# DOES VEGETATION REDUCE AIR POLLUTION ?

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eftec
Economics for the Environment Consultancy

EMRC

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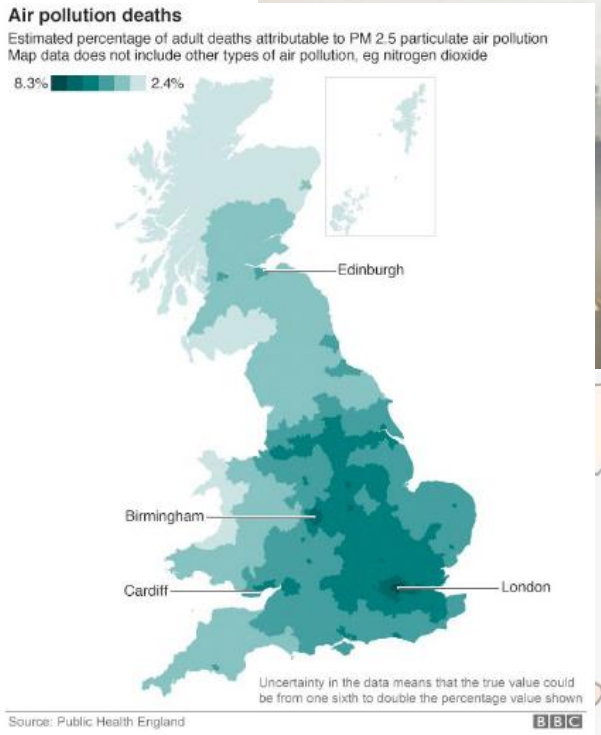
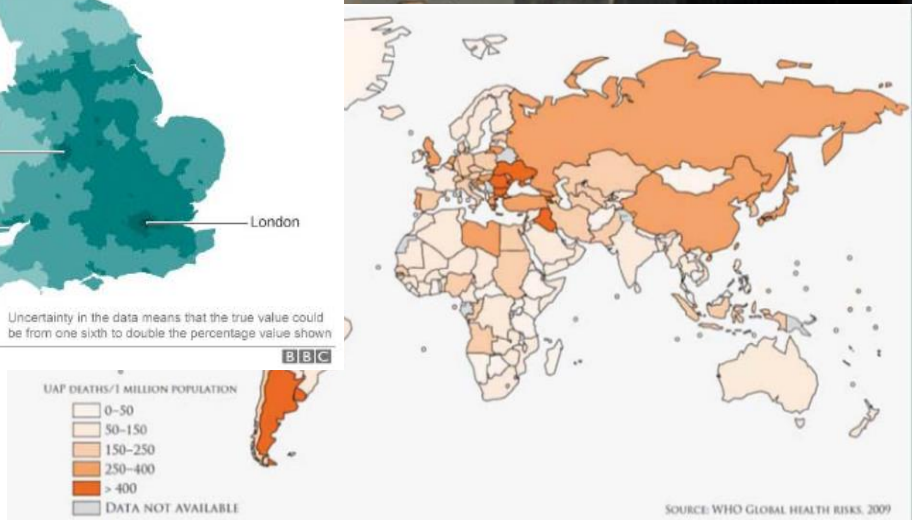
# AIR POLLUTION AND HUMAN HEALTH

5.5 million deaths globally

40,000 deaths, UK




## Which pollutants are harmful ?

PM10

PM2.5

NO2

NH3

O3

SO2

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# AIR POLLUTION REMOVAL BY TREES, IN THE LITERATURE

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

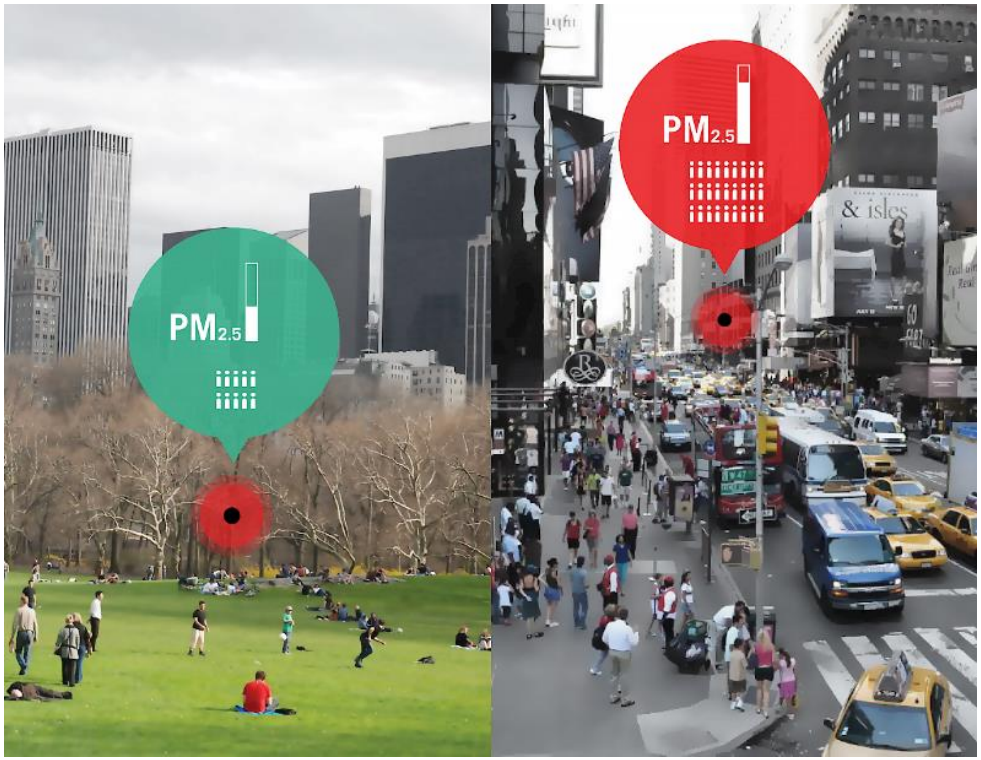
Trees reduce pollutant concentrations by 1 – 10% **(Nowak et al. 2013)**

