Air Quality CONSULTANTS

# Nitrogen Dioxide and Nitrogen Oxides Trends in the UK 2005 to 2016

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Experts in air quality management & assessment

## Document Control

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## Contents

# 1 Introduction

1.1 There is considerable current interest in exposure to nitrogen dioxide ($NO_2$) in the UK. This is driven largely by the failure of vehicle emission controls imposed through Euro standards to deliver the improvements expected for diesel vehicles. This was initially brought to light by the analysis of trends in concentrations, which did not fall as expected from the introduction of 'tighter' emission standards[1] during the 2000s (Carslaw et al., 2011) (Carslaw and Rhys-Tyler, 2013). This report extends previous analyses of trends to see what can be learnt about the continued delivery of 'tighter' Euro standards over the 11-year period from 2005 to 2016[1], as well as changes to emissions from other sectors. It takes account of geographical variations across the UK, as well as monitor setting. Clearly sites near to roads will give the clearest information on the role of vehicle emissions, while rural sites will include the role of other sources, such as industry and power stations, as well as the contribution long-range transport from Europe-wide sources, the trends for which will be different to those of UK road traffic. Urban sites will be intermediate between road and rural sites.

1.2 The UK has an extensive national network of automatic monitoring sites measuring $NO_2$ and nitrogen oxides (NOx), including the Automatic Urban and Rural Network (AURN) and some affiliated sites, mainly owned and operated by local authorities. In addition, there are numerous other sites operated by local authorities, many of which are linked into networks for data reporting. This report draws together data from as many of these networks as was practicable at the time of data collection.

1.3 The openair software package (Carslaw and Ropkins, 2012) has been used to analyse the data for trends for a range of categorisations of the sites. The analysis has covered both NOx and $NO_2$. The focus is on trends across sites, rather than an analysis of trends at specific sites.

1.4 The data in the tables and figures are critical to understanding the text. To facilitate the ability to look at the text, tables and figures at the same time, two separate pdf documents have been created, one for the tables and one for figures, which can be opened at the same time as the main report (available at http://www.aqconsultants.co.uk/Resources/Download-Reports.aspx).

[1] Light Duty Vehicles: Euro 3 in 2000, Euro 4 in 2005, Euro 5 in 2009/11, Euro 6 in 2014. Heavy Duty Vehicles: Euro III in 2000, Euro IV 2005, Euro V in 2008, Euro VI in 2013

# 2 Methodology

2.1 The approach can be described according to the following three steps:

- data compilation;
- data processing; and
- data analysis.

## Data compilation

2.2 Hourly-mean $NO_2$ and NOx concentrations from 2005 to 2016 (inclusive) have been collated from the following air quality networks:

- Automatic Urban and Rural Network (https://uk-air.defra.gov.uk/networks/find-sites)
- London Air Quality Network (Kings College London) (http://www.londonair.org.uk/)
- Scottish Air Quality Network (http://www.londonair.org.uk/)
- Kent Air (http://www.kentair.org.uk/)
- Welsh Air Quality (http://www.welshairquality.co.uk/)
- Sussex Air (http://www.sussex-air.net/)
- UK Air Quality (http://www.ukairquality.net/)

2.3 A total of 247 sites have been identified for further consideration. Various criteria have then been applied to define an appropriate data set of 156 sites for further analysis of the trends, as set out below.

## Data processing

2.4 To help ensure a robust outcome of the analyses, sites have been excluded from the analysis based on the following criteria:

- sites with no data for both 2005 and 2006 and/or for both 2015 and 2016; and
- sites with data capture for the full 11 years of less than 75%[2].

2.5 For some sites, data are made available on more than one website. This applies in particular to Defra's AURN sites, which in London are also included on the London Air website operated by King's College London (KCL). Where duplicate sites have been identified, the approach has been to retain the results made available on the Defra website.

[2] Six additional roadside sites with a lower data capture, but a good spread across the study period, were included in the analysis.

2.6 Sites are categorised as follows: Industrial, Kerbside, Roadside, Rural Background, Suburban and Urban Background. For the purpose of this analysis, Industrial sites have been removed from the dataset, as they are designed to reflect the influence of local industrial sources and will therefore not be representative of more general exposure. In one case, the 'urban background' AURN site 'London Hillingdon' has been reclassified as a roadside site, as it is around 30 m from the busy M4 motorway.

2.7 The sites included in the analyses and their features are set out in Table A1 in Appendix A1, while those excluded are set out in Table A2. A number of sites included provisional data for 2016 at the time of data collection; examination of the results for these sites indicates that it is appropriate to retain them in the analyses.

## Data analysis

2.8 The *openair* package used in this report is open-source software based on R (Carslaw and Ropkins, 2012)[3] which provides a consistent set of tools for analysing and understanding air pollution data. Two particular components of *openair* have been used, a smooth trend fit to the data and a statistical TheilSen linear fit. In each case, monthly mean data have been used in the analysis, with data only included when the 1-hour mean data capture for the month exceeds 75%.

### *smoothTrend*

2.9 The smoothTrend function in *openair* helps check the linearity of a trend. Monthly averages are calculated from the hourly concentrations and the Generalized Additive Model finds the most appropriate level of smoothing. The plots show the smoothed trend line fitted to the monthly data, along with the 95% confidence interval, which is shown by the shading around the trend line.

### *TheilSen*

2.10 The TheilSen function in *openair* provides an analysis of the statistical significance of trends in air pollution data and yields accurate confidence intervals, that are resistant to outliers. The plots show the best fit linear trend line, together with the lines representing the 10% confidence interval (p=0.1). The plots also give the trend (in this case as a percentage change in concentration per year) and the associated 10% confidence interval values and the significance of the trends (where the confidence interval values both have the same sign, either both positive or both negative). The significance of the trend is also shown, as follows: *** for p=0.001, ** for p=0.01, * for p=0.05 and $^{+}$ for p=0.1.

### *Spatial Analysis*

2.11 The geographical analysis has been carried out using GIS mapping.

[3] Further information at: http://www.openair-project.org/Default.aspx

### *Categorisation of Trends*

2.12 The trends, in % per yr, for each site, from the TheilSen analysis, have been categorised into:

- **significant positive trend** (a significant increase in concentrations over the 11 years);
- **no significant trend** (no significant change concentrations over the 11 years); and
- **significant negative trend** (a significant decrease in concentrations over the 11 years).

2.13 In addition, the significant trends have been categorised into those of <2% per year and those >2% per year, to reflect the magnitude of the changes, as well as their significance.

### *Presentation of Trends*

2.14 All trends are presented as values in percent per year (%/yr) rather than microgrammes per cubic metre per year (µg/m$^3$/yr), to make comparisons between sites with different concentrations more meaningful.

2.15 The focus of the analysis is on grouped sites, to strengthen the confidence in the findings. This will help overcome unusual results due to specific features of some of the monitoring sites, e.g. sites may be affected by local measures that have changed traffic flows or changed the proportion of buses on the road(s) near to the site. It is recognised that specific features near to a site are more likely to affect roadside/kerbside sites than urban background or rural sites.

2.16 The analysis covers:

- comparison of **trends by site type**, based on three groupings:
  - **Road**: kerbside and roadside;
  - **Urban**: urban centre, urban background suburban; and
  - **Rural**: sites away from urban and road traffic sources.
- the pattern of **geographic trends** across the UK; and
- comparison of **trends by NOx concentrations**, which is broadly a surrogate for fresh emissions of NOx, but also related to site type and part of the country. The sites have been grouped into four categories by the mean NOx concentration over the 11-year period:
  - **NOx >120 µg/m$^3$**
  - **NOx 80-120 µg/m$^3$**
  - **NOx 40-80 µg/m$^3$**
  - **NOx <40 µg/m$^3$.**

# 3 Results

3.1 The trend analysis has been carried out for each of 156 monitoring sites, for both $NO_2$ and NOx concentrations, with the results set out in Appendix A2. The results are summarised in a series of Tables in Section 4 and in Figures in Section 5. The observations are set out below.

## Overall Trends across the UK

3.2 The overall pattern of trends in $NO_2$ and NOx across all site types and all geographic areas is set out in Table 1. There is a significant downward trend in both $NO_2$ and NOx over the period 2005 to 2016, with the overall magnitudes of the reductions being essentially the same for both pollutants, at 1.50% per year and 1.48% per year respectively.

3.3 These overall reductions for the period 2005 to 2016 may be compared with those reported by Carslaw *et al* (2011) over the period 2004 to 2009, which were *"best described as having been weakly downward".* The trends in $NO_2$ over this period were reported as being *"decreases in the range 0.5 to 1% per year, although rural sites* (showed) *a greater decrease ~1.4% per year".* In contrast to the present study, the NOx trends reported by Carslaw *et al* (2011) were higher than those of $NO_2$, being reported as decreases of 1 to 2% per year, compared with the 0.5 to 1% per year for $NO_2$, although subsequent work by Font & Fuller (2015) examining trends in London showed that *"Between 2010 and 2014, sites that exhibited decreasing* (trends in NOx and $NO_2$) *showed an approximate 1:1 ratio* (for the NOx and $NO_2$ trends)", which is consistent with the current study. Carslaw and Rhys-Tyler (2013) subsequently reported the trends for 23 roadside sites in London as being downward at 1.07% per year for NOx and 0.59% per year for $NO_2$ over the period 2003 to 2012. The overall UK trends for 2005 to 2016 are thus slightly higher than those previously reported (but important qualifications are provided in subsequent sections which disaggregate the trends).

3.4 The smoothTrend plots are shown in Figure 1 for $NO_2$ and Figure 2 for NOx, while the TheilSen plots are shown in Figure 3 for $NO_2$ and Figure 4 for NOx. The smoothTrend results show a slight indication of an inverse S-shaped pattern for $NO_2$ and NOx with a flattish period from 2005 to 2009, a steeper downward trend from 2010 to 2014, then a flattening out in 2015 to 2016.

3.5 The current understanding of real-world emissions from diesel vehicles leads to the expectation of a minimal downward trend in the early years, 2005 to 2013, with a steepening downward trend in the last few years (since Euro VI HDVs started to enter the fleet from around 2013 and Euro 6 cars around 2015)[4]. The analysis does not, however, show this expected pattern. Somewhat

[4] A fixed date does not apply in practice, hence the use of 'around'. There are different dates for new models and existing models, and there may be an element of anticipation by suppliers that might lead to early introduction, prior to the legal deadline.

surprisingly, there appears to be a flattening out of the downward trend in recent years, when it would be expected to be accelerating. This may, however, be due to the influence of meteorological conditions, which will cause variations from year to year. In this case, it is possible that 2016 is a higher pollution year due to meteorological conditions and/or 2015 is a lower pollution year. Once 2017 data become available it will be possible to see if this apparent plateau remains, or is smoothed out. Further analysis of the pattern is provided by site type in the next section, including recognition of the role of trends in other sources of NOx.

3.6 It is considered somewhat surprising that the percentage reductions are not smaller for $NO_2$ than for NOx, especially at higher concentrations, as there is a non-linear relationship between $NO_2$ and NOx, which is most evident at higher NOx concentrations (AQEG 2004). It would thus be expected that the percentage reduction in $NO_2$ should be less than that of NOx. (This is examined as a function of NOx concentrations in paragraph 3.17, with a less clear pattern apparent). The departure from expectation may however be due to the role of changing fraction of primary $NO_2$ emissions, which is known to have varied over this period, although primary $NO_2$ will mainly affect the concentrations at Road sites.

3.7 The overall downward trends across the UK do hide important differences for individual sites. This is illustrated in Figure 5 and Figure 6 where:

- a small number of sites (~3% for $NO_2$ and ~4% for NOx) show significant increases over the 11 years;
- around a third of the sites (~31% for $NO_2$ and ~36% for NOx)) show no significant trends over the 11 years; and
- around two thirds of the sites (66% for $NO_2$ and 60% for NOx) show significant downward trends.

## Overall Pattern of Trends across the UK by Site Type

3.8 The overall trends for $NO_2$ and NOx for the three site types: Road, Urban and Rural, are set out in Table 1. As with the overall trend across all UK sites, there is an overall:

- significant downward trend in both NOx and $NO_2$, for all site types, with the overall magnitudes of the reductions being similar for both pollutants; while
- the overall percentage reductions for both $NO_2$ and NOx are greater at Rural sites (~2.5-2.6% per year) than at Urban sites (~1.5-1.7% per year) and Road sites (~1.6% per year)[5].

[5] When interpreting these results, it should be recognised that there are fewer sites incorporated in the rural category, which may increase the uncertainty of the overall trend for rural sites. There is, however, consistency in the pattern of a greater reduction in rural sites across each of the geographic areas, as discussed in the next section, which does give confidence in the observation.

3.9 Figure 7 to Figure 11 again show how these overall trends hide differences for individual sites, but confirm that there are more Rural sites with significant downward trends and that there is little difference between trends for $NO_2$ and NOx.

3.10 The smooth trends by site type are set out for $NO_2$ in Figure 12 to Figure 14 and for NOx in Figure 15 to Figure 17. They show:

- essentially a linear downward trend for both $NO_2$ and NOx at Road sites, and for $NO_2$ at Urban sites, over the 11 years; and
- a slight indication of an inverse S-shaped pattern for $NO_2$ and NOx at Rural sites, and for NOx at Urban sites, with a flattish period from 2005 to 2009, a steeper downward trend from 2009 to 2014, then a flattening out in 2015 to 2016. This is similar to the overall trend for all UK sites discussed in the previous section.

3.11 The TheilSen trend analyses, underpinning the results by site type in Table 1, are set out in Figure 18 to Figure 20 for $NO_2$ and Figure 21 to Figure 23 or NOx.

## Overall Trends by Geographic Area

3.12 The overall patterns of significant downward trends also hide some important differences between different parts of the country. This is evident in Figure 24 and Figure 25, which show the results for trends in $NO_2$ and NOx respectively for all individual sites across the UK. It is evident that there are some sites with significant upward trends, some with no significant trends and some with downward trends (see also paragraph 3.9 above). Based on a visual examination of the data, there appear to be different overall patterns in different parts of the UK. Three areas have been defined:

1) Scotland and Northern Ireland,

2) Central and Northern England and North Wales,

3) Southern England and Southern Wales

3.13 The overall results for these three areas are set out in Table 2, with the trends shown in Figure 26 to Figure 28 for $NO_2$ and Figure 29 to Figure 31 for NOx. It is evident that there are

- significant overall downward trends for both $NO_2$ and NOx in Areas 1 and 3; but
- no significant trends for either $NO_2$ or NOx in Area 2.

This pattern applies to all site types in the three areas as shown in Table 3, so it is not a feature of the mix of sites. It thus appears that there are clear regional differences in overall trends for both $NO_2$ and NOx in Central and Northern England and North Wales.

3.14 Trends for $NO_2$ and NOx in Areas 1 and 3 are very similar in magnitude, and so it is not clear why in Area 2 there are no overall significant downward trends. The differences may reflect different patterns of vehicle turnover and hence age profile, differences in traffic growth, changes in congestion between the areas, different contributions from other NOx sources, including power stations, industry and domestic sources, and different roles for the long-range transport of NOx and $NO_2$ from elsewhere in Europe. It is also possible that the differences are not systematic, instead relating to a random coincidence of differently-affected sites in each area, but this seems unlikely, given the large number of sites considered and the consistency of the finding across site types.

3.15 The general absence of significant downward trends in Central and Northern England and North Wales will be an important consideration for the development of clean air plans for these areas. Measures to bring about improvements may need to be more stringent than in the other two areas.

3.16 The pattern of trends across London and the South East of England is shown in greater detail in Figure 32 for $NO_2$ and Figure 33 for NOx. There is no clear spatial pattern, although there does appear to be a tendency for greater reductions along the Thames Estuary to the east of central London, and more trends that are not significant on the western side of Greater London, including a significant increase in $NO_2$ at the site near the M4 in Hounslow.

## Trends as a Function of NOx Concentration

3.17 Trends in both $NO_2$ and NOx are summarised for sites grouped by the site NOx concentration in Table 4. The pattern is consistent with that shown for site type in Table 1, with the greatest reductions at sites with low NOx concentrations (NOx <40 $\mu g/m^3$). It is noted that for the high NOx sites (NOx >120 $\mu g/m^3$) the downward trend in NOx is smaller (0.99% per year) than that for $NO_2$ (1.45% per year), whereas at all other sites the trends in NOx are greater than those for $NO_2$. The latter is what would be expected given the non-linear relationship between $NO_2$ and NOx, while the former could be suggestive of a reduction in the fraction of primary $NO_2$ emissions, which would have a greater effect at sites with a high proportion of fresh emissions, i.e. sites close to large roads.

3.18 The relationships with NOx concentration are shown in greater detail in Table 5, where the results are set out for the three geographic areas. Greater care should be exercised in interpreting these findings, as there are fewer sites in some of the grouping; in particular there is only one site in each of the higher NOx concentration groupings for Area 2, and the results for these two grouping should not be interpreted as reflecting more generalised patterns.

3.19 In Southern England and Southern Wales, the trend is downward irrespective of the NOx concentration for both $NO_2$ and NOx, although for NOx sites in the 40-80 $\mu g/m^3$ grouping, the NOx trend is only marginally significant. In Scotland and Northern Ireland, the sites in the 40-80 $\mu g/m^3$

grouping have no significant trend for either $NO_2$ or NOx; in terms of air quality assessments this may be of less significance, as these sites have $NO_2$ concentrations below the objective for $NO_2$.

## Comparison with Predicted Trends

### *Roadside*

3.20 The technical guidance provided to local authorities in 2009 (LAQM.TG(09)) included a table that projected roadside concentrations of $NO_2$ (Box 2.1). This predicted annual reductions of 3.5% to 4.5% per year over the period 2006 to 2016. With the publication of the updated guidance in 2016 Defra changed from a fixed table to one on the Defra website that could be updated from time to time. The latest version was updated towards the end of 2017[6], and predicts annual reductions of $NO_2$ at roadside sites of 3.9% per year from 2015 to 2016 and 4.3% per year from 2016 to 2017. These projections contrast with the ~1.6% reduction at Road sites in this study (Table 1) across the full 11 years for both $NO_2$ and NOx, with no evidence in the smoothTrend plots that the reduction has become steeper in recent years (Figure 12 and Figure 15). This, together with the absence of significant trends in Central and Northern England and North Wales, raises questions about the appropriateness of the projections used to generate the roadside projections in Defra's advice to local authorities.

### *Rural and Urban*

3.21 Trends in concentrations can also be derived from the Defra background maps[7]. The percentage changes in $NO_2$ and NOx for each of the years 2015 to 2016 and 2016 to 2017 have been calculated for each of the three geographic areas, as averages for all of the background grid squares. The results are:

- Area 1 2015 to 2016: a 2.9% per year reduction in $NO_2$ from and a 3.0% reduction for NOx;
- Area 1 2016 to 2017: a 3.0% per year reduction in $NO_2$ from and a 3.1% reduction for NOx;
- Area 2 2015 to 2016: a 3.0% per year reduction in $NO_2$ from and a 3.2% reduction for NOx;
- Area 2 2016 to 2017: a 3.1% per year reduction in $NO_2$ from and a 3.3% reduction for NOx;
- Area 3 2015 to 2016: a 2.8% per year reduction in $NO_2$ from and a 3.0% reduction for NOx;
- Area 3 2016 to 2017: a 2.8% per year reduction in $NO_2$ from and a 3.0% reduction for NOx.

3.22 The projected reductions for $NO_2$ at background (Rural and Urban) sites are ~3% per year between 2015 and 2016, which is greater than the observed trend for the 2005 to 2016 period across Rural and Urban sites across the whole of the UK, ~ 1.5 to 2.6% per year (Table 1) and does not reflect the absence of significant downward trends over the 2005 to 2016 period at Rural

6 https://laqm.defra.gov.uk/tools-monitoring-data/roadside-no2-projection-factor.html

7 https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html

and Urban sites in Area 2 (Table 3). While the latter results are the trends across an 11-year period, the evidence from the smoothTrend plots shows no evidence of a steepening in recent years. This raises questions about the appropriateness of the projections used to generate the future year background maps.

# 4 Summary

4.1 A detailed analysis of trends in $NO_2$ and NOx concentrations at 156 automatic monitoring sites across the UK over an 11-year period, 2005-2016, has been carried out.

4.2 The results show:

- an overall downward trend for $NO_2$ and NOx of ~1.5% per year;
- smoothTrend fits to the data that suggest an inverse S-shaped pattern for $NO_2$ and NOx with a flattish period from 2005 to 2009, a steeper downward trend from 2010 to 2014, then a flattening out in 2015 to 2016;
- around two thirds of the sites with a significant downward trend, around a third showing no significant trend and a small percentage ~3 to 4% having a significant increasing trend;
- a greater downward trend in both $NO_2$ and NOx across Rural sites than at Urban and Road sites;
- an important geographical pattern to the trends, with no significant overall trend in either $NO_2$ or NOx across sites in Central and Northern England and North Wales, but significant reductions for both pollutants in other grouped regions;
- projected trends for $NO_2$ and NOx provided by Defra for local authority use have more significant downward trends than those identified from the analysis of monitoring data. This must raise questions about the appropriateness of the projections provided by Defra.

4.3 In summary, while there are optimistic signs of an overall reduction in $NO_2$ and NOx concentrations across the UK as a whole, over the 11-year period, 2005 to 2016, there are important spatial differences which may have implications for air quality management. Furthermore, the evidence is that the projections provided to air quality practitioners have been, and possibly continue to be, over-optimistic. Further work is clearly required to understand these findings in order to ensure that the measures being put in place to improve air quality will deliver the expected reductions in concentrations. It will also be interesting to revisit trends in $NO_2$ and NOx once the ratified data for 2017 become available.

# 5 Tables

## Tables

**Table 1: Summary Results by for All UK and by Site Type**

| Name | Number of Sites | $NO_2$ | | NOx | |
|---|---|---|---|---|---|
| | | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) |
| **All UK** | | | | | |
| **All UK** | 156 | 34.46 | -1.50*** | 75.28 | -1.48*** |
| **By Site Type** | | | | | |
| **Road all UK** | 76 | 45.54 | -1.60*** | 112.89 | -1.60*** |
| **Urban all UK** | 63 | 27.60 | -1.48*** | 46.36 | -1.74*** |
| **Rural all UK** | 17 | 10.34 | -2.59*** | 14.28 | -2.47*** |

[a] Mean of all years and all sites

**Table 2: Summary Results for all Site Types for 3 Areas 1) Scotland and Northern Ireland, 2) Central & Northern England + North Wales, 3) Southern England and Southern Wales**

| Area | Number of Sites | $NO_2$ | | NOx | |
|---|---|---|---|---|---|
| | | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) |
| **Area 1 - Scotland and Northern Ireland** | 27 | 30.28 | -1.56*** | 78.75 | -1.51*** |
| **Area 2 - Central & Northern England + North** | 25 | 24.89 | -0.11 (n/s) | 45.62 | -0.04 (n/s) |
| **Area 3 Southern England and Southern Wales** | 104 | 36.83 | -1.66*** | 80.07 | -1.61** |

[a] Mean of all years and all sites

**Table 3: Summary Results by Site Type for 3 Areas 1) Scotland and Northern Ireland, 2) Central & Northern England + North Wales, 3) Southern England and Southern Wales**

| Name | Number of Sites | $NO_2$ | | NOx | |
|---|---|---|---|---|---|
| | | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) |
| **Area 1 - Scotland and Northern Ireland** | | | | | |
| **Road** | 18 | 39.02 | -1.48*** | 107.24 | -1.48*** |
| **Urban** | 6 | 22.87 | -2.32** | 39.36 | -2.32** |
| **Rural** | 3 | 5.80 | -3.68*** | 8.24 | -3.83*** |
| **Area 2 - Central & Northern England + North Wales** | | | | | |
| **Road** | 5 | 32.49 | -0.53 (n/s) | 75.35 | +0.15 (n/s) |
| **Urban** | 15 | 26.80 | -0.51 (n/s) | 45.39 | -1.07 (n/s) |
| **Rural** | 5 | 11.03 | -0.59 (n/s) | 15.65 | -0.67 (n/s) |
| **Area 3 Southern England and Southern Wales** | | | | | |
| **Road** | 53 | 49.63 | -1.68*** | 121.47 | -1.58*** |
| **Urban** | 42 | 28.66 | -1.78*** | 47.87 | -2.0* |
| **Rural** | 9 | 9.62 | -2.75*** | 12.86 | -2.44*** |

[a] Mean of all years and all sites

**Table 4: Summary Results by NOx Concentration for All UK Sites**

| Site NOx Concentration ($\mu g/m^3$) [a] | Number of Sites | $NO_2$ | | NOx | |
|---|---|---|---|---|---|
| | | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) | Mean Conc ($\mu g/m^3$) [a] | Mean Trend (%/yr) |
| **NOx >120 all UK** | 25 | 66.91 | -1.45*** | 182.27 | -0.99** |
| **NOx 80 - 120 all UK** | 31 | 42.89 | -1.59*** | 97.51 | -2.05*** |
| **NOx 40-80 all UK** | 52 | 30.59 | -1.37*** | 57.08 | -1.50* |
| **NOx <40 all UK** | 48 | 16.30 | -1.95*** | 24.90 | -2.16*** |

[a] Based on mean site concentration for all years

[b] Mean of all years and all sites

**Table 5: Summary Results by NOx Concentration for 3 Areas 1) Scotland and Northern Ireland, 2) Central & Northern England + North Wales, 3) Southern England and Southern Wales**

| Site NOx Concentration (µg/m$^3$) [a] | Number of Sites | $NO_2$ | | NOx | |
|---|---|---|---|---|---|
| | | Mean Conc (µg/m$^3$) [b] | Mean Trend (%/yr) | Mean Conc (µg/m$^3$) [b] | Mean Trend (%/yr) |
| **Area 1 - Scotland and Northern Ireland** | | | | | |
| **NOx >120** | 4 | 61.56 | -1.28*** | 200.25 | -1.21* |
| **NOx 80 - 120** | 7 | 35.95 | -2.24*** | 90.26 | -2.45*** |
| **NOx 40-80** | 9 | 26.36 | -0.89 (n/s) | 54.98 | -0.88 (n/s) |
| **NOx <40** | 7 | 9.67 | -3.4*** | 14.73 | -3.32*** |
| **Area 2 - Central & Northern England + North Wales** | | | | | |
| **NOx >120** | 1 | 53.12 | +3.56*** | 149.34 | +3.74*** |
| **NOx 80 - 120** | 1 | 39.71 | -2.32*** | 102.43 | -0.67 (n/s) |
| **NOx 40-80** | 9 | 31.70 | -0.83 (n/s) | 56.93 | -1.28+ |
| **NOx <40** | 14 | 16.76 | -0.36 (n/s) | 24.89 | -0.91 (n/s) |
| **Area 3 Southern England and Southern Wales** | | | | | |
| **NOx >120** | 20 | 69.66 | -1.58*** | 184.38 | -1.11** |
| **NOx 80 - 120** | 23 | 45.43 | -1.29*** | 99.27 | -1.89*** |
| **NOx 40-80** | 34 | 30.41 | -1.71*** | 55.79 | -1.77* |
| **NOx <40** | 27 | 15.55 | -2.27*** | 22.75 | -2.33*** |

