRONMENT

Ozone gardens 2015

White clover

Poznan ozone garden
(Klaudia Borowiak, Anna Budka)

French bean

Wheat

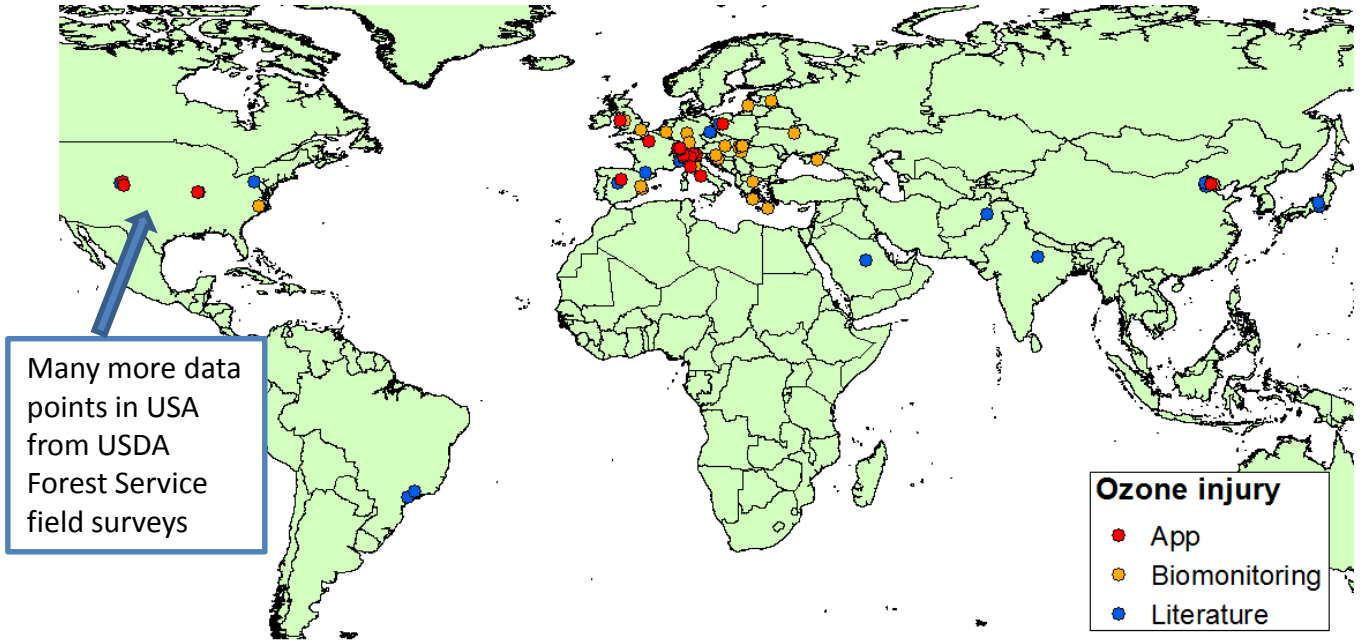
Tobacco

3 gardens: UK (Bangor), France (Paris), Poland (Poznan)