**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

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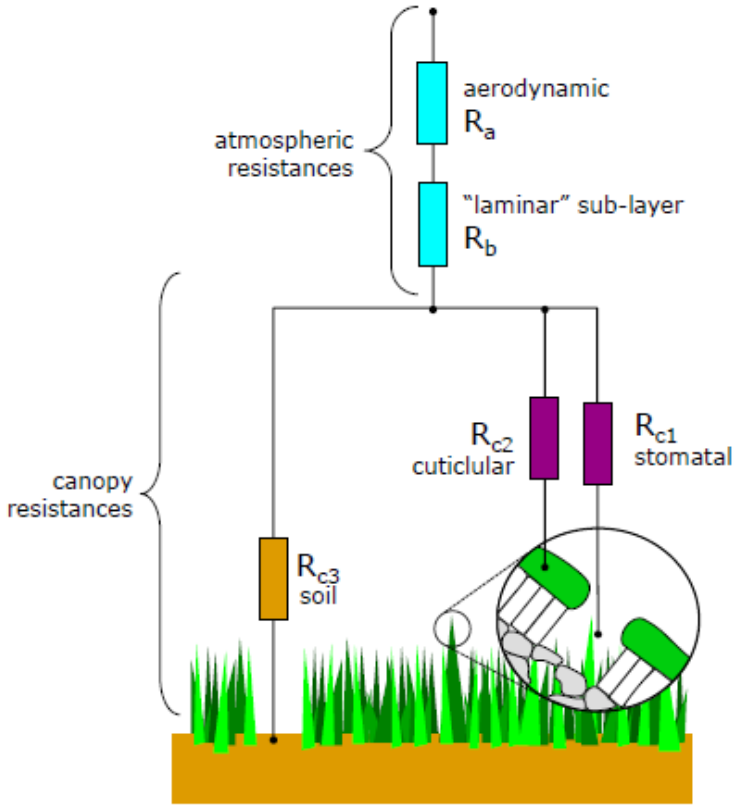
# MECHANISMS OF POLLUTANT REMOVAL

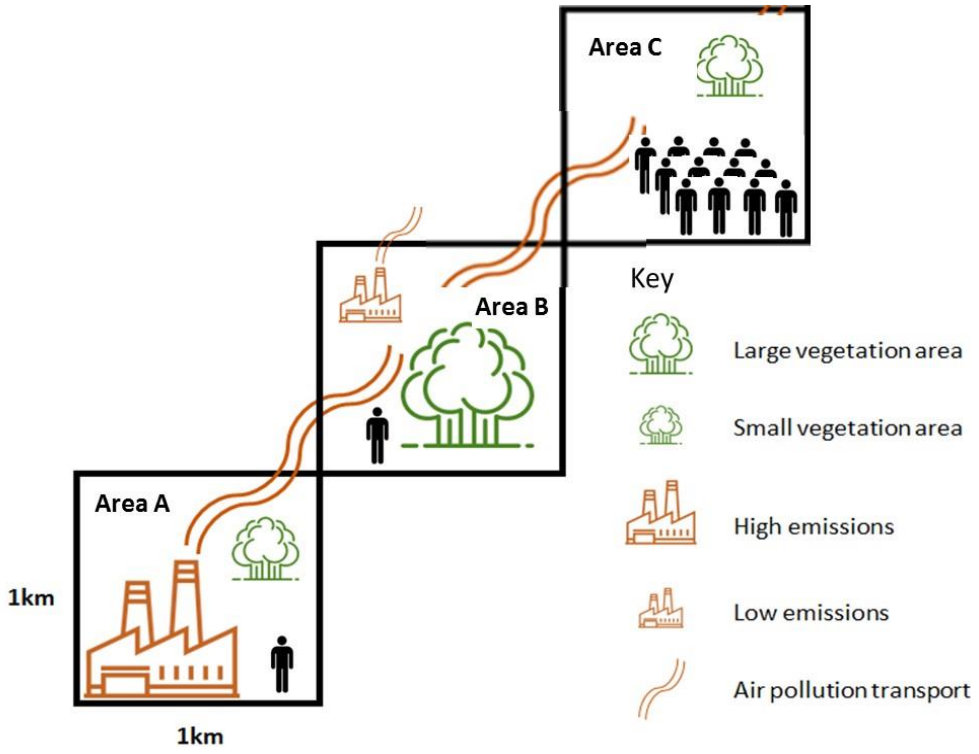
- Aerodynamic resistance
- Boundary resistance
- Canopy resistance
  - To surface
  - To stomata