[a] Based on mean site concentration for all years

[b] Mean of all years and all sites

# 6 Figures

## Figures

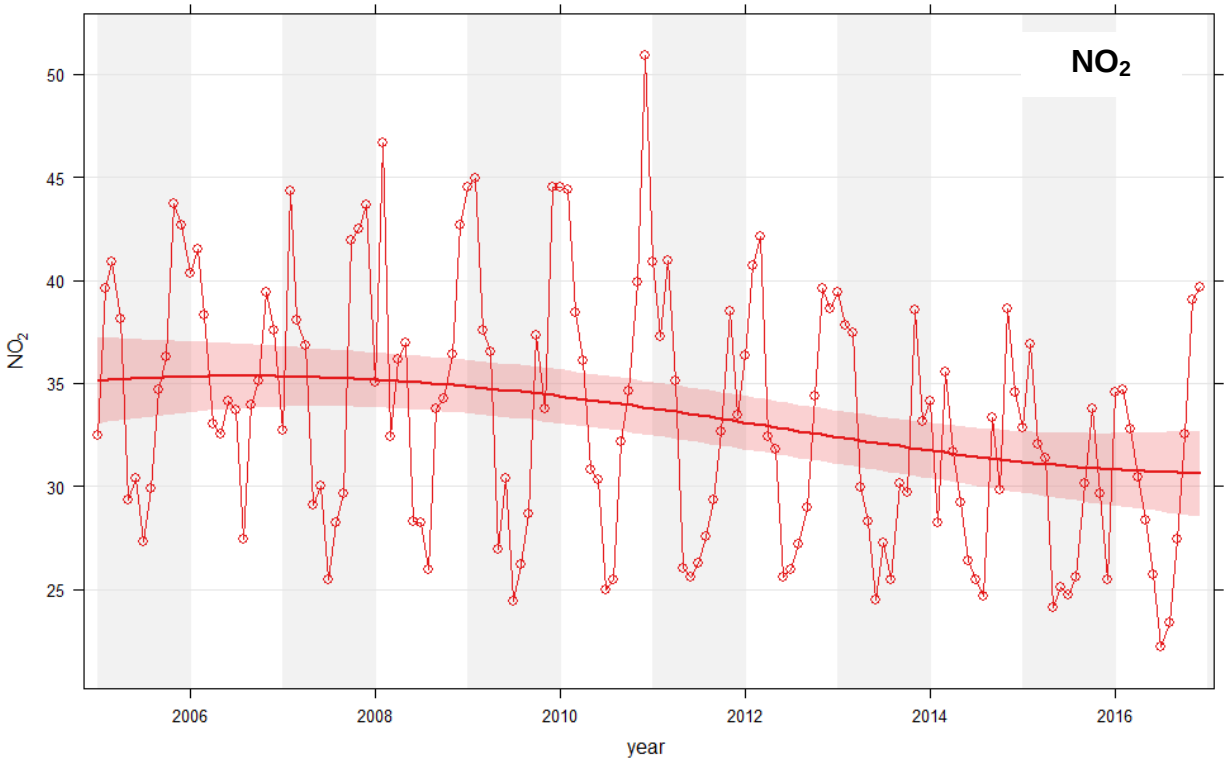


**Figure 1: Overall $NO_2$ Trend across All UK Sites and SmoothTrend Fit**

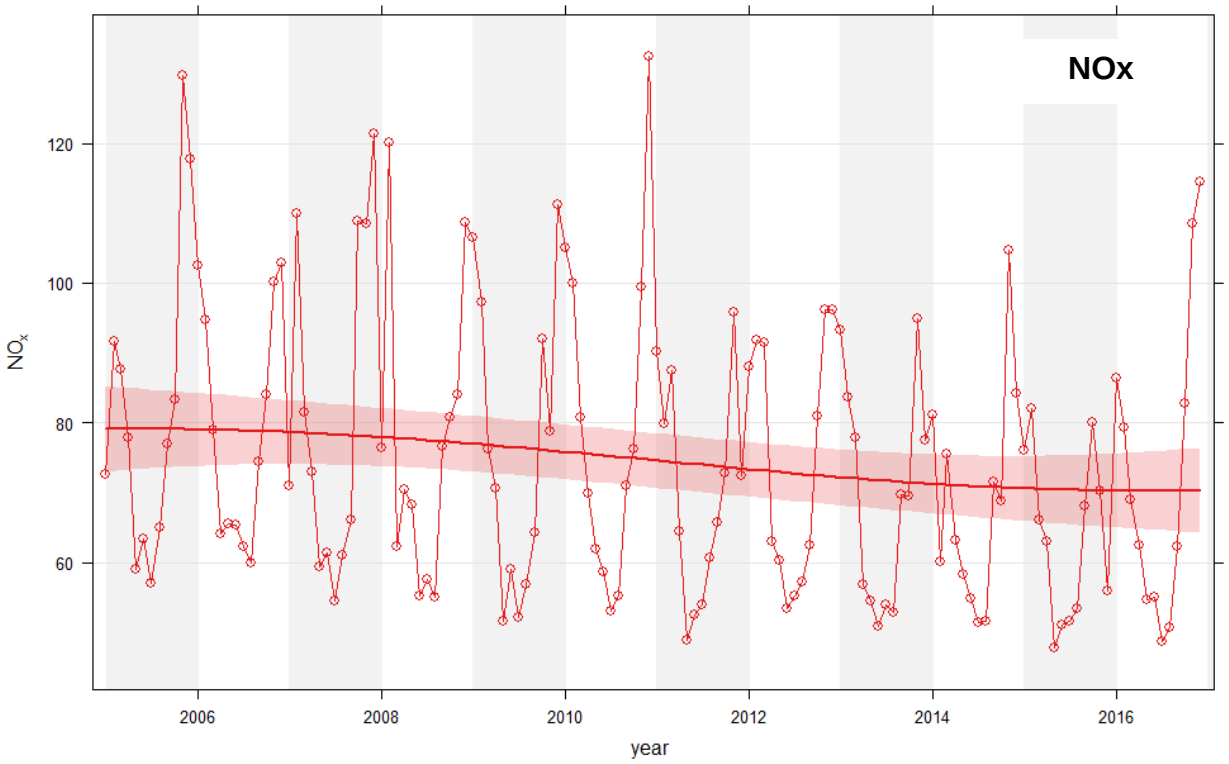


**Figure 2: Overall NOx Trend across All UK Sites and SmoothTrend Fit**

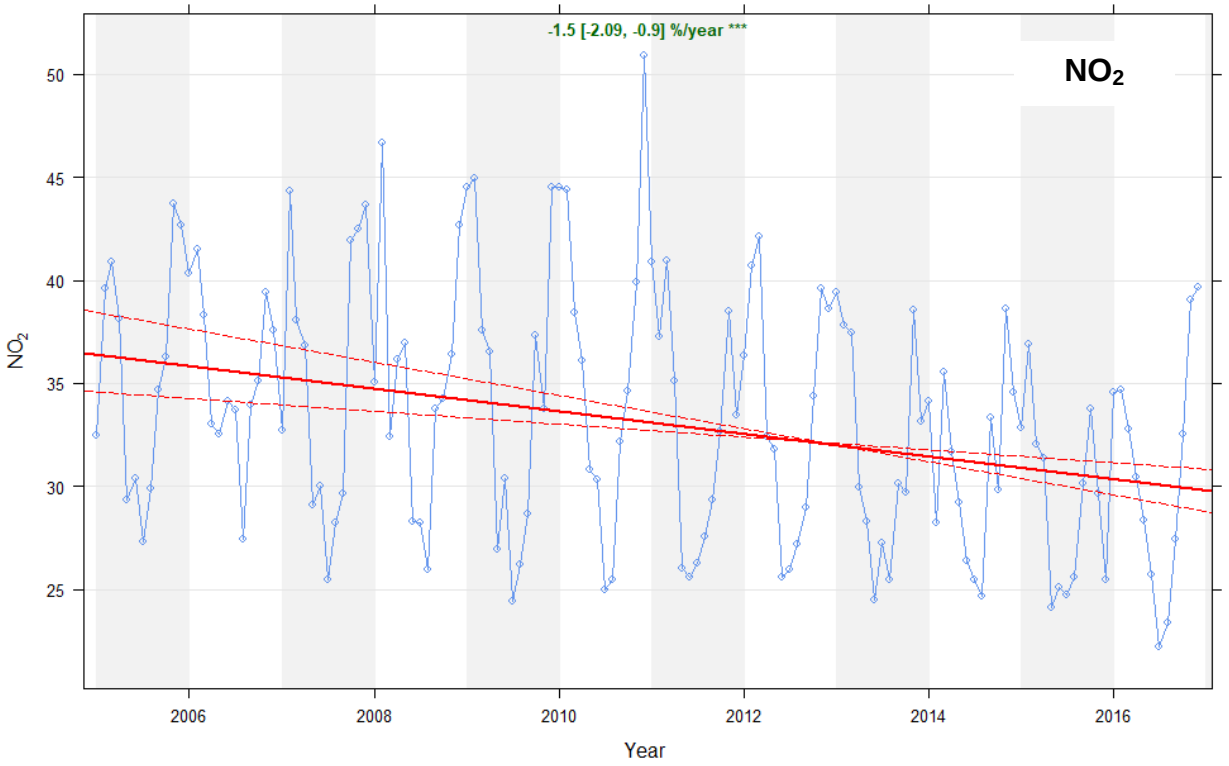


**Figure 3: Overall $NO_2$ Trend across All UK Sites and TheilSen Fit (% per yr)**

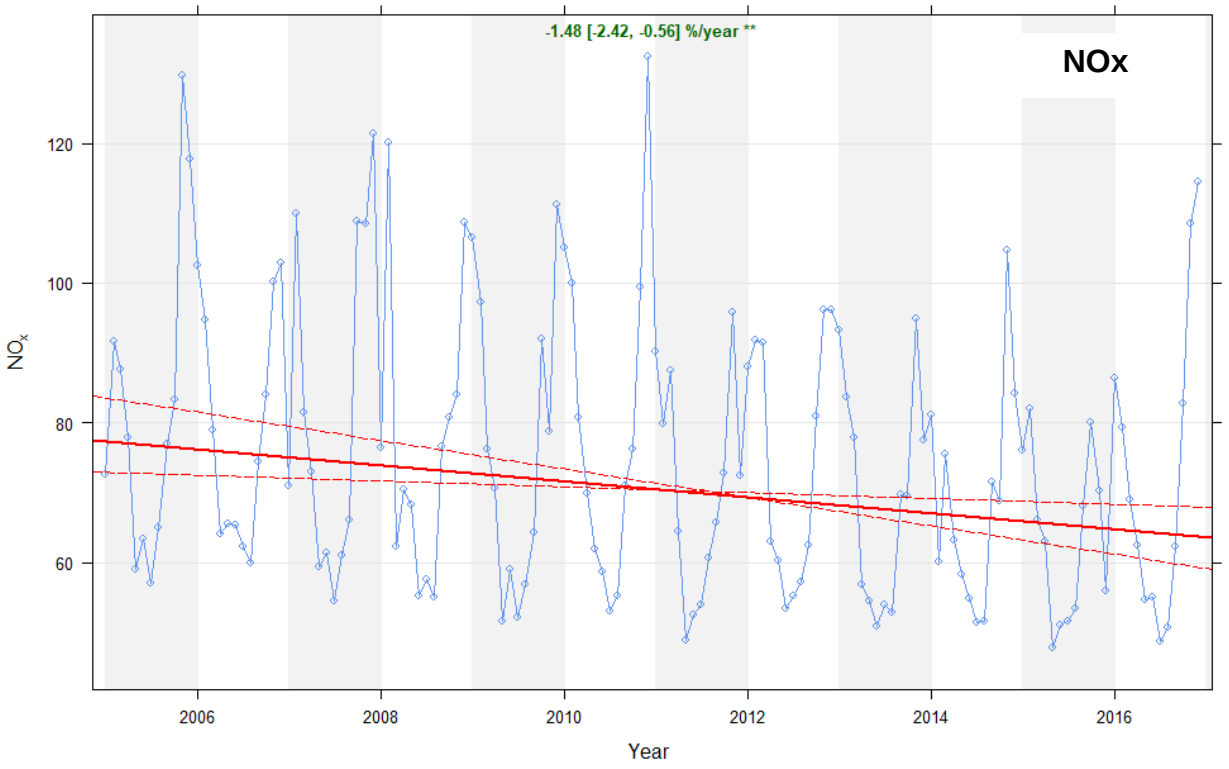


**Figure 4: Overall NOx Trend across All UK Sites and TheilSen Fit (% per yr)**

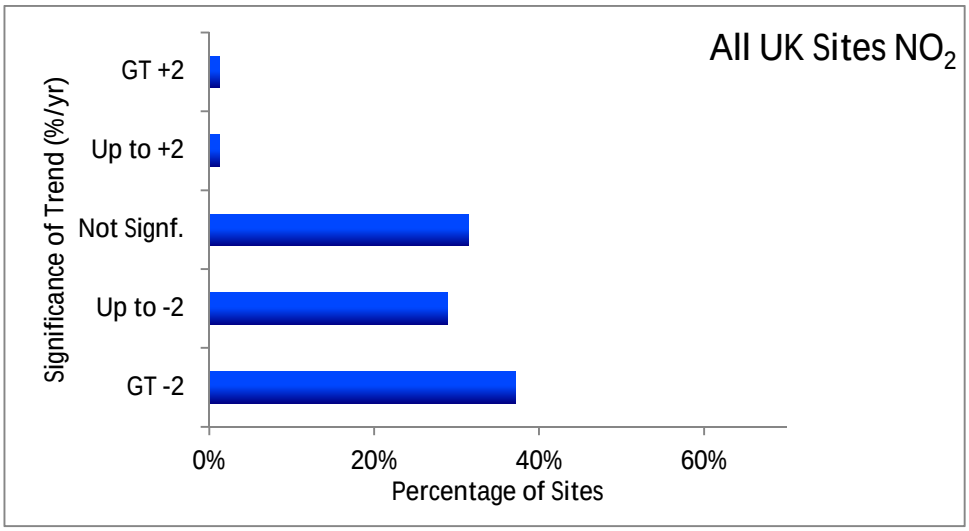


**Figure 5: Significance of $NO_2$ Trends at All UK Sites**

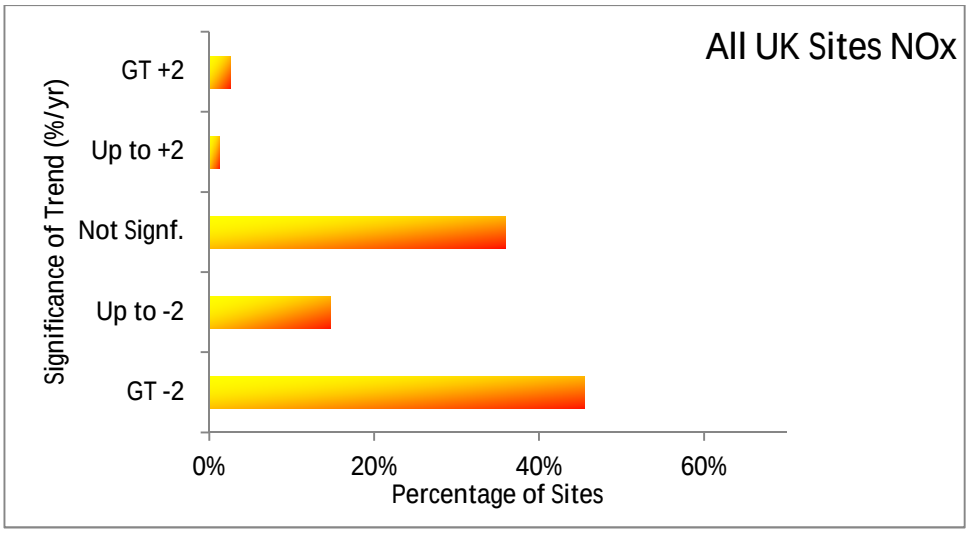


**Figure 6: Significance of NOx Trends at All UK Sites**

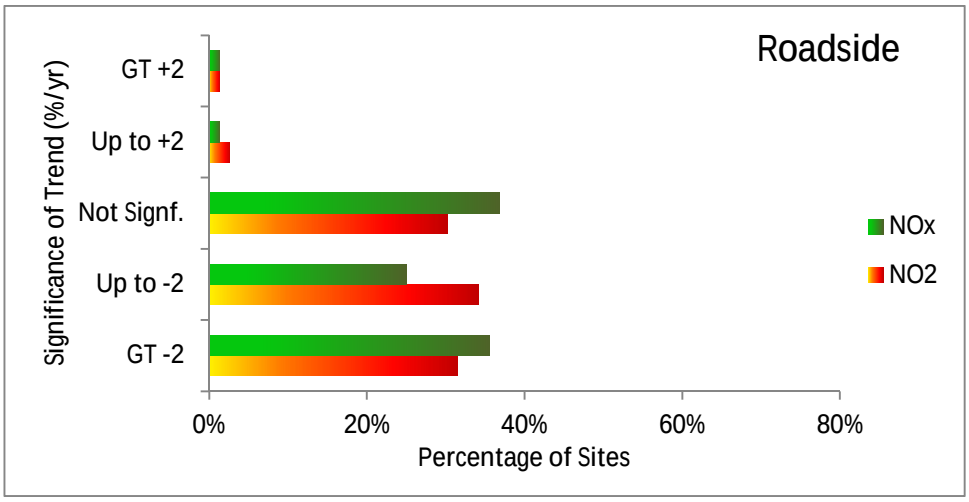


**Figure 7: Significance of $NO_2$ and $NO_x$ Trends at All UK Roadside Sites**

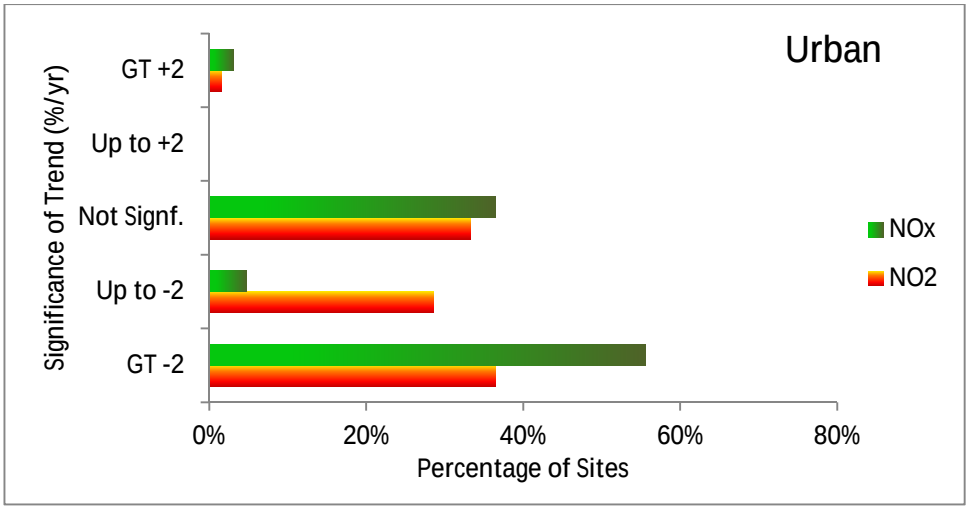


**Figure 8: Significance of $NO_2$ and $NO_x$ Trends at All UK Urban Sites**

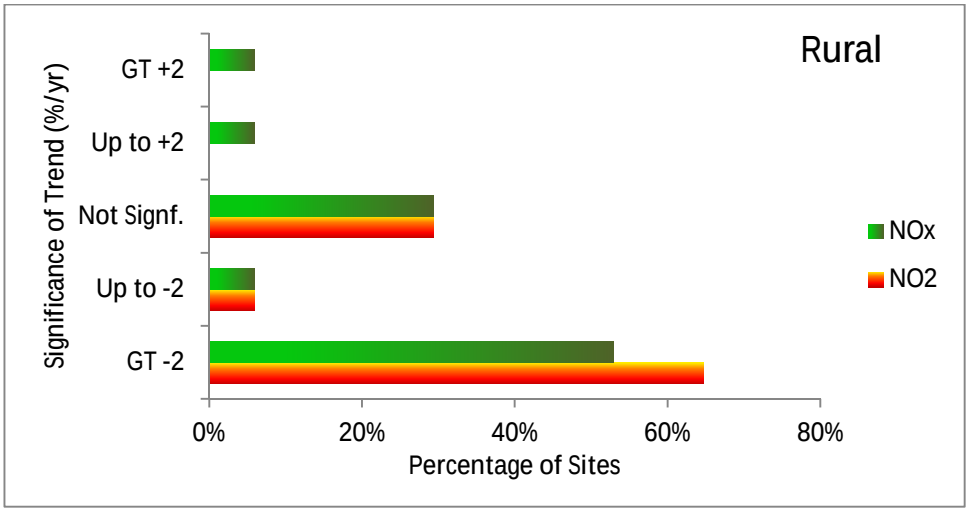


**Figure 9: Significance of $NO_2$ and NOx Trends at All UK Rural Sites**

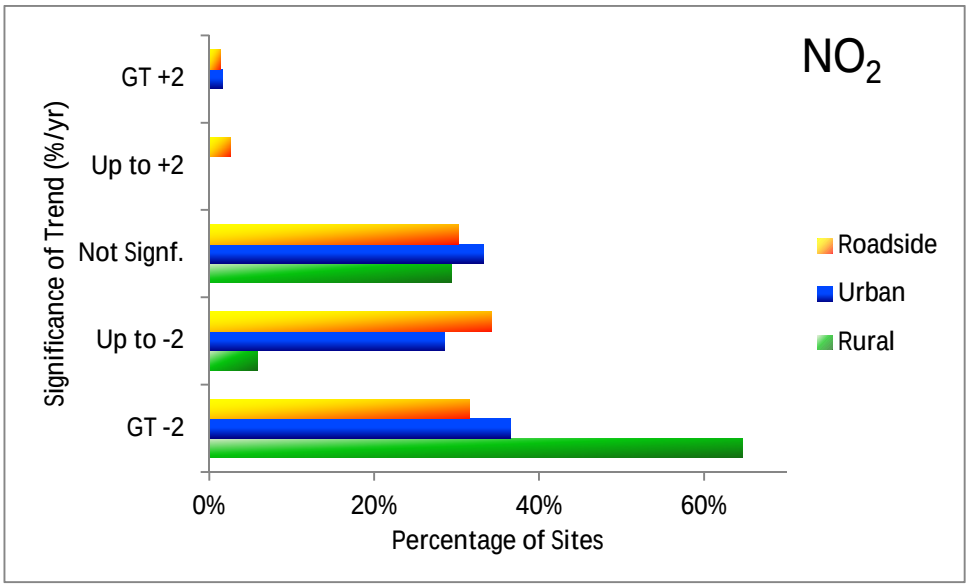


**Figure 10: Significance of $NO_2$ Trends at All UK Sites**

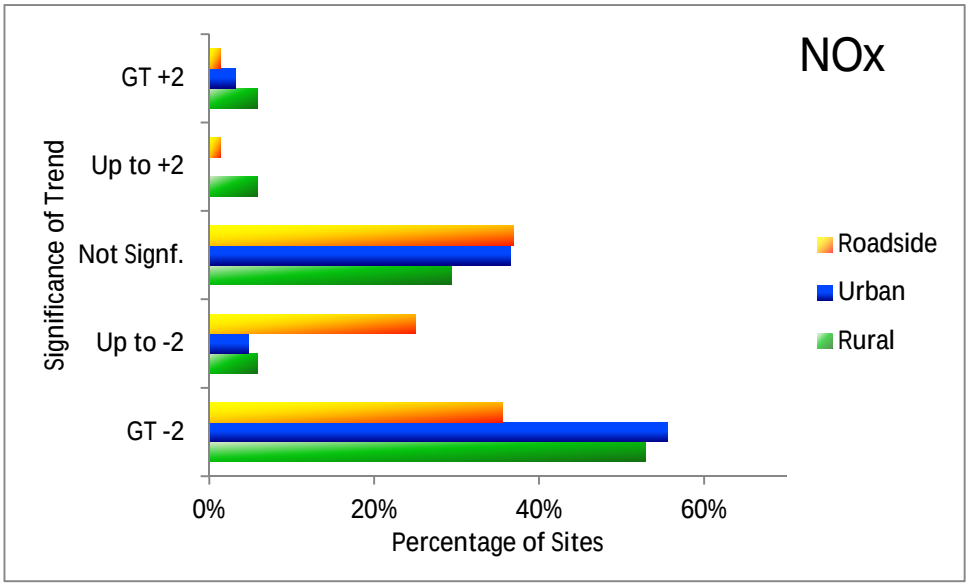


**Figure 11: Significance of NOx Trends at All UK Sites**

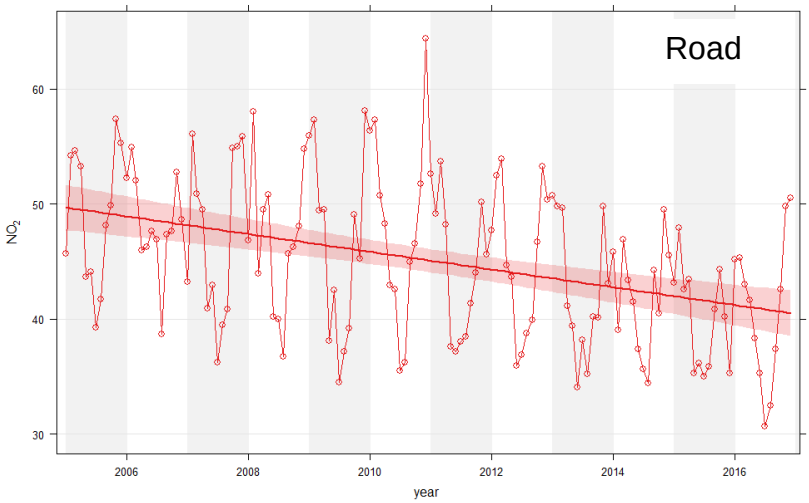


**Figure 12: Overall $NO_2$ Trend across All UK Road Sites and SmoothTrend Fit**

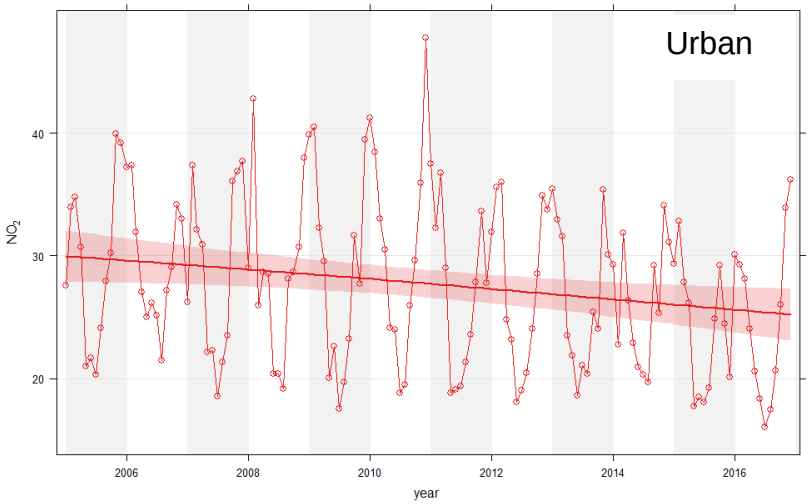


**Figure 13: Overall $NO_2$ Trend across All UK Urban Sites and SmoothTrend Fit**

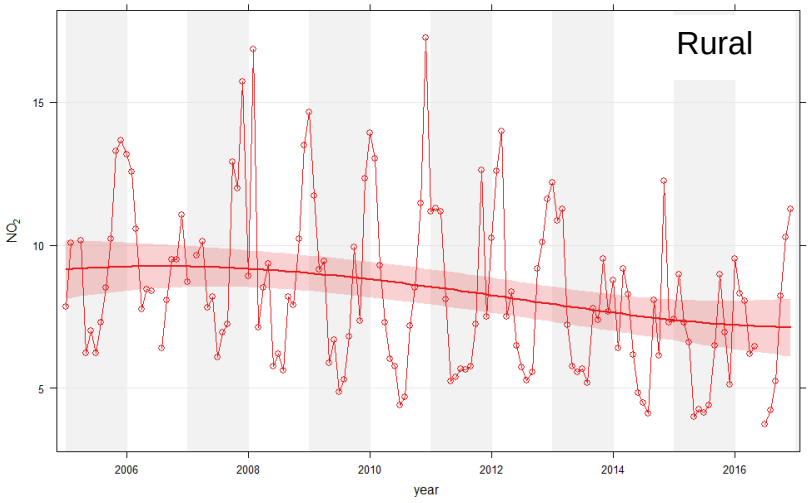


**Figure 14: Overall $NO_2$ Trend across All UK Rural Sites and SmoothTrend Fit**


**Figure 15: Overall NOx Trend across All UK Road Sites and SmoothTrend Fit**

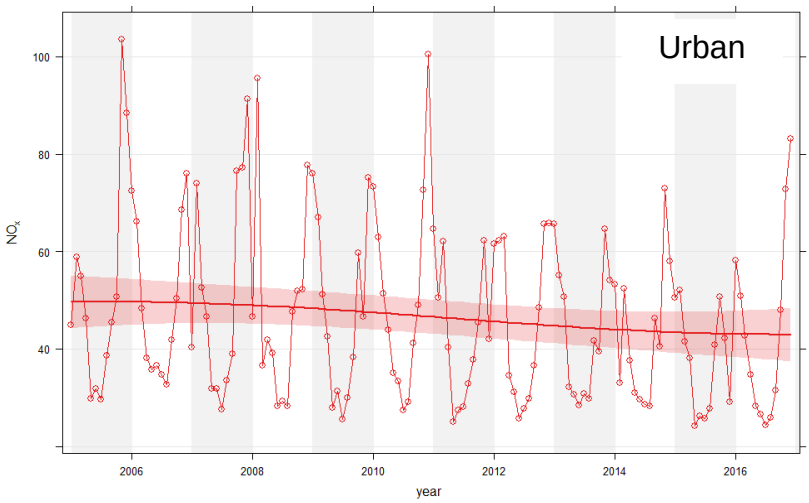


