



# **A WGE analysis of the achievements, potential benefits and damages on health, materials and the environment of Gothenburg Protocol scenarios**

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All WGE's ICPs and TF

# Relevant information from the WGE indicators for the revision of the Gothenburg protocol

In the context of revision of the Gothenburg Protocol,

- What do WGE indicators from field observations and modelling show?
- What are the main conclusions for each pollutants?

# Conclusions

Lots of information, mostly giving the same messages:

Baseline scenario already providing significant improvement to the condition of the environment. MTRF goes further but not enough to provide total protection against acidification for all ecosystems (esp. the most sensitive ecosystems)

## Acidification

## Eutrophication

Nitrogen remains a wide-spread problem although improvements are expected. Impacts biodiversity, ecosystem resilience...

## Ozone

Effects of ozone on food security, ecosystem services and human health are important.

## Multi-pollutant

Effects of air pollution on materials and health probably underestimated in urban areas

# WORK DONE SINCE FEBRUARY



# ICP VEGETATION



## Quantifying the threat from ozone pollution to food security: UK and Europe

Gina Mills, Felicity Hayes, David Norris, Jane Hall, Harry Harmens, Mhairi Coyle, David Simpson, Howard Cambridge, Steve Cinderby, John Abbott, Sally Cooke, Tim Murrells, Max Posch etc.

**CCE**

 **AEA**

**EMEP**

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# Ozone affects food and feed quality (1)

- ❑ Change primary metabolites (carbohydrates, proteins)
- ❑ Change secondary metabolites:
  - vitamins and other anti-oxidants
  - compounds with range of anti-fungal/bacterial/microbial activities & anticarcinogenic properties
- ❑ **Wheat/potato:**  
Decrease carbohydrate, increase protein content
  - positive & negative impacts on baking/frying quality or further food processing (depending on use)
- ❑ **Oil producing crops:** often decrease oil content
- ❑ **Grapes and watermelon:** decline sugar content



# Ozone affects food and feed quality (2)

## ❑ Decline forage quality:

Can lead to lower milk and meat production

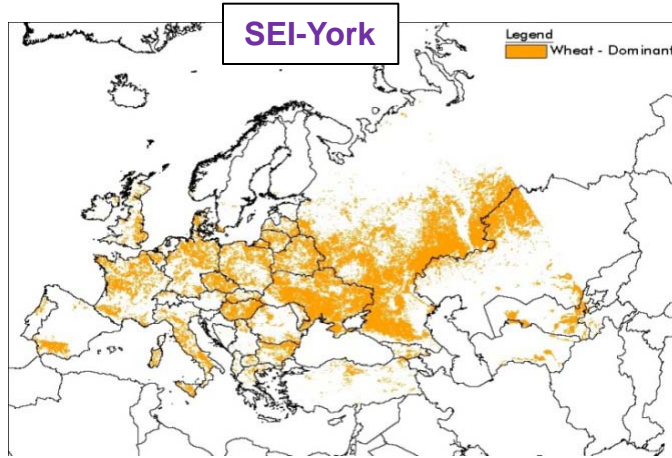
- reduced digestibility (increase lignine, early die-back, decline legumes)
- changes nutrient content (protein, sugars, starch, minerals)
- secondary metabolites ('anti-nutrients')



## ❑ Development of ozone critical levels food/feed quality required

- ❑ **Total loss of consumable food value** (fractional reduction in yield × fractional reduction in nutritive quality) need to be considered in economic impact assessments