# IMPROVEMENTS TO THE METHODOLOGY

Spatial context:

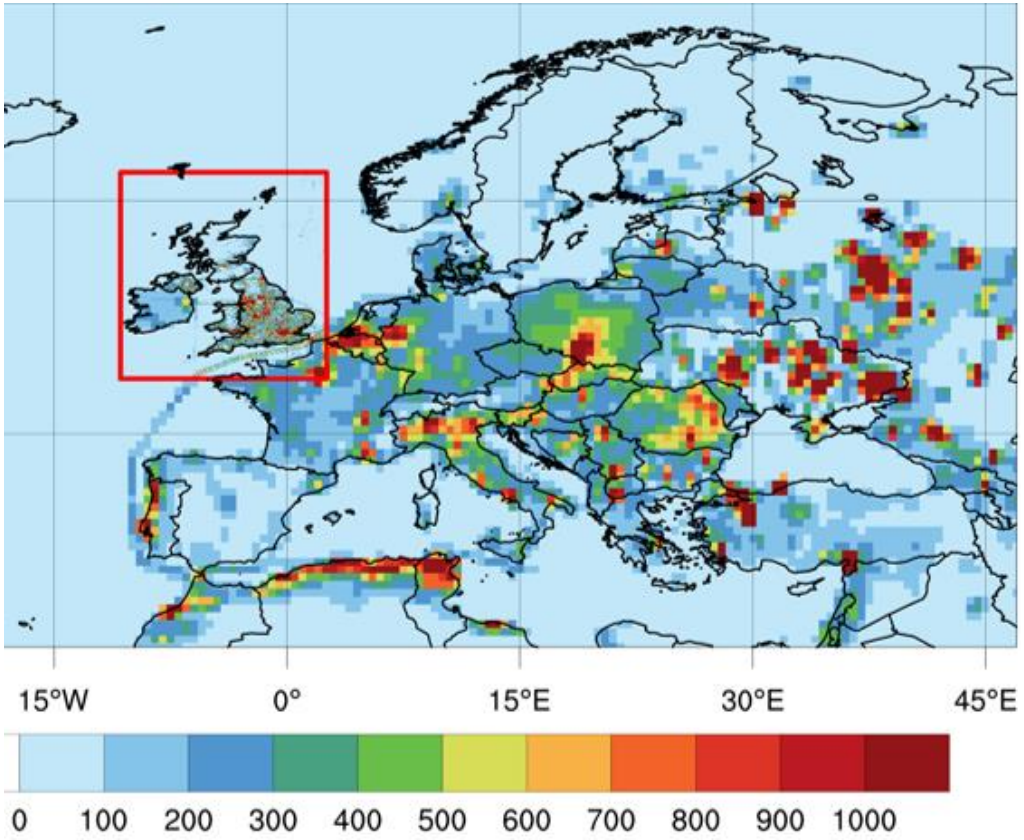
I. Location of beneficiaries
II. Health damage function
III. Chemical and climate interactions



# 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

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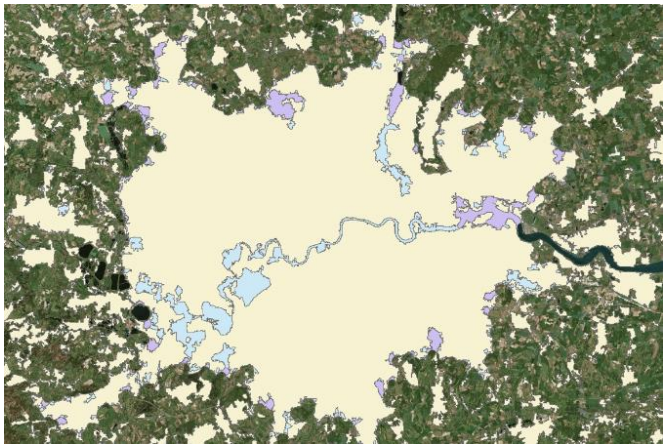
# SCENARIO APPROACH TO MODELLING

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



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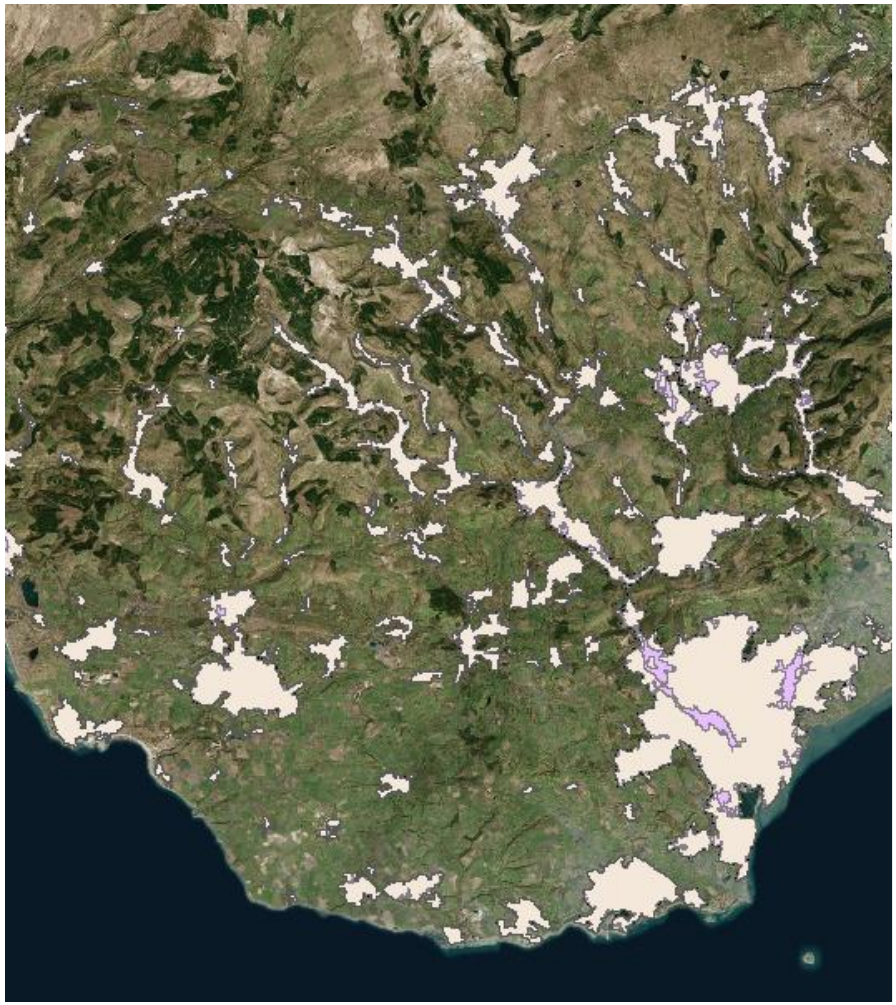
# NEW URBAN EXTENT, DETAIL ON CARDIFF



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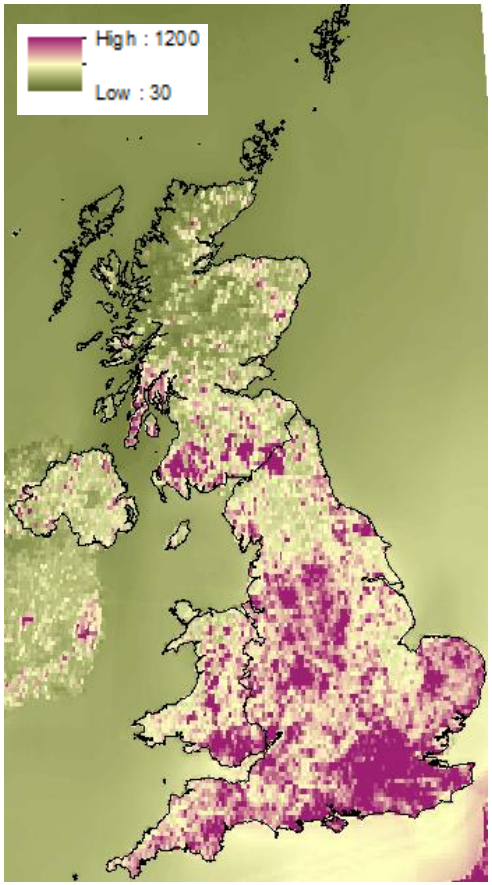
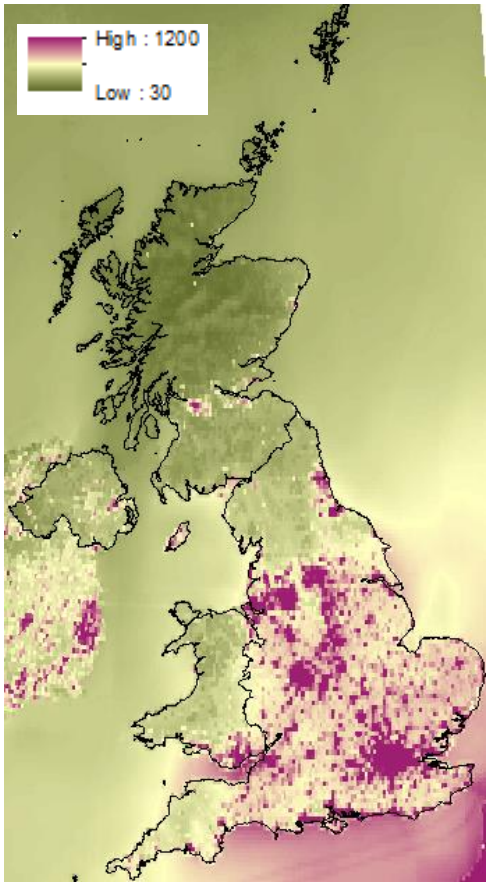
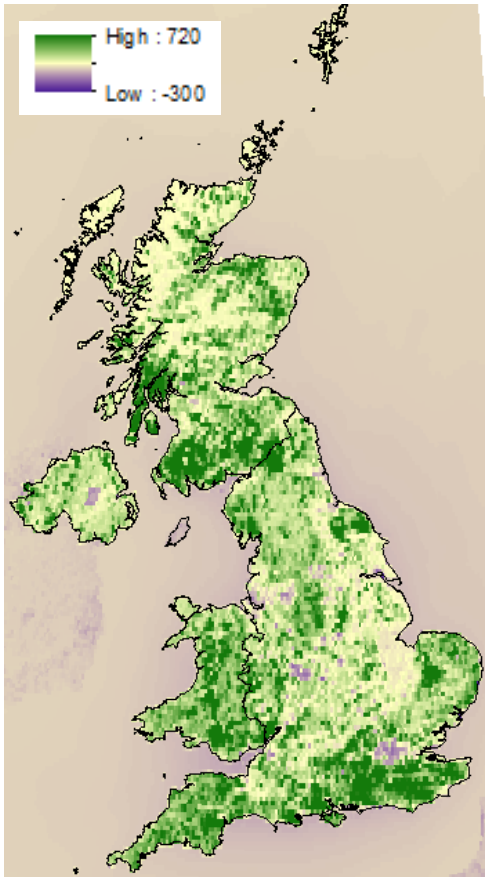
Base map, 2015




No vegetation scenario




Difference map




**Quantity of PM2.5 removed (mg/m2)**

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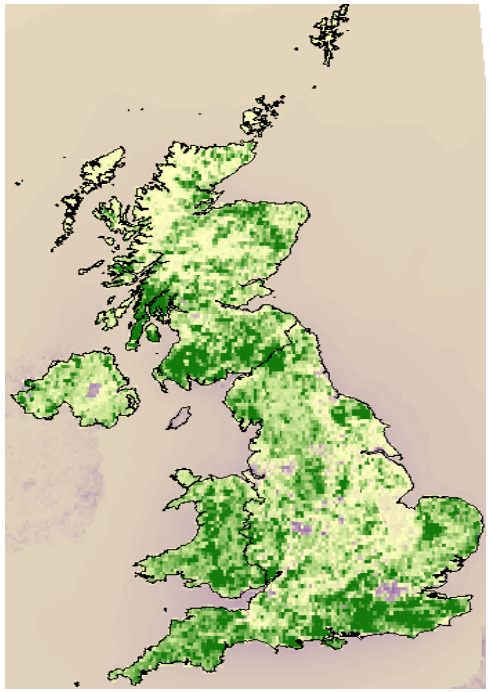
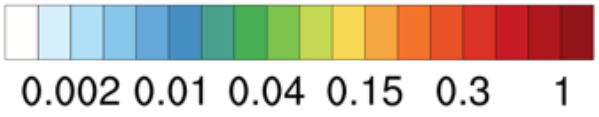
# Quantities of pollutant removed (kt/yr)

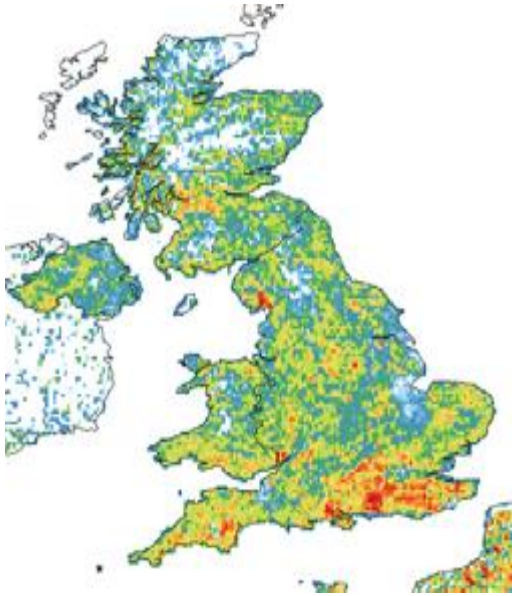
| Habitat | Coniferous woodland | Deciduous woodland | Semi-natural (grassland, moorland) | Crops | Total vegetation |
|---|---|---|---|---|---|
| Area CEH landcover ($km^2$) | 15,361 | 13,950 | 135,909 | 63,161 | 228,381 |
| $PM_{10}$ | 21.3 | 14 | 7.7 | 0 | 43 |
| $PM_{2.5}$ | 9.6 | 8.2 | 4.5 | -0.1 | 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



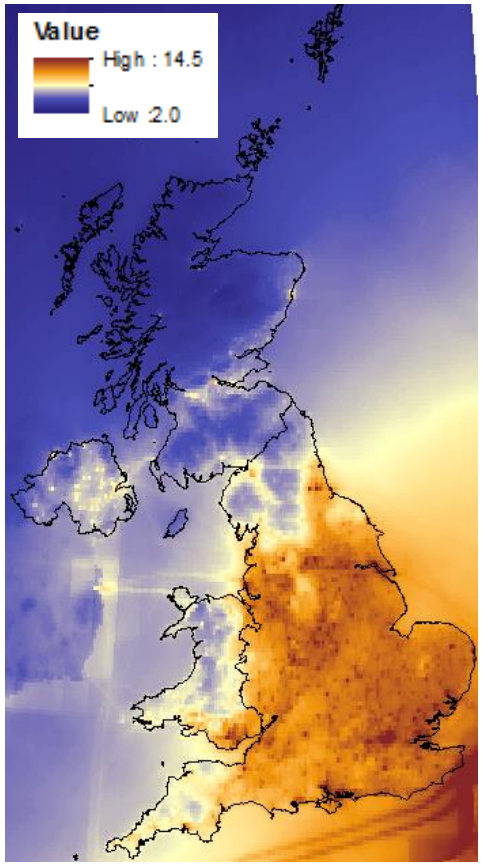



Coniferous woodland

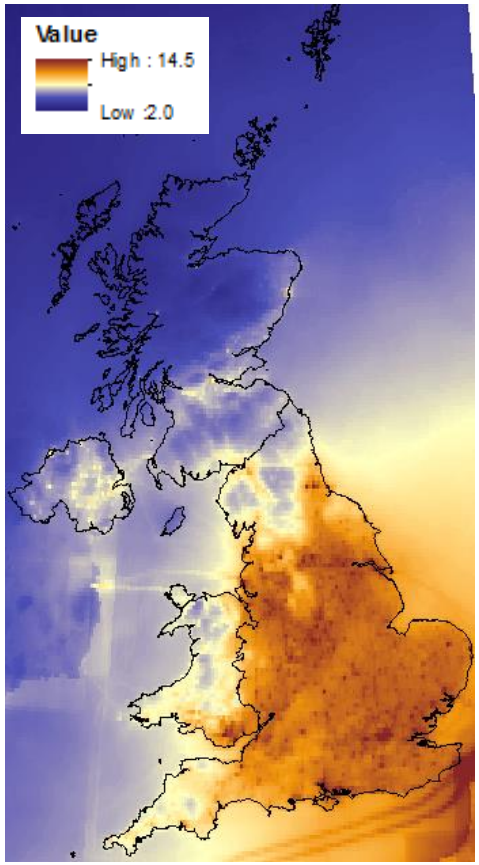


Deciduous woodland

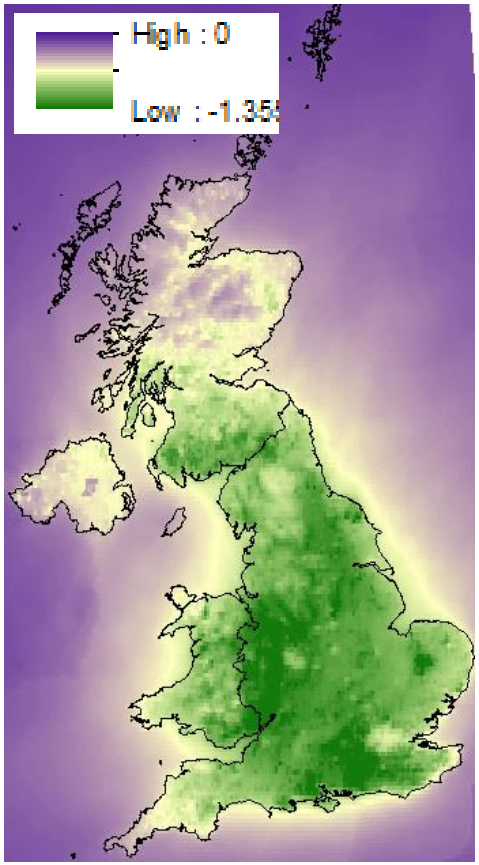
Base map, 2015




No vegetation scenario




Difference map




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

**Ave: -0.55 (-10%)**

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# 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** |

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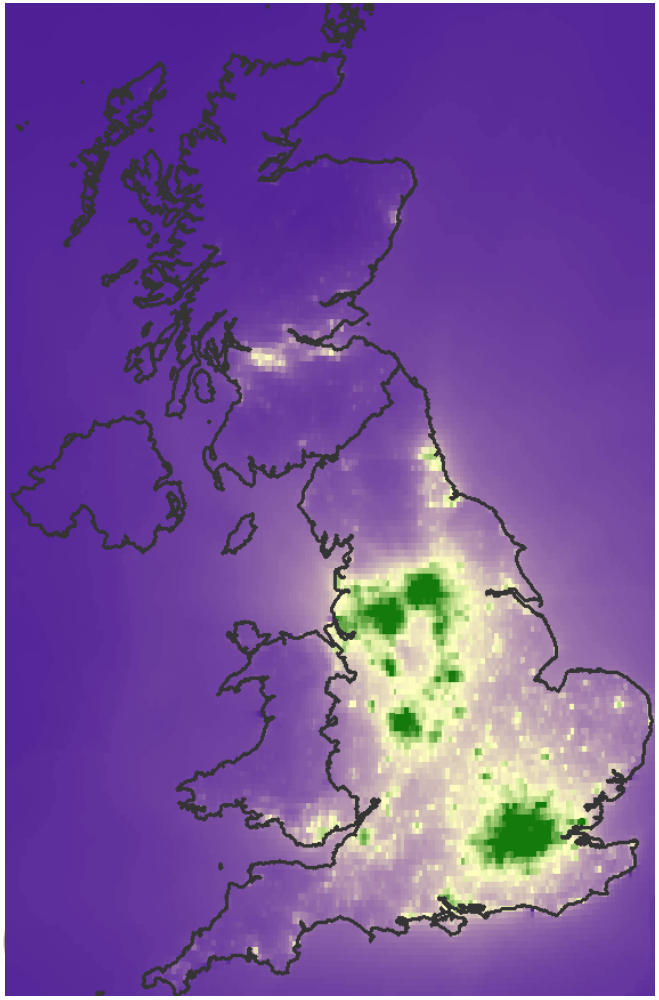
# EMEP model outputs – urban natural capital

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



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# 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 |

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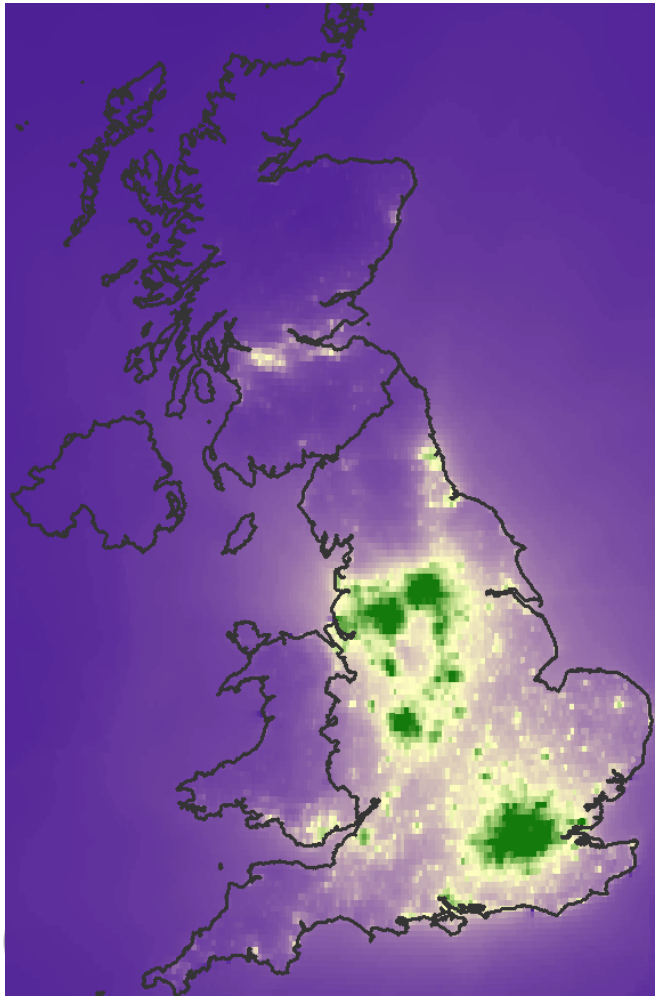
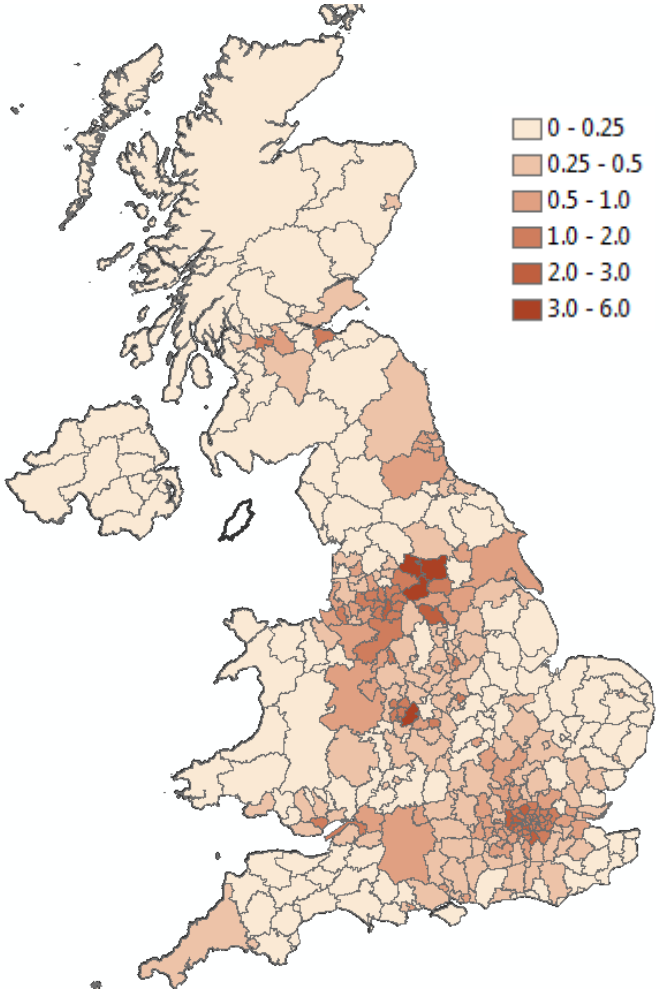
# Economic value of health outcomes

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



**Value of health outcomes (£m)**



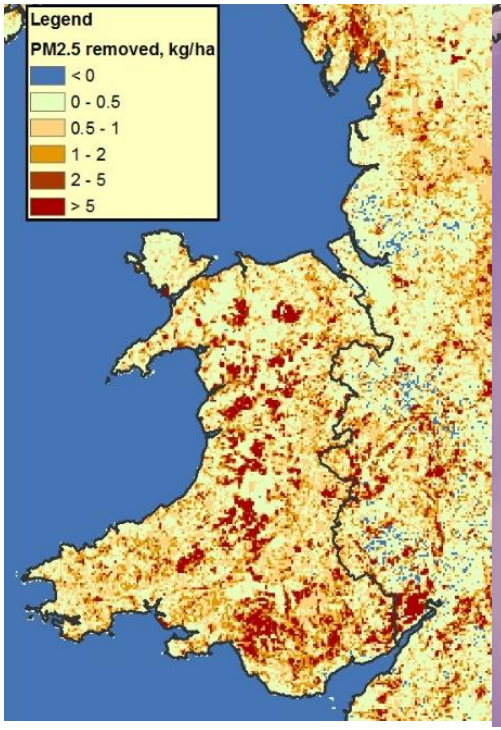
# URBAN ACCOUNT - MONETARY

**Annual value of health benefit**

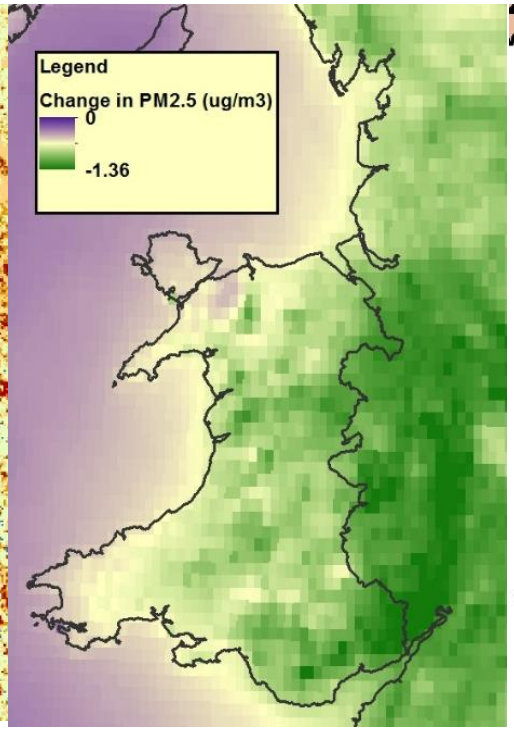
| | | Annual value | |
|---|---|---|---|
| | | 2015 | 2030 |
| | | £/yr | £/yr |
| **PM2.5** | Respiratory hospital admissions | £800,000 | £500,000 |
| | Cardiovascular hospital admissions | £700,000 | £500,000 |
| | Life years lost | £193,800,000 | £106,500,000 |
| **SO2** | Respiratory hospital admissions | £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)

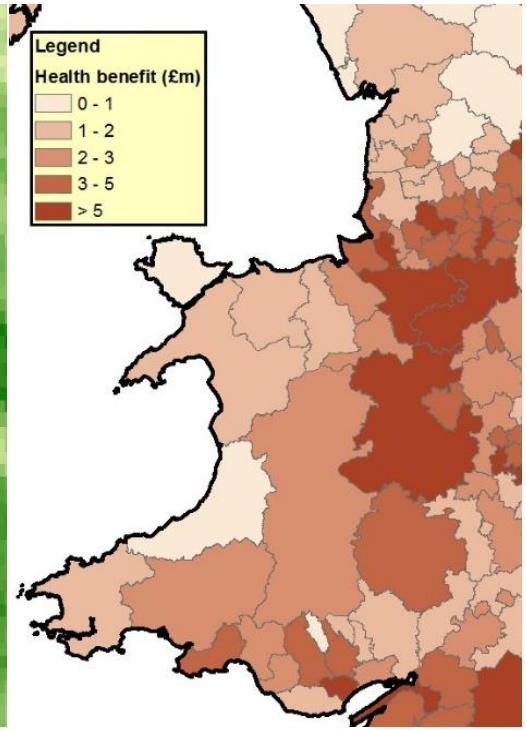
**PM2.5 removal (kg/ha)**




**Change in PM2.5 concentration (ug/m3)**




**Value of health outcomes (£m)**

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# 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)