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

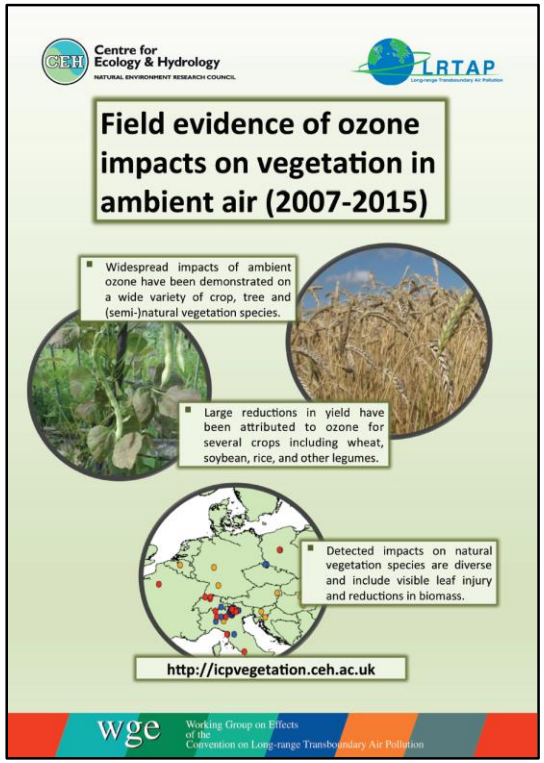
NERC SCIENCE OF THE ENVIRONMENT

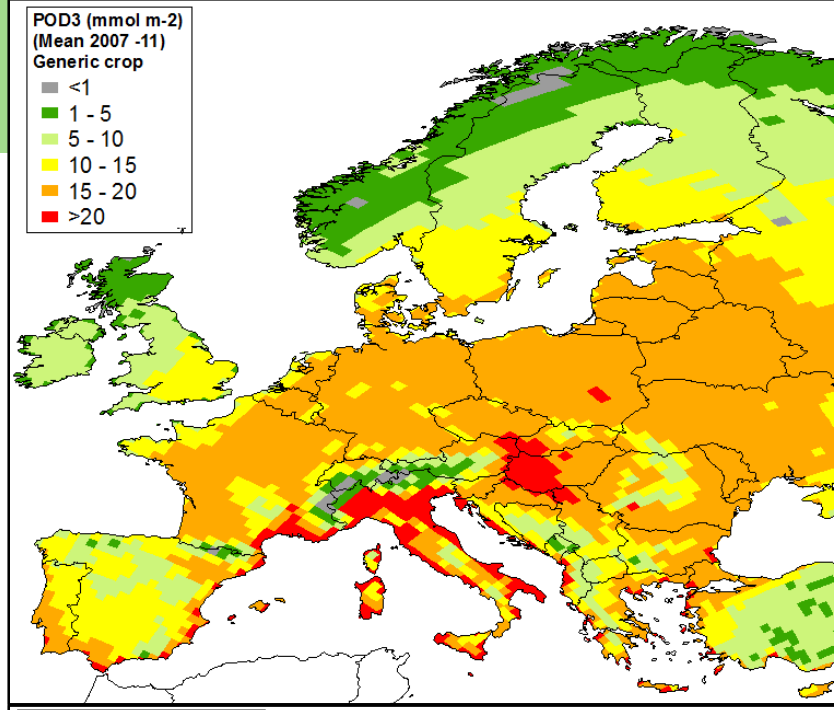
Visible injury in ambient air

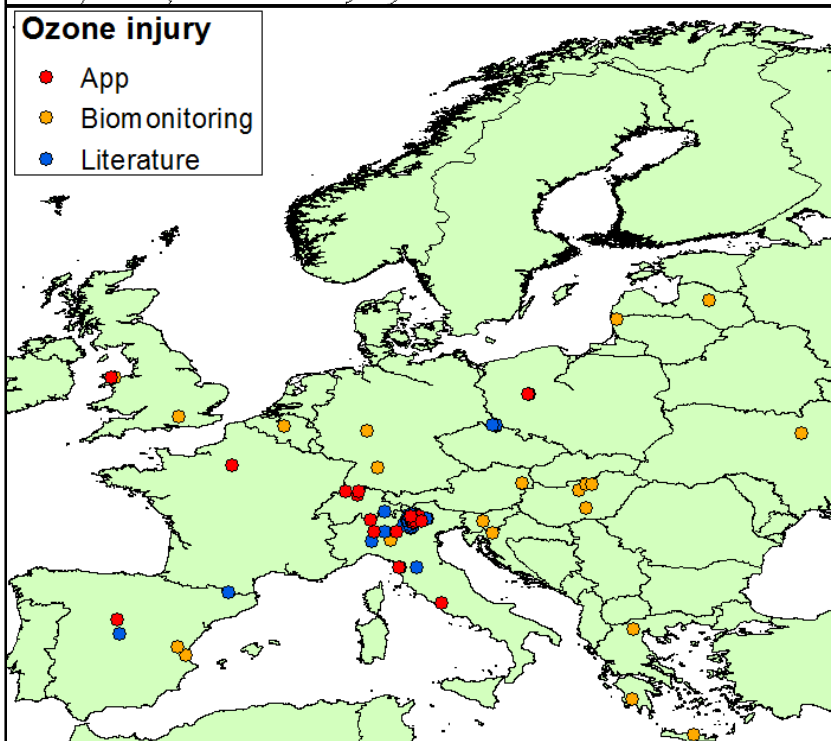


- These records are from 2006 onwards, from the App, biomonitoring experiments and from published literature
- Visible injury symptoms have been observed on **over 60** species of crops, grasses, forbs, shrubs and trees.
- ICP Forests data also shows many records of ozone injury symptoms in central and Eastern Europe.
- Injury has been observed in 19 countries from Europe, Asia and North and South America.
- Records are still centred in areas where ozone specialists are active!

Evidence for Europe







- Field-based evidence of ozone damage on crops, trees and wild flowers (2007 – 2015) in Europe is coherent with risk of damage as estimated from ozone flux, i.e. widespread.

Crops – experimental evidence

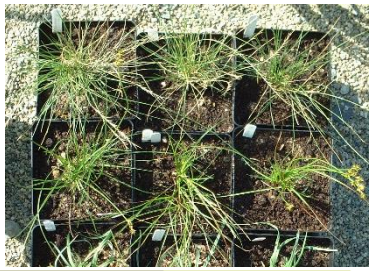
Crop	Number of data points	% crop reduction
Soybean	3	22.5
Rice	17	9.4
Sugar beet	2	5.9
Wheat	14	8.3
Durum wheat	2	14.2
Peas and beans	4	26.1

Country	Number of data points	% crop reduction
Belgium	2	5.9
China	15	**
India	19	19.5
Japan	2	3.2
Pakistan	5	40.0

- Experiments using charcoal-filtered compared to non-filtered air have shown large reductions in crop yield.
- Changes in crop quality have been shown for some e.g. rice and wheat.
- There are some confounding factors because some countries only used the most sensitive crops.
- There were very high ozone concentrations for the Pakistan studies.
- The efficiency of the charcoal filter can have a large influence on reported reductions (range of CF is 4 to >20ppb).

(Semi-)natural vegetation

- Many species (>60) have been tested in filtered air vs non filtered experiments.
- Most of the data is from before 2006 and for many species there is no replication in different experiments.
- The parameters measured are also diverse. Many report biomass, but sometimes this is above-ground biomass only, and sometime total biomass only (there is evidence that root biomass is more sensitive than shoot biomass for some species).
- Size and direction of effect on biomass for semi-natural vegetation (grasses and forbs) from the CF NF experiments (2000-15) was variable (overall mean, 6% reduction).



