DOES VEGETATION REDUCE AIR POLLUTION ?

Laurence Jones[1], Bill Bealey[1], Eiko Nemitz[1], Stefan Reis[1], Dan Morton[1], Gina Mills[1], Felicity Hayes[1], Massimo Vieno[1], Ed Carnell[1], Jane Hall[1], Rachel Beck[1], Ian Dickie[2], Philip Cryle[2], Mike Holland[3]

[1] Centre for Ecology & Hydrology, NERC; [2] Economics for the Environment Consultancy (Eftec); [3] Ecometrics Research and Consulting (EMRC)

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

eftec
Economics for the Environment Consultancy

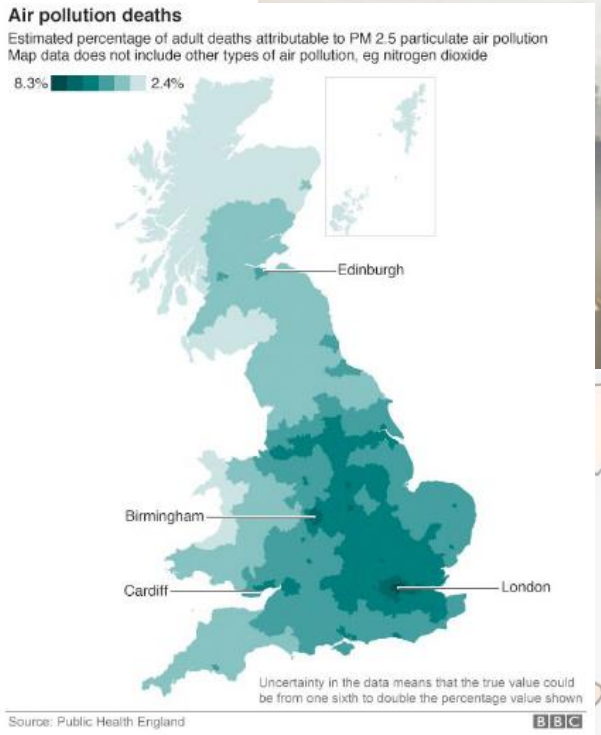
EMRC

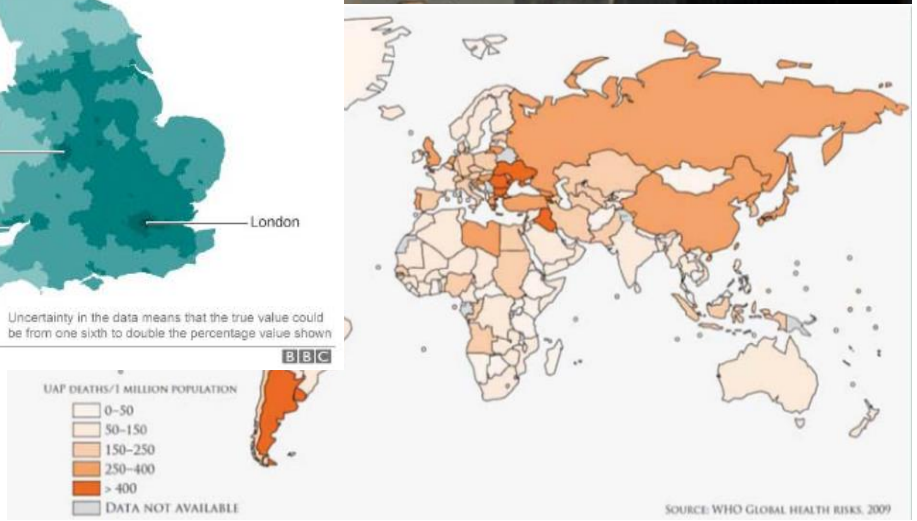
NERC SCIENCE OF THE ENVIRONMENT

AIR POLLUTION AND HUMAN HEALTH

5.5 million deaths globally

40,000 deaths, UK





Which pollutants are harmful ?

PM10

PM2.5

NO2

NH3

O3

SO2

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

AIR POLLUTION REMOVAL BY TREES, IN THE LITERATURE

London's trees remove 2.2 kt pollutants **(i-tree Eco)**

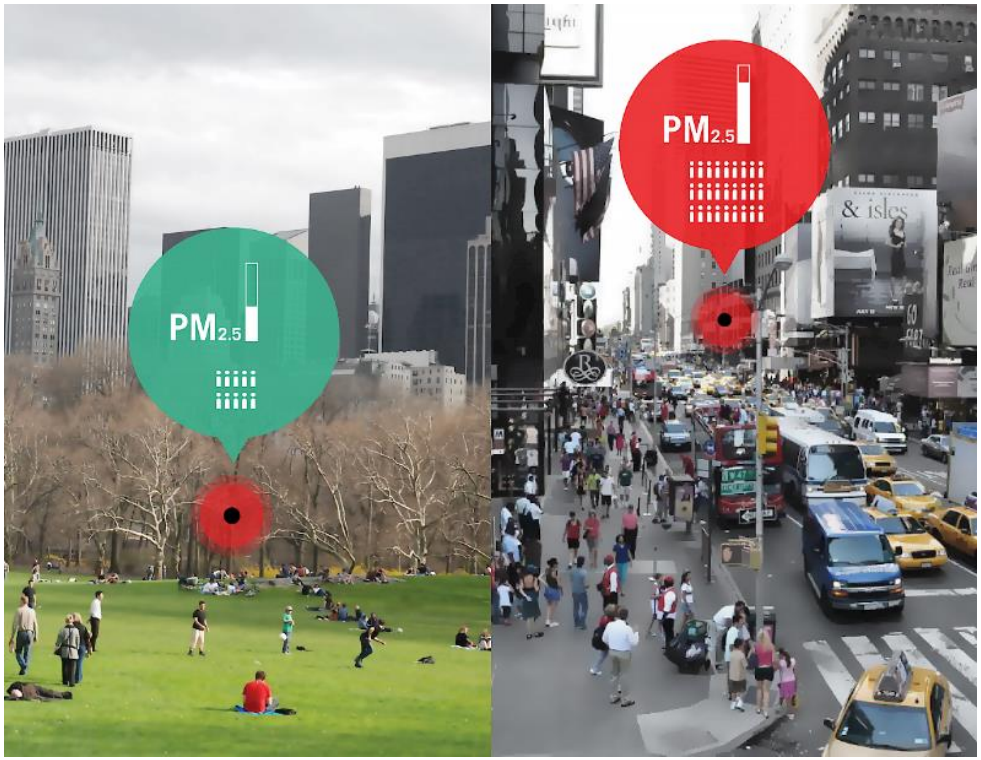
Trees reduce pollutant concentrations by 1 – 10% **(Nowak et al. 2013)**

Rome (Manes *et al.*, 2012)

- Ozone ~$3 million/yr for human health benefits (risk of mortality due to ozone)
- PM_{10} $36 million/yr

Case study small area (10 km x 10 km) in London (Tiwary *et al.*, 2009)

- PM10 2 less deaths and 2 less hospital emissions per year.



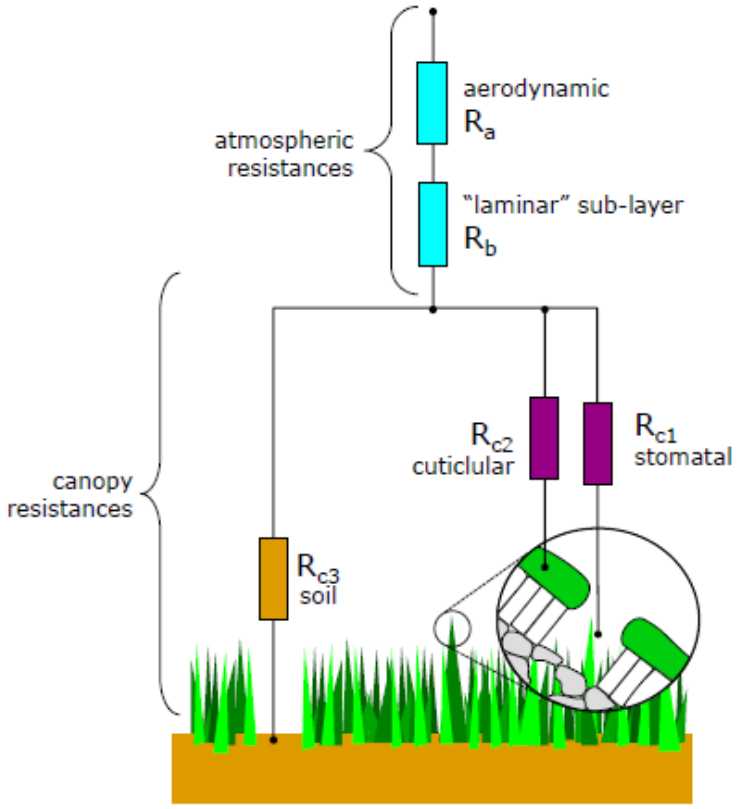
Nyhan M. 2015, SENSEable City Lab, MIT

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

MECHANISMS OF POLLUTANT REMOVAL

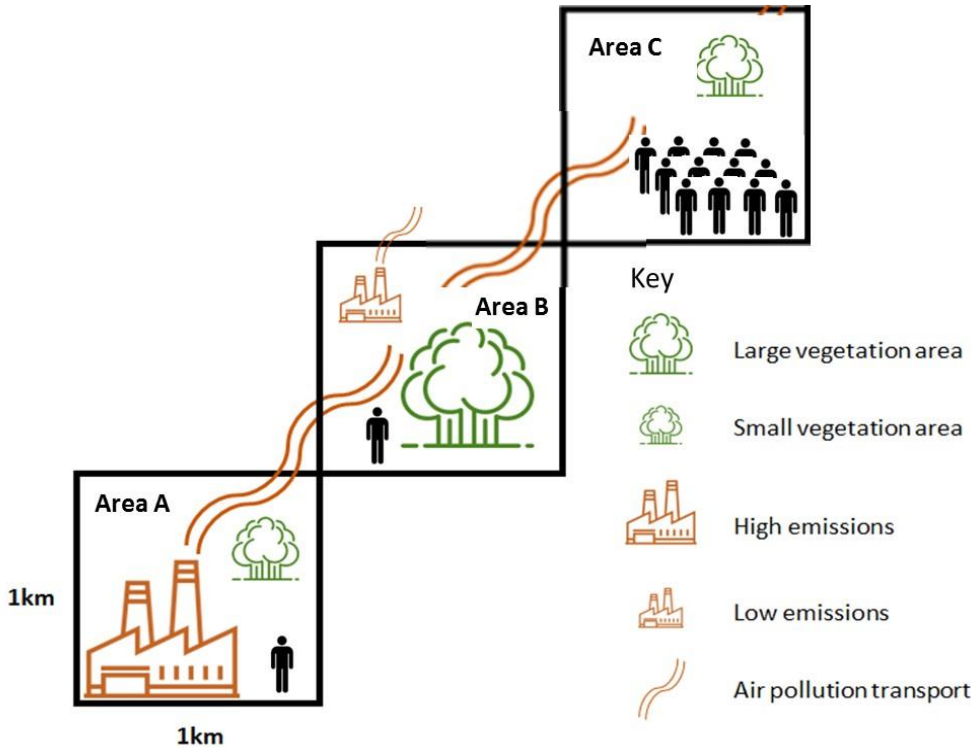
- Aerodynamic resistance
- Boundary resistance
- Canopy resistance
  - To surface
  - To stomata



IMPROVEMENTS TO THE METHODOLOGY

Spatial context:

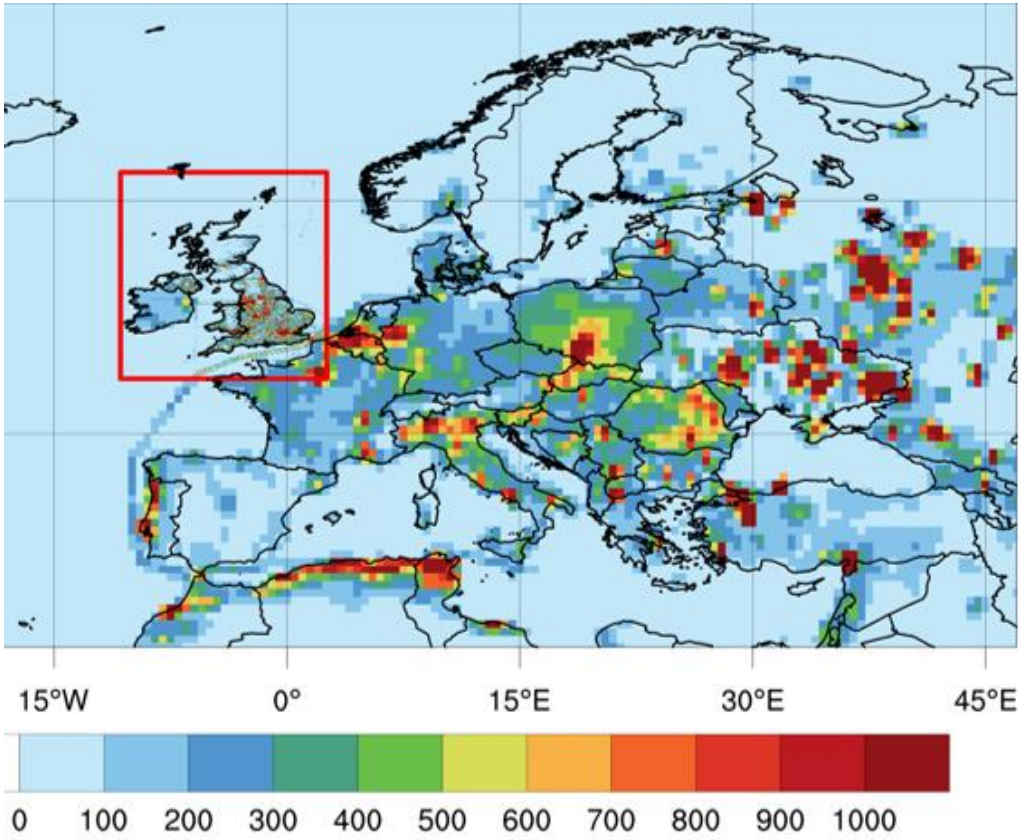
I. Location of beneficiaries
II. Health damage function
III. Chemical and climate interactions



THE EMEP4UK ATMOSPHERIC CHEMISTRY TRANSPORT MODEL

- 5x5km (~2x2km)
- Hourly timestep
- Generates concentrations from emissions
- Chemical & meteorological interactions
- Transport
- Five pollutants (PM2.5, SO2, NH3, NO2, O3)

2015, emissions PM2.5 mg/m2

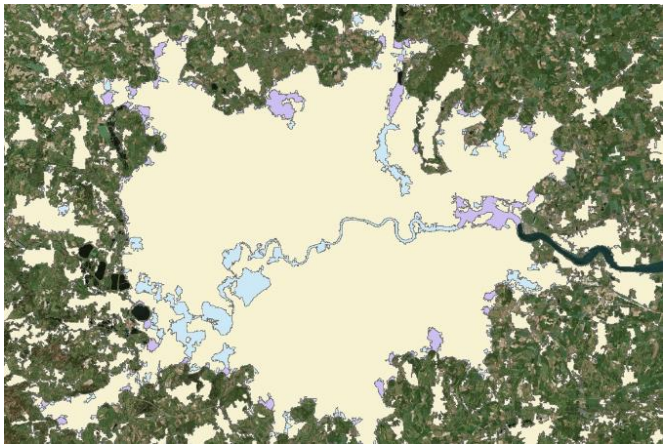


Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

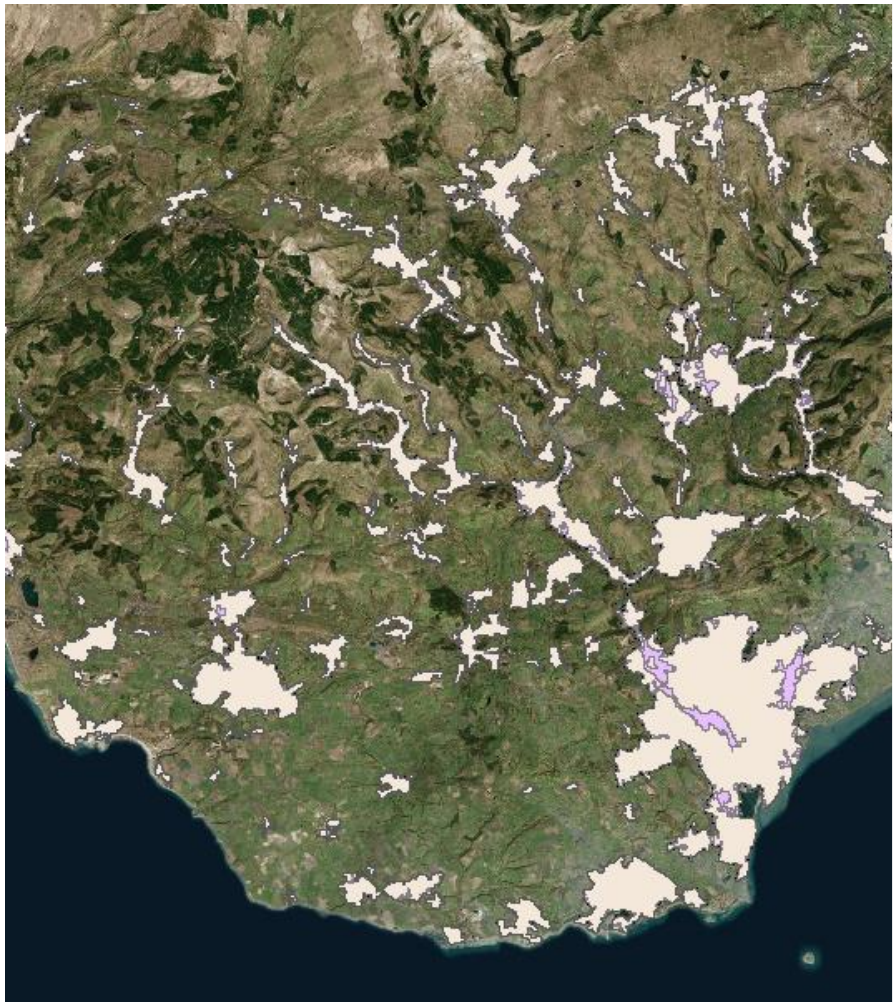
SCENARIO APPROACH TO MODELLING

- Physical account: EMEP4UK atmospheric transport model
- Health and monetary account: ALPHA RiskPoll model
- Scenario approach
- Separate UK & urban calculations



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

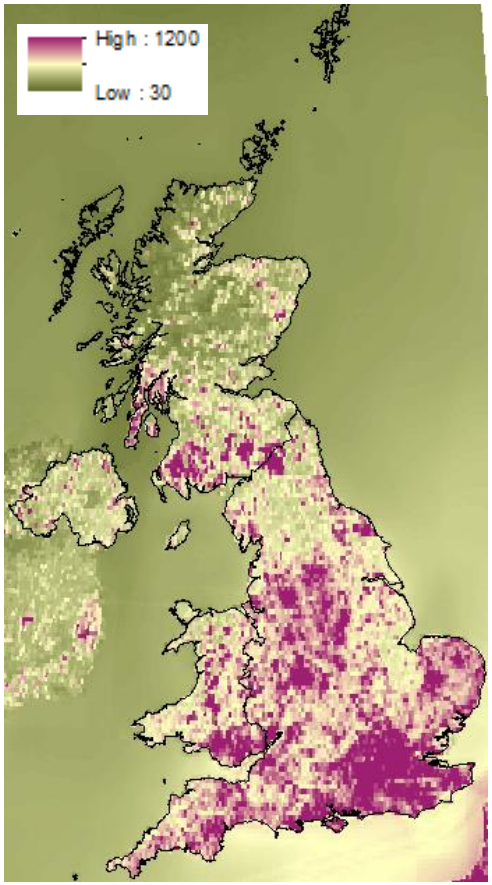
NEW URBAN EXTENT, DETAIL ON CARDIFF



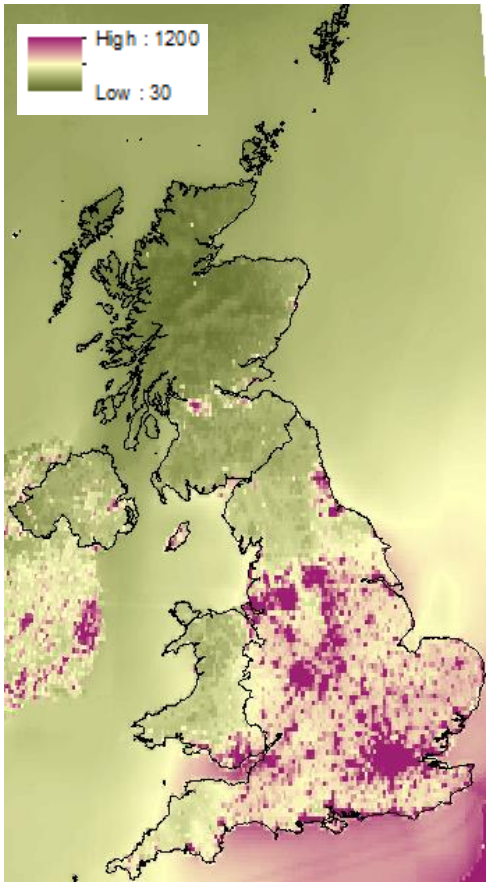
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

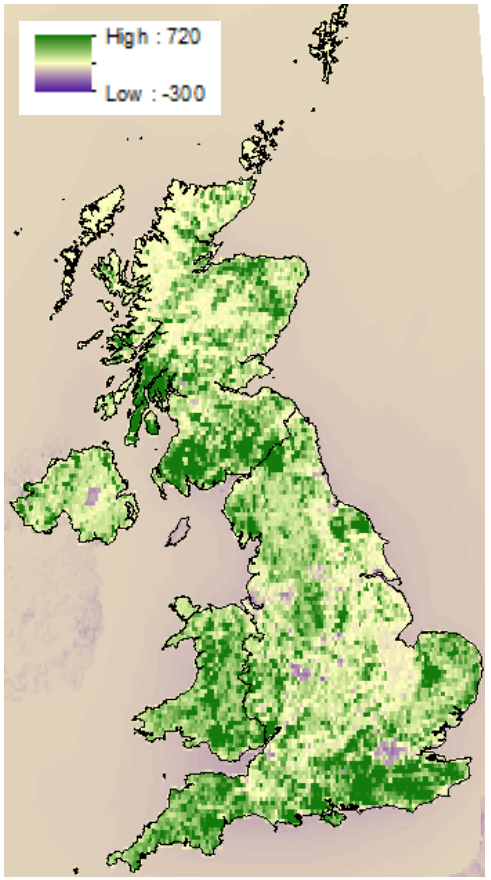
Base map, 2015



No vegetation scenario



Difference map



Quantity of PM2.5 removed (mg/m2)

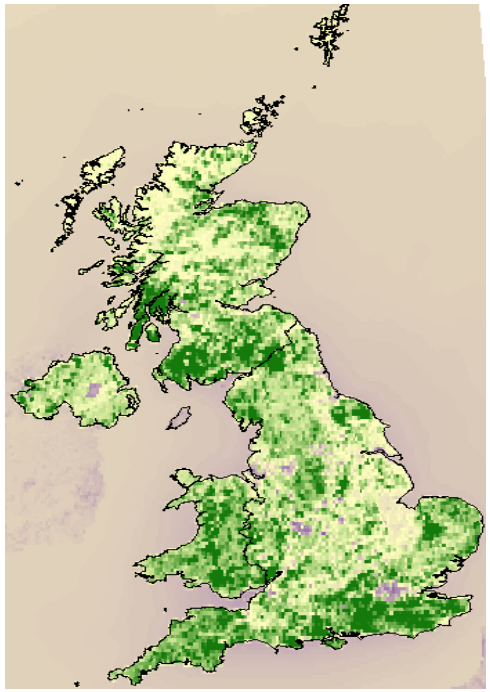
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

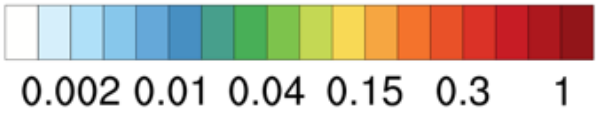
NERC SCIENCE OF THE ENVIRONMENT

Quantities of pollutant removed (kt/yr)

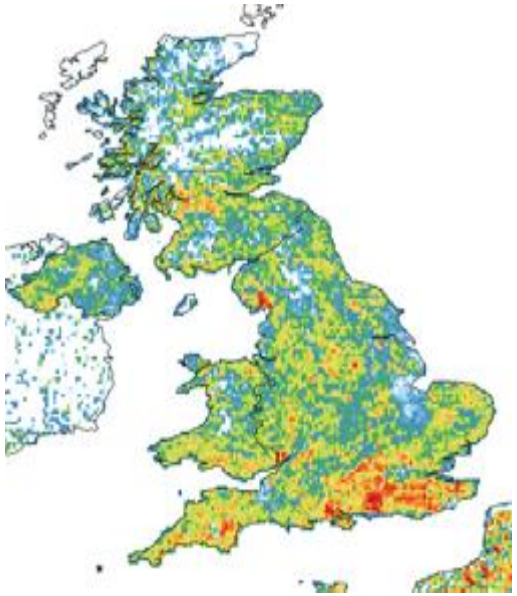
Habitat	Coniferous woodland	Deciduous woodland	Semi-natural (grassland, moorland)	Crops	Total vegetation
Area CEH landcover (km^2)	15,361	13,950	135,909	63,161	228,381
PM_{10}	21.3	14	7.7	0	43
$PM_{2.5}$	9.6	8.2	4.5	-0.1	22.2
SO_2	4	7.1	17.7	9.5	38.3
NH_3	4.7	8.4	26.5	7.8	47.4
NO_2	1.6	2.6	10.4	9.1	23.7
O_3	121.6	95.5	597.1	383.9	1198.2

Where is the PM2.5 being removed



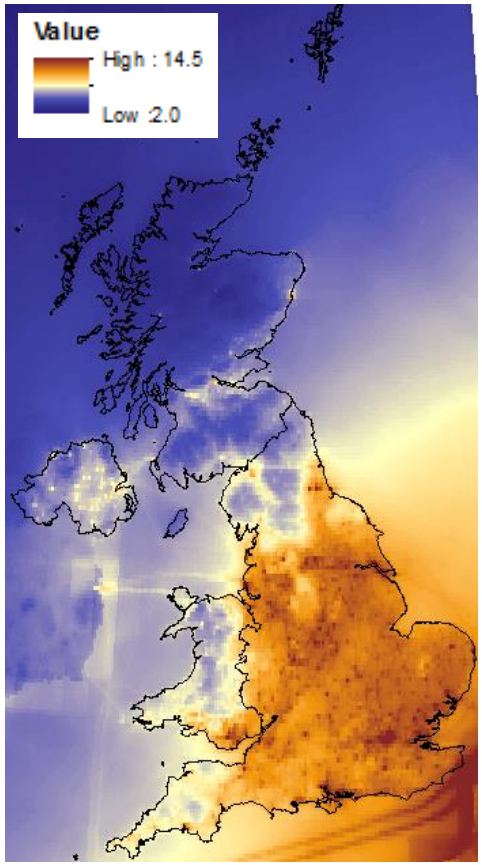


Coniferous woodland

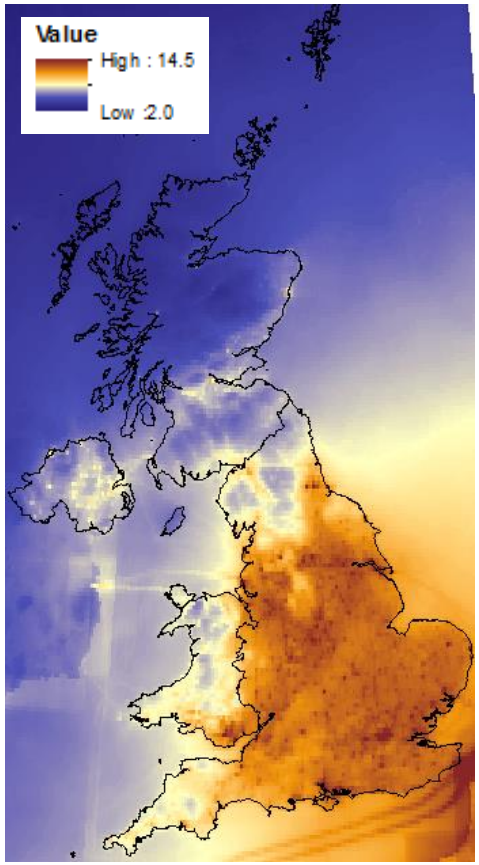


Deciduous woodland

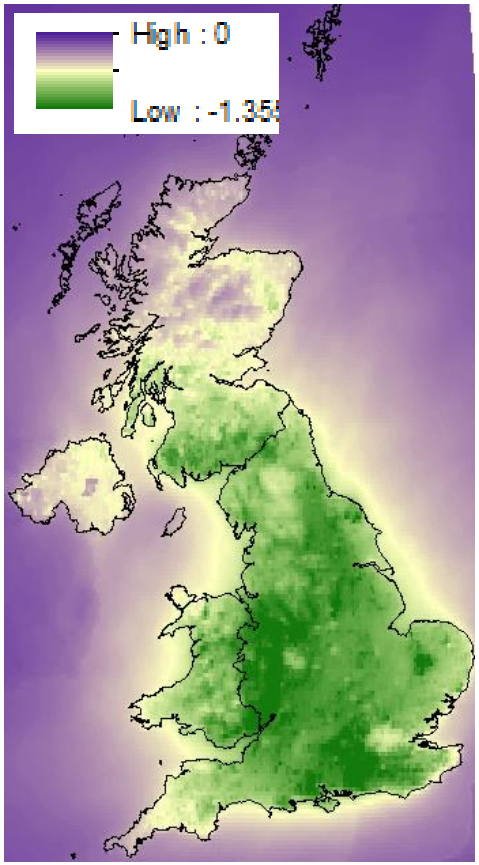
Base map, 2015



No vegetation scenario



Difference map



Change in exposure to PM2.5 (ug/m3)

Ave: -0.55 (-10%)

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

Physical account- national

Change in pollutant concentration due to vegetation

Pollutant	Habitat	2007	2011	2015	2030
PM10	Current vegetation	11.55	10.74	9.9	8.01
	No vegetation	12.53	11.6	10.55	8.38
	Absolute difference	-0.98	-0.86	-0.65	-0.37
	Difference (%)	-7.8	-7.4	-6.2	-4.4
PM2.5	Current vegetation	6.36	6.08	4.85	3.31
	No vegetation	7.2	6.83	5.4	3.61
	Absolute difference	-0.84	-0.75	-0.55	-0.3
	Difference (%)	-11.7	-11.0	-10.2	-8.3
SO2	Current vegetation	1.46	1.07	0.85	0.5
	No vegetation	2.07	1.55	1.21	0.72
	Absolute difference	-0.61	-0.48	-0.36	-0.22
	Difference (%)	-29.5	-31.0	-29.8	-30.6

Health outcomes

		Change in no. of hospital admissions/life years lost/deaths attributable to presence of UK vegetation			
		2007	2011	2015	2030
		no./yr	no./yr	no./yr	no./yr
PM2.5	Respiratory hospital admissions	-814	-693	-533	-318
	Cardiovascular hospital admissions	-715	-609	-469	-279
	Life years lost	-42,736	-34,656	-25,209	-12,725
SO2	Respiratory hospital admissions	-308	-240	-181	-110
NO2	Respiratory hospital admissions	-346	-188	-125	-3
	Cardiovascular hospital admissions	-294	-160	-106	-3
	Life years lost	-5,618	-2,913	-1,843	-16
O3	Respiratory hospital admissions	-4,679	-4,889	-5,017	-5,861
	Cardiovascular hospital admissions	-722	-755	-775	-905
	Deaths	-1,798	-1,743	-1,899	-2,110
All pollutants combined	Respiratory hospital admissions	-6,146	-6,011	-5,856	-6,291
	Cardiovascular hospital admissions	-1,731	-1,524	-1,349	-1,186
	Life years lost	-48,354	-37,568	-27,051	-12,741
	Deaths	-1,798	-1,743	-1,899	-2,110

Economic value attributable to vegetation

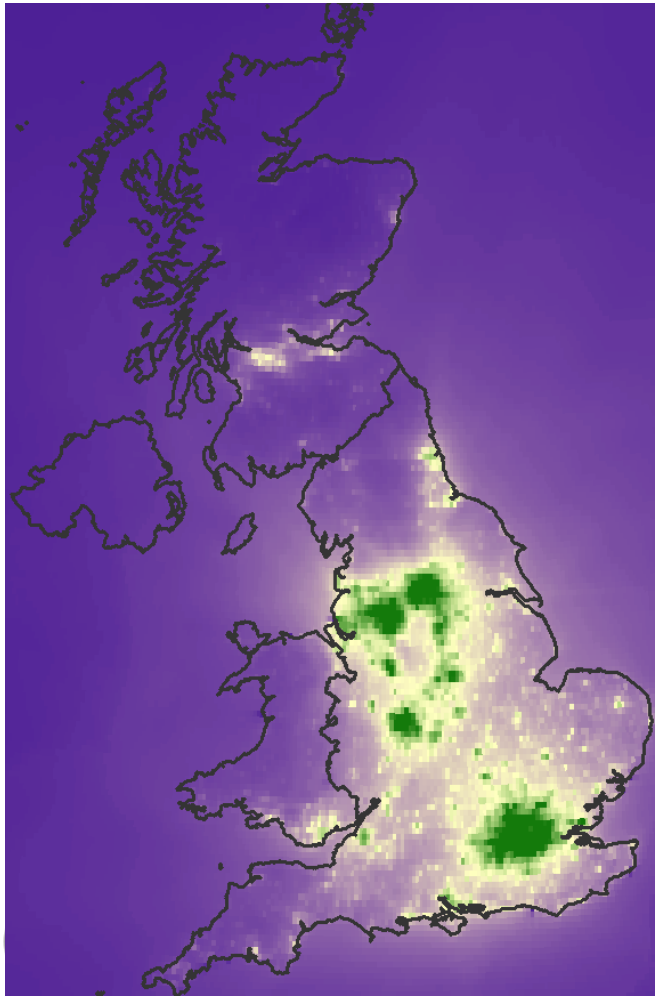
		Annual value (2012 prices)			
		2007 £m/yr	2011 £m/yr	2015 £m/yr	2030 £m/yr
PM2.5	Respiratory hospital admissions	£5.4	£4.6	£3.5	£2.1
	Cardiovascular hospital admissions	£4.6	£3.9	£3.0	£1.8
	Life years lost	£1,495.8	£1,212.9	£882.3	£445.4
SO2	Respiratory hospital admissions	£2.1	£1.6	£1.2	£0.7
NO2	Respiratory hospital admissions	£2.3	£1.3	£0.8	£0.02
	Cardiovascular hospital admissions	£1.9	£1.0	£0.7	£0.02
	Life years lost	£196.6	£101.9	£64.5	£0.5
O3	Respiratory hospital admissions	£31.1	£32.5	£33.4	£39.0
	Cardiovascular hospital admissions	£4.7	£4.9	£5.0	£5.8
	Deaths	£10.8	£10.5	£11.4	£12.7
Total		**£1,755.2**	**£1,375.2**	**£1,005.8**	**£508.1**

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

EMEP model outputs – urban natural capital

Change in exposure to PM2.5 (ug/m3) Ave: -0.06 (-1%)



NERC SCIENCE OF THE ENVIRONMENT

Urban natural capital: pollutant removed & health outcomes

Pollutant removed (ktonnes)

	Habitat	2015
All pollutants	Urban woodland	38.2
	Urban grassland	4.9
	Urban fresh/saltwater	0.1
	Total urban natural capital	43.2

Health outcomes

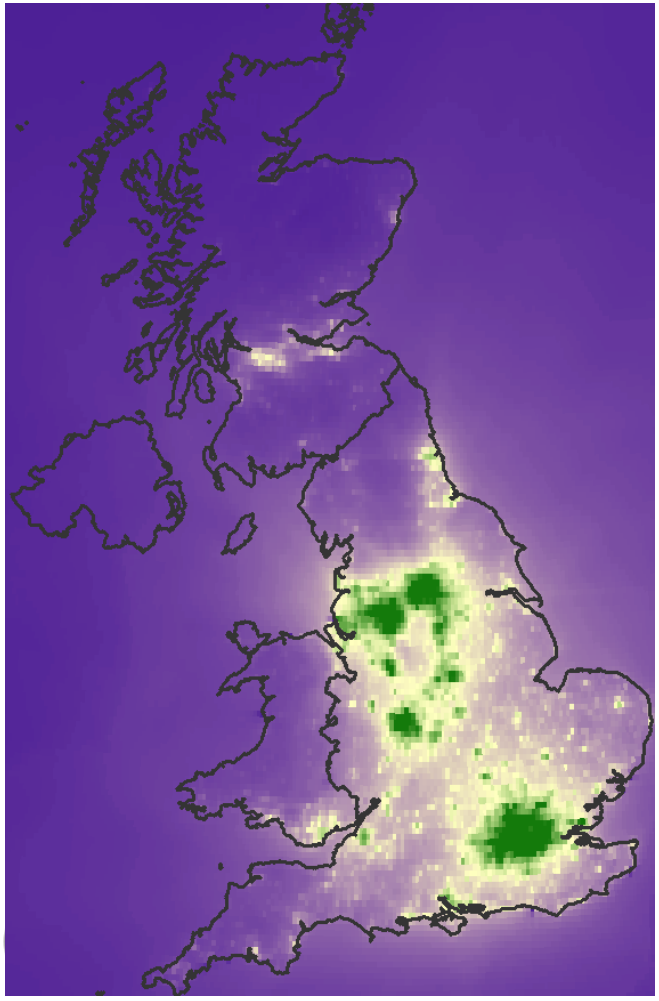
	Health outcome	No/yr
All pollutants combined	Respiratory hospital admissions	-538
	Cardiovascular hospital admissions	-182
	Life years lost	-5,899
	Deaths	-105

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

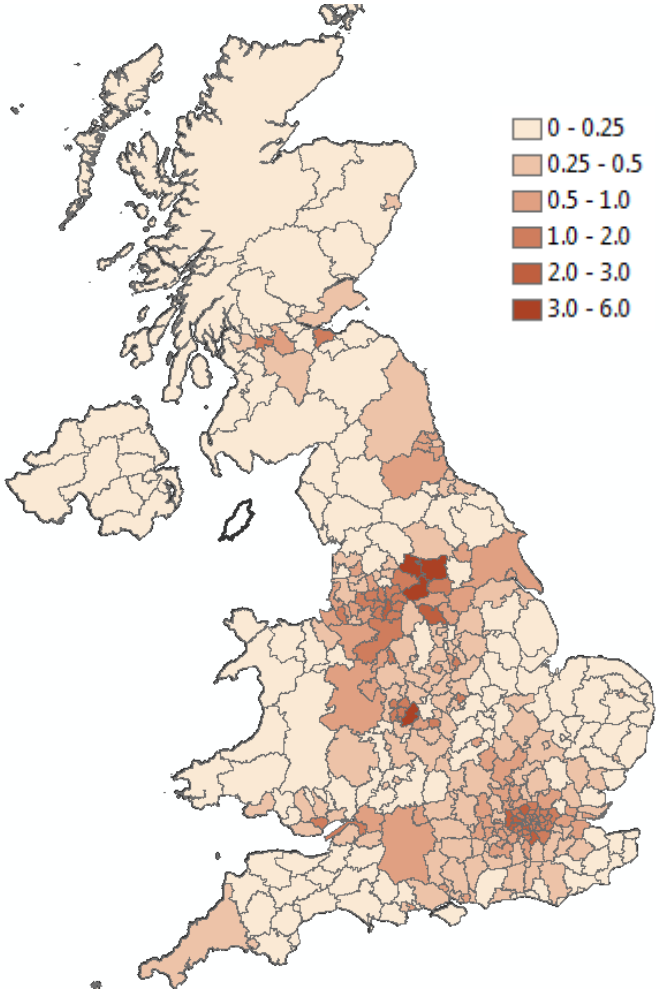
NERC SCIENCE OF THE ENVIRONMENT

Economic value of health outcomes

Change in exposure to PM2.5 (ug/m3) Ave: -0.06 (-1%)



Value of health outcomes (£m)



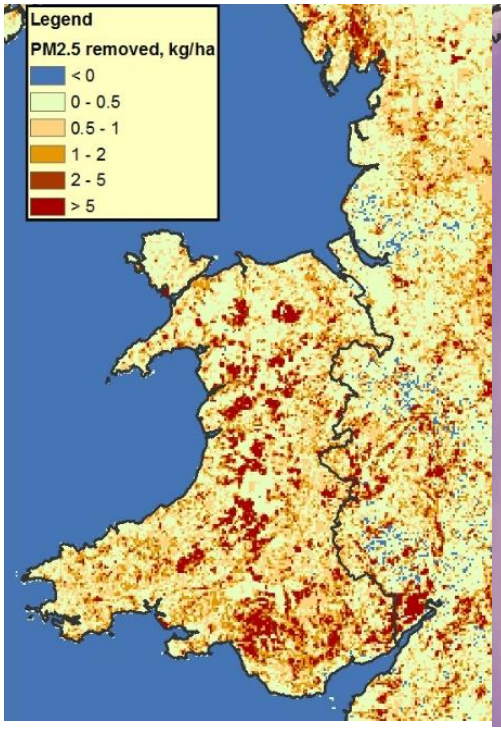
URBAN ACCOUNT - MONETARY

Annual value of health benefit

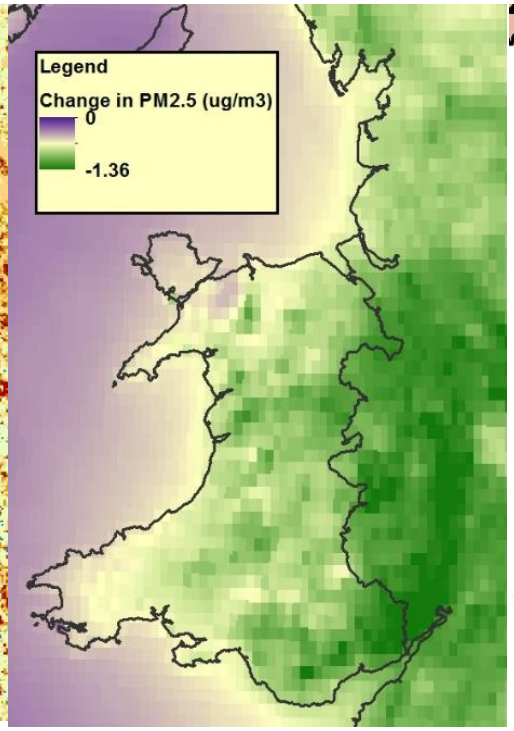
		Annual value	
		2015	2030
		£/yr	£/yr
PM2.5	Respiratory hospital admissions	£800,000	£500,000
	Cardiovascular hospital admissions	£700,000	£500,000
	Life years lost	£193,800,000	£106,500,000
SO2	Respiratory hospital admissions	£300,000	£200,000
NO2	Respiratory hospital admissions	£200,000	£50,000
	Cardiovascular hospital admissions	£100,000	£40,000
	Life years lost	£12,600,000	£3,800,000
O3	Respiratory hospital admissions	£2,200,000	£2,800,000
	Cardiovascular hospital admissions	£300,000	£400,000
	Deaths	£600,000	£700,000
	Total	**£211,600,000**	**£115,490,000**

The picture in Wales (PM2.5)

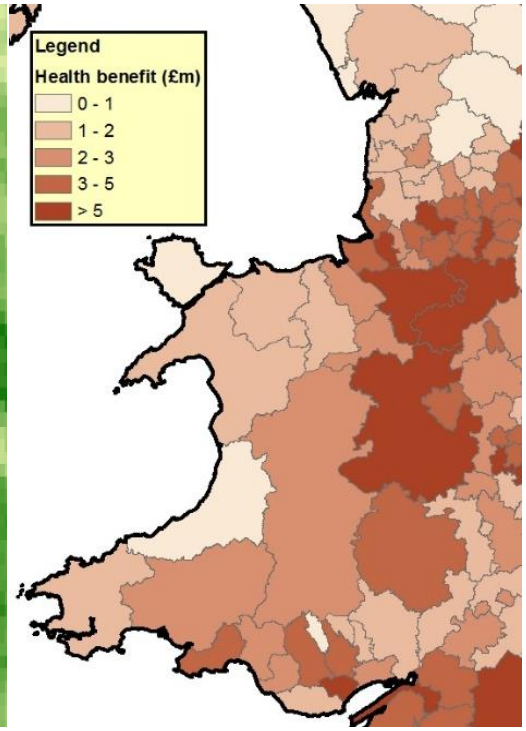
PM2.5 removal (kg/ha)



Change in PM2.5 concentration (ug/m3)



Value of health outcomes (£m)



Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

SUMMARY

- Approach is based on realistic chemical interactions, meteorology and pollutant transport
- National account shows substantial benefit (£1bn)
- Urban accounts show wider benefit to surrounding areas
- Results are broadly comparable to other studies (i-tree, USA, but differ by pollutant)