**Figure 16: Overall NOx Trend across All UK Urban Sites and SmoothTrend Fit**


**Figure 17: Overall NOx Trend across All UK Rural Sites and SmoothTrend Fit**

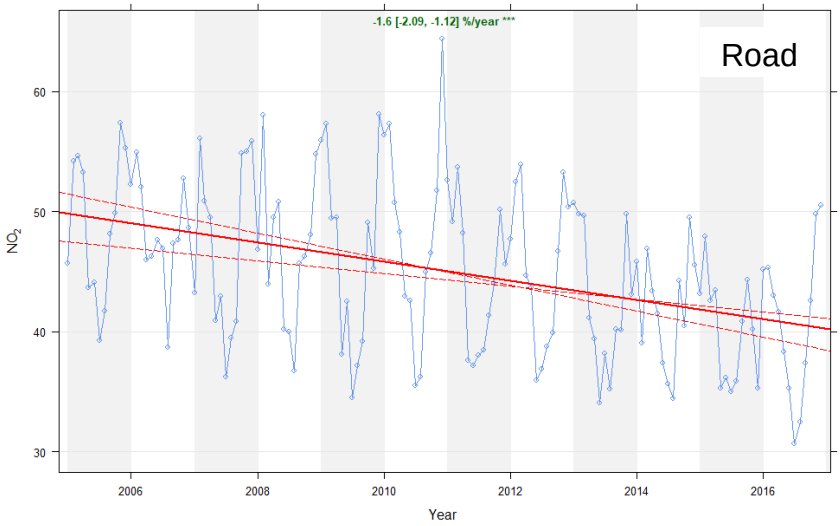


**Figure 18: Overall $NO_2$ Trend across All UK Road Sites and TheilSen Fit (% per yr)**

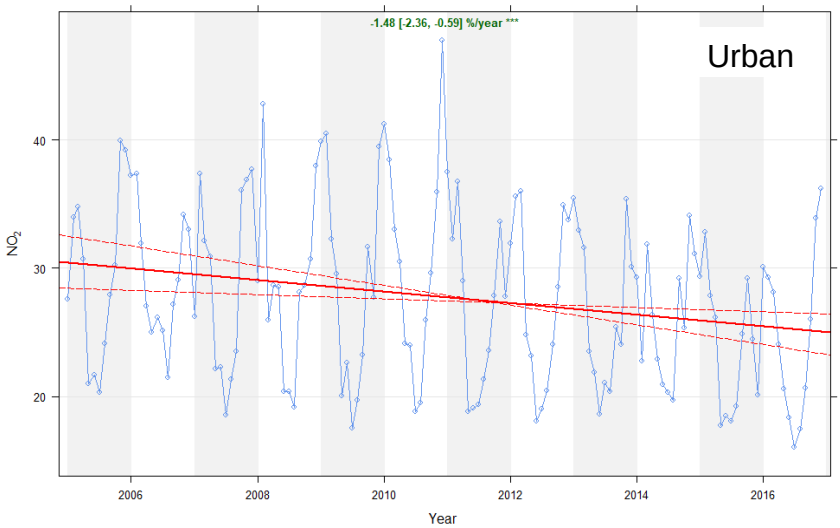


**Figure 19: Overall $NO_2$ Trend across All UK Urban Sites and TheilSen Fit (% per yr)**

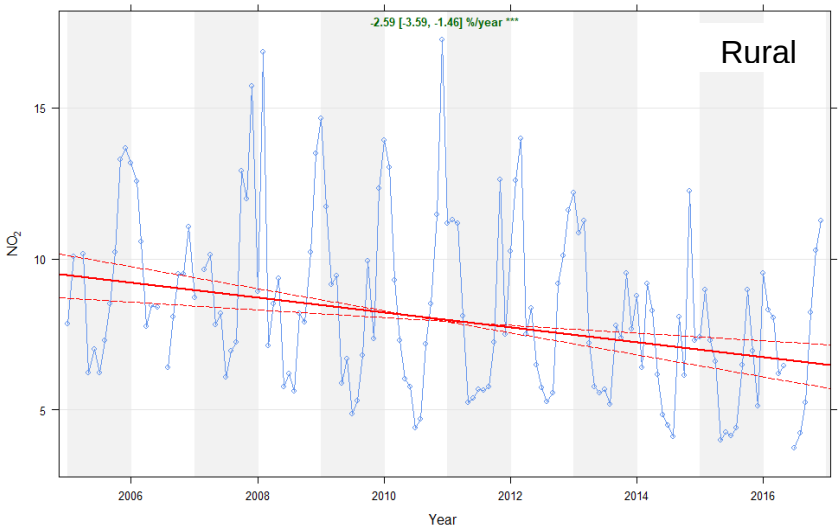


**Figure 20: Overall $NO_2$ Trend across All UK Rural Sites and TheilSen Fit (% per yr)**

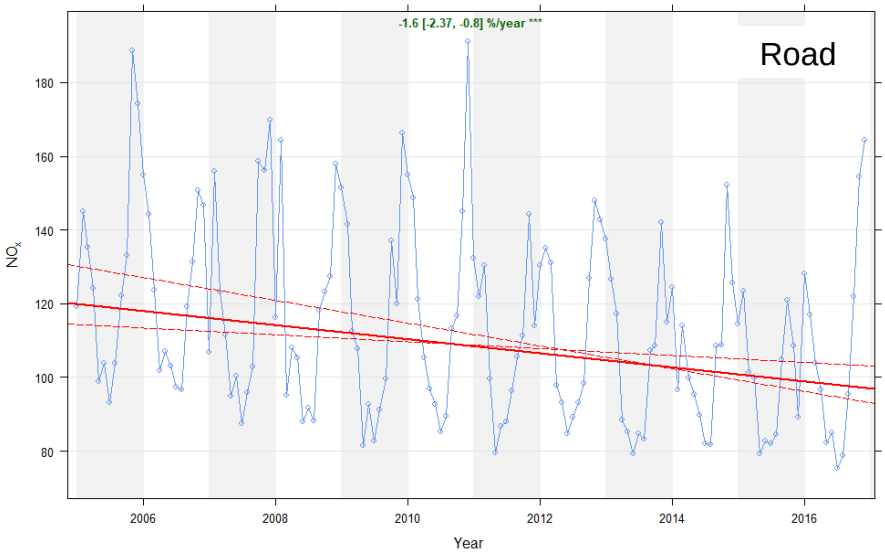


**Figure 21: Overall NOx Trend across All UK Road Sites and TheilSen Fit (% per yr)**

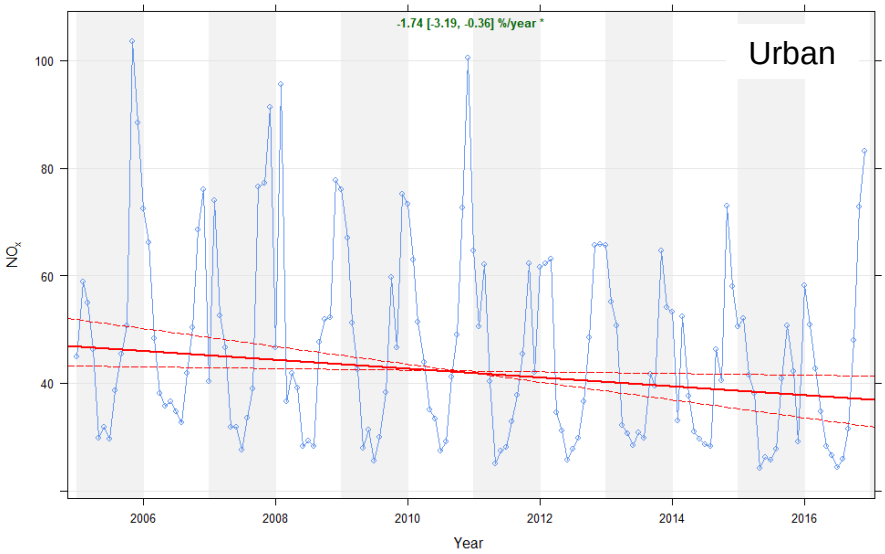


**Figure 22: Overall NOx Trend across All UK Urban Sites and TheilSen Fit (% per yr)**

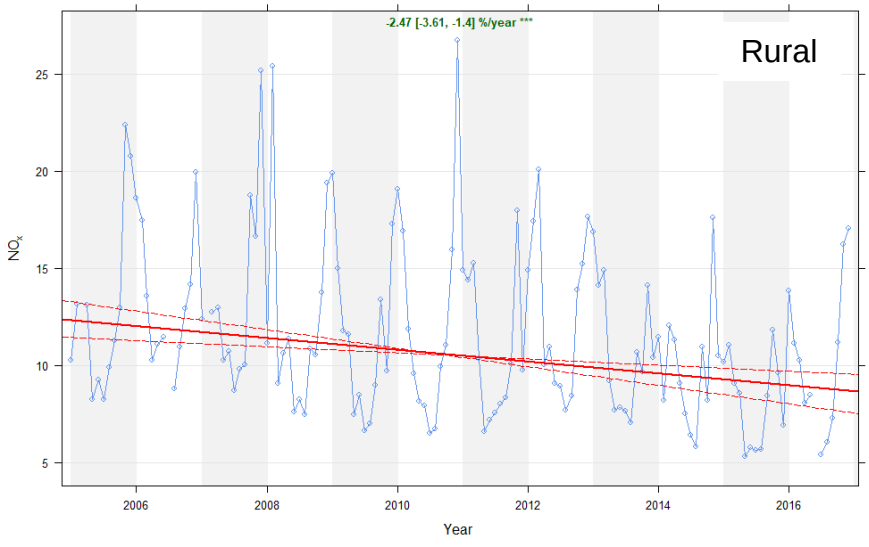


**Figure 23: Overall NOx Trend across All UK Rural Sites and TheilSen Fit (% per yr)**

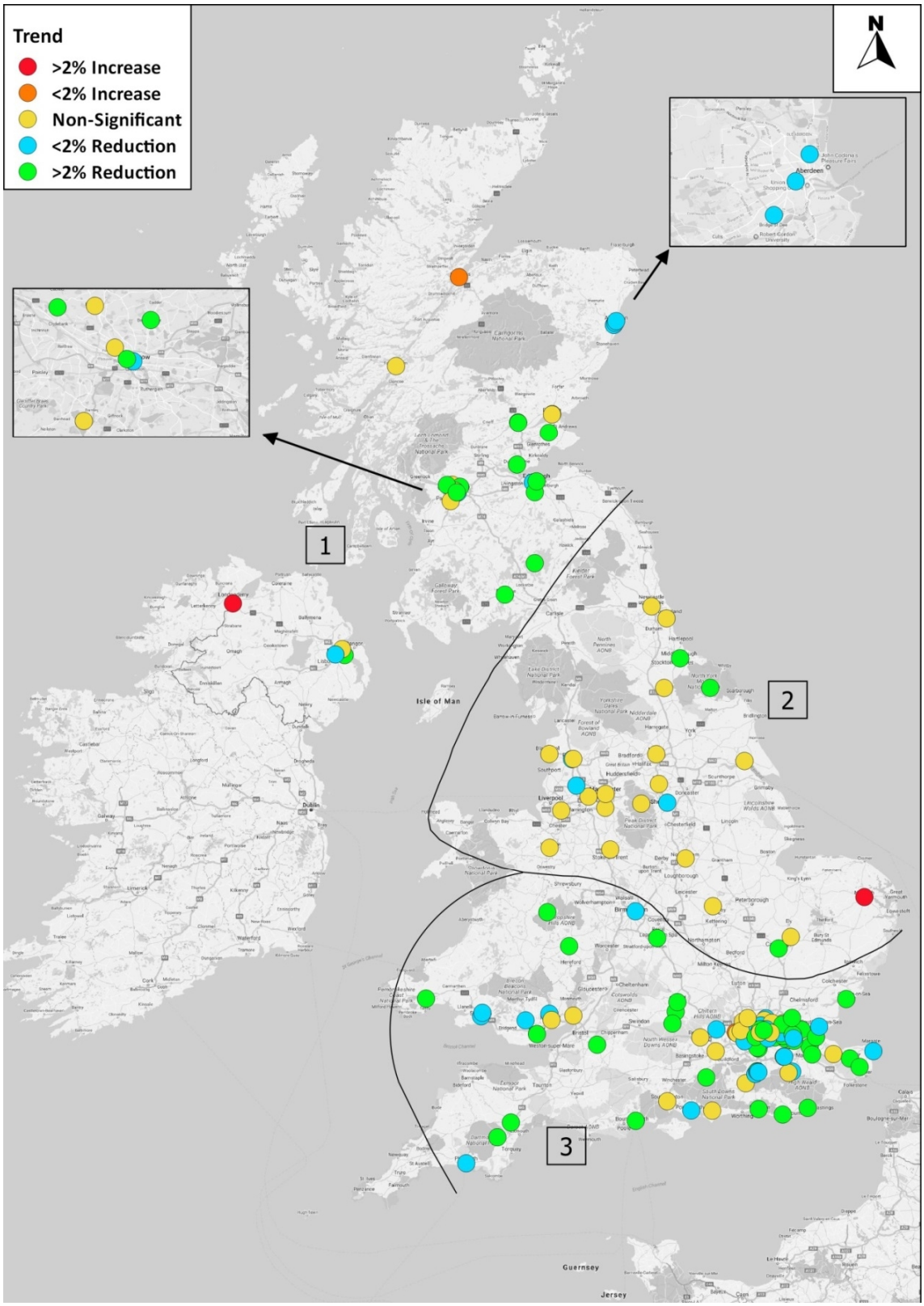


**Figure 24** **Significance of $NO_2$ Trends at All UK Sites and for 3 Areas 1) Scotland and Northern Ireland, 2) Central & Northern England + North Wales, 3) Southern England and Southern Wales**

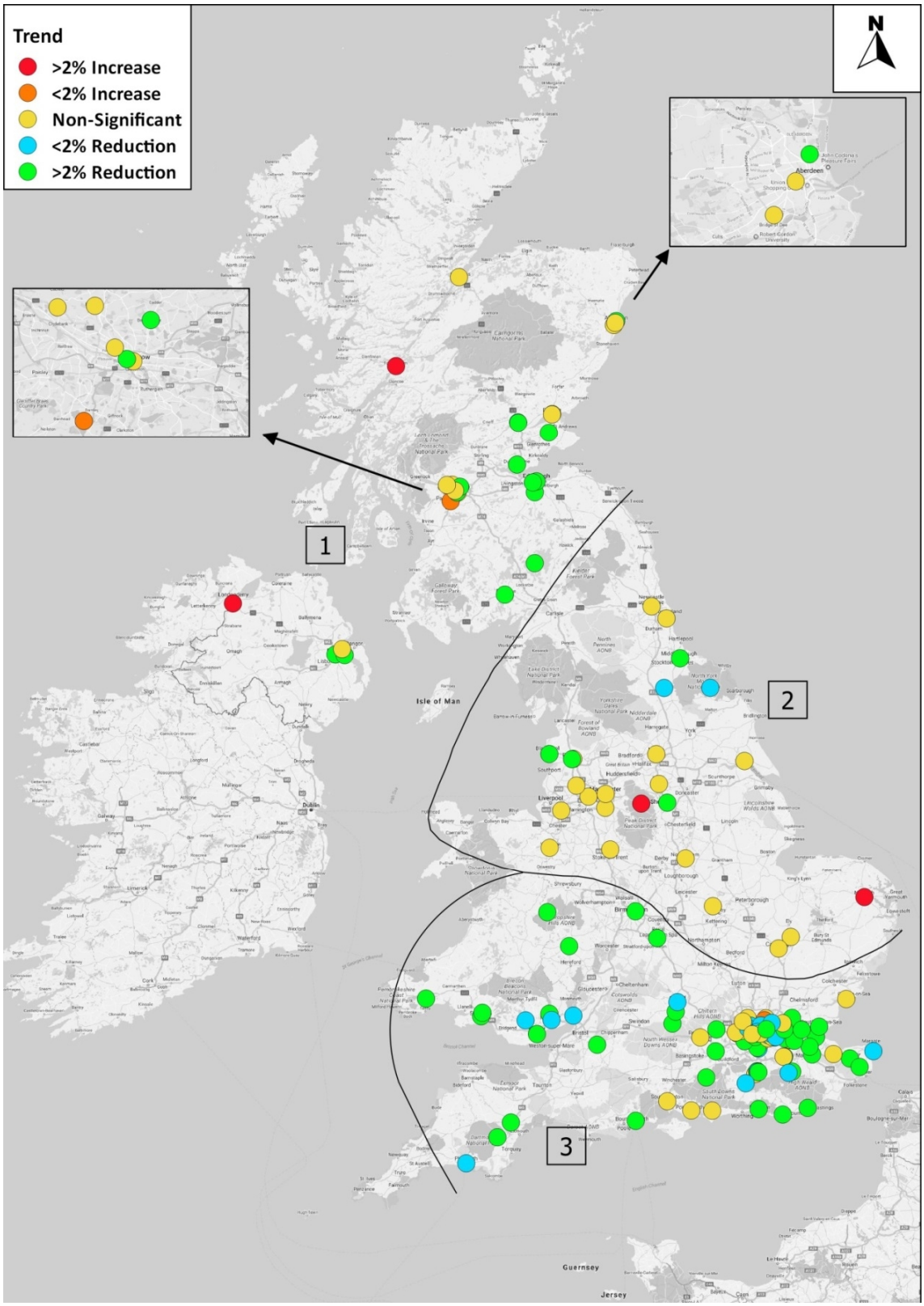


**Figure 25: Significance of NOx Trends at All UK Sites and for 3 Areas 1) Scotland and Northern Ireland, 2) Central & Northern England + North Wales, 3) Southern England and Southern Wales**

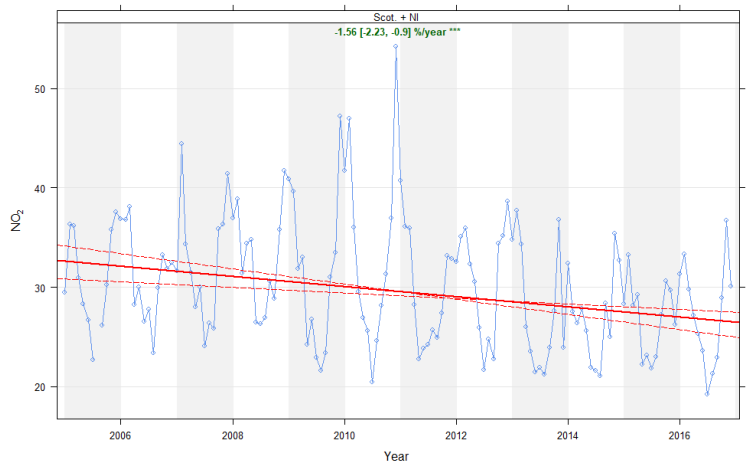


**Figure 26: Overall $NO_2$ Trend across All Sites in Scotland and Northern Ireland, with TheilSen Fit (% per yr)**

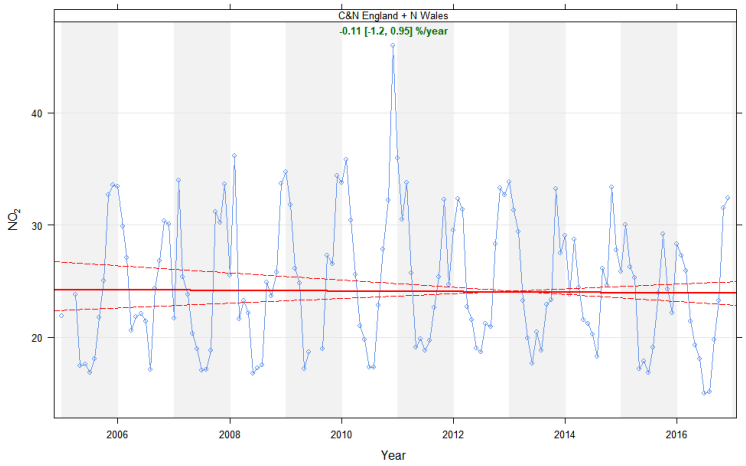


**Figure 27: Overall $NO_2$ Trend across All Sites in Central and Northern England and Northern Wales, with TheilSen Fit (% per yr)**

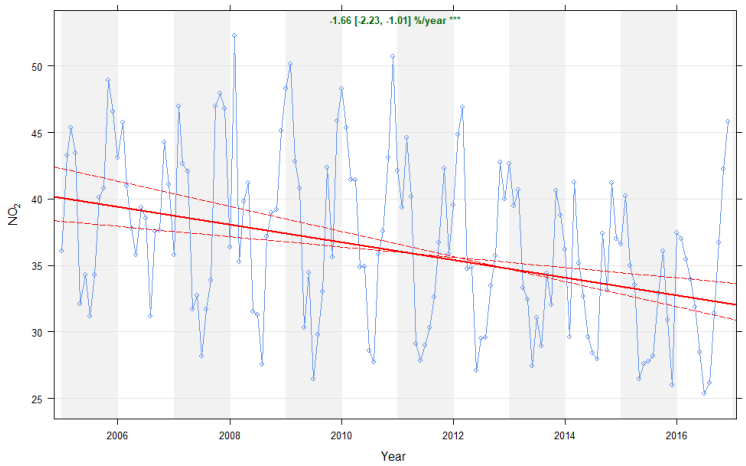


**Figure 28: Overall $NO_2$ Trend across All Sites in Southern England and Southern Wales, with TheilSen Fit (% per yr)**