# Economic impact assessment



Distribution map - wheat

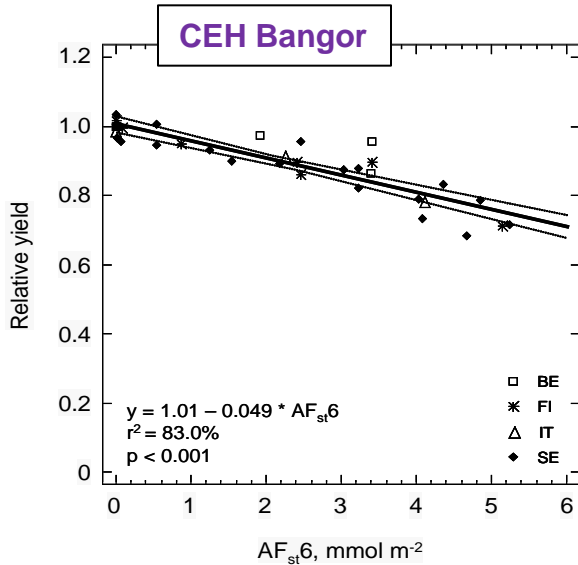


Production statistics

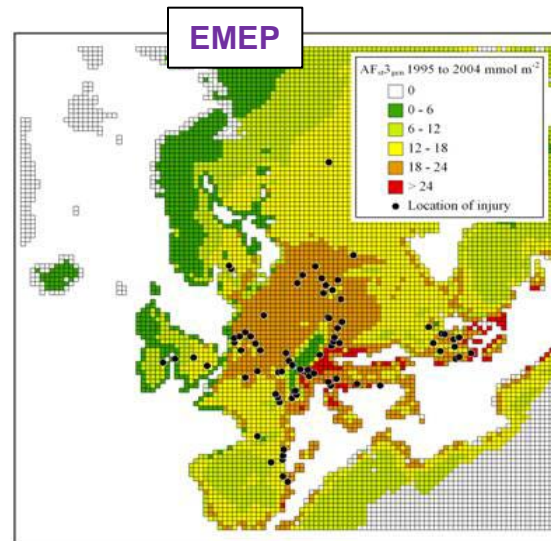


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Response function: wheat