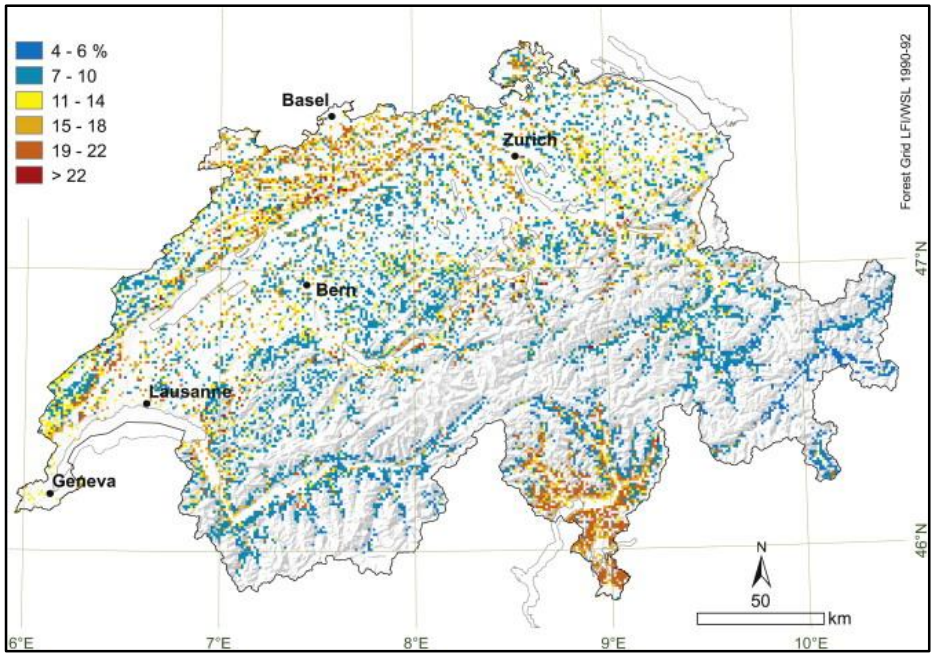
Epidemiology studies

- Epidemiological studies have been used to show impacts on mature trees in the field.

- In Switzerland, based on measurements of ~ 4800 trees, it was estimated that the reduction in annual growth due to ozone during the period 1991 to 2011 was 19.5% for deciduous trees and 6.6% for conifers (Braun *et al*., 2014).

- Epidemiological analysis has also been used in northern Italy and southern France to show that ozone injury symptoms on forest trees were better explained by ozone uptake (POD) rather than ozone concentrations (Sicard *et al*., 2016).

Reduction in annual tree growth in Switzerland



Map from Braun et al., 2014

(Braun et al., 2014, Environmental Pollution 192, 129-138)
(Sicard et al., 2016, Science of the Total Environment 541, 729-741)

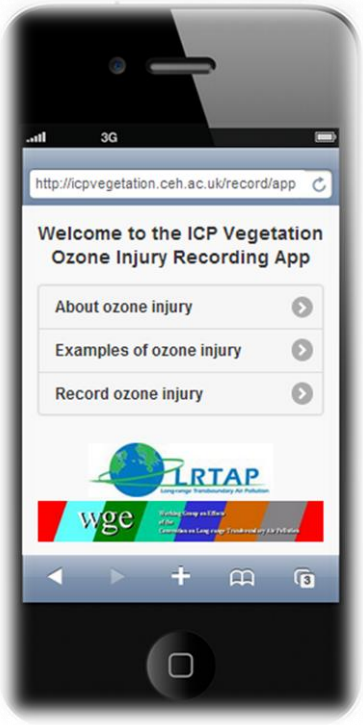
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

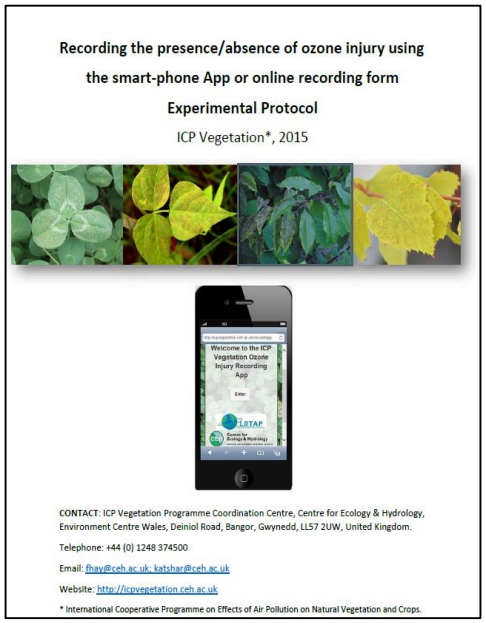
NERC SCIENCE OF THE ENVIRONMENT

Summary

- There is widespread field-based evidence of ambient ozone impacts.
- For some regions there is much evidence of impacts (particularly visible injury), but coverage remains poor in South America, Africa and Asia.
- The largest evidence source is visible leaf injury, but this is ‘presence’ only and not quantifiable.
- CF NF experiments remain good sources of evidence, but global coverage is very low and the relative sensitivity of the species tested is problematic when analysing data between sites.
- Epidemiological analysis is a useful tool, but requires a long timescale and so is less useful for investigating impacts in individual years.

Get involved?





http://icpvegetation.ceh.ac.uk/record/index

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Acknowledgements

We'd like to thank the UK Department for Environment, Food and Rural Affairs (Defra) and the UK Natural Environment Research Council (NERC) for funding this project.

Thank you for your attention!

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT