The Effects of Air Pollution on the Environment:

Conclusions of the Review of Transboundary Air Pollution (RoTAP)

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RoTAP: Core Members

Name	Role	Organisation
Prof David Fowler	RoTAP Chair Lead Author Chapters 1, 3 & 8	CEH
Prof Mike Ashmore	Lead Author Chapter 5 (Vegetation)	University of York
Prof Neil Cape	Lead Author Chapter 6	CEH
Prof Dick Derwent		rdscientific
Dr Chris Dore	Lead Author Chapter 2	Aether Ltd
Dr Tony Dore	Lead Author Chapter 4	CEH
Prof Bridget Emmett	Lead Author Chapter 5 (Soils)	CEH
Prof Peringe Grennfelt	Lead Author Chapter 7	IVL
Jane Hall	Lead Co-Author Chapter 8 (Recovery)	CEH
Heath Malcolm	RoTAP Secretary	CEH
Don Monteith	Lead Author Chapter 5 (Freshwaters)	CEH
Ron Smith	Statistical Evaluation	CEH

National Expert Group on Transboundary Air Pollution (NEGTAP, 2001)

NEGTAP Report published in 2001
Provided a detailed description of

- acid deposition
- eutrophication
- ground level ozone

RoTAP Project began in February 2008 with the aim of reviewing the current UK status of :

- acid deposition
- eutrophication
- ground level ozone
- heavy metals

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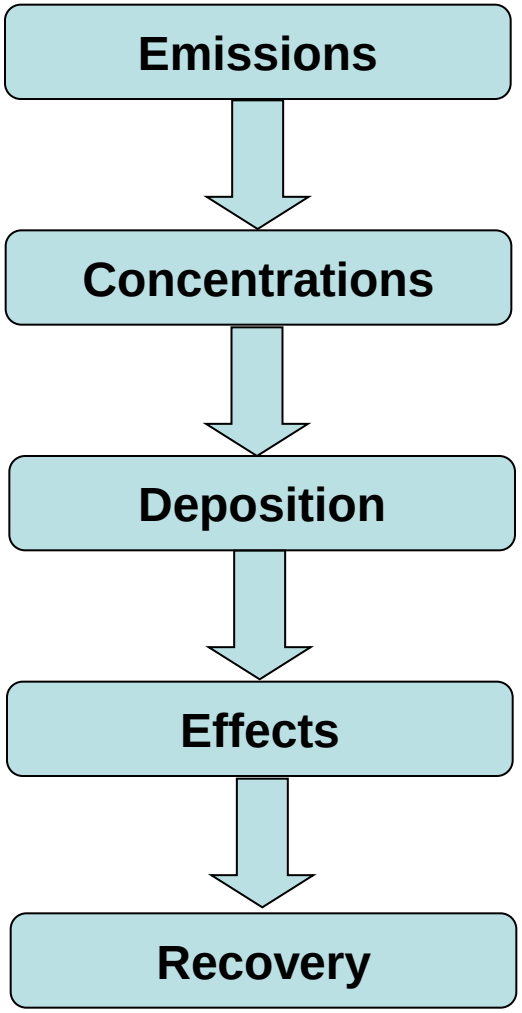
Stucture of the RoTAP Report

1) Introduction
2) Emissions
3) Concentrations & Deposition
4) Modelling Concentrations and Deposition
5) Effects on Soils, Freshwater Vegetation
6) Heavy Metals
7) European & Global Perspectives
8) Recovery
9) Recommendations

Executive & Technical Summary

Summary for Policy Makers



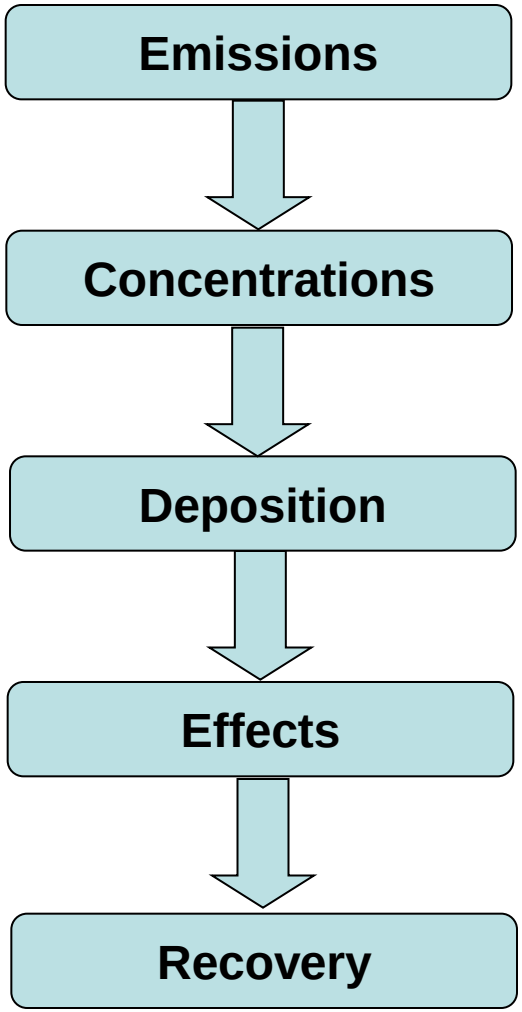
RoTAP Key Messages

Acidification

Eutrophication

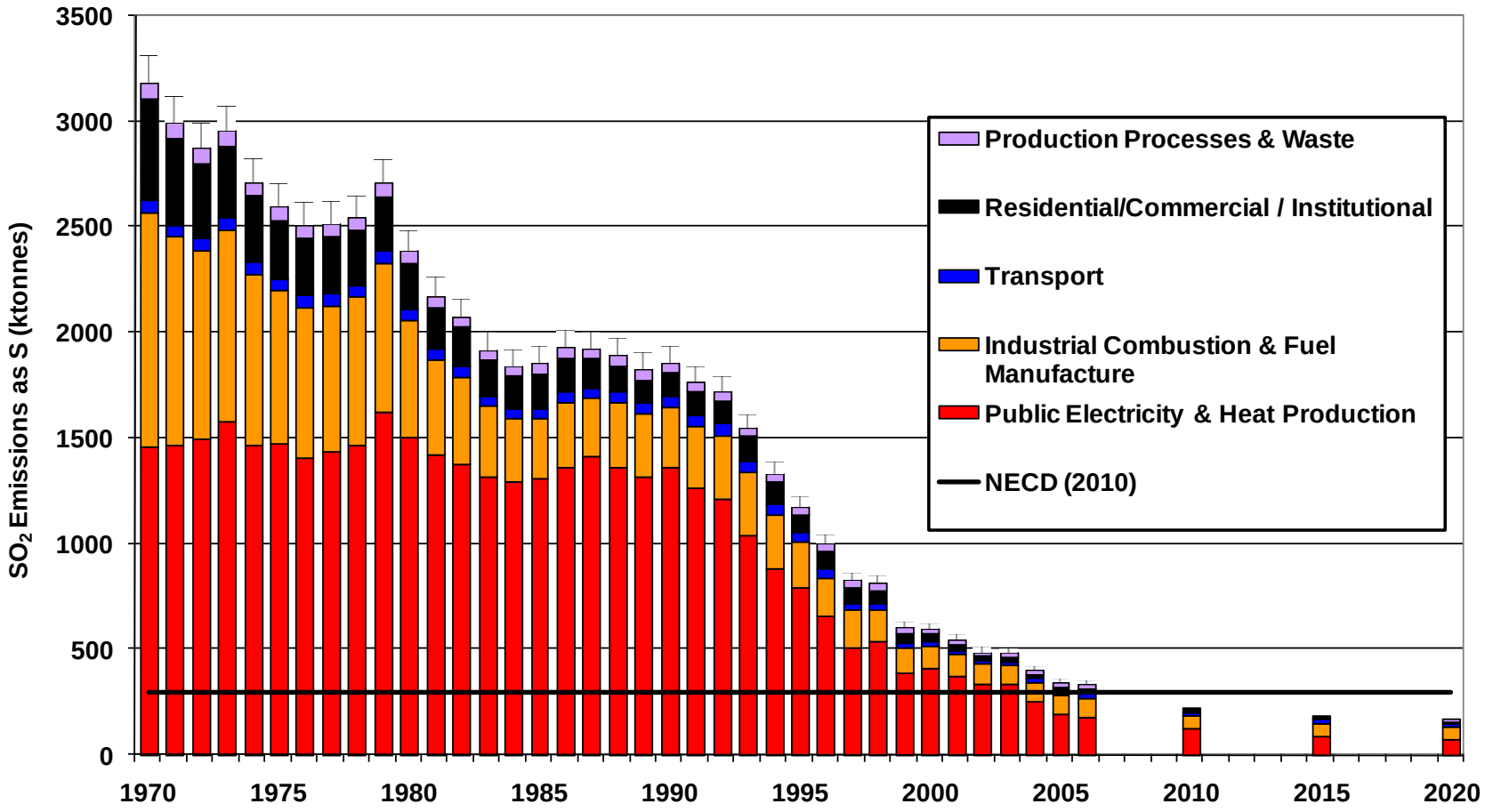
Ground Level Ozone

Heavy Metals

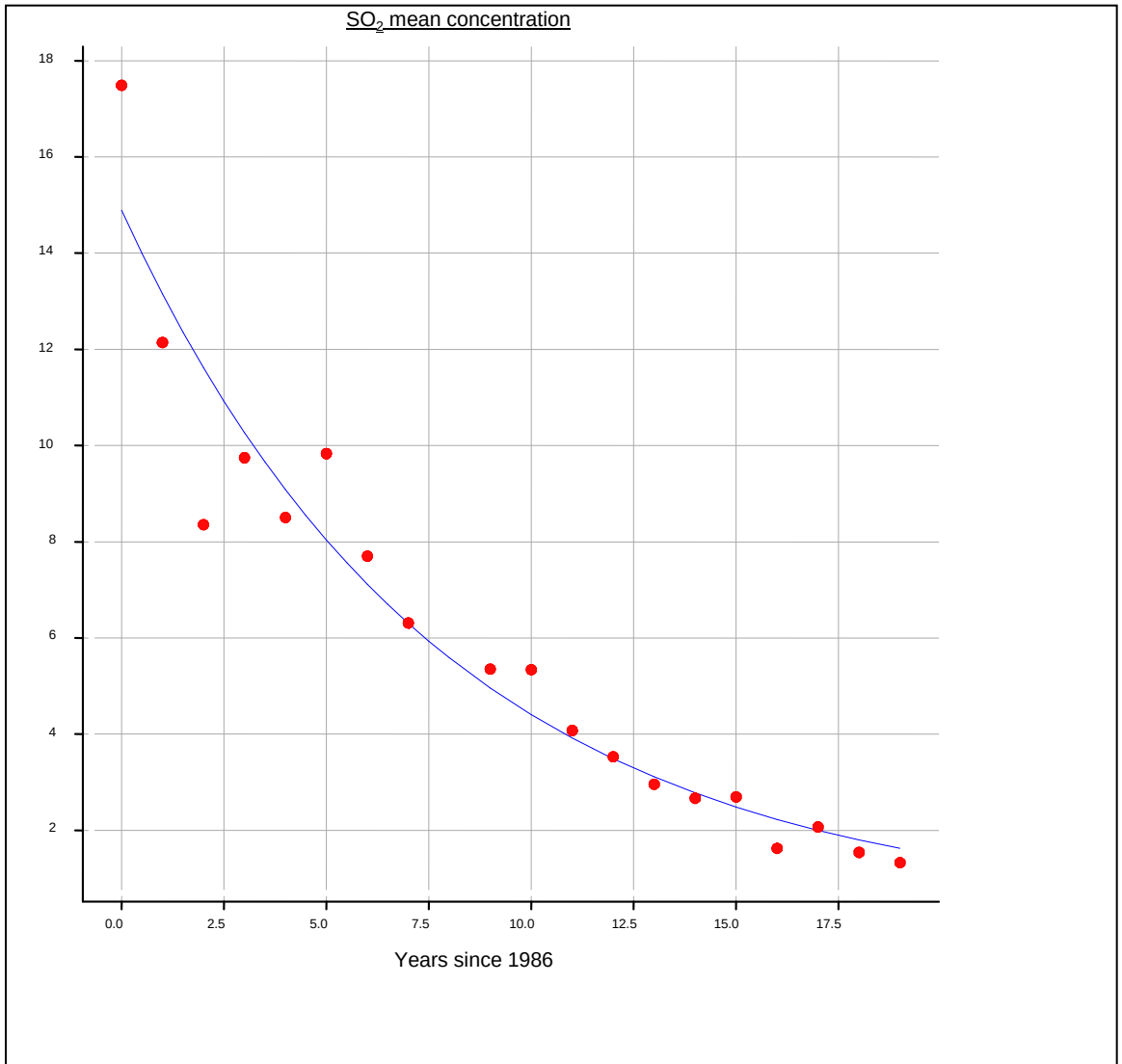


Acidification - Emissions

UK Emissions of sulphur (ktonnes S) decreased by 84% since 1990

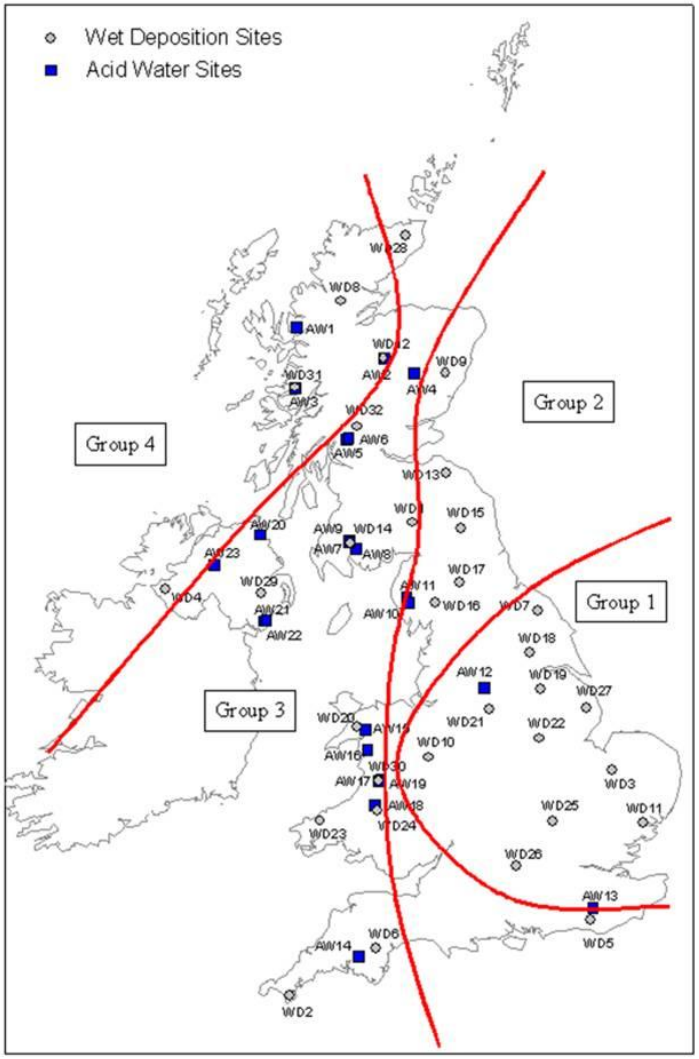


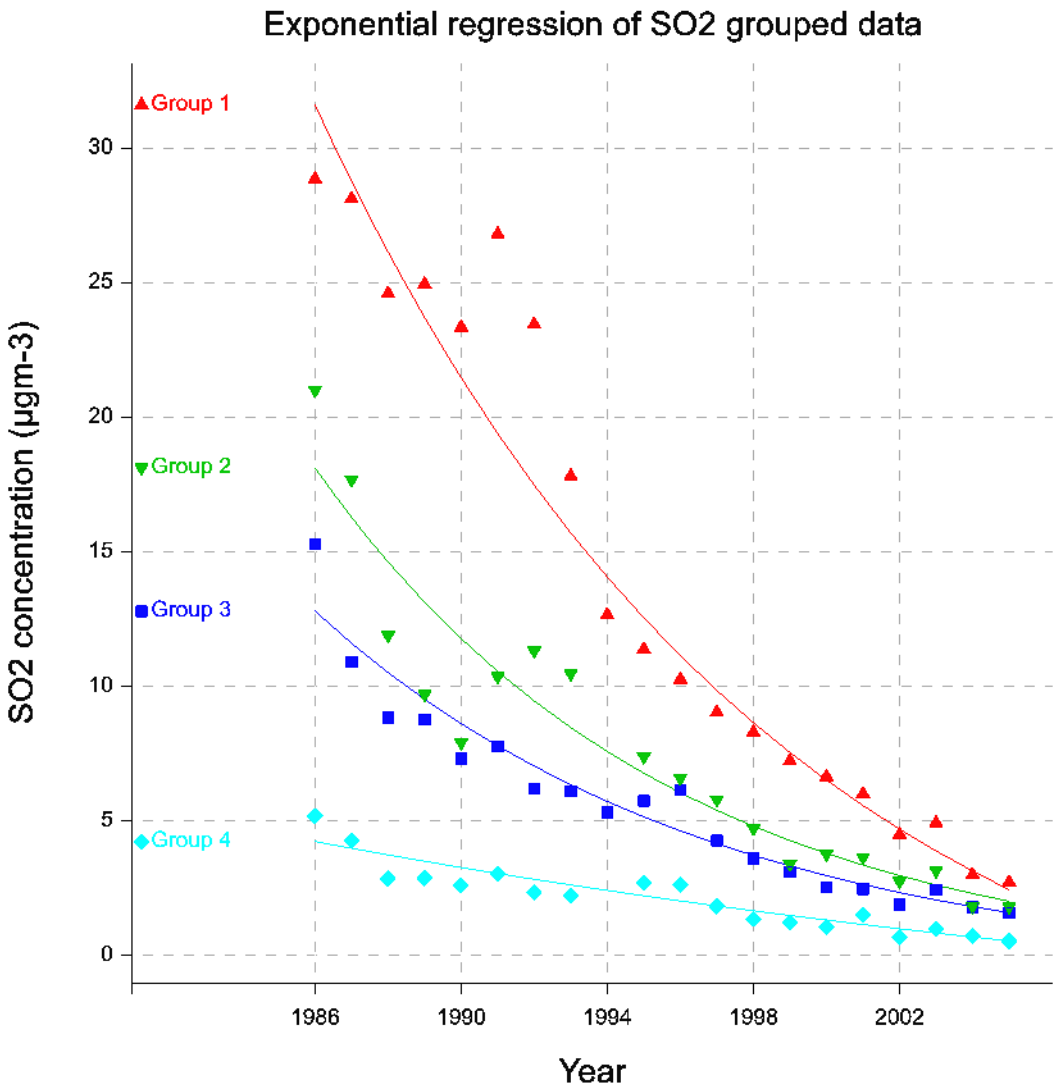
Trend in SO_2 Concentrations



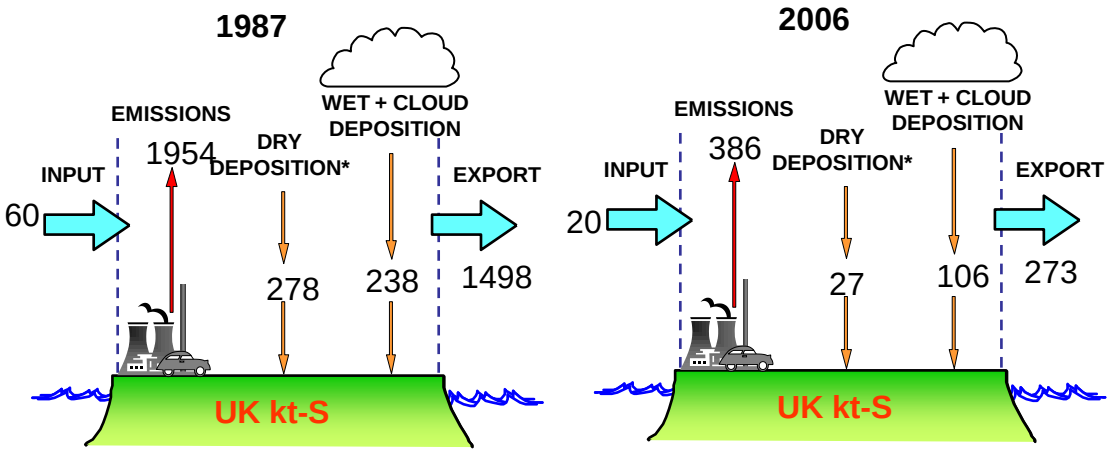
Emissions decreased by 84%
Concentrations decreased by 90%

Changes in SO_2 Concentrations Across the UK





Acidification - Deposition
Changes in UK Sulphur Budget



Emissions decreased by 84%
Concentrations decreased by 90%
Total Deposition decreased by 74%

Acidification - Effects

Loss of sensitive species

- Mosses
- Lichens
- Diatoms

Reduction in growth of crops and semi-natural vegetation

Reduction in acid neutralising capacity of freshwaters

Low pH

- Increased bioavailability of pollutants such as aluminium causing loss of aquatic plants, invertebrates and fish

Exceedance of Critical Loads for Acidity
% habitat area exceeded

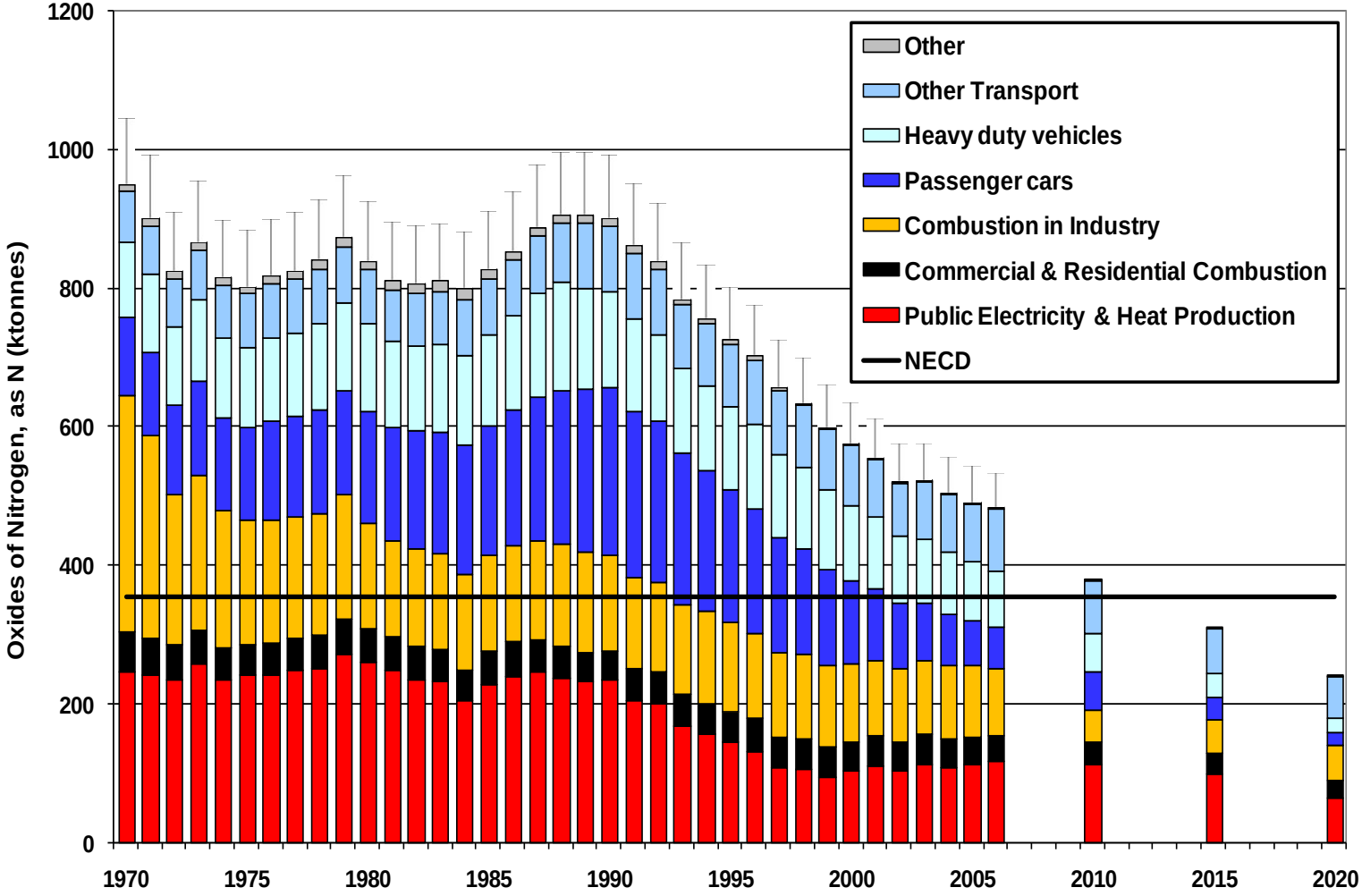
Broad Habitat	1986-1988	1996-1998	2004-2006	2020
Acid grassland	95.9	90.2	83.1	68.0
Calcareous grassland	9.1	0	0	0
Dwarf shrub heath	92.7	66.9	46.5	22.4
Bog	95.9	85.1	67.1	41.8
Montane	99.9	94.7	96.8	76.5
Managed Conifer	85.1	78.7	68.2	50.9
Managed Broadleaf	78.6	76.1	66.9	48.6
Unmanaged Woodland	76.7	70.1	56.4	35.9
Freshwaters	39.1	29.1	21.9	14.3
All Habitats	**83.5**	**70.8**	**58.3**	**39.8**

Recovery from Acidification

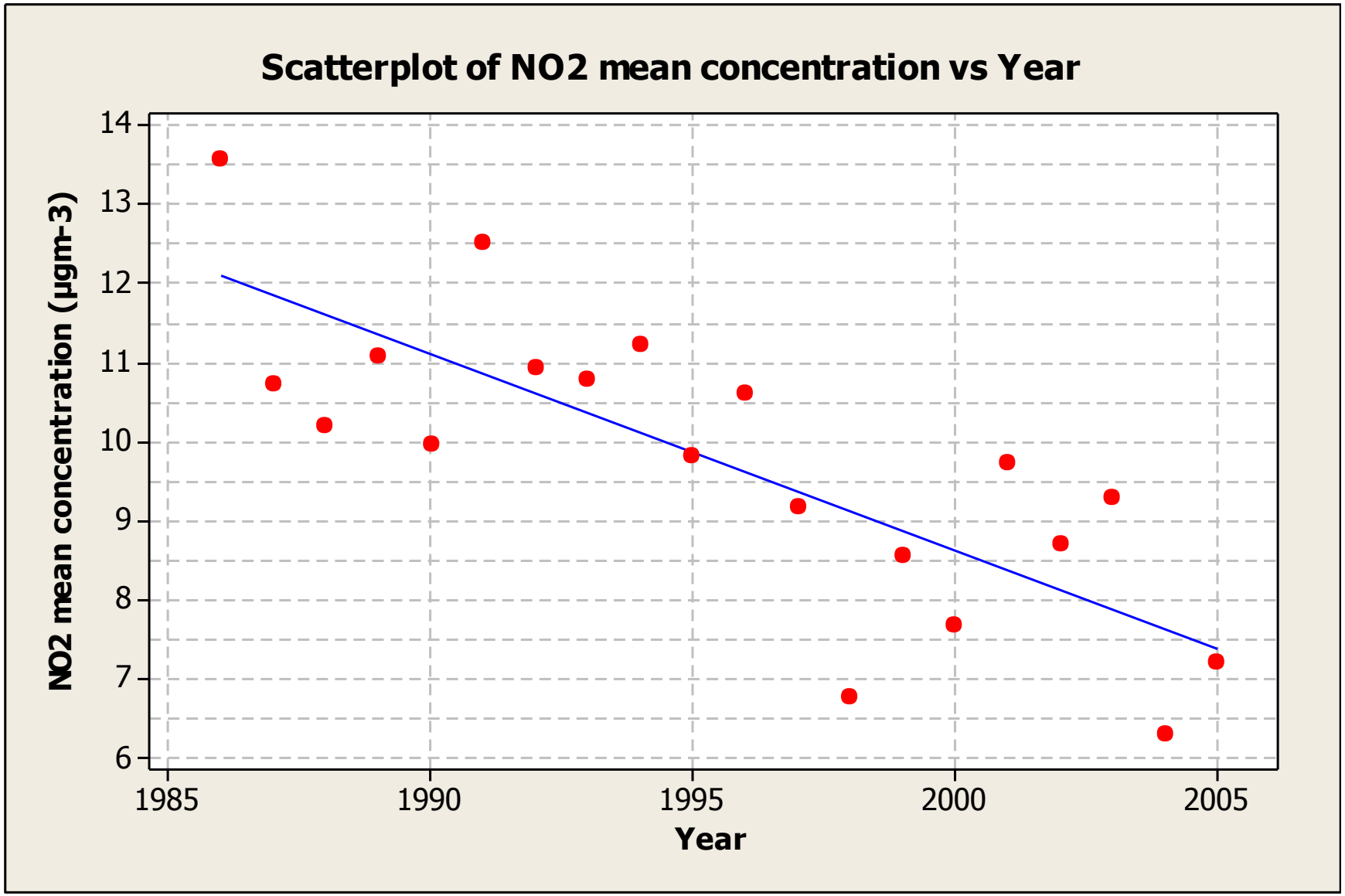
- Chemical recovery is evident in acidified soils and freshwaters (S concentration decreased, pH increased)
- Biological recovery is evident via the re-appearance of acid-sensitive biota (lichens, bryophytes, diatoms)
- Therefore policies on acidification were successful
- However, ecological recovery is a slow process and the end point may differ from pre-acidification status
- 39.8% of all habitat areas will exceed the Critical Load for acidification in 2020

Eutrophication – Emissions

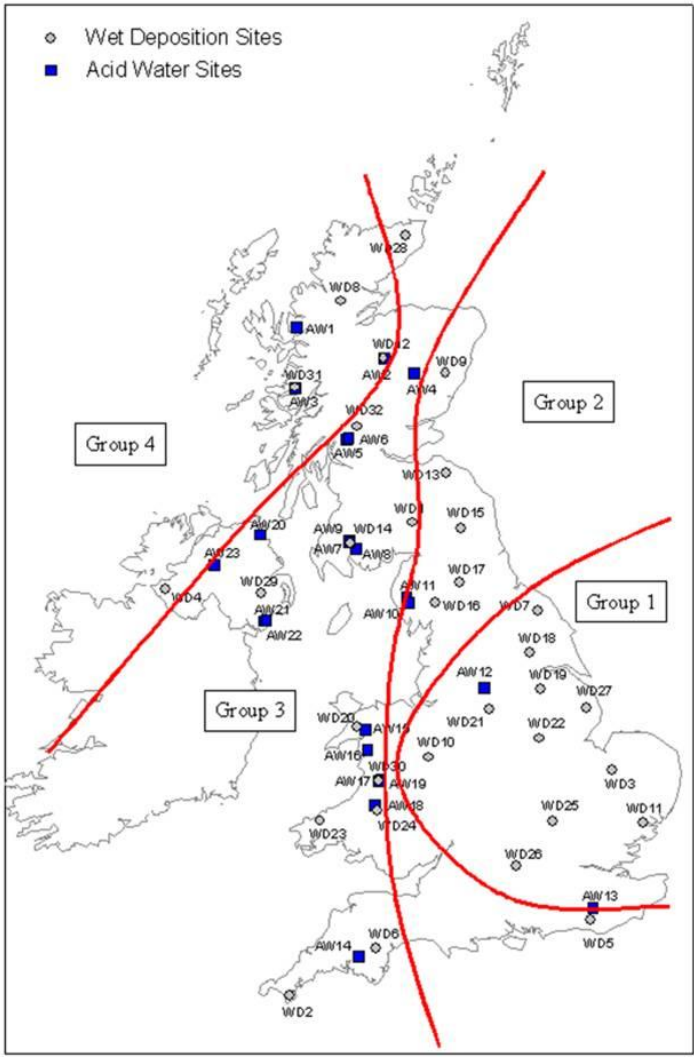
UK Emissions of NO_x (ktonnes N) decreased by 46% since 1990

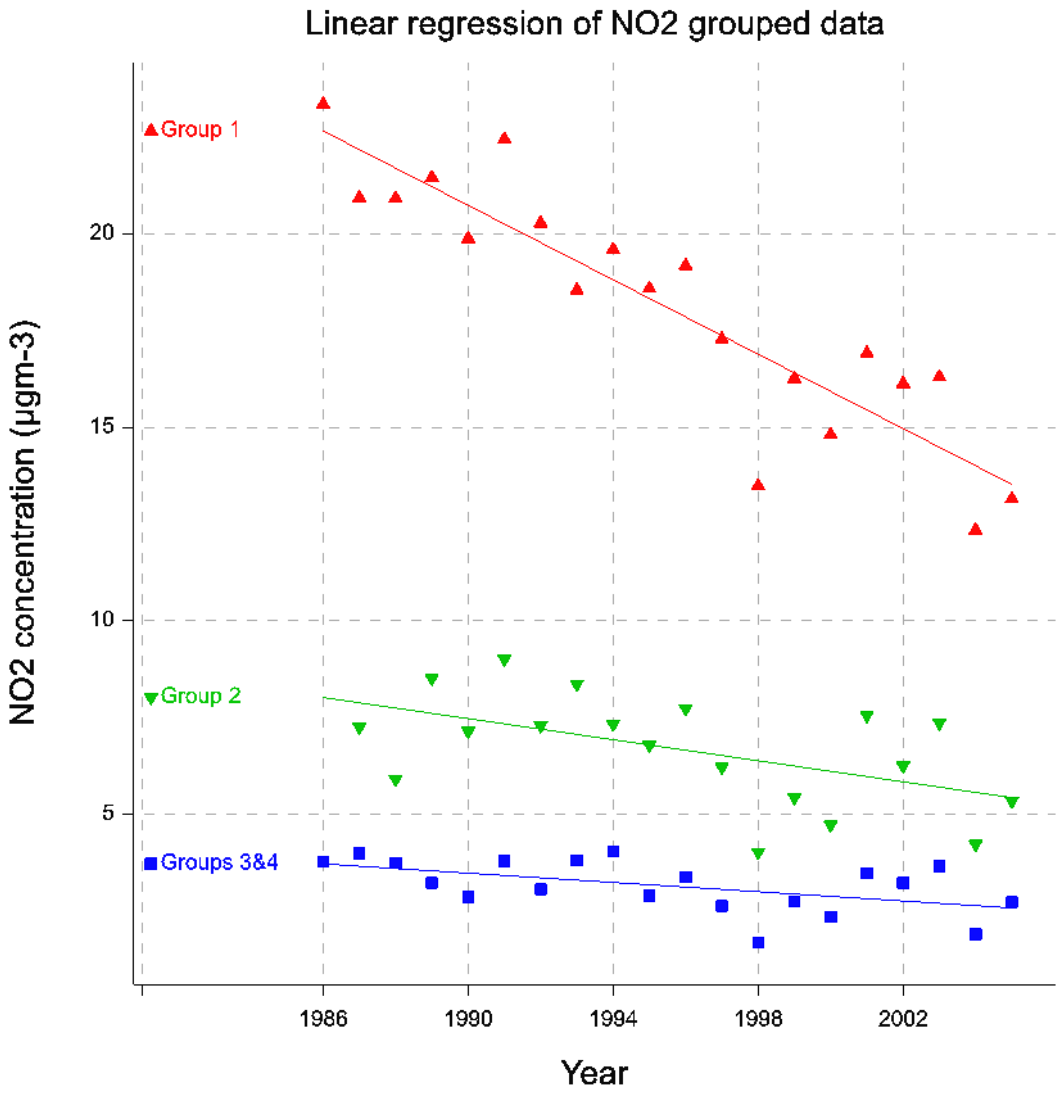


Concentrations of NO_x

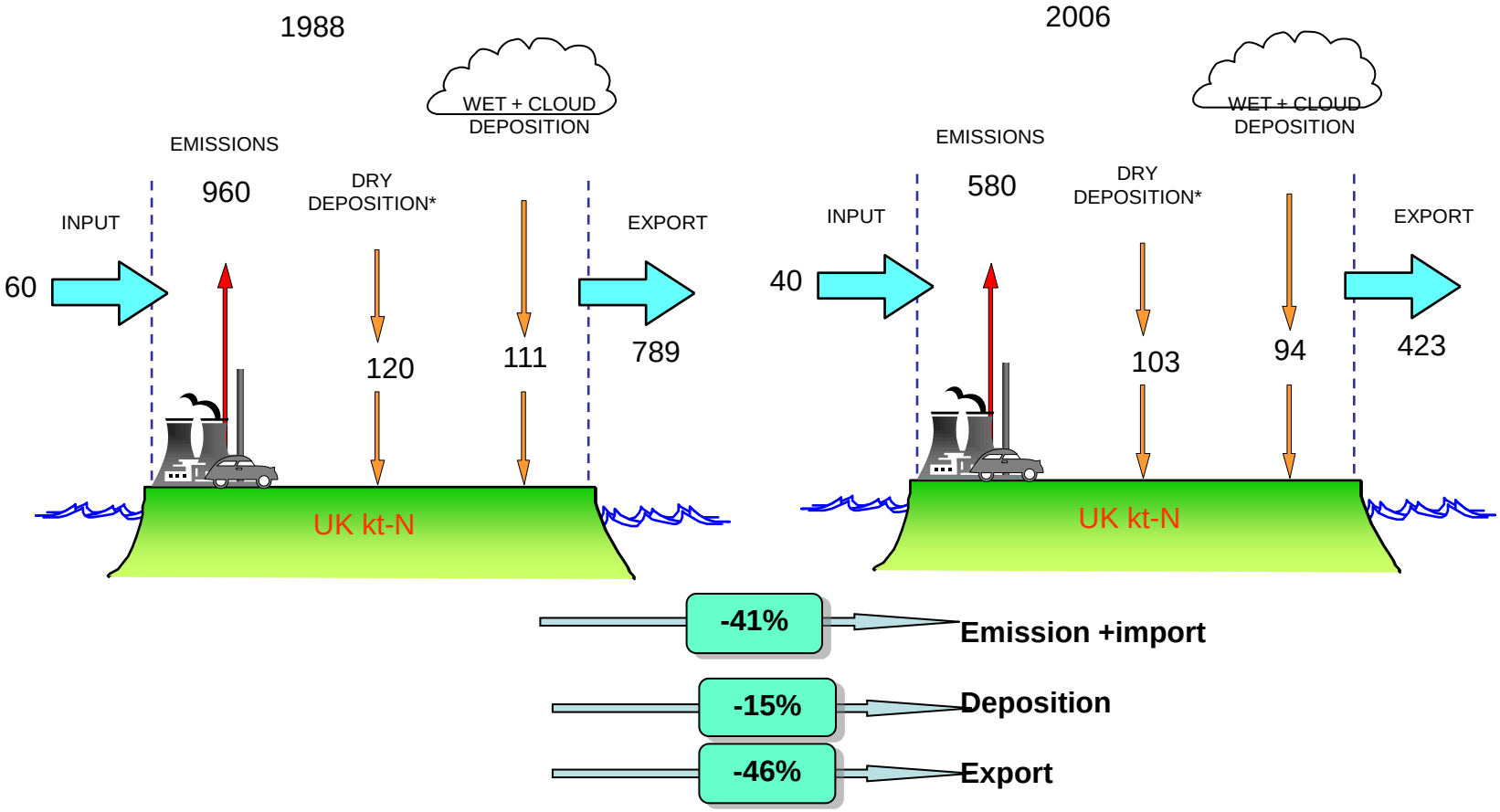


Changes in NO_2 Concentrations Across the UK

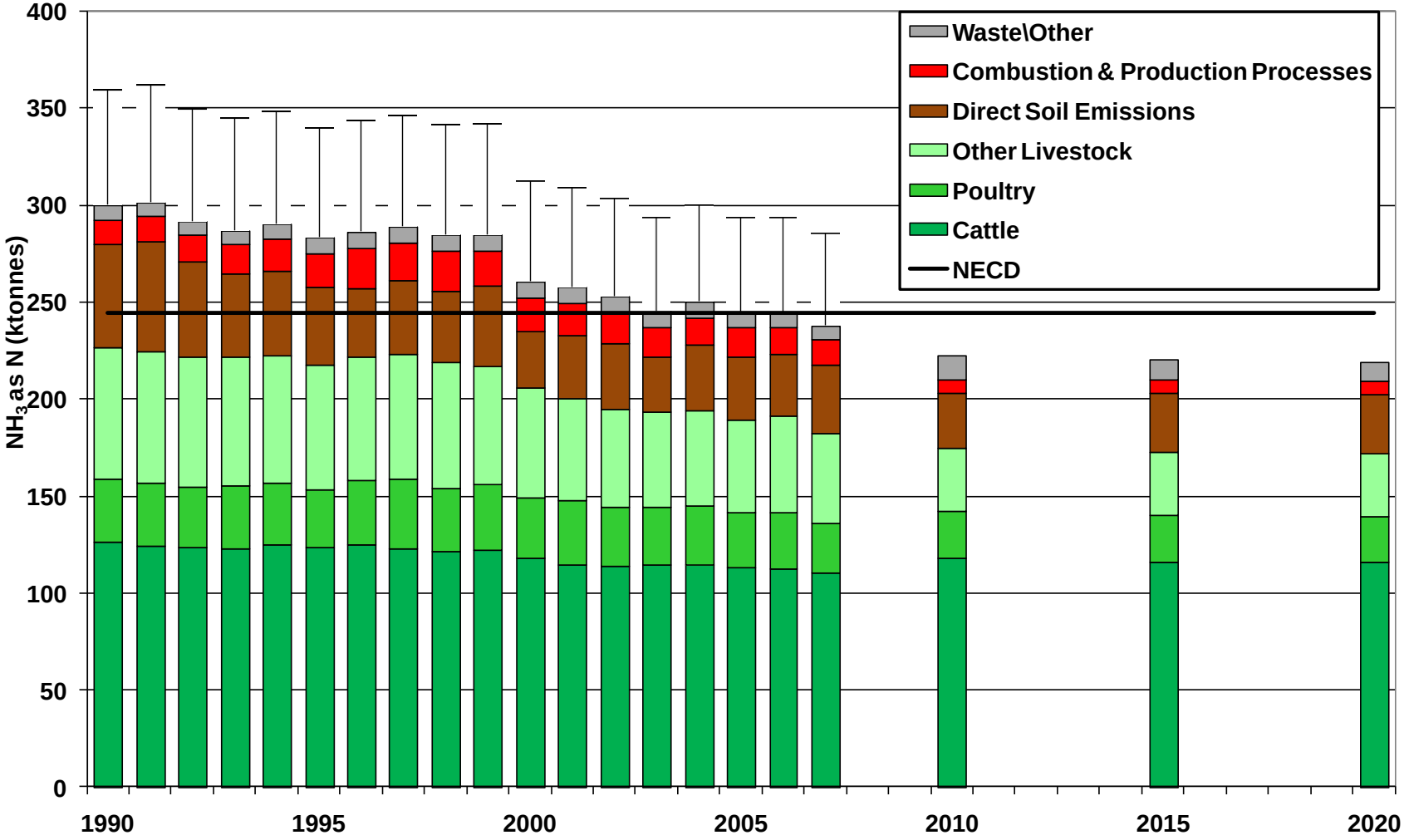




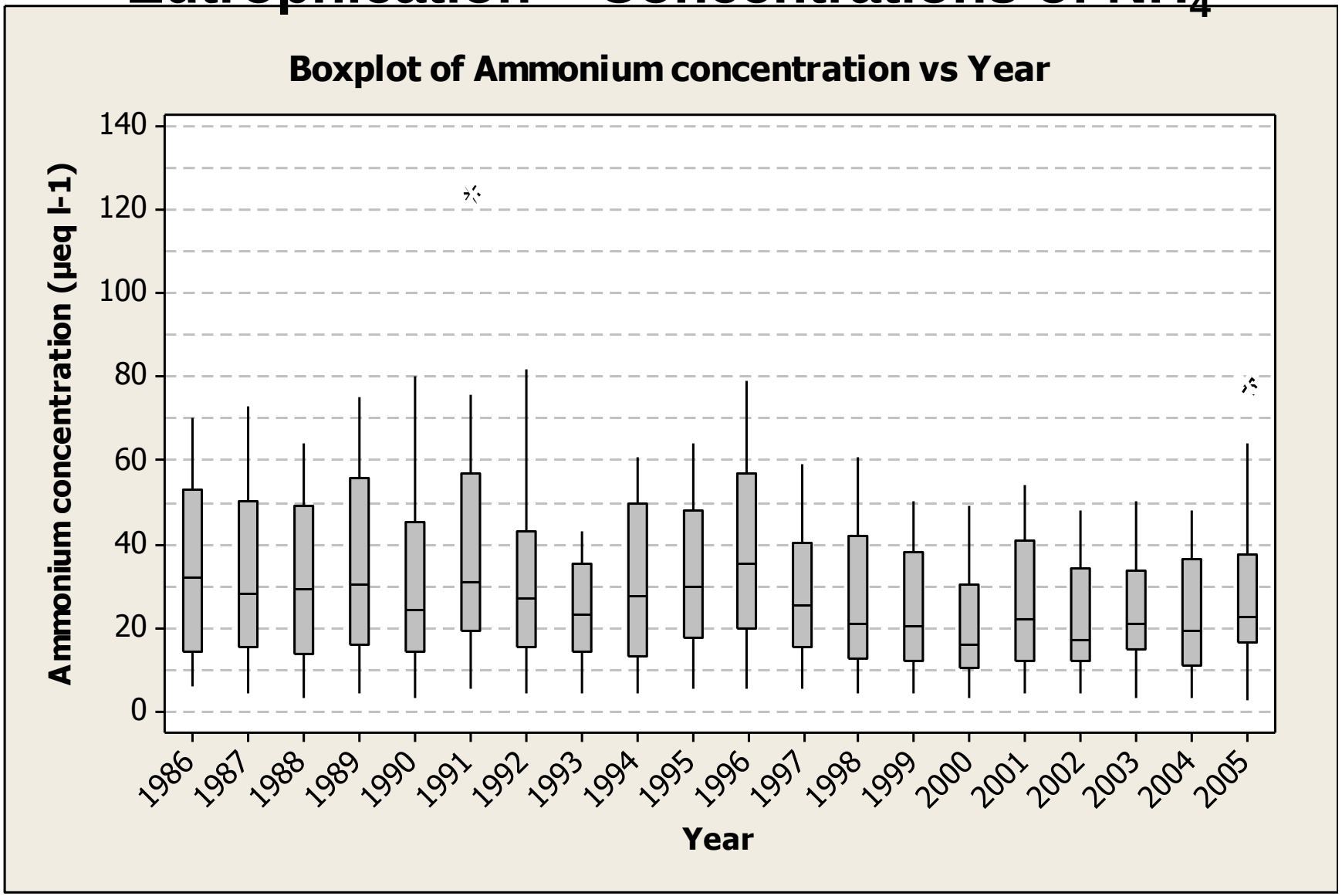
Eutrophication – NO_x Budget



Eutrophication – NH_3 Emissions



Eutrophication – Concentrations of NH_4



Eutrophication - Effects

- Reduced diversity in terrestrial plant species in a range of habitats of conservation value.
- Changes in algal productivity in upland lakes

Exceedance of Critical Loads for Eutrophication
% habitat area exceeded

Broad Habitat	1986-1988	1996-1998	2004-2006	2020
Acid grassland	65.3	68.7	61.9	40.4
Calcareous grassland	79.1	78.6	61.4	19.6
Dwarf shrub heath	34.0	36.3	34.2	20.7
Bog	44.7	45.8	44.7	40.1
Montane	97.5	92.1	98.0	91.5
Managed Conifer	92.7	94.4	93.3	87.4
Managed Broadleaf	97.9	98.2	98.2	96.7
Unmanaged Woodland	95.9	96.3	96.5	94.7
Atlantic Oak (epiphytic lichens)	95.9	97.2	97.7	87.3
Supralittoral sediment	26.7	38.5	16.8	3.9
All Habitats	**62.3**	**64.2**	**60.7**	**47.8**

Eutrophication - Recovery

There is no UK evidence of recovery from eutrophication caused by nitrogen deposition. This is due to a variety of factors including

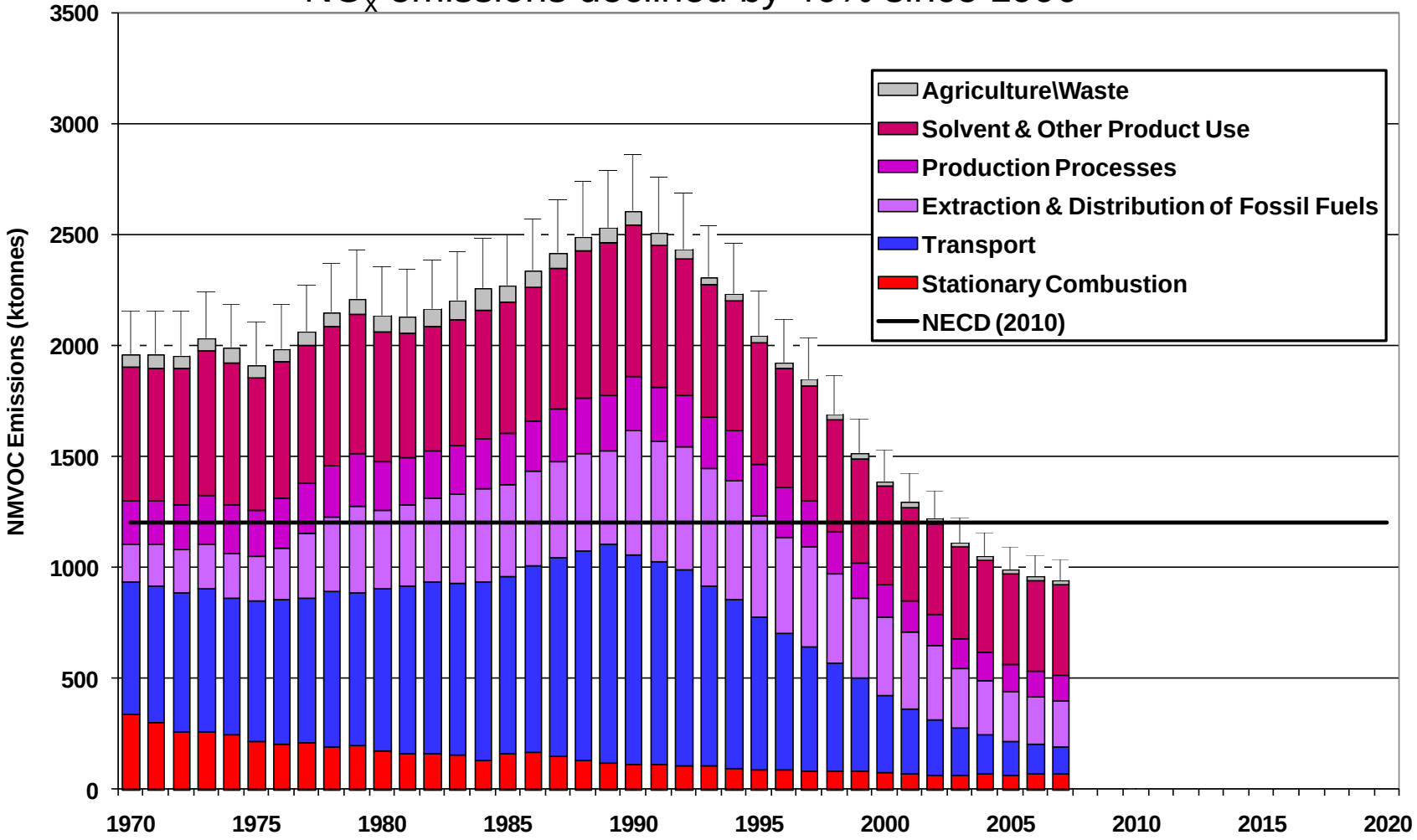
- Minimal change in total N deposition (5% over last 20 years)
- Accumulation of deposited N in vegetation and soils
- Concentrations of ammonia have not reduced in the UK

Further reductions in emissions of N compounds are required, with the priority being reducing emissions of ammonia.