Ozone flux on 50 x 50km grid

CEH Bangor

**Future Scenarios (2020, 2030)**

**+ Costs**

**= Quantification**

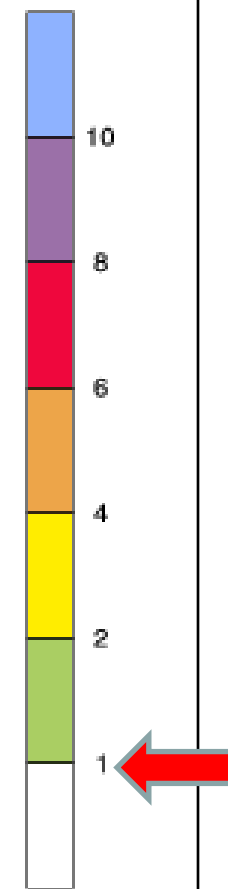
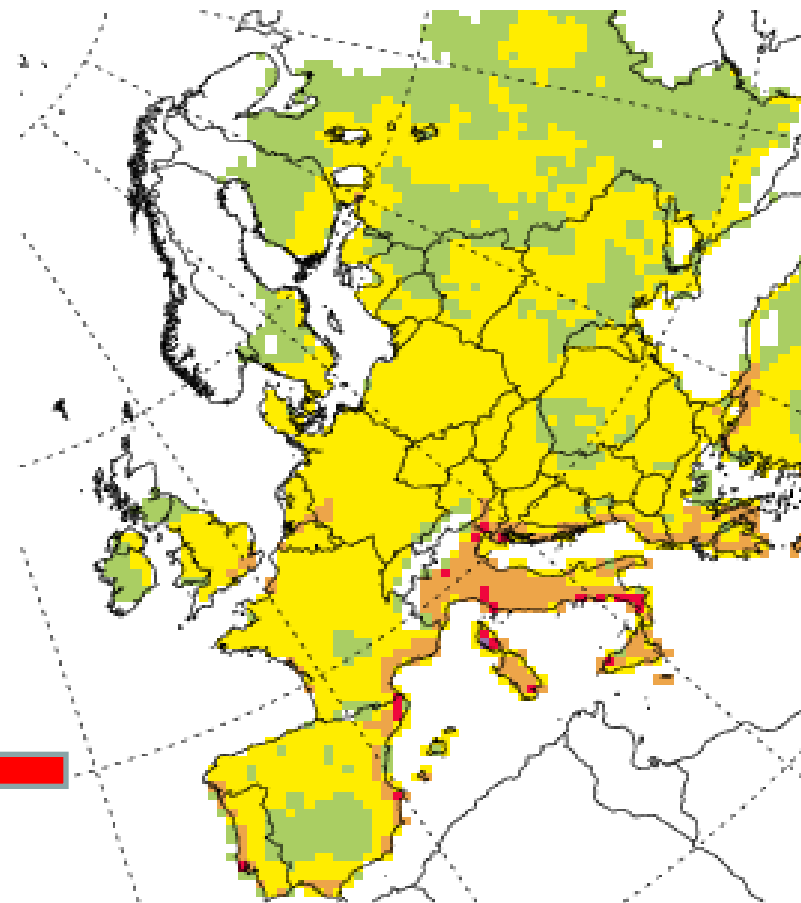
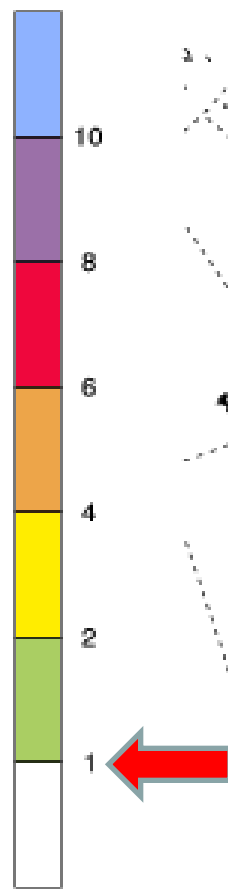
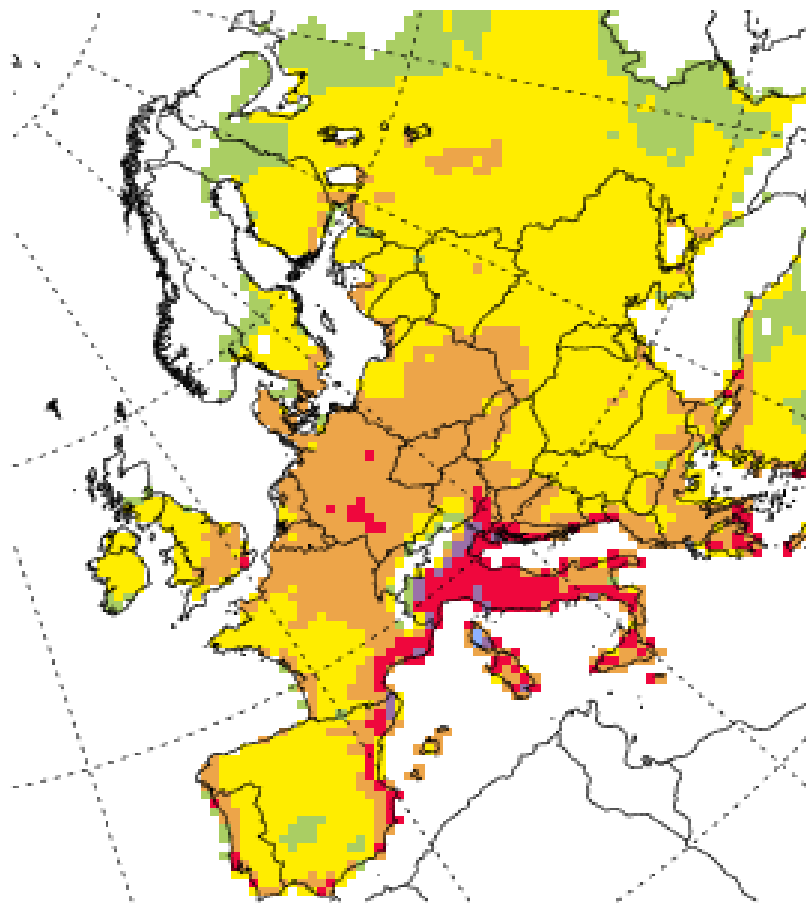


# Potential impact on wheat (assessed with POD6).

## 2000 NAT

## 2020 NAT

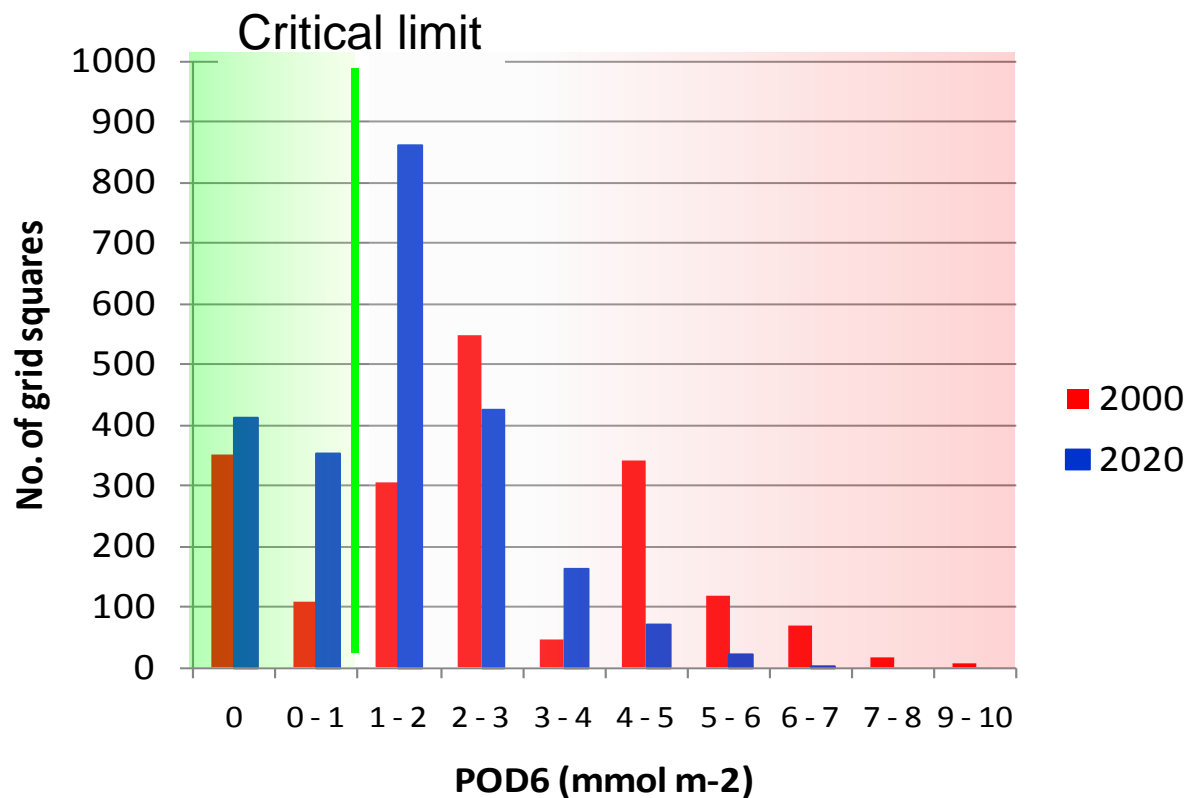
ICP VEGETATION



Maps: EMEP/MSC-West

\* Assuming no water limitations

# Scaling POD6 for wheat growing areas



<b>EU27+CH+NO, NAT scenario</b>	<b>Number of grid squares</b>
Wheat grown	2311
2000, exceeding critical level	1960
2020, exceeding critical level	1900

- Calculated for squares in wheat growing areas only
- CL of 1 mmol m<sup>-2</sup> is exceeded in > 80% of grid squares
- POD<sub>6</sub> decreases in 2020 (NAT scenario), but very small reduction in critical level exceedance

# End-product: Monetarised losses

## Lost value in £million

	Wheat	Potato	Oilseed rape	Maize	Barley	Sugar beet	Pea and bean	Salad leaf crops	Total lost value
<b>2006</b>	77.6	9.9	25.0	30.4	13.3	17.5	5.9	25.3	£205 million
<b>2008</b>	91.2	0.3	32.9	8.3	17.7	4.4	3.0	n.a.	£218 million

**Indicative certainty**



\*Based on mean crop value (1996 to 2009), uncorrected for flux underestimations

\*\* report to be published in June

## Conclusions are robust

Areas impacted decrease, amplitude of exceedances decreases

- Biological recovery clearly observed and modelled at aquatic sites.
- Evaluation of effects of ozone on vegetation has improved using fluxes and studies on crops are providing first monetary evaluation.
- Forest data: decrease and increase of pH in soil mirroring S emissions; C/N suggest N rich ecosystems become more common.
- Effects on materials (soiling, corrosion) may now be quantified.
- Effects on health and materials in urban areas are likely greater than modelled.
- Monitoring and modelling indicate where the impacts are the most observed and expected.

Different ambition levels lead to different proportions of ecosystems, material and population protected.

# Challenges ahead

## Communicate results efficiently

- Develop the monetised approach?
  - ⇒ Done for human health.
  - ⇒ Being done for crops.
  - ⇒ Feasible for materials.
  - ⇒ For natural ecosystems, approaches to be investigated.
  
- More systematic reporting on effects
  
- Common TFIAM / WGE report
  - ⇒ What is/are the scenario(s) to be used?