Ground Level Ozone – Emissions of VOCs

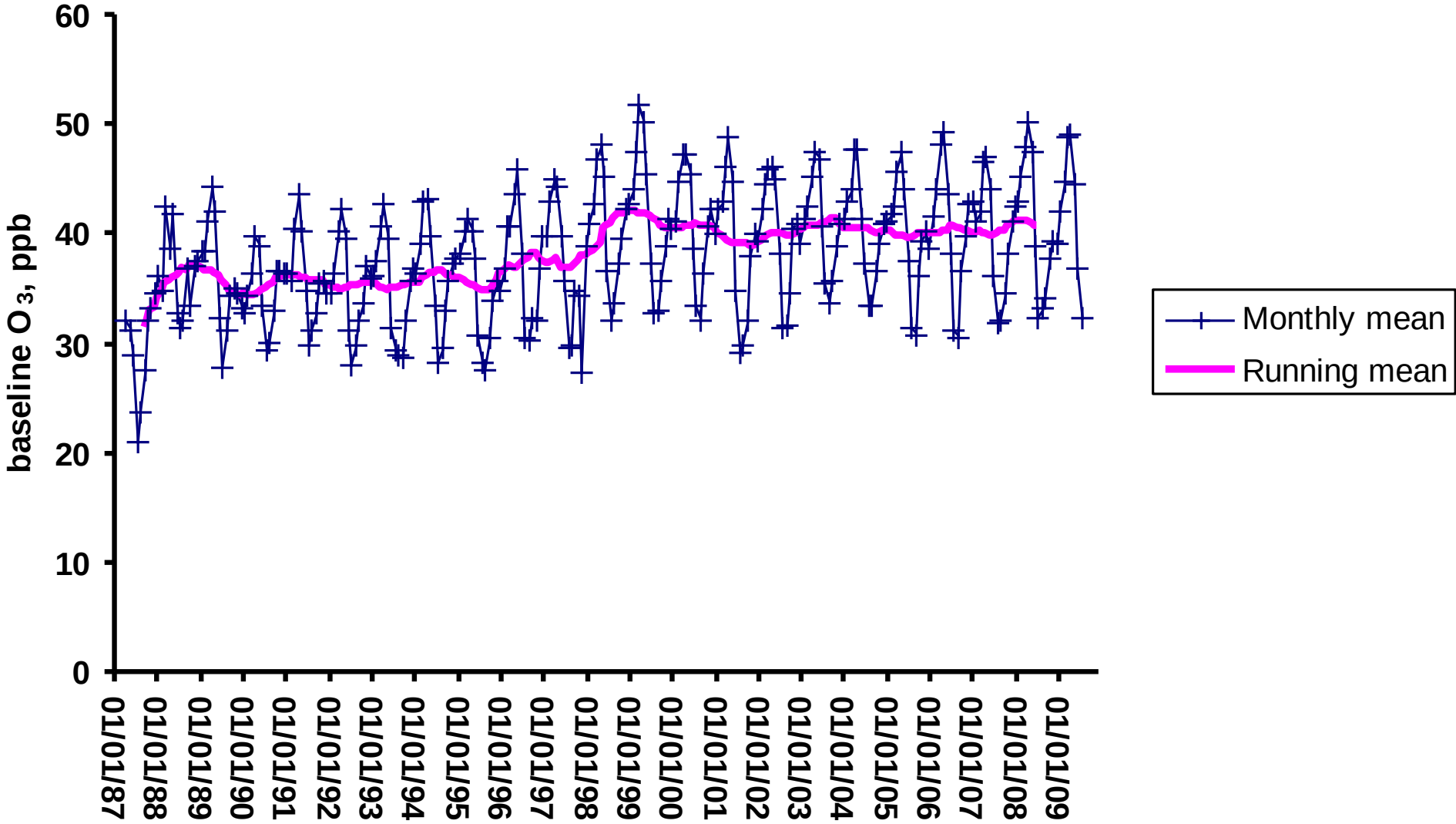
VOC emissions declined by 64% since 1990

NO_x emissions declined by 46% since 1990



Ground Level Ozone

Measured at Mace Head, line represents running 12 month mean



Effects of Ozone

- Adverse effects on crops and semi-natural vegetation
- Reductions of 5 to 15% in yield of wheat grown in southern Britain, equivalent to 2 million tonnes in 2000
- Effects on semi-natural vegetation leading to problems with complying with the Habitats Directive
- Reduction in ability of vegetation to sequester carbon

Ozone – Exceedance of the Critical Levels

Habitat	% of UK area exceeding Critical Level (April to September)	Effects
Calcareous Grassland	71.5%	Reduced cover of dominant fine grass species and characteristic forb species
Acid Grassland	25.9%	Decreased cover of characteristic grass species and forbs
Mesotrophic Grassland	21.8%	Reduced total productivity, reduced cover of dominant fine grass and legume species
Deciduous woodland	57.3%	Reduced flowering and bulb growth in characteristic woodland species, increased cover of shade-intolerant woodland species

Ozone Recovery

No evidence of biological recovery

UK Background ozone concentrations exceed thresholds for sensitive species of vegetation

There is a need to control emissions of ozone precursors at the hemispheric rather than European scale

Heavy Metals

- Emissions have declined since the early 1970s
- Concentrations in the atmosphere have also declined
- Discrepancy between reported emissions and deposition
- Difficult to determine effects caused by transboundary air pollution compared to localised point source effects

Chapter 9 Recommendations

9.1 Monitoring and assessment of the chemical climate of the UK

9.2 Terrestrial and freshwater effects of acidification,eutrophication, ground level ozone and heavy metals

9.3 UK contributions to the international development of control measures for long range transport

Chapter 9 Recommendations

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(13 recommendations)

9.2 Terrestrial and freshwater effects of acidification,eutrophication, ground level ozone and heavy metals
(16 recommendations)

9.3 UK contributions to the international development of control measures for long range transport
(4 recommendations)

Chapter 9 Recommendations

9.1 Monitoring and assessment of the chemical climate of the UK
(13 recommendations)

- Maintain monitoring networks and establish long term ozone flux site
- Further development of modelling across a range of spatial scales
- Improved emissions inventories, especially for VOCs and heavy metals
- Further study of non-linearities in the NO_x emissions / deposition relationship
- Determine the role of shipping in sulphur and nitrogen deposition
- Determine the interactions between air quality and climate change

Chapter 9 Recommendations

9.2 Terrestrial and freshwater effects of acidification,eutrophication, ground level ozone and heavy metals

(16 recommendations)

- Improve existing monitoring schemes to ensure that recovery from air pollution effects can be reported with accuracy
- Further research into the fate of deposited nitrogen and the possible mechanisms which may release nitrogen in the future
- Further research to determine the ecological impact of N deposition on sensitive ecosystems, with greater integration of policies on air pollution and biodiversity
- Develop ozone evaluation polices based upon flux-based methods rather than AOT40, with application of flux-based methods to a wider range of vegetation including plant communities

Chapter 9 Recommendations

9.3 UK contributions to the international development of control measures for long range transport

(4 recommendations)

- Continue the UK's contribution to the development of science and policy implication, along with interaction with international agencies
- Determine and quantify the current and future role of shipping in acidification, eutrophication and ground level ozone
- Quantify the interactions between transboundary air pollution and climate change and their policy significance

Thank you for listening.

Further details are available at
http://www.rotap.ceh.ac.uk

The final report is due to be launched in the summer