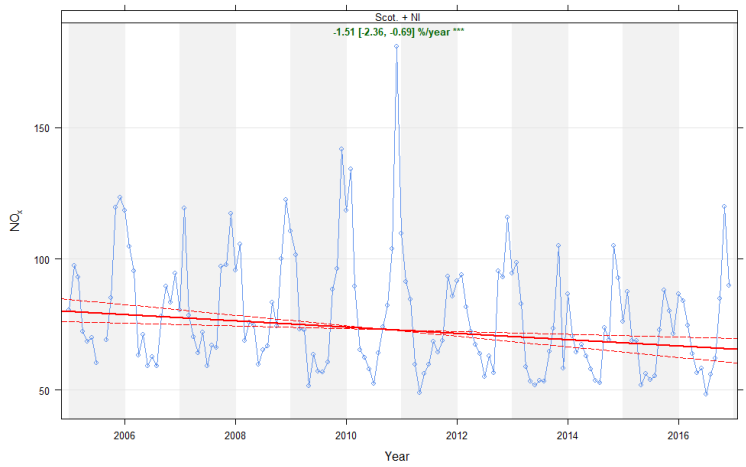


**Figure 29: Overall NOx Trend across All Sites in Scotland and Northern Ireland, with TheilSen Fit (% per yr)**

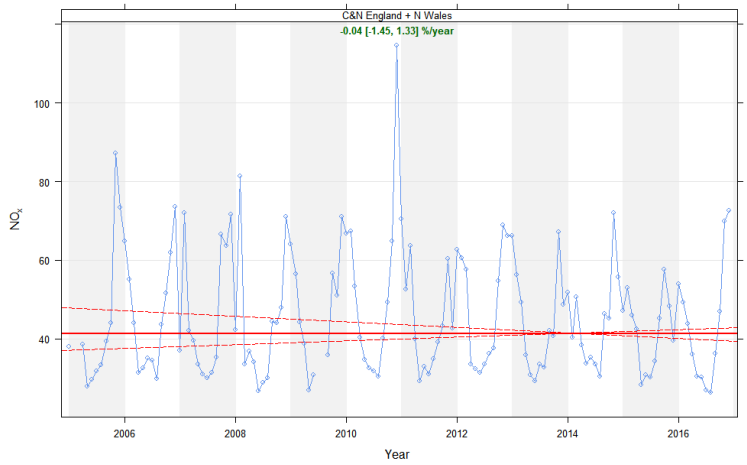


**Figure 30: Overall NOx Trend across All Sites in Central and Northern England and Northern Wales, with TheilSen Fit (% per yr)**

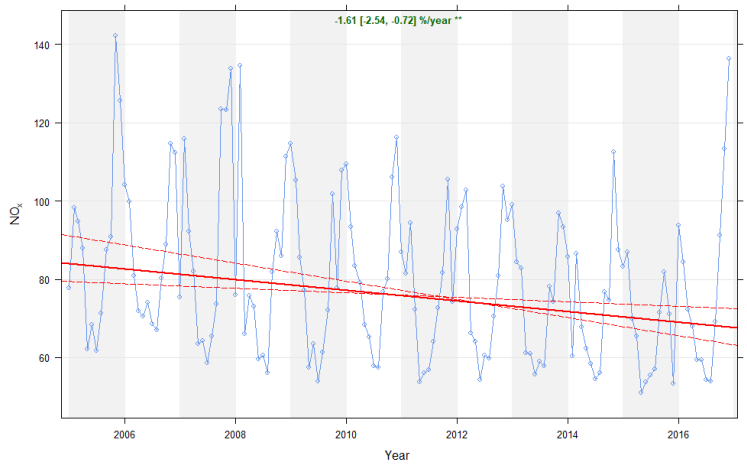


**Figure 31: Overall NOx Trend across All Sites in Southern England and Southern Wales, with TheilSen Fit (% per yr)**

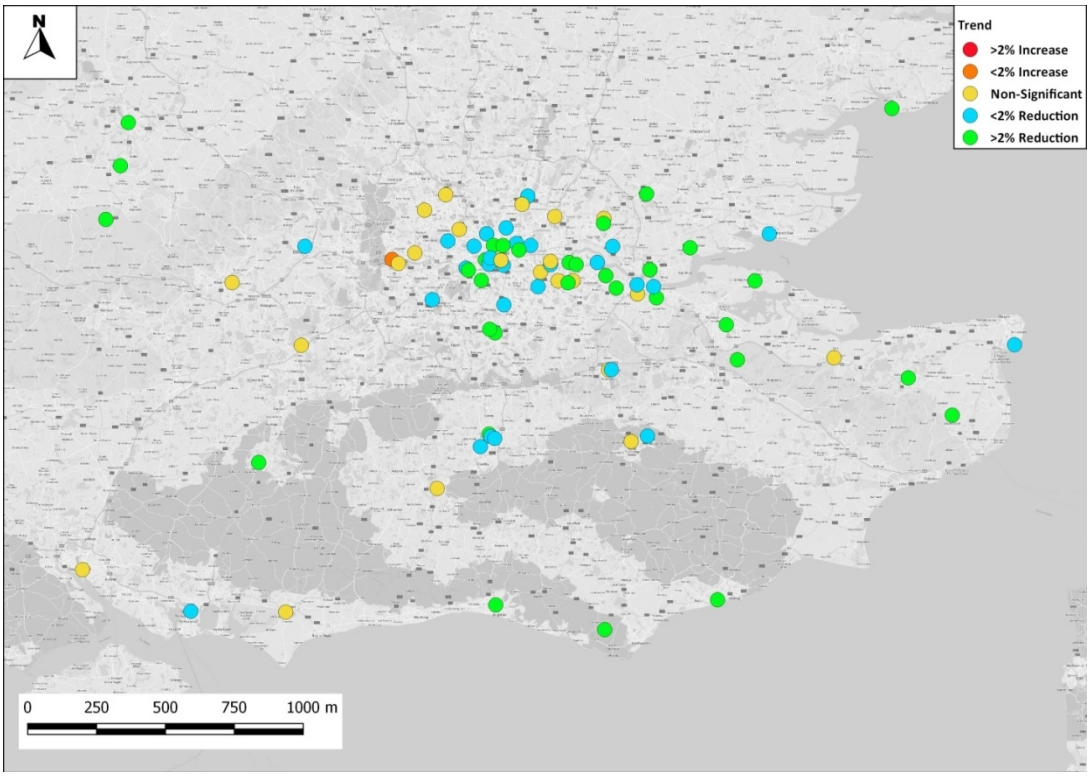


**Figure 32: Significance of $NO_2$ Trends at All Sites in London and SE England**



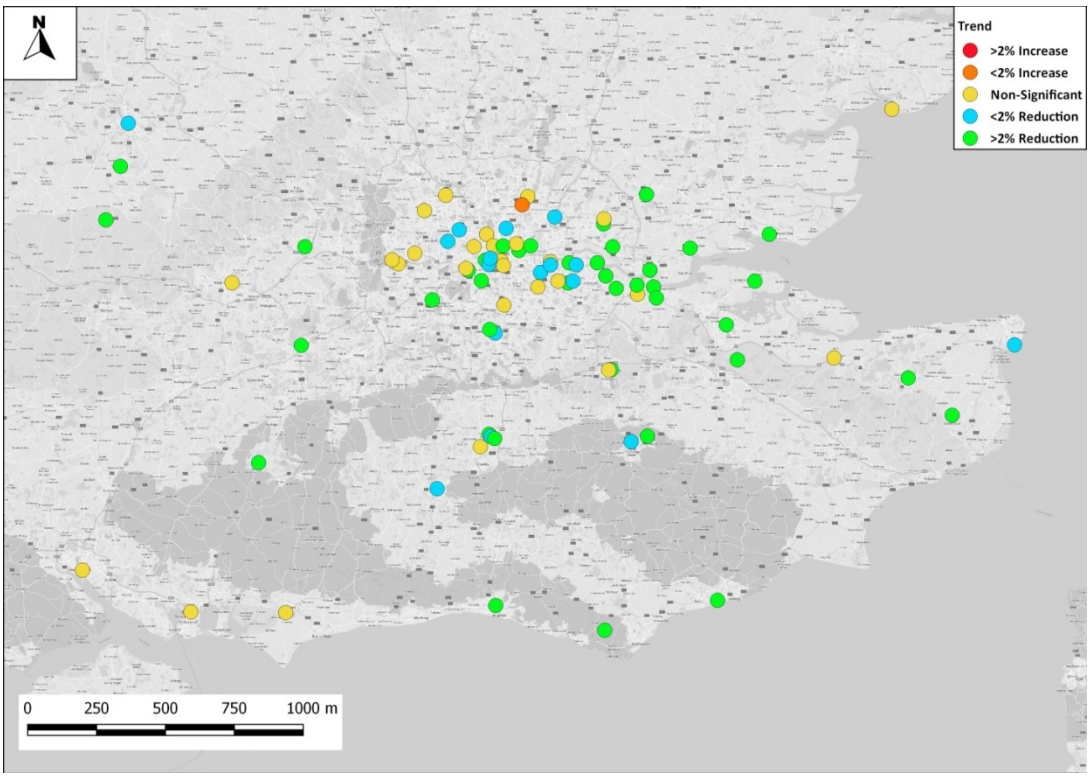


**Figure 33: Significance of $NO_x$ Trends at All Sites in London and SE England**

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Carslaw D. C. and Ropkins, K. (2012) openair - An R package for air quality data analysis, Environmental Modelling & Software, 52-61, Vol 27-28

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# 8 Appendices

# A1 Included sites

A1.1 Table A1.1 is a list of the sites included in the analyses set out in this report, together with the Network that they are part of and the categorisation by site type and geographic area. Table A1.2 is a list of the sites excluded from further analysis.

**Table A1.1 Sites Included in the Analyses and their Categorisation**

| Name | Code | Network | Type | Category | Area [a] |
|---|---|---|---|---|---|
| **Aberdeen** | ABD | AURN | Urban Background | Urban | 1 |
| **Aston Hill** | AH | AURN | Rural Background | Rural | 3 |
| **Barnsley Gawber** | BAR3 | AURN | Urban Background | Urban | 2 |
| **Bath Roadside** | BATH | AURN | Roadside | Road | 3 |
| **Belfast Centre** | BEL2 | AURN | Urban Background | Urban | 1 |
| **Birmingham Tyburn** | BIR1 | AURN | Urban Background | Urban | 3 |
| **Blackpool Marton** | BLC2 | AURN | Urban Background | Urban | 2 |
| **Bournemouth** | BORN | AURN | Urban Background | Urban | 3 |
| **Brighton Preston Park** | BRT3 | AURN | Urban Background | Urban | 3 |
| **Bush Estate** | BUSH | AURN | Rural Background | Rural | 1 |
| **Cambridge roadside** | CAM | AURN | Roadside | Road | 2 |
| **Camden Kerbside** | CA1 | AURN | Kerbside | Road | 3 |
| **Canterbury** | CANT | AURN | Urban Background | Urban | 3 |
| **Cardiff Centre** | CARD | AURN | Urban Background | Urban | 3 |
| **Derry** | DERY | AURN | Urban Background | Urban | 1 |
| **Dumfries** | DUMF | AURN | Roadside | Road | 1 |
| **Edinburgh St Leonards** | ED3 | AURN | Urban Background | Urban | 1 |
| **Eskdalemuir** | ESK | AURN | Rural Background | Rural | 1 |
| **Exeter Roadside** | EX | AURN | Roadside | Road | 3 |
| **Glasgow Kerbside** | GLA4 | AURN | Kerbside | Road | 1 |
| **Glazebury** | GLAZ | AURN | Rural Background | Rural | 2 |
| **Harwell** | HAR | AURN | Rural Background | Rural | 3 |
| **High Muffles** | HM | AURN | Rural Background | Rural | 2 |
| **Hull Freetown** | HL2 | AURN | Urban Background | Urban | 2 |
| **Inverness** | INV2 | AURN | Roadside | Road | 1 |
| **Ladybower** | LB | AURN | Rural Background | Rural | 2 |
| **Leamington Spa** | LEAM | AURN | Urban Background | Urban | 3 |
| **Leeds Centre** | LEED | AURN | Urban Background | Urban | 2 |
| **Leominster** | LEOM | AURN | Suburban | Urban | 3 |
| **Liverpool Speke** | LVP | AURN | Urban Background | Urban | 2 |
| **London Bexley** | BEX | AURN | Suburban | Urban | 3 |
| **London Bloomsbury** | CLL2 | AURN | Urban Background | Urban | 3 |

| Name | Code | Network | Type | Category | Area [a] |
|---|---|---|---|---|---|
| **London Eltham** | LON6 | AURN | Suburban | Urban | 3 |
| **London Harlington** | HRL | AURN | Urban Background | Urban | 3 |
| **London Hillingdon** | HIL | AURN | Roadside | Road | 3 |
| **London N. Kensington** | KC1 | AURN | Urban Background | Urban | 3 |
| **London Teddington** | TED | AURN | Urban Background | Urban | 3 |
| **London Westminster** | HORS | AURN | Urban Background | Urban | 3 |
| **Lullington Heath** | LH | AURN | Rural Background | Rural | 3 |
| **Manchester Piccadilly** | MAN3 | AURN | Urban Background | Urban | 2 |
| **Manchester South** | MAN4 | AURN | Suburban | Urban | 2 |
| **Market Harborough** | MKTH | AURN | Rural Background | Rural | 2 |
| **Middlesbrough** | MID | AURN | Urban Background | Urban | 2 |
| **Narberth** | PEMB | AURN | Rural Background | Rural | 3 |
| **Newcastle Centre** | NEWC | AURN | Urban Background | Urban | 2 |
| **Nottingham Centre** | NOTT | AURN | Urban Background | Urban | 2 |
| **Oxford Centre Road** | OX | AURN | Roadside | Road | 3 |
| **Plymouth Centre** | PLYM | AURN | Urban Background | Urban | 3 |
| **Portsmouth** | PMTH | AURN | Urban Background | Urban | 3 |
| **Preston** | PRES | AURN | Urban Background | Urban | 2 |
| **Reading New Town** | REA1 | AURN | Urban Background | Urban | 3 |
| **Rochester Stoke** | ROCH | AURN | Rural Background | Rural | 3 |
| **Sheffield Tinsley** | SHE | AURN | Urban Background | Urban | 2 |
| **Southampton Centre** | SOUT | AURN | Urban | Urban | 3 |
| **Southend-on-Sea** | SEND | AURN | Urban | Urban | 3 |
| **Stoke-on-Trent Centre** | STOK | AURN | Urban | Urban | 2 |
| **St Osyth** | OSY | AURN | Rural Background | Rural | 3 |
| **Sunderland Silksworth** | SUN2 | AURN | Urban | Urban | 2 |
| **Thurrock** | THUR | AURN | Urban | Urban | 3 |
| **Tower Hamlets Roadside** | TH2 | AURN | Roadside | Road | 3 |
| **Wicken Fen** | WFEN | AURN | Rural Background | Rural | 2 |
| **Wigan Centre** | WIG5 | AURN | Urban | Urban | 2 |
| **Wrexham** | WREX | AURN | Roadside | Road | 2 |
| **Yarner Wood** | YW | AURN | Rural Background | Rural | 3 |
| **Barking and Dagenham – Rush Green** | BG1 | KCL | Suburban | Urban | 3 |

| Name | Code | Network | Type | Category | Area [a] |
|---|---|---|---|---|---|
| **Bexley - Belvedere** | BX2 | KCL | Suburban | Urban | 3 |
| **Bexley – Slade Green** | BX1 | KCL | Suburban | Urban | 3 |
| **Brent - Ikea** | BT4 | KCL | Roadside | Road | 3 |
| **Brentwood – Brentwood Town Hall** | BW1 | KCL | Urban | Urban | 3 |
| **Camden – Swiss Cottage** | CD1 | KCL | Kerbside | Road | 3 |
| **City of London – Sir John Cass School** | CT3 | KCL | Urban | Urban | 3 |
| **Croydon - Norbury** | CR5 | KCL | Kerbside | Road | 3 |
| **Ealing - Hanger Lane Gyratory** | EA6 | KCL | Roadside | Road | 3 |
| **Ealing - Southall** | EA7 | KCL | Urban | Urban | 3 |
| **Enfield – Derby Road** | EN4 | KCL | Roadside | Road | 3 |
| **Greenwich and Bexley - Falconwood** | GB6 | KCL | Roadside | Road | 3 |
| **Greenwich - A206 Burrage Grove** | GN0 | KCL | Roadside | Road | 3 |
| **Greenwich - Blackheath** | GR7 | KCL | Roadside | Road | 3 |
| **Greenwich – Millennium Village** | GN2 | KCL | Urban | Urban | 3 |
| **Greenwich – Plumstead High Street** | GN3 | KCL | Roadside | Road | 3 |
| **Greenwich – Westhorne Avenue** | GR9 | KCL | Roadside | Road | 3 |
| **Greenwich – Woolwich Flyover** | GR8 | KCL | Roadside | Road | 3 |
| **Hackney – Old Street** | HK6 | KCL | Roadside | Road | 3 |
| **Harrow – Pinner Road** | HR2 | KCL | Roadside | Road | 3 |
| **Harrow - Stanmore** | HR1 | KCL | Urban | Urban | 3 |
| **Havering - Rainham** | HV1 | KCL | Roadside | Road | 3 |
| **Havering - Romford** | HV3 | KCL | Roadside | Road | 3 |
| **Islington – Holloway Road** | IS2 | KCL | Roadside | Road | 3 |
| **Kensington and Chelsea – Cromwell Road** | KC2 | KCL | Roadside | Road | 3 |
| **Kensington and Chelsea – Kings Road** | KC4 | KCL | Roadside | Road | 3 |
| **Kensington and Chelsea - Knightsbridge** | KC3 | KCL | Roadside | Road | 3 |

| Name | Code | Network | Type | Category | Area [a] |
|---|---|---|---|---|---|
| **Lambeth - Bondway Interchange** | LB5 | KCL | Roadside | Road | 3 |
| **Lewisham - Catford** | LW1 | KCL | Urban | Urban | 3 |
| **Redbridge – Gardner Close** | RB4 | KCL | Roadside | Road | 3 |
| **Reigate and Banstead - Horley** | RG1 | KCL | Suburban | Urban | 3 |
| **Reigate and Banstead – Horley South** | RG2 | KCL | Suburban | Urban | 3 |
| **Reigate and Banstead – Poles Lane** | RG3 | KCL | Rural Background | Rural | 3 |
| **Richmond Upon Thames - Castelnau** | RI1 | KCL | Roadside | Road | 3 |
| **Richmond Upon Thames – Barnes Wetlands** | RI2 | KCL | Suburban | Urban | 3 |
| **Sevenoaks – Bat and Ball** | ZV2 | KCL | Roadside | Road | 3 |
| **Sevenoaks – Greatness Park** | ZV1 | KCL | Urban | Urban | 3 |
| **Sutton - Carshalton** | ST3 | KCL | Suburban | Urban | 3 |
| **Sutton - Wallington** | ST4 | KCL | Kerbside | Road | 3 |
| **Thurrock - London Road (Grays)** | TK1 | KCL | Urban | Urban | 3 |
| **Thurrock – Standford-le-Hope** | TK3 | KCL | Roadside | Road | 3 |
| **Westminster – Horseferry Road** | WM0 | KCL | Urban | Urban | 3 |
| **Windsor and Maidenhead – Frascati Way** | MW1 | KCL | Roadside | Road | 3 |
| **Westminster – Marylebone Road** | MY1 | KCL | Kerbside | Road | 3 |
| **Wandsworth – Wandsworth Town Hall** | WA2 | KCL | Urban | Urban | 3 |
| **Chatham Roadside** | CHAT | Kent Air | Roadside | Road | 3 |
| **Dartford Bean Interchange Roadside** | DTBI | Kent Air | Roadside | Road | 3 |
| **Dartford St Clements Roadside** | DSTC | Kent Air | Roadside | Road | 3 |
| **Dartford Town Centre Roadside** | DTTC | Kent Air | Roadside | Road | 3 |
| **Gravesham A2 Roadside** | GRA2 | Kent Air | Roadside | Road | 3 |
| **Gravesham Industrial Background** | GRAI | Kent Air | Urban | Urban | 3 |

| Name | Code | Network | Type | Category | Area [a] |
|---|---|---|---|---|---|
| **Maidstone A229 Kerbside** | MSA2 | Kent Air | Kerbside | Road | 3 |
| **Maidstone Rural** | MSR | Kent Air | Rural Background | Rural | 3 |
| **Swale Ospringe Roadside 2** | SWAL | Kent Air | Roadside | Road | 3 |
| **Thanet Airport** | THA | Kent Air | Urban | Urban | 3 |
| **Thanet Ramsgate Roadside** | THR | Kent Air | Roadside | Road | 3 |
| **Tunbridge Wells A26 Roadside** | TUNB | Kent Air | Roadside | Road | 3 |
| **Aberdeen Anderson Dr** | ABD1 | SAQ | Roadside | Road | 1 |
| **Aberdeen Union Street Roadside** | ABD3 | SAQ | Roadside | Road | 1 |
| **Dundee Seagate** | DUN5 | SAQ | Kerbside | Road | 1 |
| **Dundee Whitehall Street** | DUN7 | SAQ | Roadside | Road | 1 |
| **East Dunbartonshire Bearsden** | EDB2 | SAQ | Roadside | Road | 1 |
| **East Dunbartonshire Bishopbriggs** | EDB1 | SAQ | Roadside | Road | 1 |
| **Edinburgh Gorgie Road** | ED5 | SAQ | Roadside | Road | 1 |
| **Fife Cupar** | CUPA | SAQ | Roadside | Road | 1 |
| **Fife Dunfermline** | DUNF | SAQ | Roadside | Road | 1 |
| **Fort William** | FW | SAQ | Suburban | Urban | 1 |
| **Glasgow Anderston** | GLA5 | SAQ | Urban | Urban | 1 |
| **Glasgow Byres Road** | GLA6 | SAQ | Roadside | Road | 1 |
| **Glasgow Waulkmill Glen Reservoir** | GLA7 | SAQ | Rural Background | Rural | 1 |
| **Perth Atholl Street** | PET2 | SAQ | Roadside | Road | 1 |
| **Perth High Street** | PETH | SAQ | Roadside | Road | 1 |
| **West Dunbartonshire Clydebank** | WDBWAQ3 | SAQ | Roadside | Road | 1 |
| **Chichester - A27 Chichester Bypass** | CI1 | Sussex Air | Roadside | Road | 3 |
| **Crawley – Gatwick Airport** | CA2 | Sussex Air | Urban | Urban | 3 |
| **Hastings - Bulverhythe** | HT1 | Sussex Air | Roadside | Road | 3 |
| **Horsham – Park Way** | HO2 | Sussex Air | Roadside | Road | 3 |
| **Abingdon Stert Street** | ABIN | UKAQ | Roadside | Road | 3 |
| **Castlereagh Dundonald** | CAST | UKAQ | Roadside | Road | 1 |
| **East Hampshire Bordon** | EHAM | UKAQ | Roadside | Road | 3 |

| Name | Code | Network | Type | Category | Area [a] |
|---|---|---|---|---|---|
| **London Haringey Roadside AURN** | LHRD | UKAQ | Roadside | Road | 3 |
| **Northallerton South Parade** | NSPA | UKAQ | Roadside | Road | 2 |
| **North Down Holywood A2** | NDHW | UKAQ | Roadside | Road | 1 |
| **Norwich Castle Meadow** | NCMD | UKAQ | Roadside | Road | 2 |
| **Preston Meadow Street Ringway** | PMSR | UKAQ | Roadside | Road | 2 |
| **Surrey Heath Camberley NOx** | SHCA | UKAQ | Roadside | Road | 3 |
| **Chepstow A48** | CHEP | WAQ | Roadside | Road | 3 |
| **Cwmbran** | CWMB | WAQ | Urban | Urban | 3 |
| **Newport St Julian's Comp School** | NEWP | WAQ | Urban | Urban | 3 |
| **Rhondda-Cynon-Taf Broadway** | RHON | WAQ | Roadside | Road | 3 |
| **Swansea Hafod DOAS** | SWHD | WAQ | Roadside | Road | 3 |
| **Swansea Morriston Roadside** | SWMR | WAQ | Roadside | Road | 3 |

[a] Area – (1) Scotland and Northern Ireland, (2) Central & Northern England + North Wales, (3) Southern England and Southern Wales

**Table A1.2 Sites Not Meeting Criteria to be Included in the Analyses**

| Name | Code | Network | Type |
|---|---|---|---|
| **Coventry Memorial Park** | COV3 | AURN | Urban |
| **London Cromwell Road 2** | CRD2 | AURN | Roadside |
| **Scunthorpe Town AURN** | SCN2 | AURN | Industrial |
| **Sibton** | SIB | AURN | Rural Background |
| **Strathvaich** | SV | AURN | Rural Background |
| **Wirral Tranmere** | TRAN | AURN | Urban |
| **Brent Neasden Lane** | BT5 | KCL | Industrial |
| **Camden – Shaftesbury Avenue** | CD3 | KCL | Roadside |
| **City of London - Walbrook Wharf** | CT6 | KCL | Roadside |
| **Croydon – George Street** | CR4 | KCL | Roadside |
| **Ealing Horn Lane** | EA8 | KCL | Industrial |
| **Mole Valley – Dorking** | MV3 | KCL | Urban |
| **Richmond Upon Thames – Ntl Physical Lab** | TD0 | KCL | Suburban |
| **Tower Hamlets - Blackwall** | TH4 | KCL | Roadside |
| **Westminster - Oxford Street** | WM6 | KCL | Kerbside |
| **Aberdeen King Street** | AD1 | SAQ | Roadside |
| **Aberdeen Market Street 2** | ABD0 | SAQ | Roadside |
| **Aberdeen Wellington Road** | ABD8 | SAQ | Roadside |
| **Dundee Broughty Ferry Road** | DUN4 | SAQ | Industrial |
| **East Ayrshire Kilmarnock** | KILM | SAQ | Urban |
| **East Dunbartonshire Kirkintilloch** | EDB3 | SAQ | Roadside |
| **East Lothian Musselburgh N High St** | MUSS | SAQ | Roadside |
| **Edinburgh Salamander St** | ED8 | SAQ | Roadside |
| **Edinburgh St John's Road** | ED1 | SAQ | Kerbside |

| Name | Code | Network | Type |
|---|---|---|---|
| **Falkirk Haggs** | FAL5 | SAQ | Roadside |
| **Falkirk Hope St** | FAL3 | SAQ | Roadside |
| **Falkirk West Bridge Street** | FAL6 | SAQ | Roadside |
| **Fife Kirkcaldy** | KIR | SAQ | Roadside |
| **Fife Rosyth** | ROSY | SAQ | Roadside |
| **Grangemouth Moray** | GRA2 | SAQ | Urban |
| **North Ayrshire Irvine High St** | IRV | SAQ | Kerbside |
| **N Lanarkshire Croy** | NL4 | SAQ | Roadside |
| **N Lanarkshire Moodiesburn** | NL9 | SAQ | Roadside |
| **N Lanarkshire Shawhead Coatbridge** | NL7 | SAQ | Roadside |
| **Paisley Gordon Street** | PAI3 | SAQ | Roadside |
| **Peebles** | PEEB | SAQ | Suburban |
| **South Lanarkshire East Kilbride** | EK0 | SAQ | Roadside |
| **Stirling Craig's Roundabout** | STRL | SAQ | Roadside |
| **West Lothian Linlithgow High Street** | LING | SAQ | Roadside |
| **West Lothian Broxburn** | BRX | SAQ | Roadside |
| **Chichester - Orchard Street** | CI4 | Sussex Air | Roadside |
| **Eastbourne - Devonshire Park** | EB1 | Sussex Air | Urban |
| **Eastbourne - Holly Place** | EB3 | Sussex Air | Urban |
| **Horsham – Cowfold** | HO5 | Sussex Air | Roadside |
| **Horsham – Storrington** | HO4 | Sussex Air | Roadside |
| **Lewes - West Street** | LS5 | Sussex Air | Roadside |
| **Rother - De La Warr Road** | RY2 | Sussex Air | Roadside |
| **Worthing - Grove Lodge** | WT2 | Sussex Air | Roadside |
| **Blackburn Accrington Road AURN** | BLAC | UKAQ | Roadside |

| Name | Code | Network | Type |
|---|---|---|---|
| **Breckland East Wretham** | BREC | UKAQ | Rural Background |
| **Cannock A5190 Roadside AURN** | CANN | UKAQ | Roadside |
| **East Staffordshire Derby Turn** | ESTAF | UKAQ | Roadside |
| **Elmbridge Hampton Court Parade** | ELMH | UKAQ | Roadside |
| **Elmbridge Weybridge High St** | ELMW | UKAQ | Roadside |
| **Gedling Daybrook** | GEDL | UKAQ | Roadside |
| **Hull Holderness Road AURN** | HULL | UKAQ | Roadside |
| **Kings Lynn Gaywood** | KLGW | UKAQ | Roadside |
| **Kings Lynn South Gates** | KLSG | UKAQ | Roadside |
| **Lancaster Cable Street** | LCST | UKAQ | Roadside |
| **Lancaster Dalton Square** | LDSQ | UKAQ | Roadside |
| **London Haringey Priory Park South AURN** | LHPP | UKAQ | Urban |
| **Luton A505 Roadside AURN** | LUA5 | UKAQ | Roadside |
| **Newcastle Cradlewell Roadside AURN** | NCRD | UKAQ | Roadside |
| **Newcastle Pilgrim Street** | NPST | UKAQ | Roadside |
| **Norwich Lakenfields AURN** | NLKF | UKAQ | Urban |
| **North Lincs Killingholme Roadside** | NLKR | UKAQ | Urban |
| **Nottingham Carter Gate** | NOCG | UKAQ | Roadside |
| **Nottingham Lace Street** | NOLS | UKAQ | Roadside |
| **Nottingham St Andrews Road** | NOSA | UKAQ | Roadside |
| **Nottingham Western Boulevard AURN** | NOWB | UKAQ | Kerbside |
| **Oxford St Ebbes AURN** | OXSE | UKAQ | Urban |
| **Rushcliffe A52 Stragglethorpe Road** | RA52S | UKAQ | Roadside |
| **Rushcliffe Trent Bridge Roadside** | RTBR | UKAQ | Roadside |
| **Sandy Roadside AURN** | SAND | UKAQ | Roadside |

| Name | Code | Network | Type |
|---|---|---|---|
| **South Staffordshire Penkridge** | SSTA | UKAQ | Roadside |
| **South Tyneside Boldon Lane** | STBL | UKAQ | Roadside |
| **South Tyneside Edinburgh Road** | STER | UKAQ | Roadside |
| **South Tyneside Tyne Dock** | STTD | UKAQ | Industrial |
| **St. Helens Borough Road** | STBR | UKAQ | Roadside |
| **St. Helens Linkway** | STHL | UKAQ | Roadside |
| **St. Helens Newton Southworth Road** | STHN | UKAQ | Roadside |
| **St. Helens Newton-le-Willows High Street** | STHW | UKAQ | Roadside |
| **Sunderland Wessington Way AURN** | SUNW | UKAQ | Roadside |
| **Swaffham** | SWAF | UKAQ | Roadside |
| **Warrington AURN** | WARR | UKAQ | Urban |
| **Warrington Chester Road** | WARC | UKAQ | Roadside |
| **Warrington Parker St** | WARP | UKAQ | Roadside |
| **Widnes Milton Road AURN** | WMRD | UKAQ | Rural Background |
| **Winchester Chesil Street** | WINC | UKAQ | Roadside |
| **Winchester St Georges Street** | WING | UKAQ | Roadside |
| **Marchlyn Mawr** | MARCH | WAQ | Rural Background |

# A2 Plots for Individual Sites

A2.1 This appendix sets out the TheilSen plots for the individual sites included in the analyses presented in this report. The numbers at the top of each graph show the trend and the confidence interval, and the significance of the trend, as follows: *** for p=0.001, ** for p=0.01, * for p=0.05 and + for p=0.1. The trends are shown as % per year.

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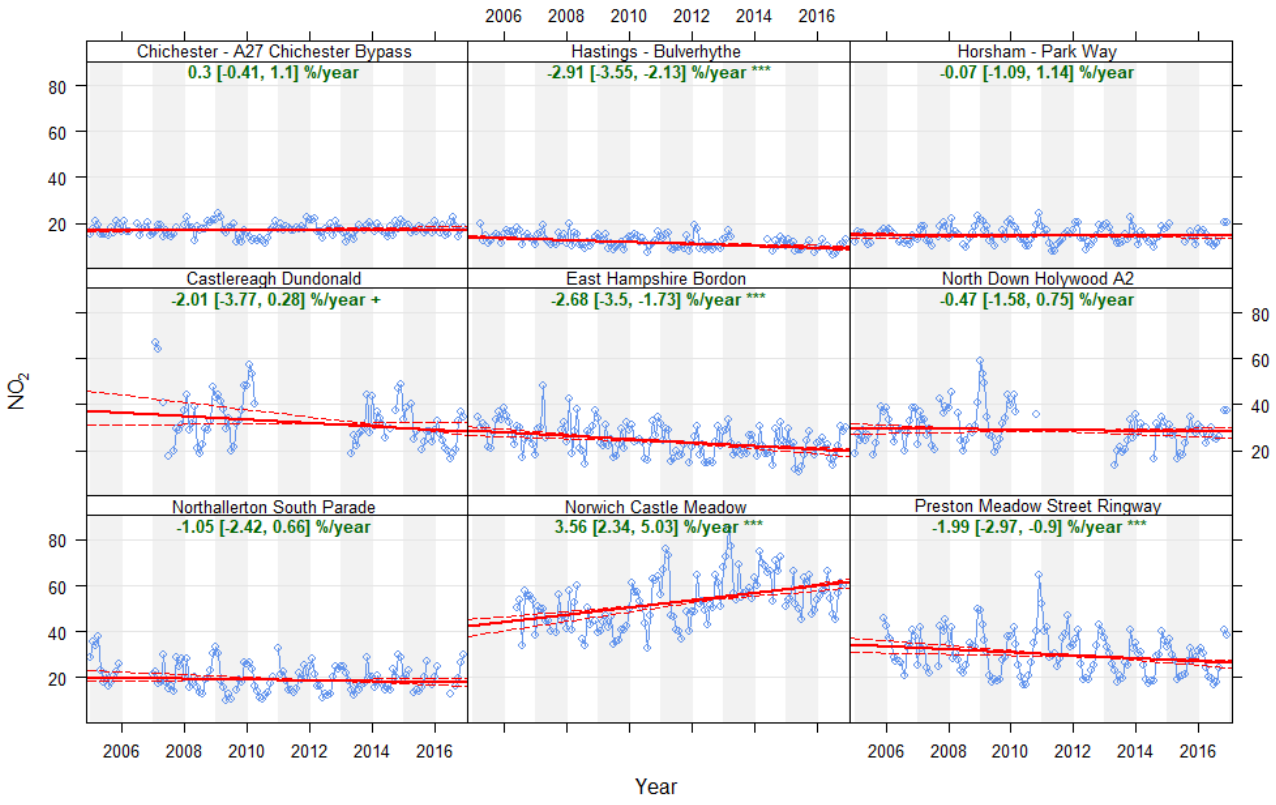
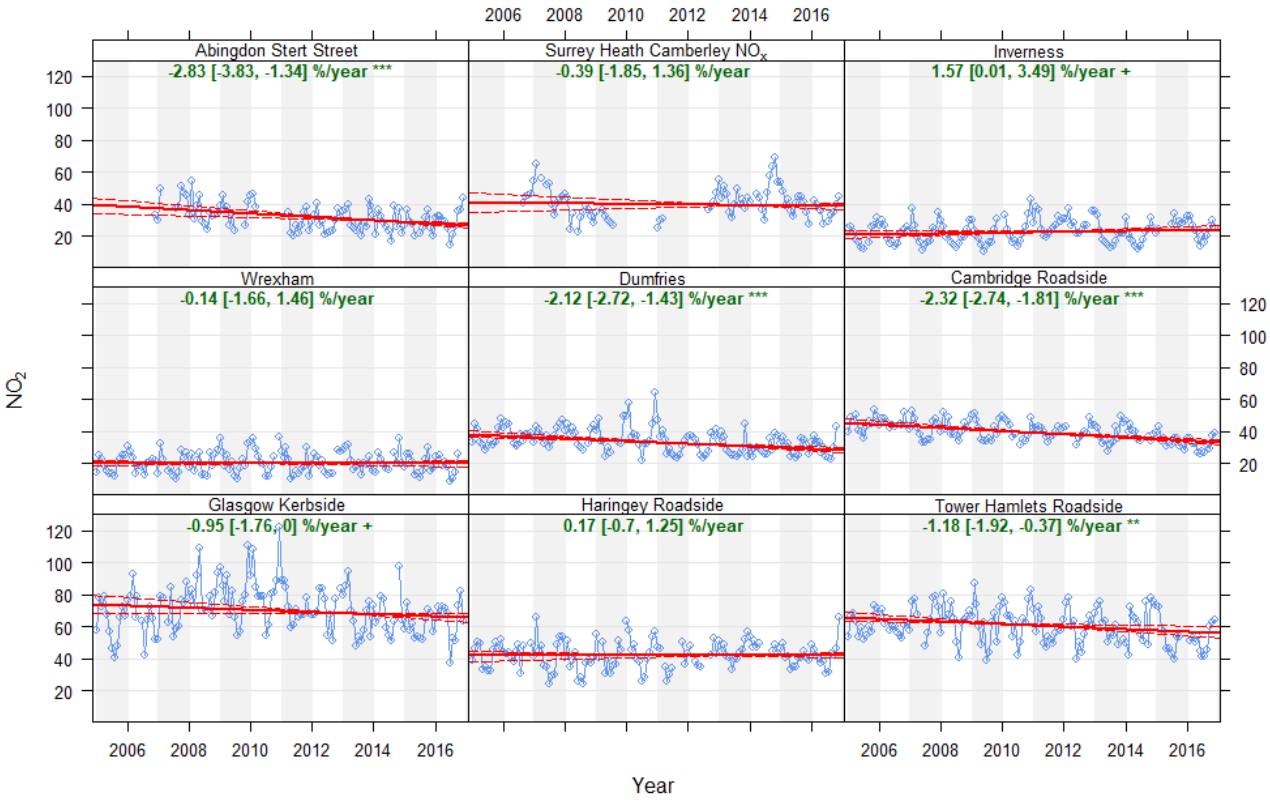
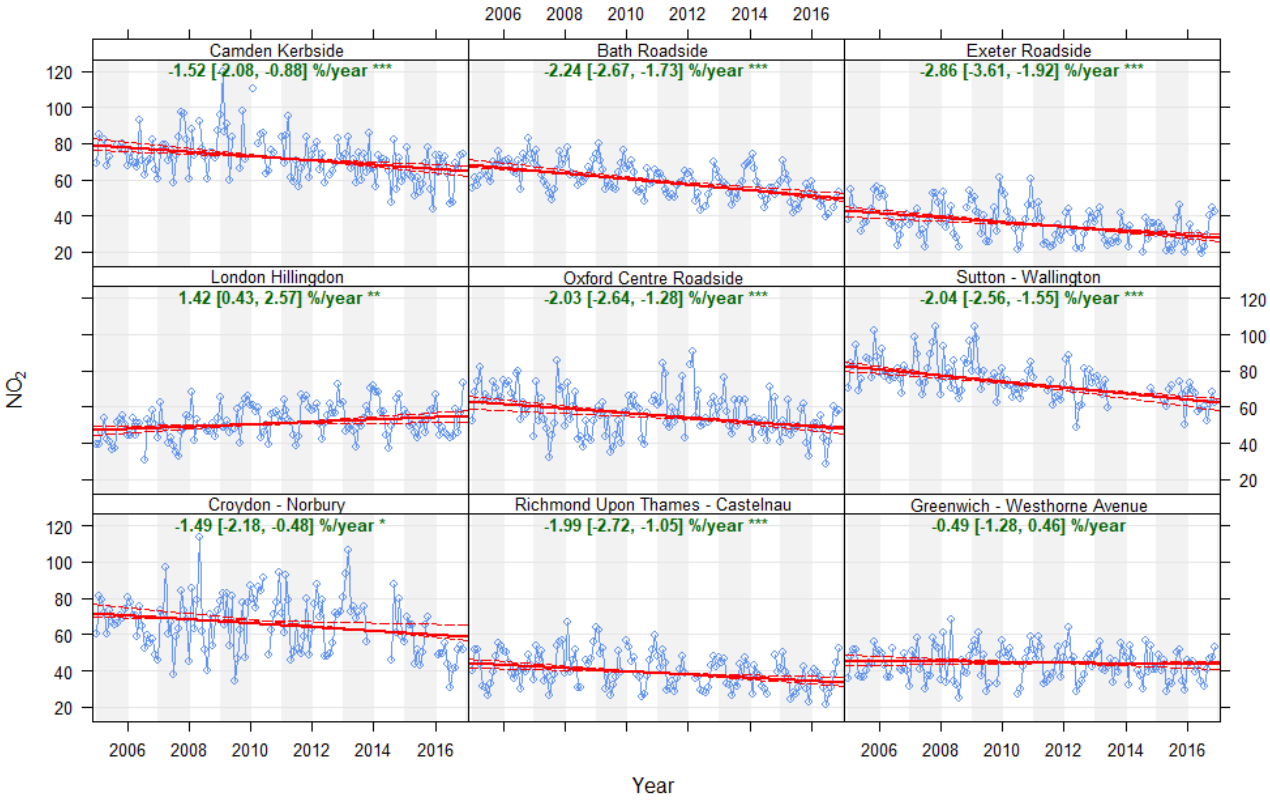


## Road Sites $NO_2$



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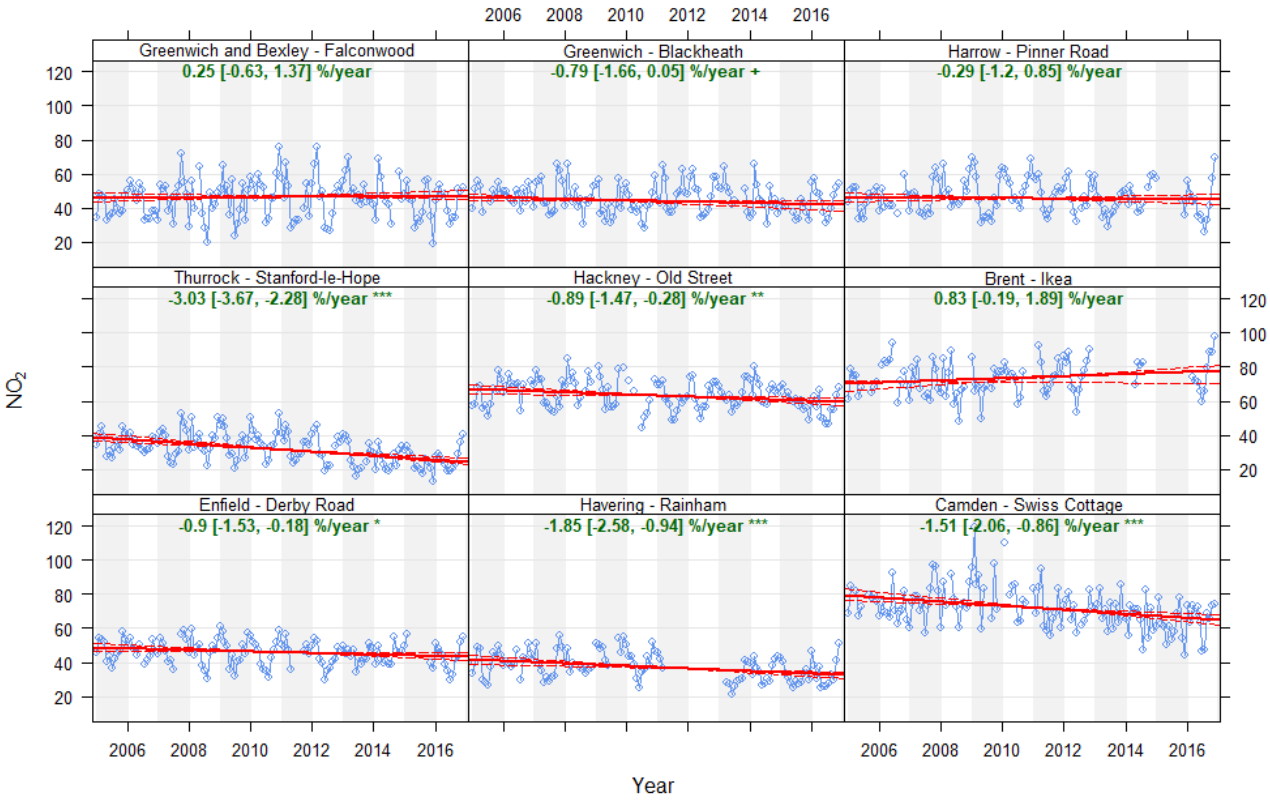


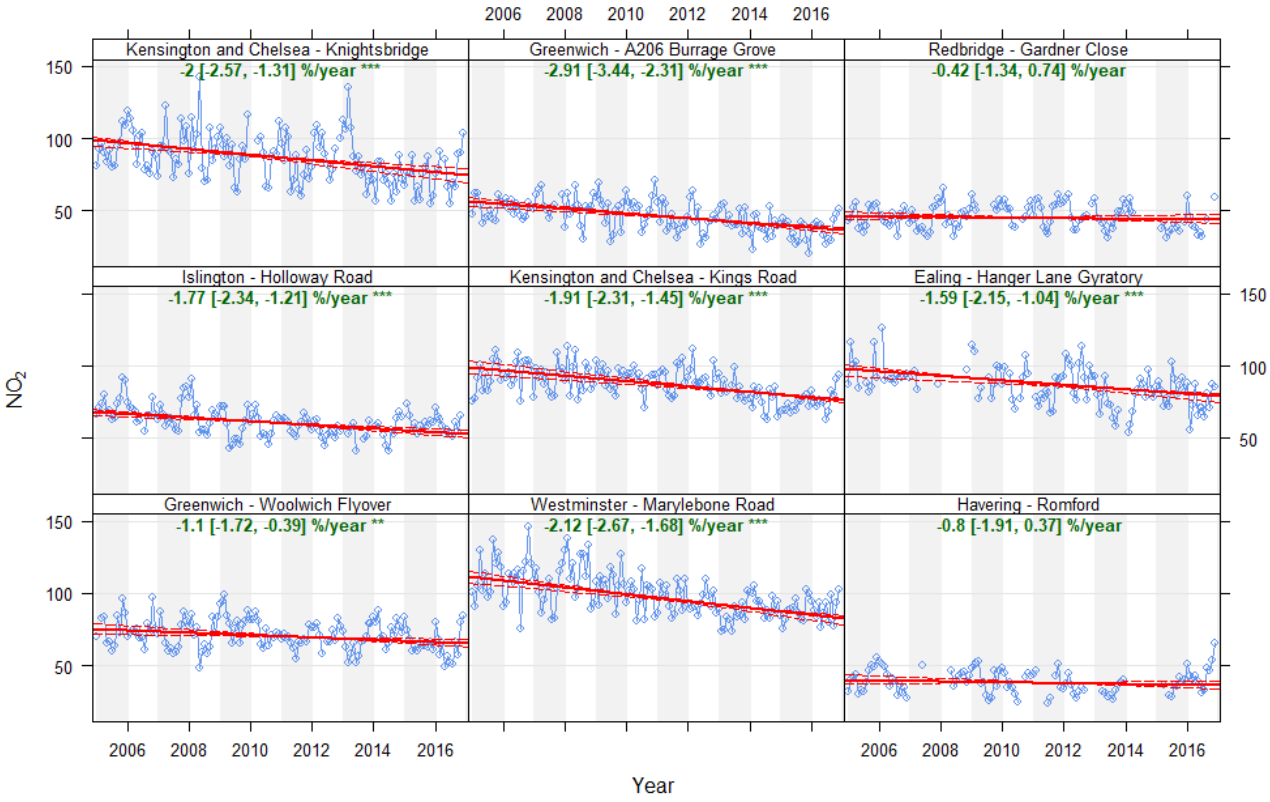

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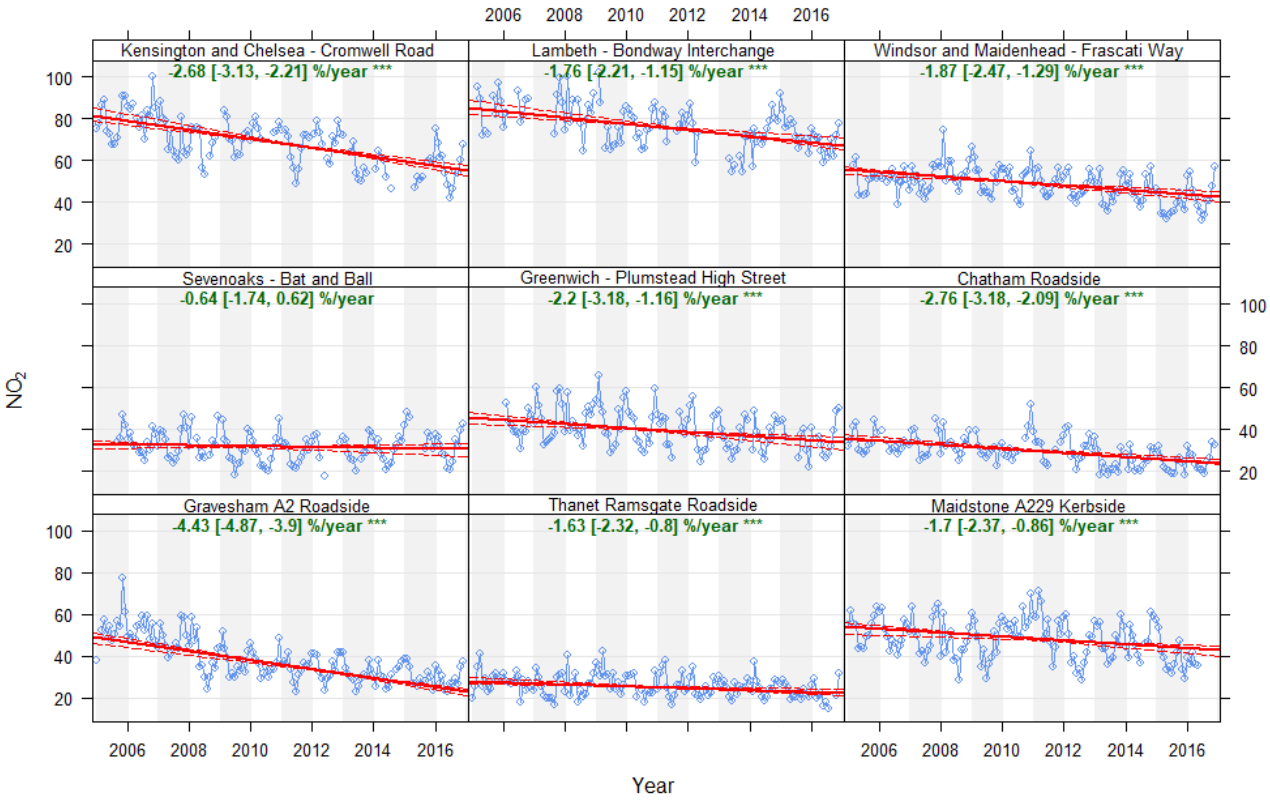


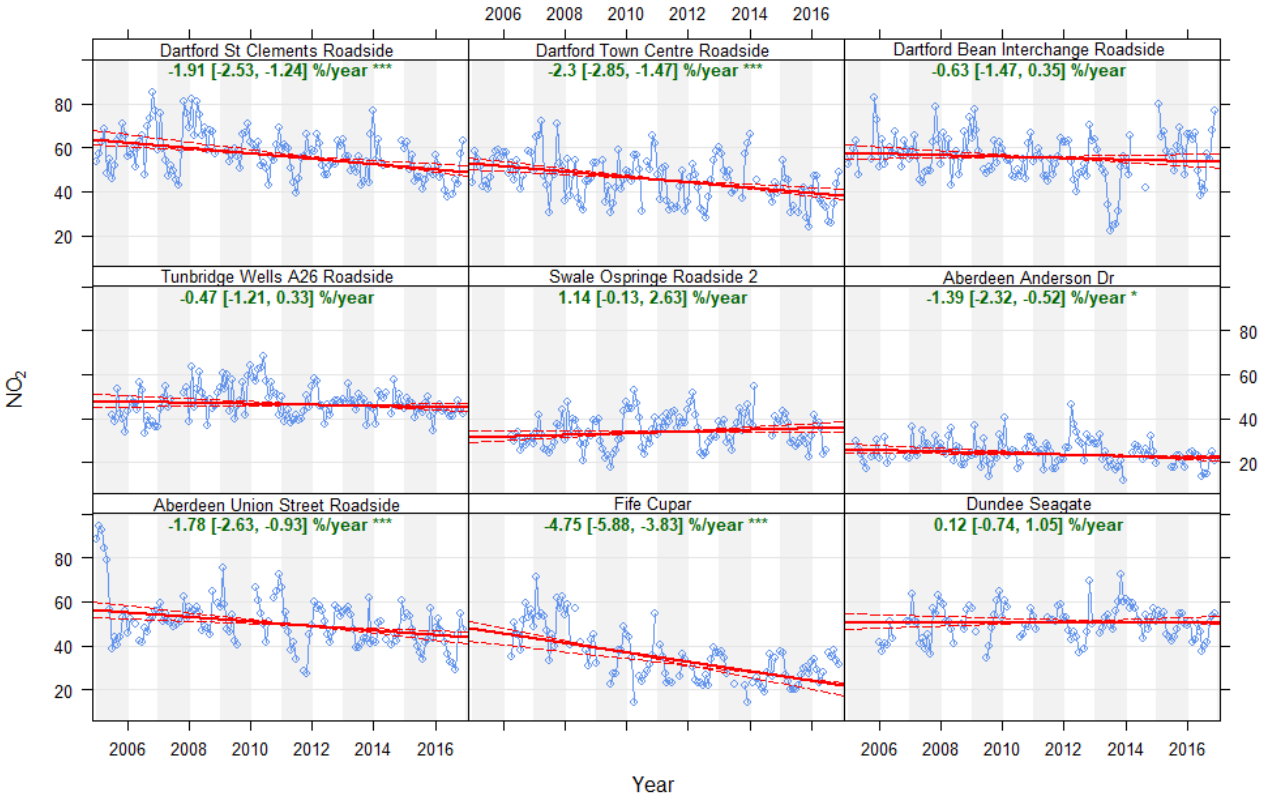

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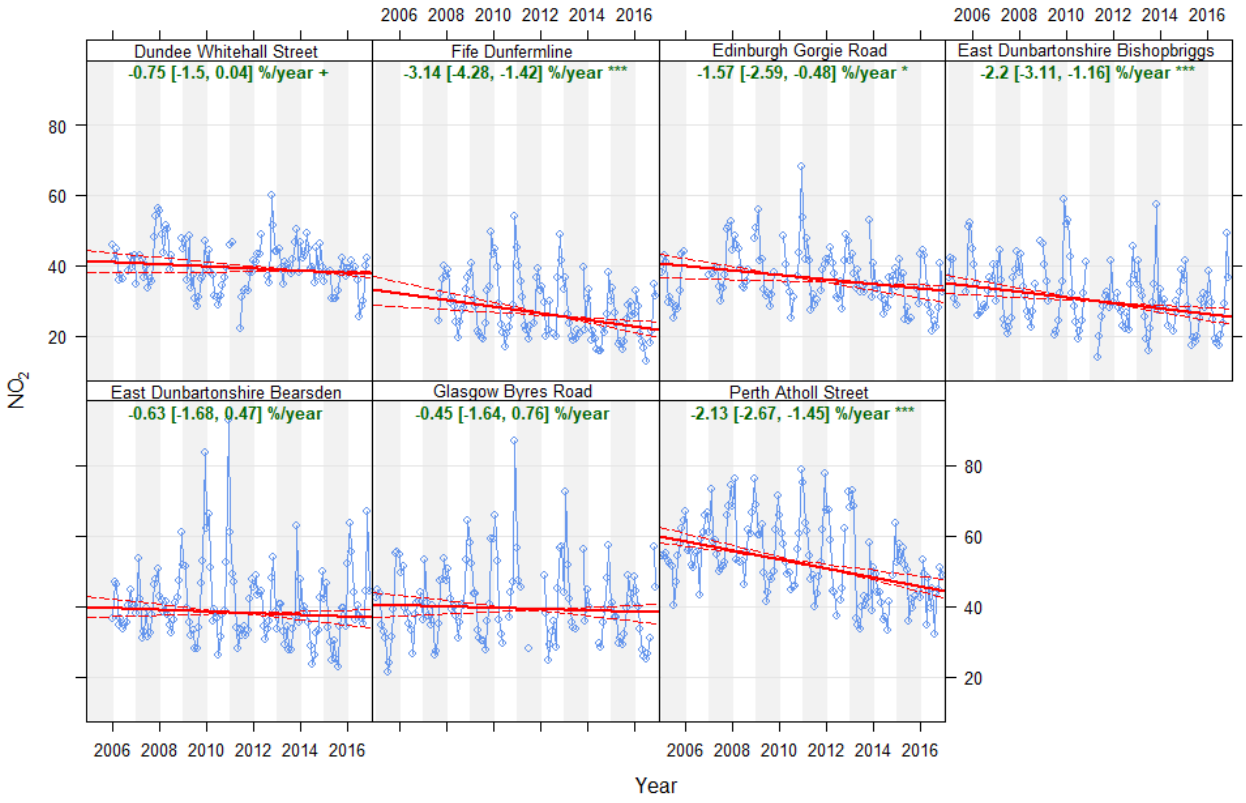


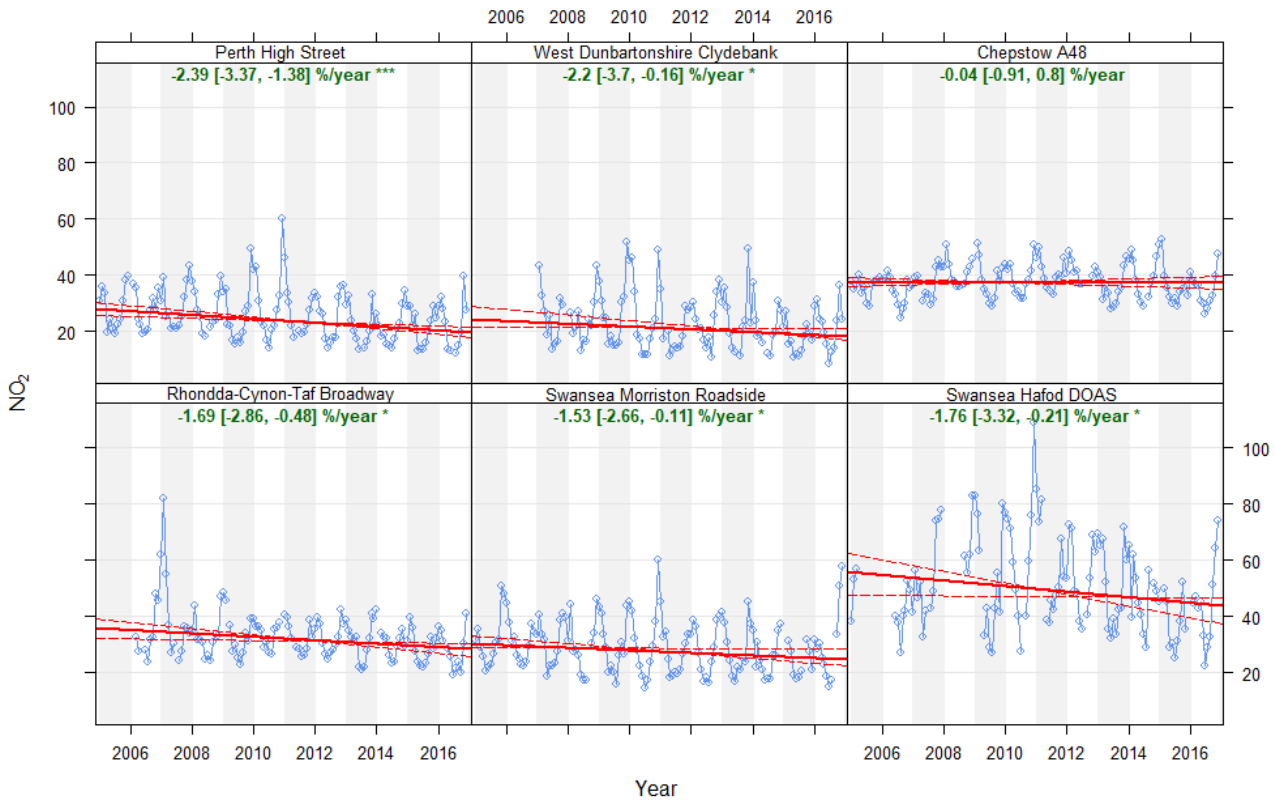

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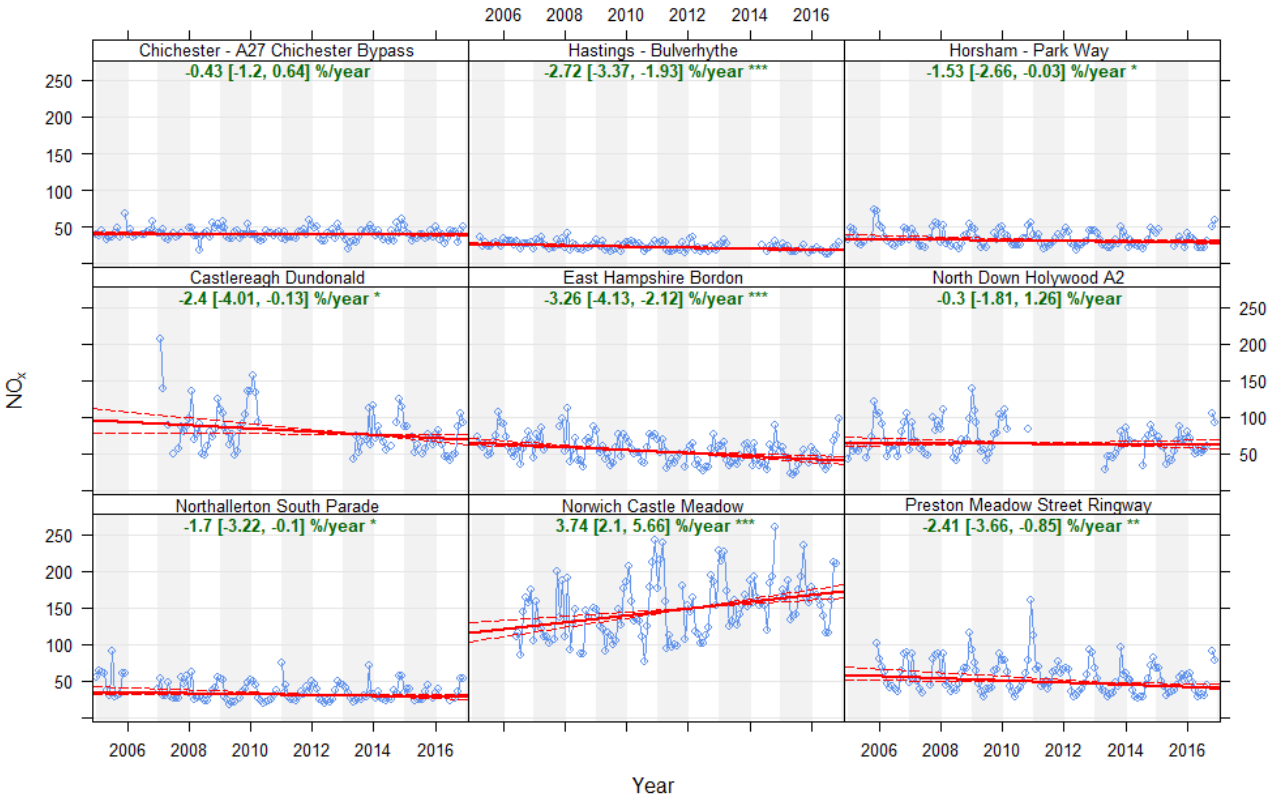


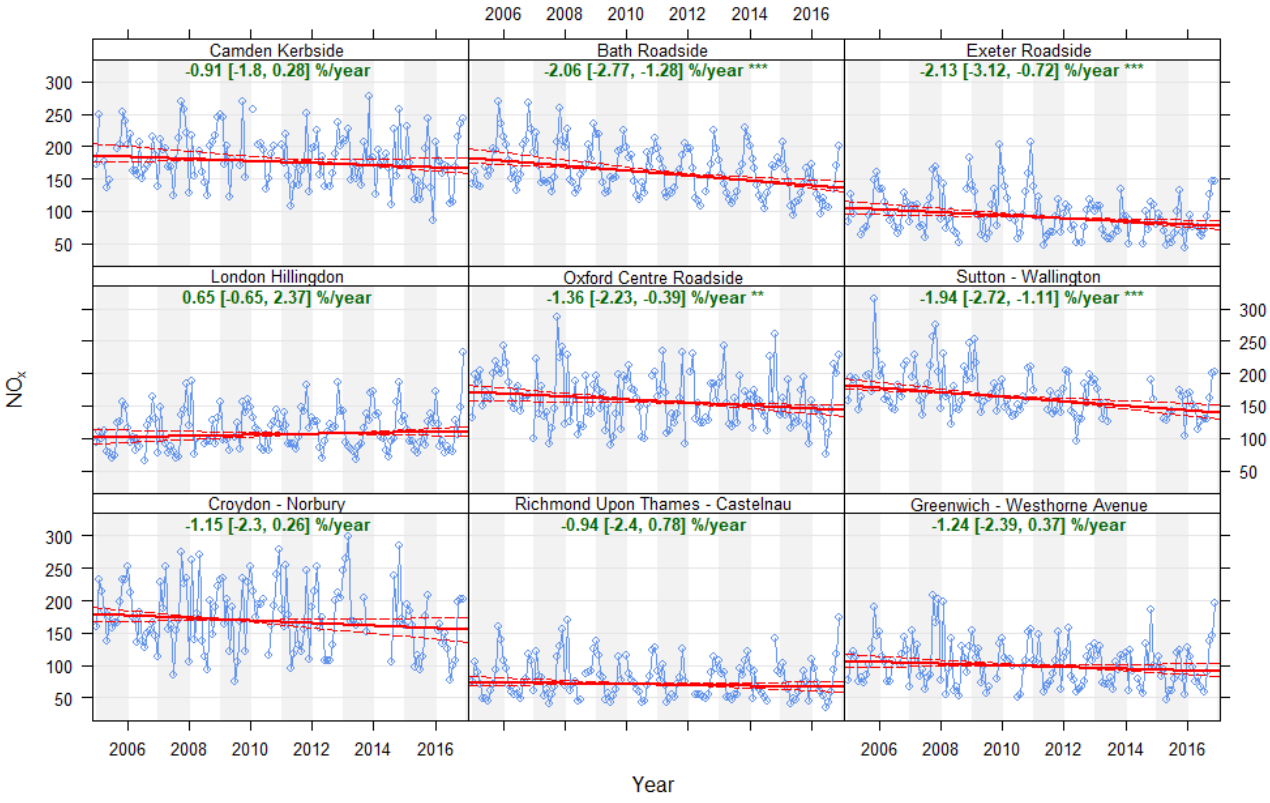

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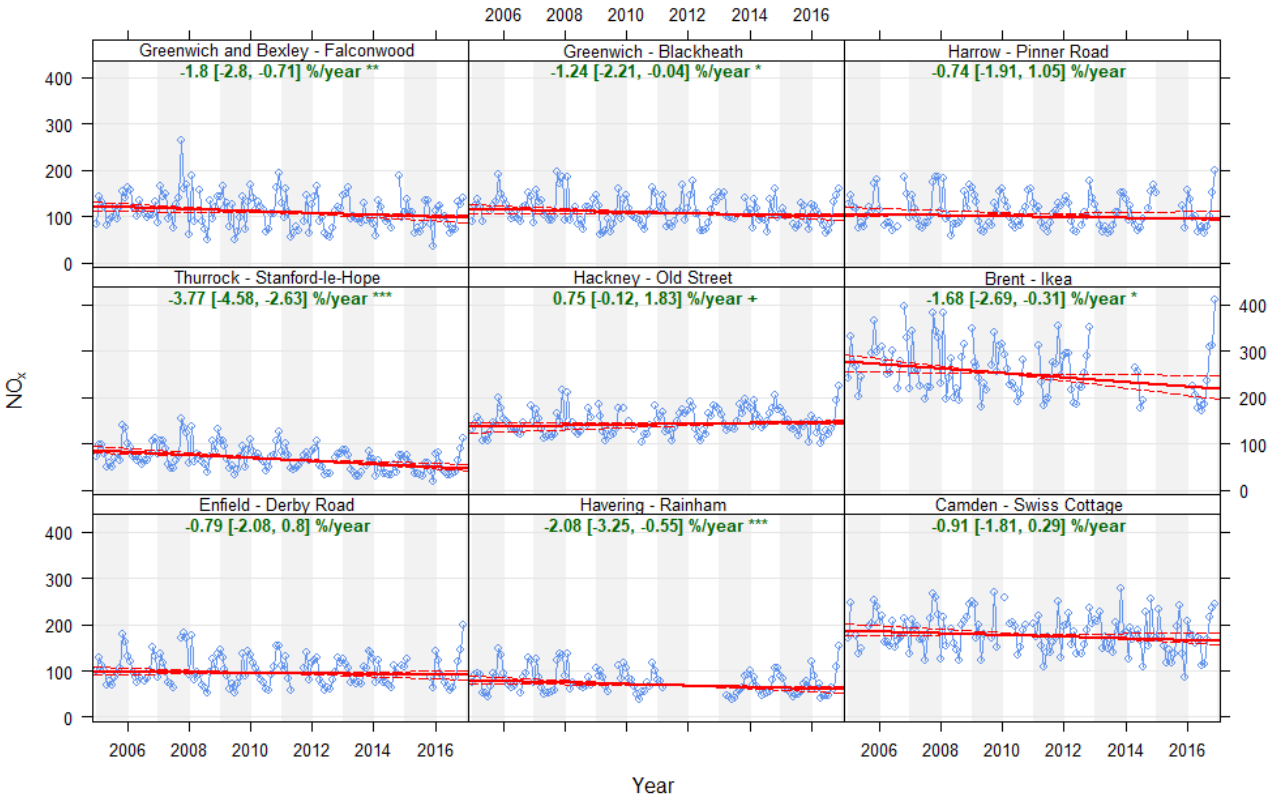


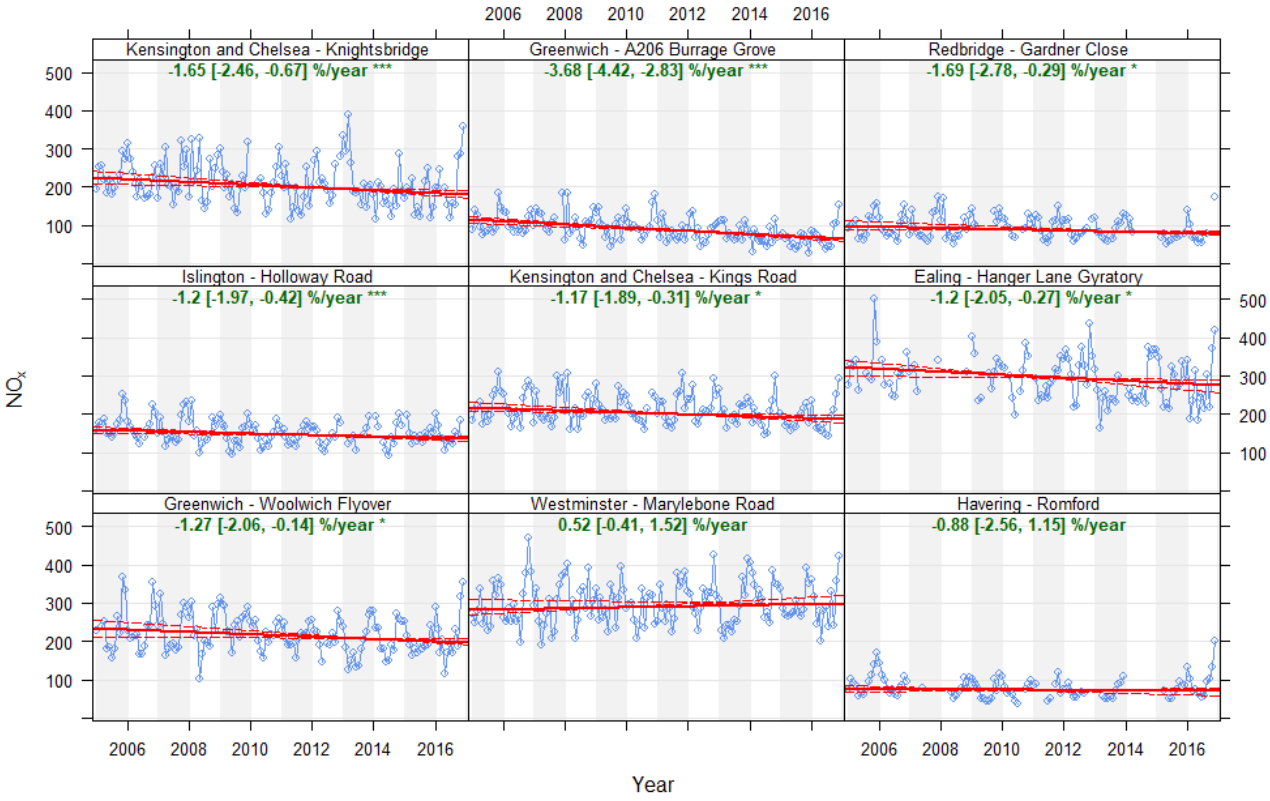

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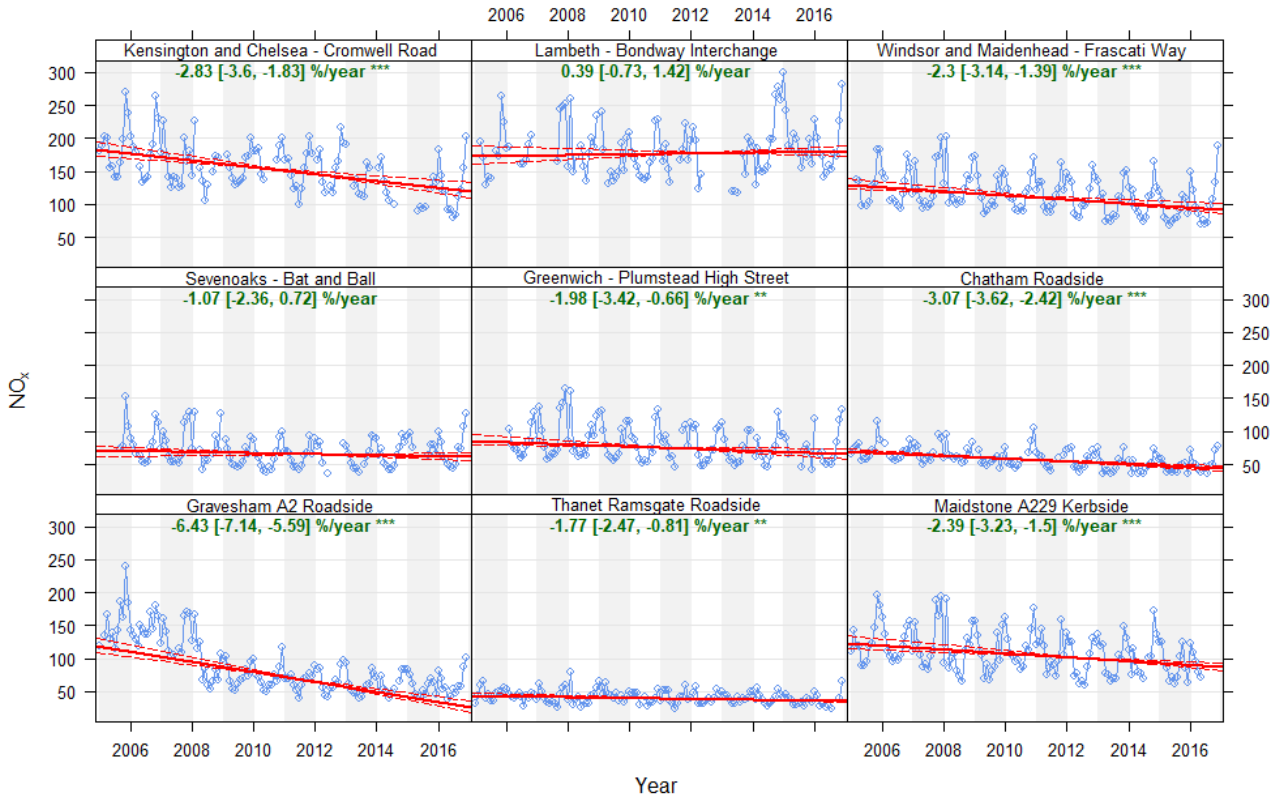


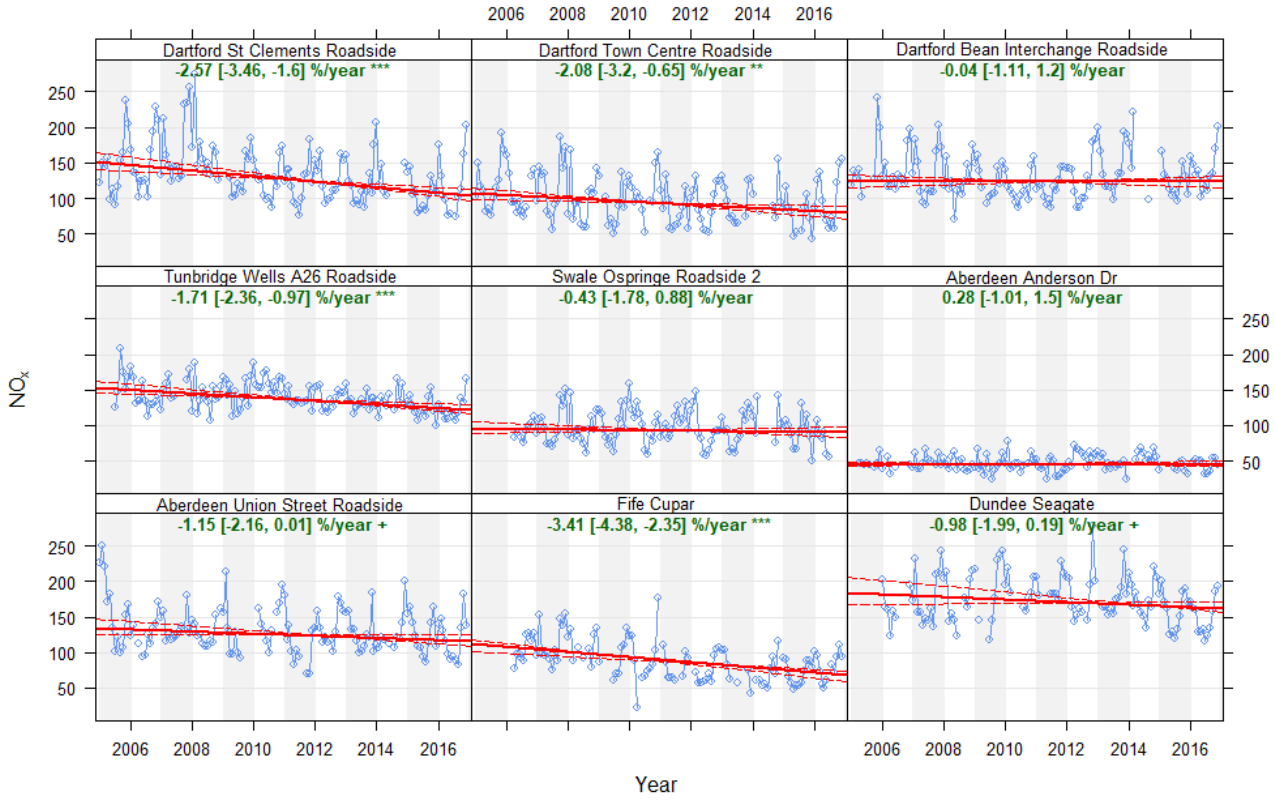

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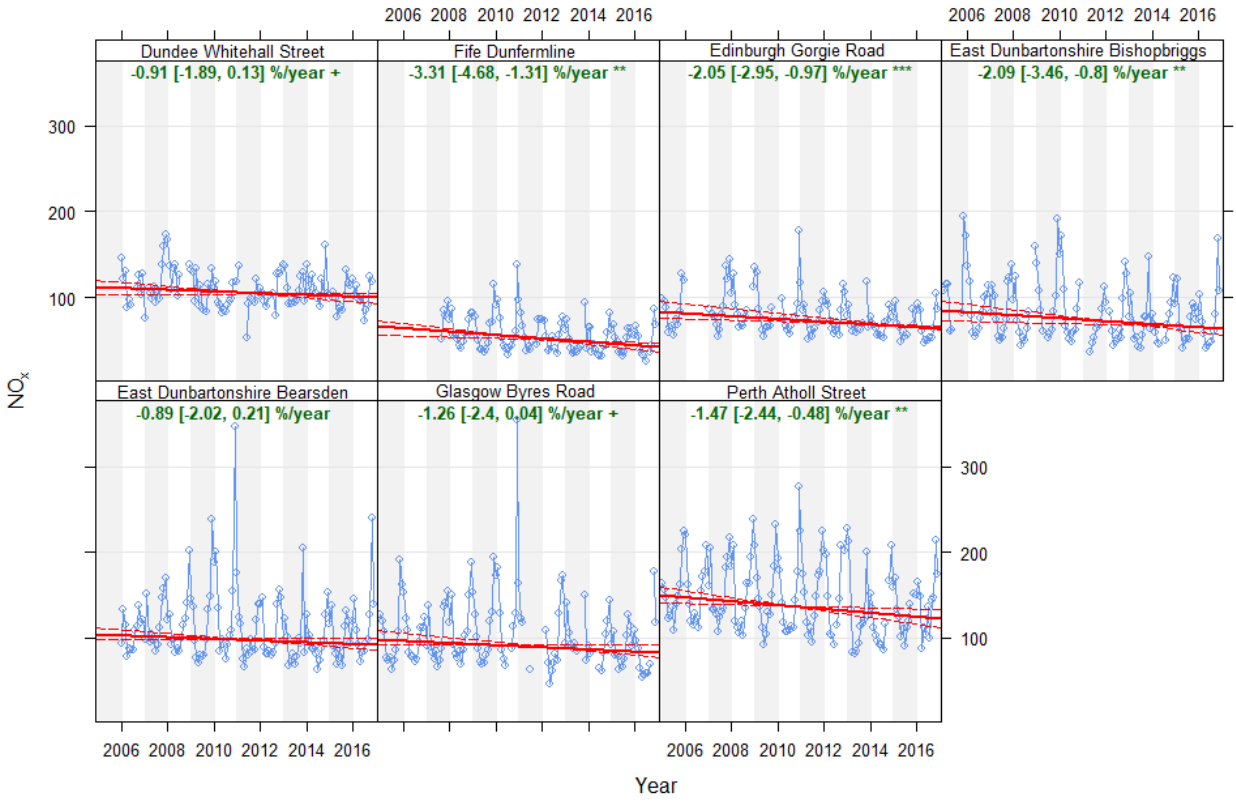


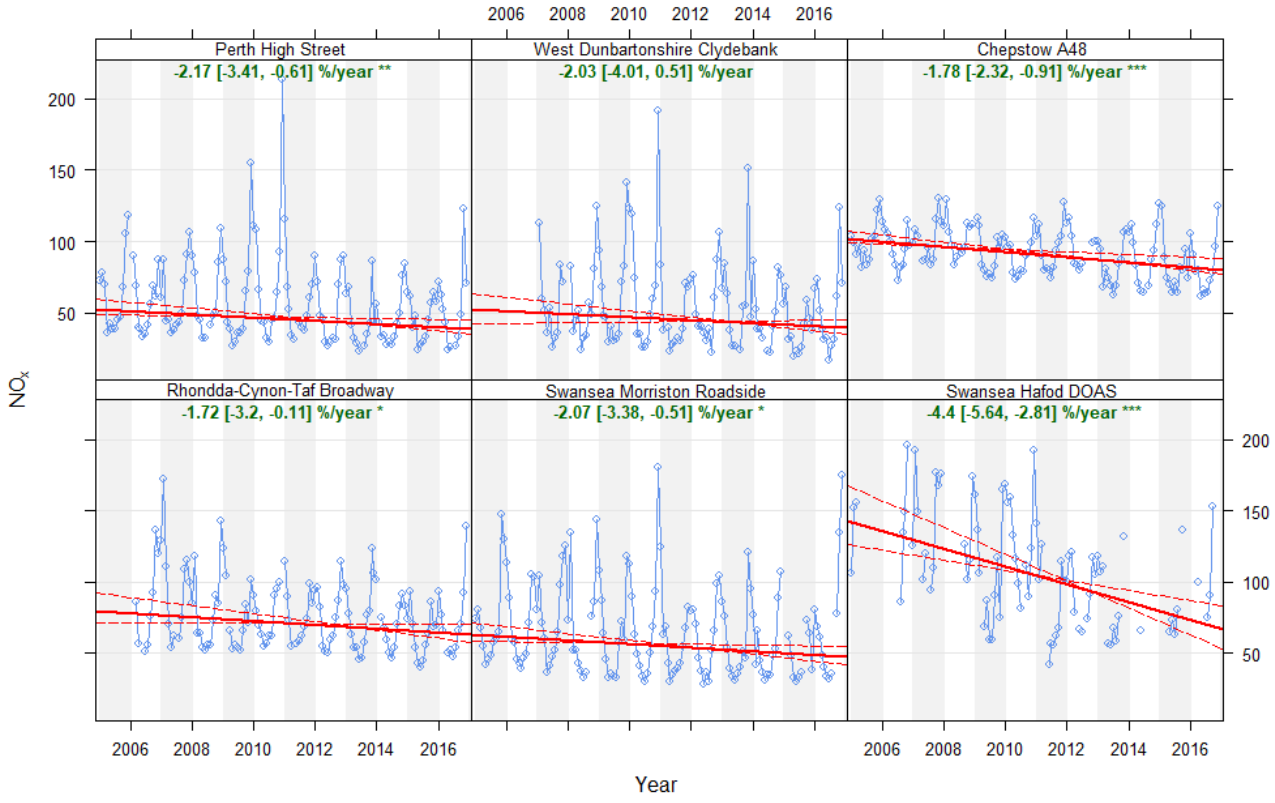

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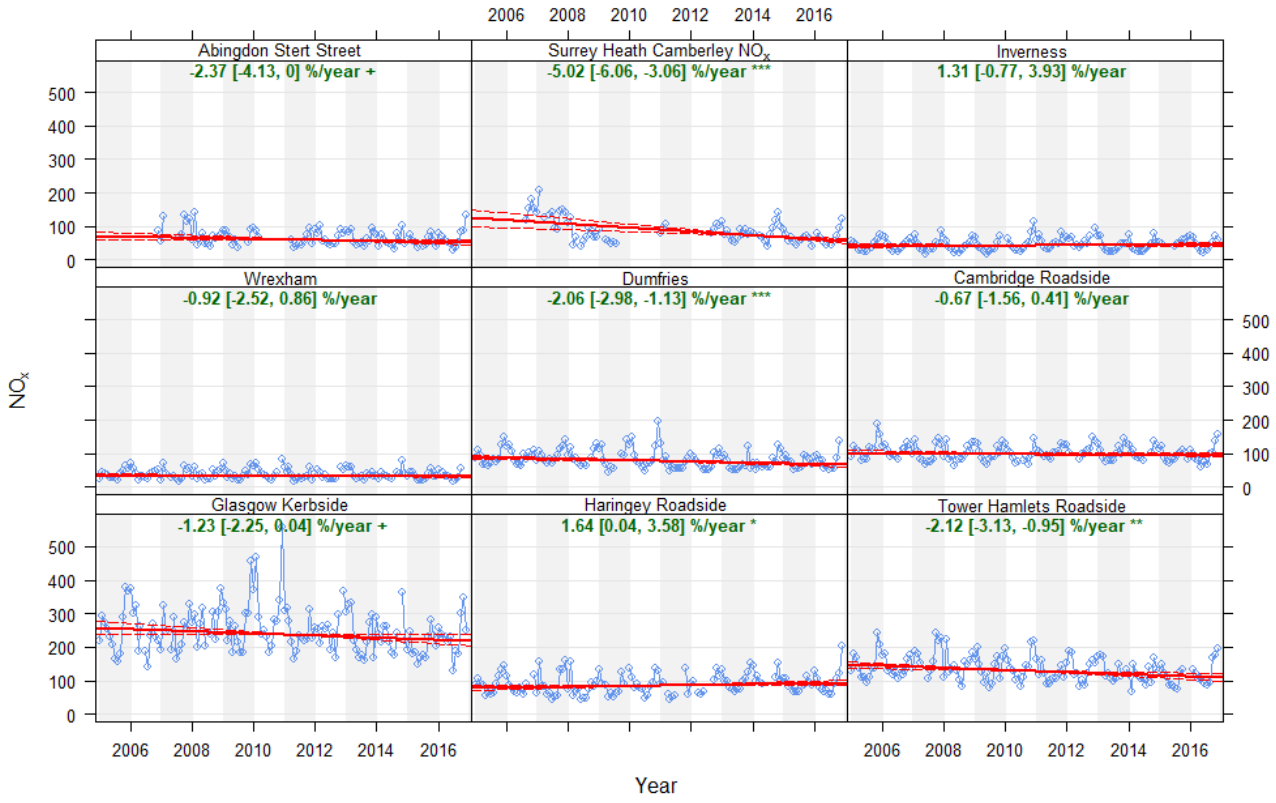

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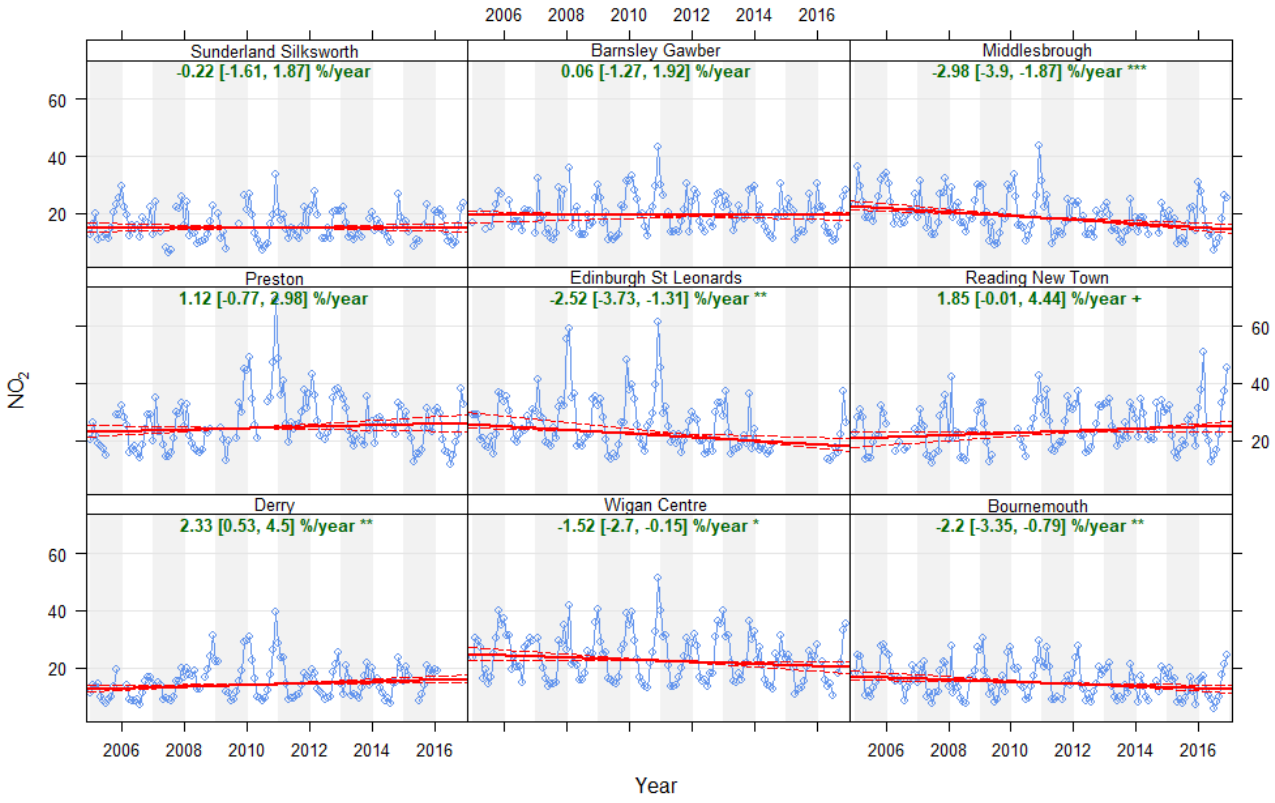


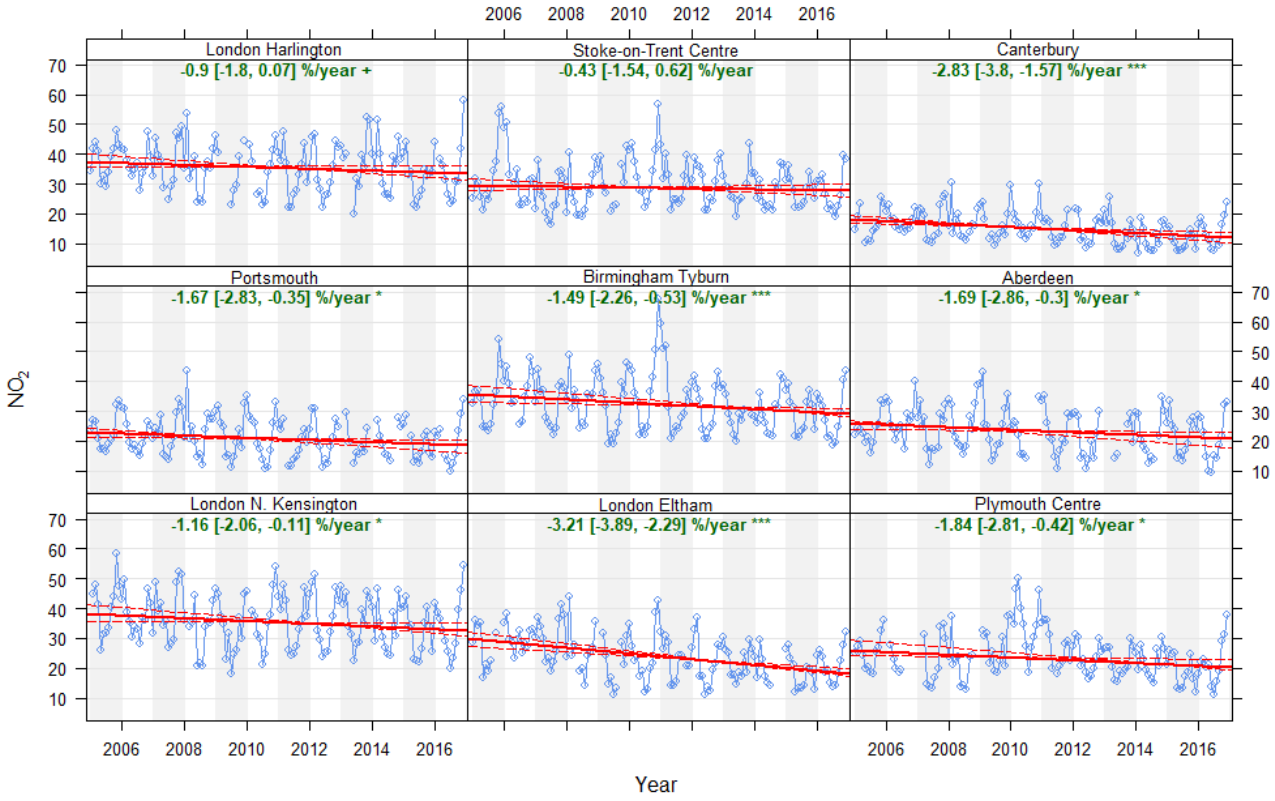

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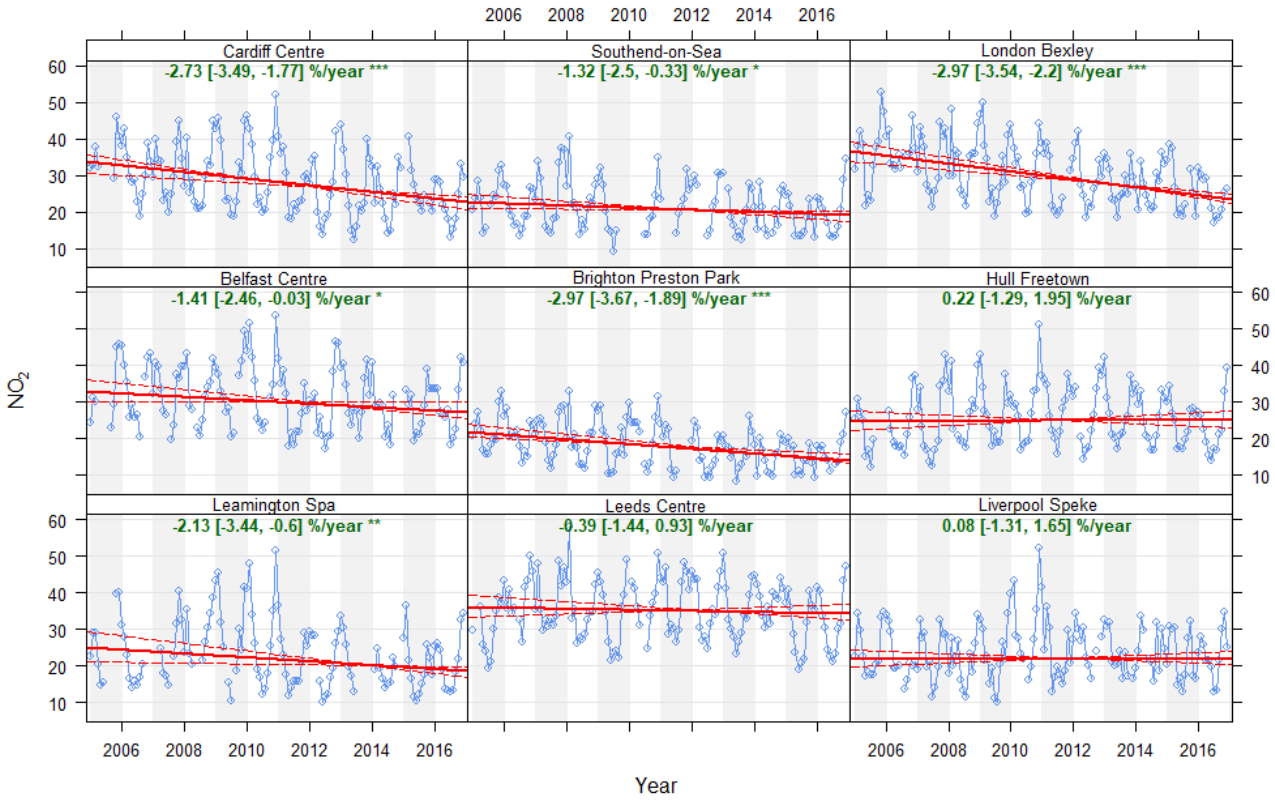


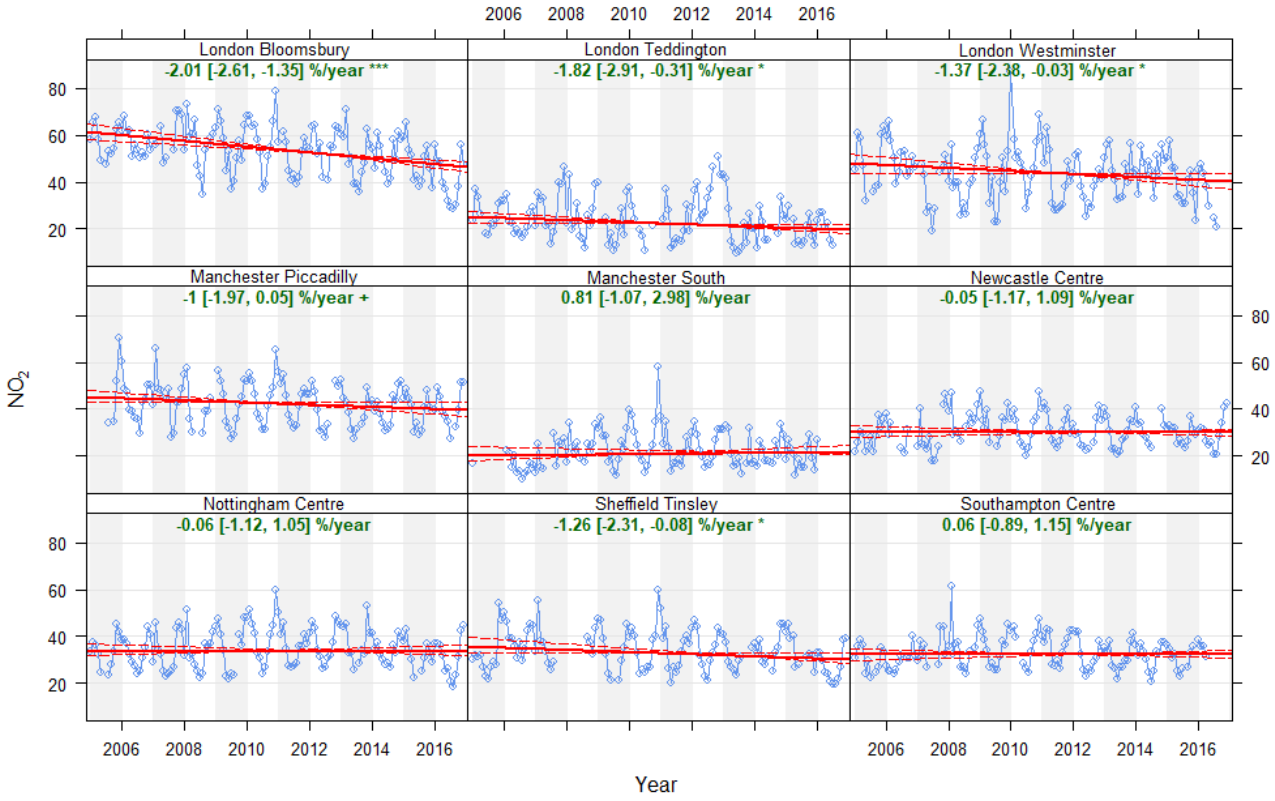

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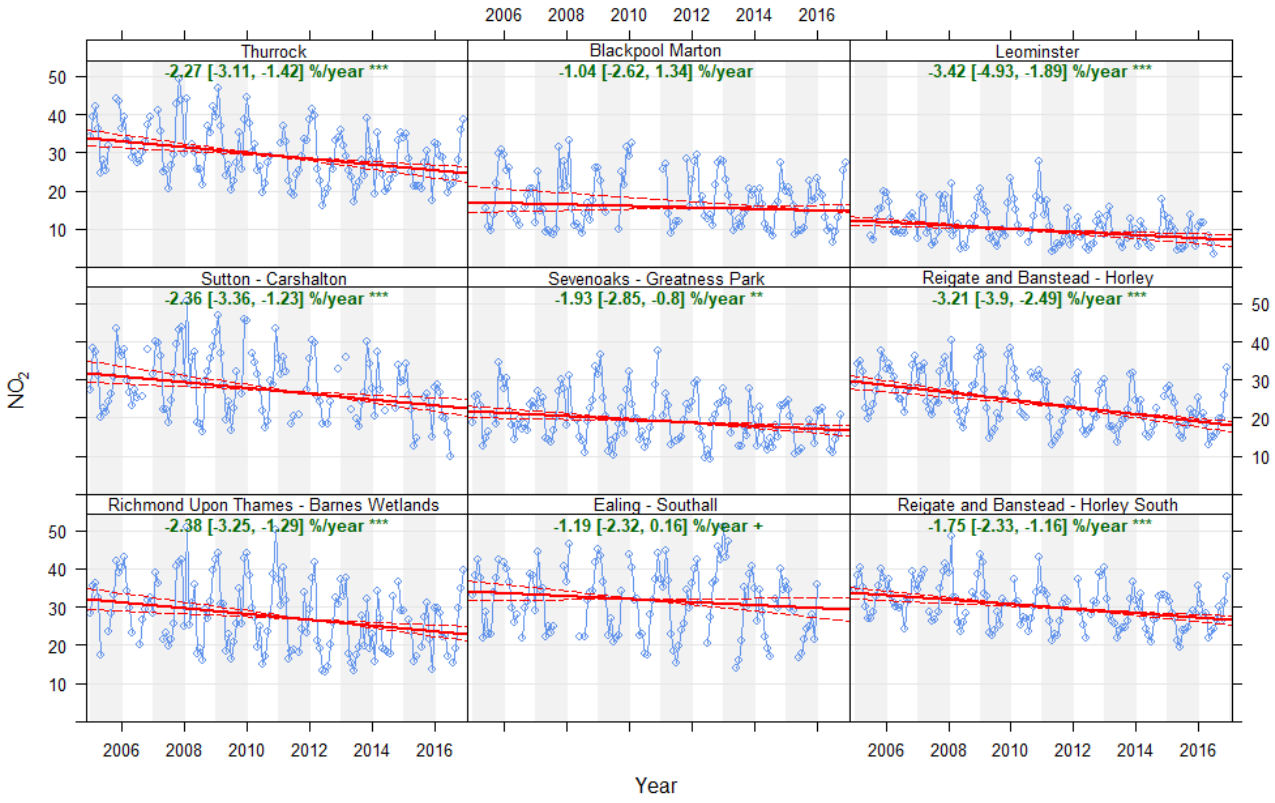


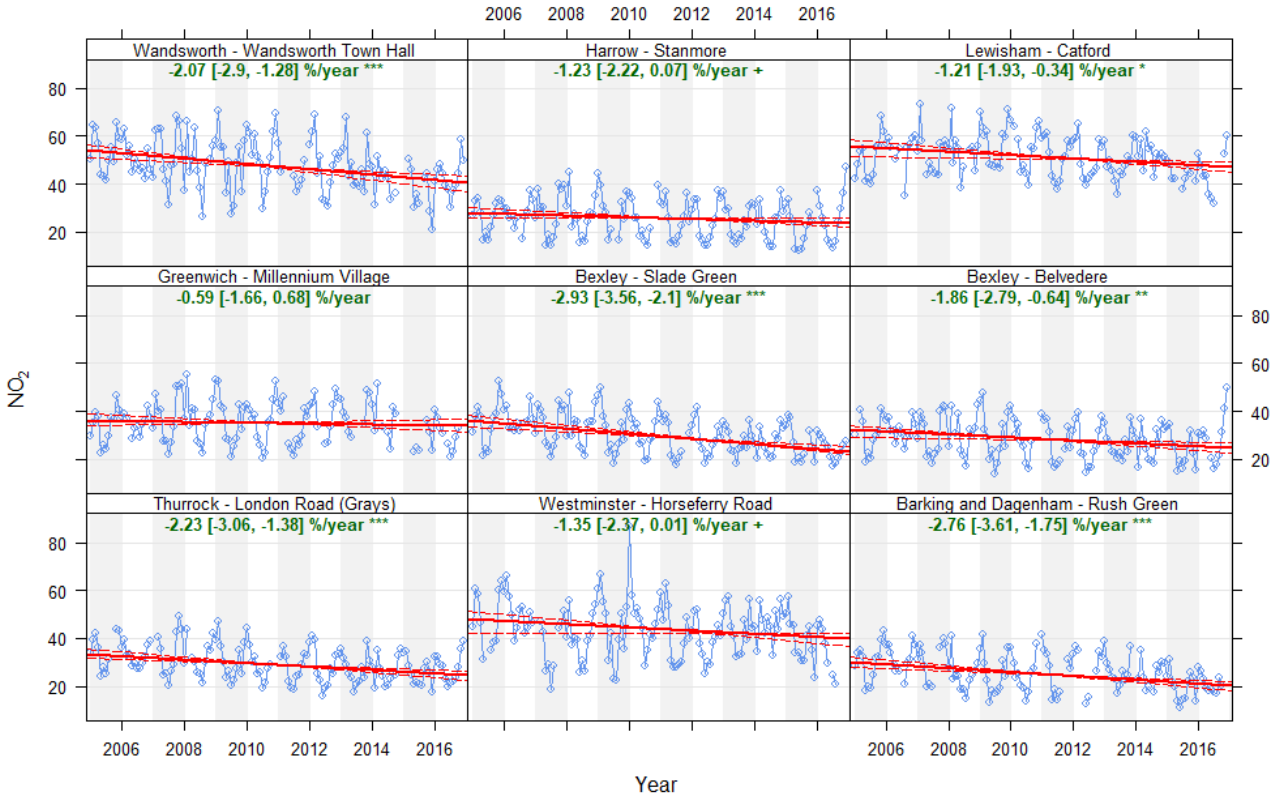

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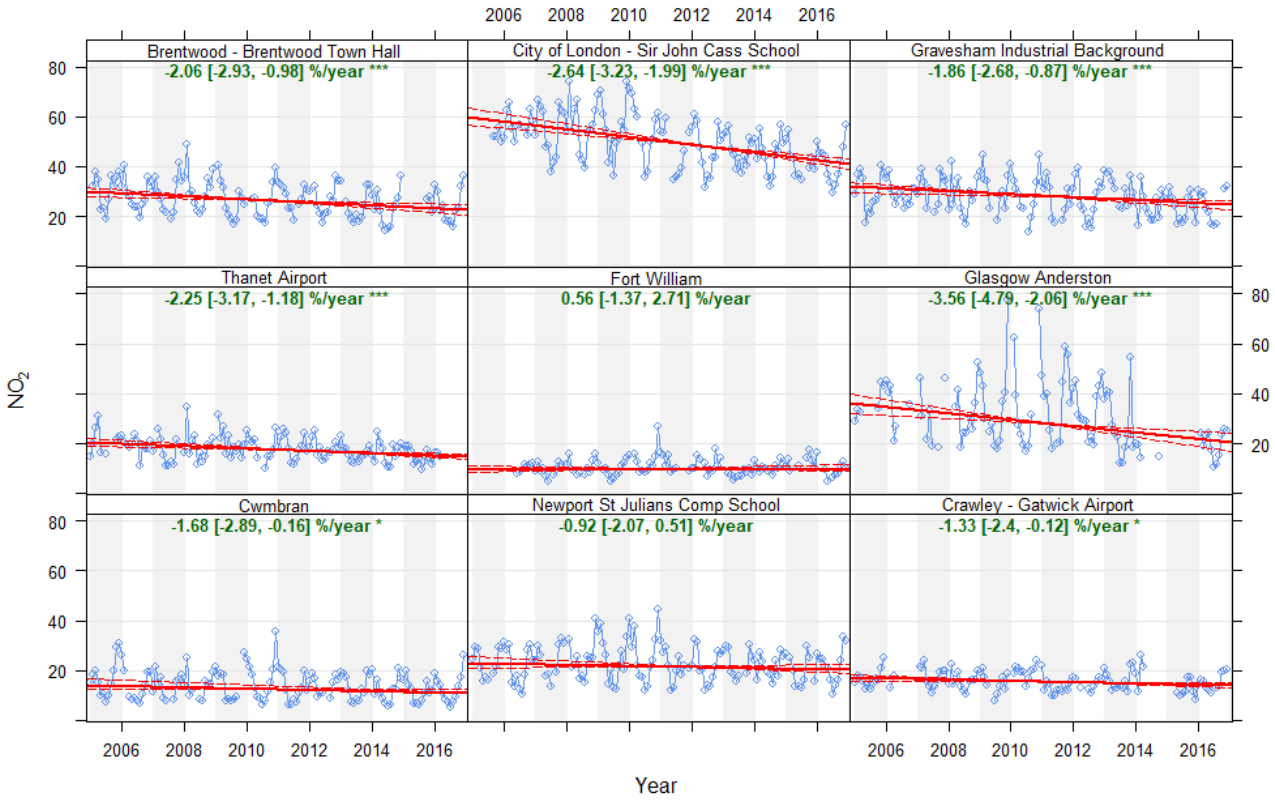

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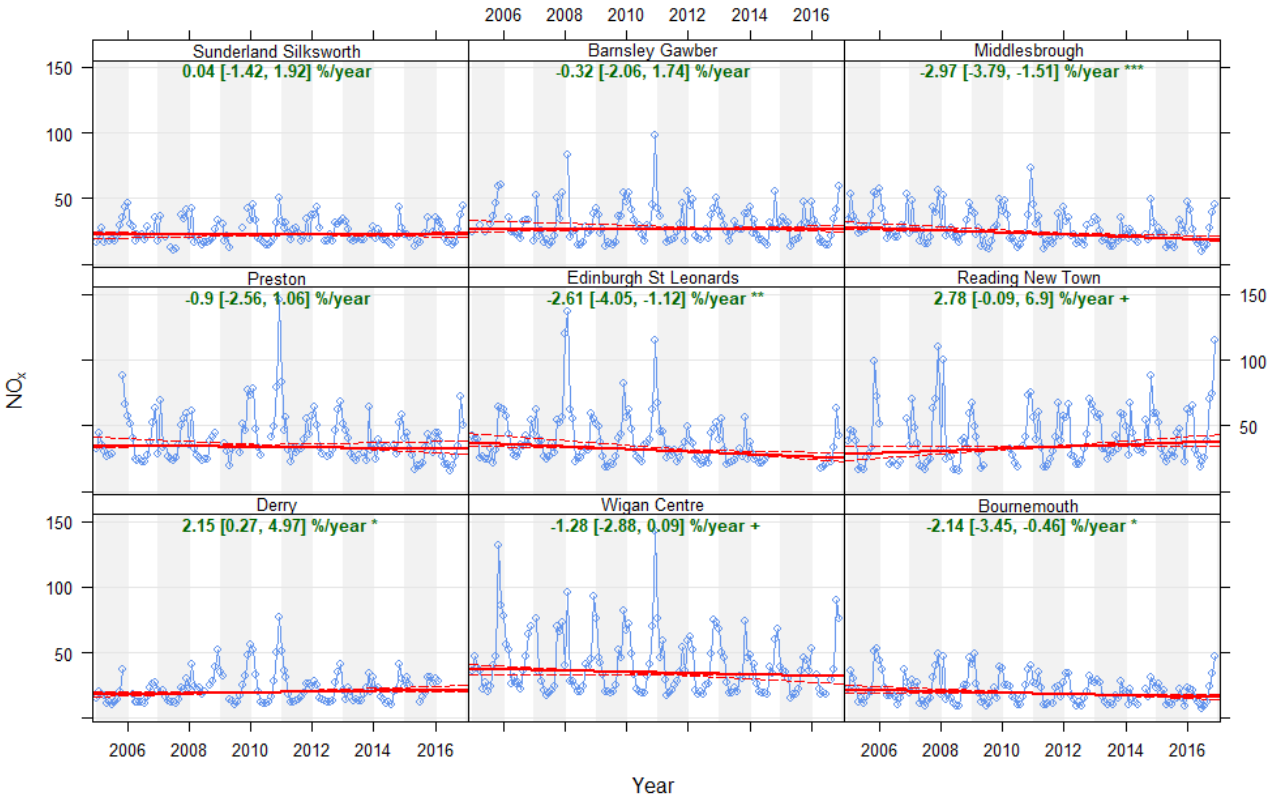


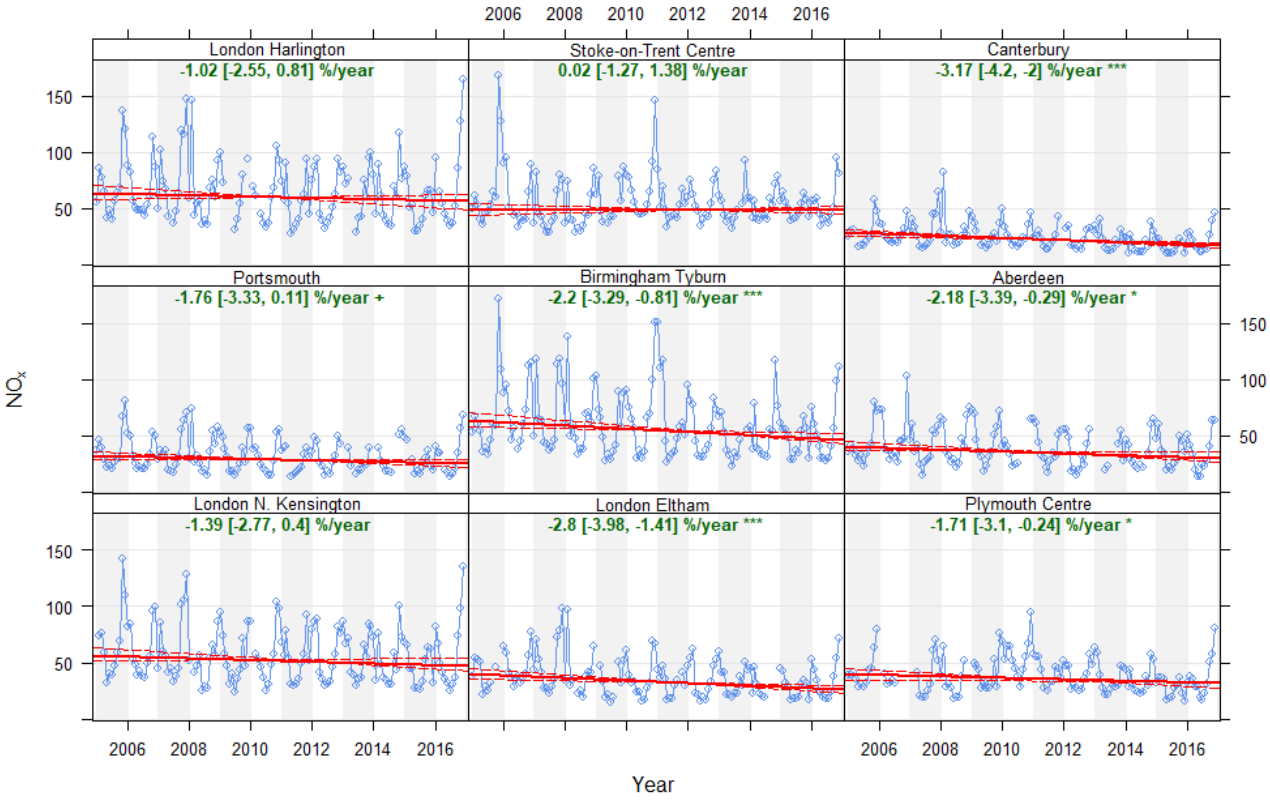

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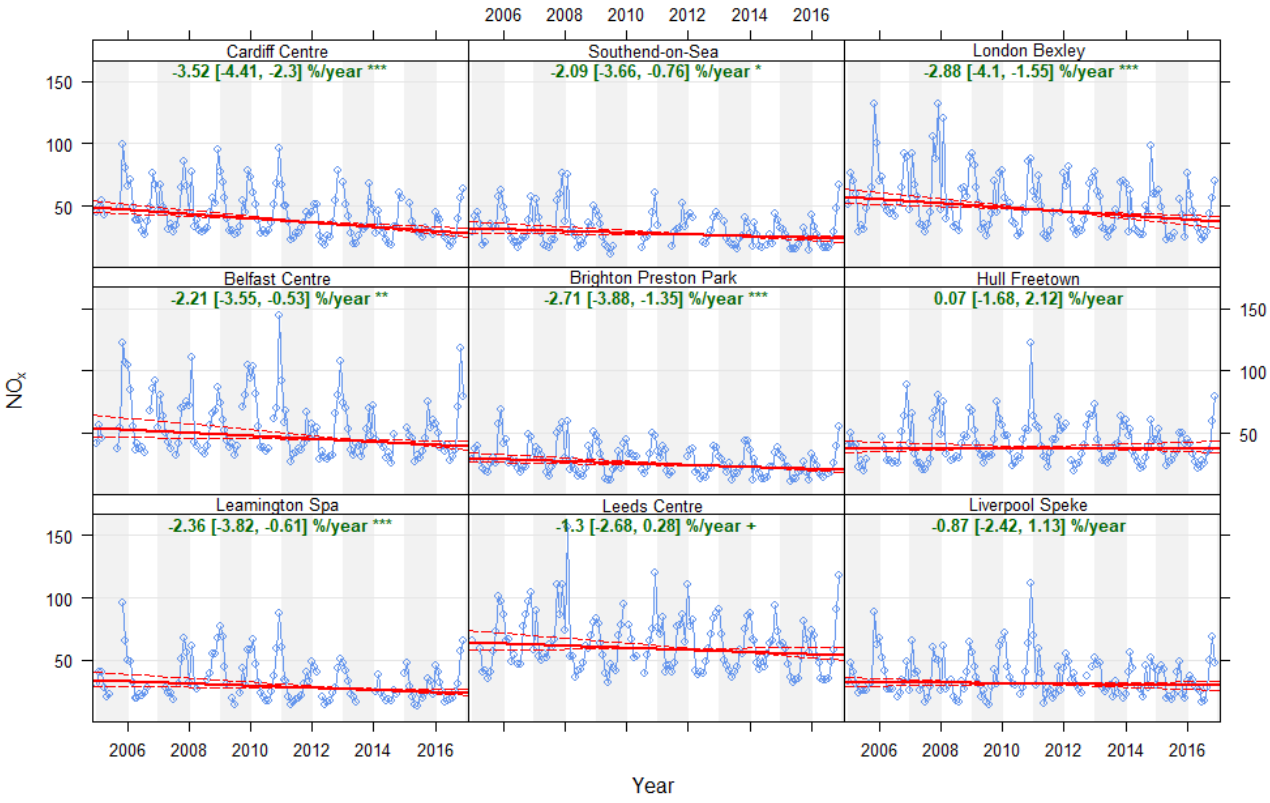


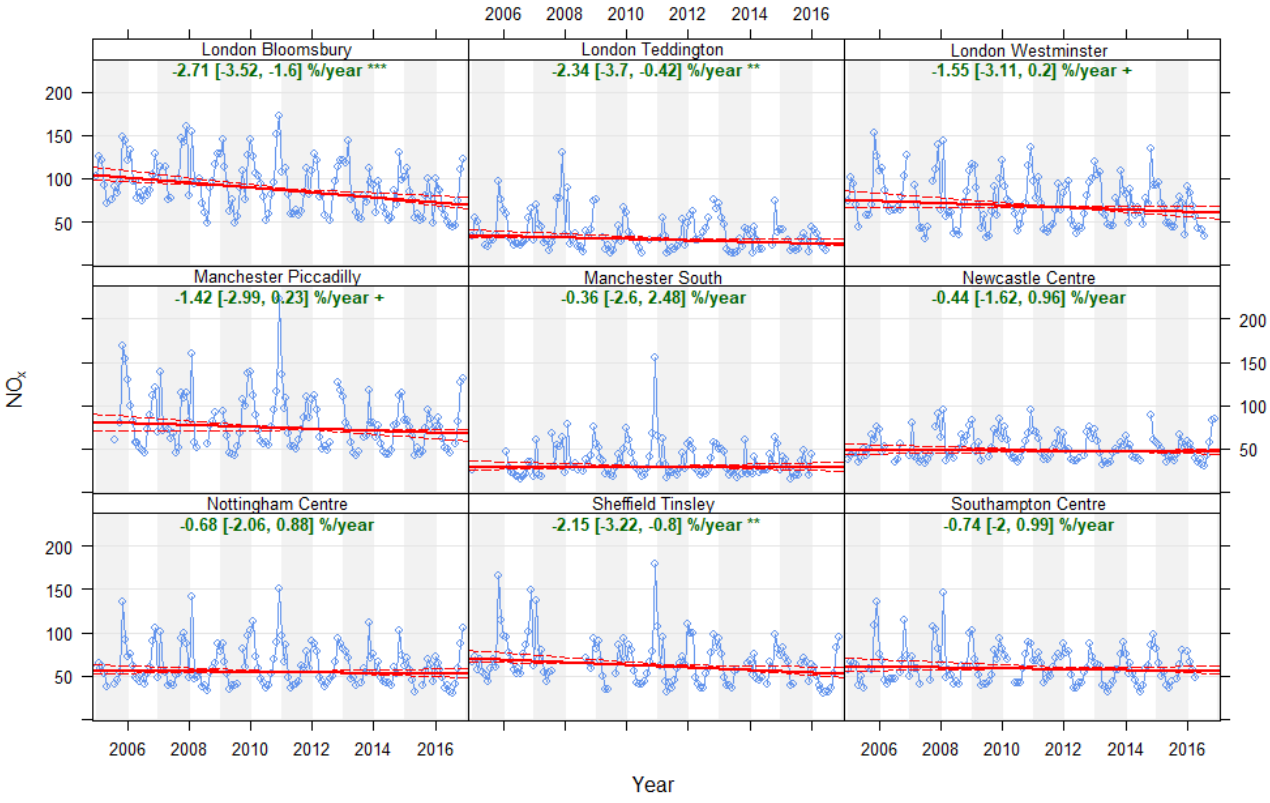

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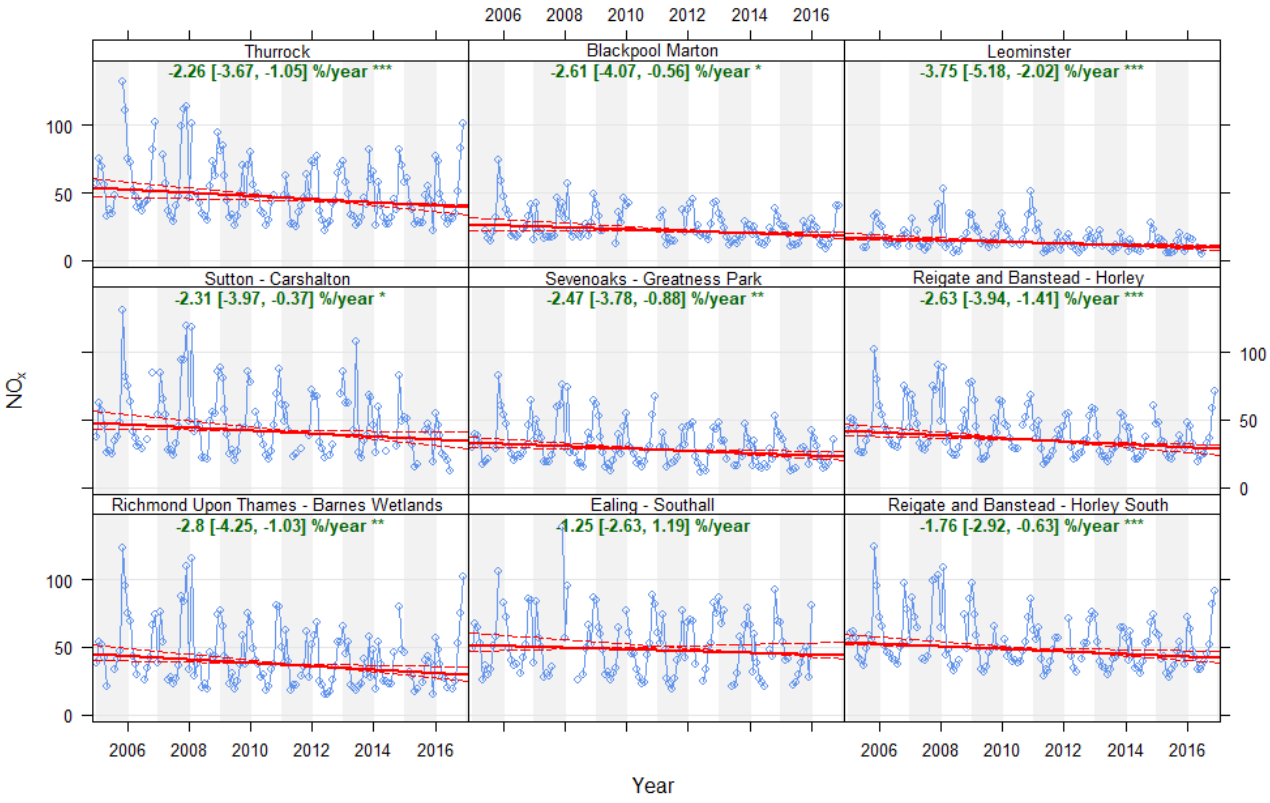


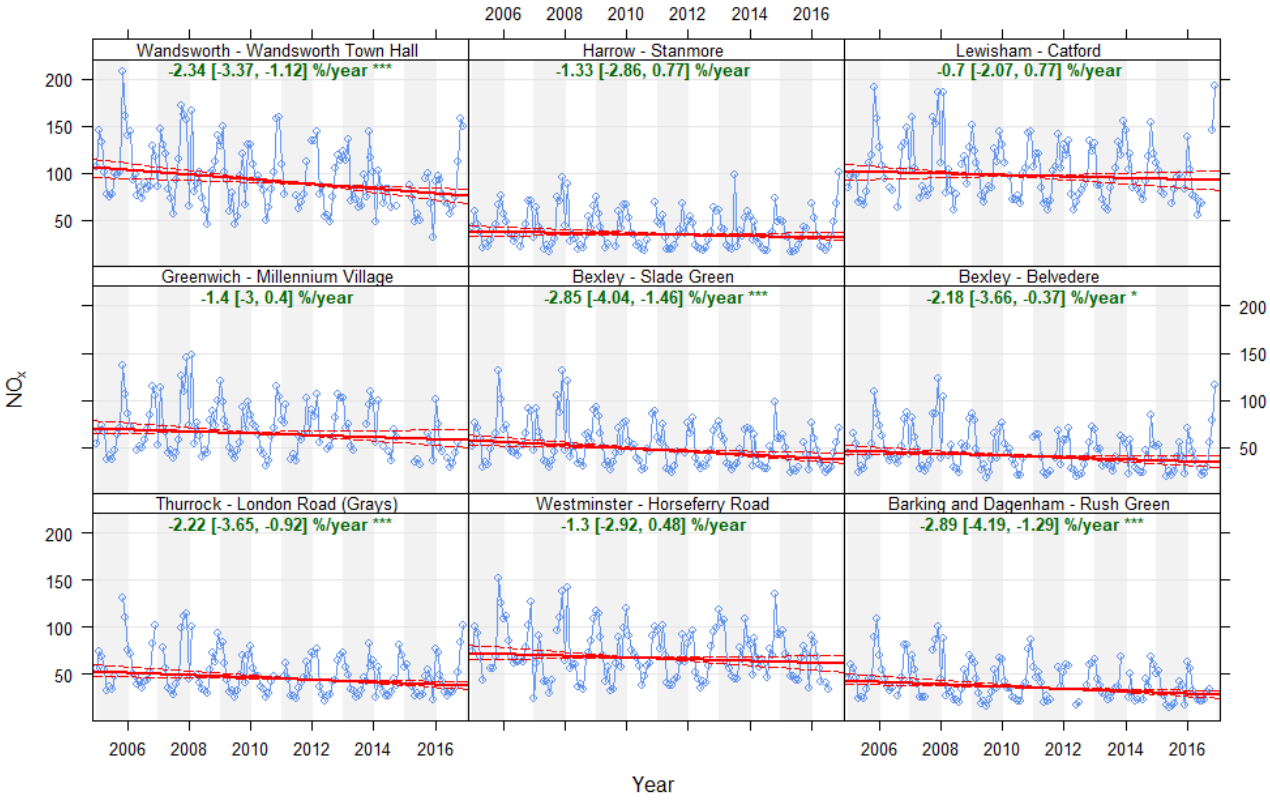

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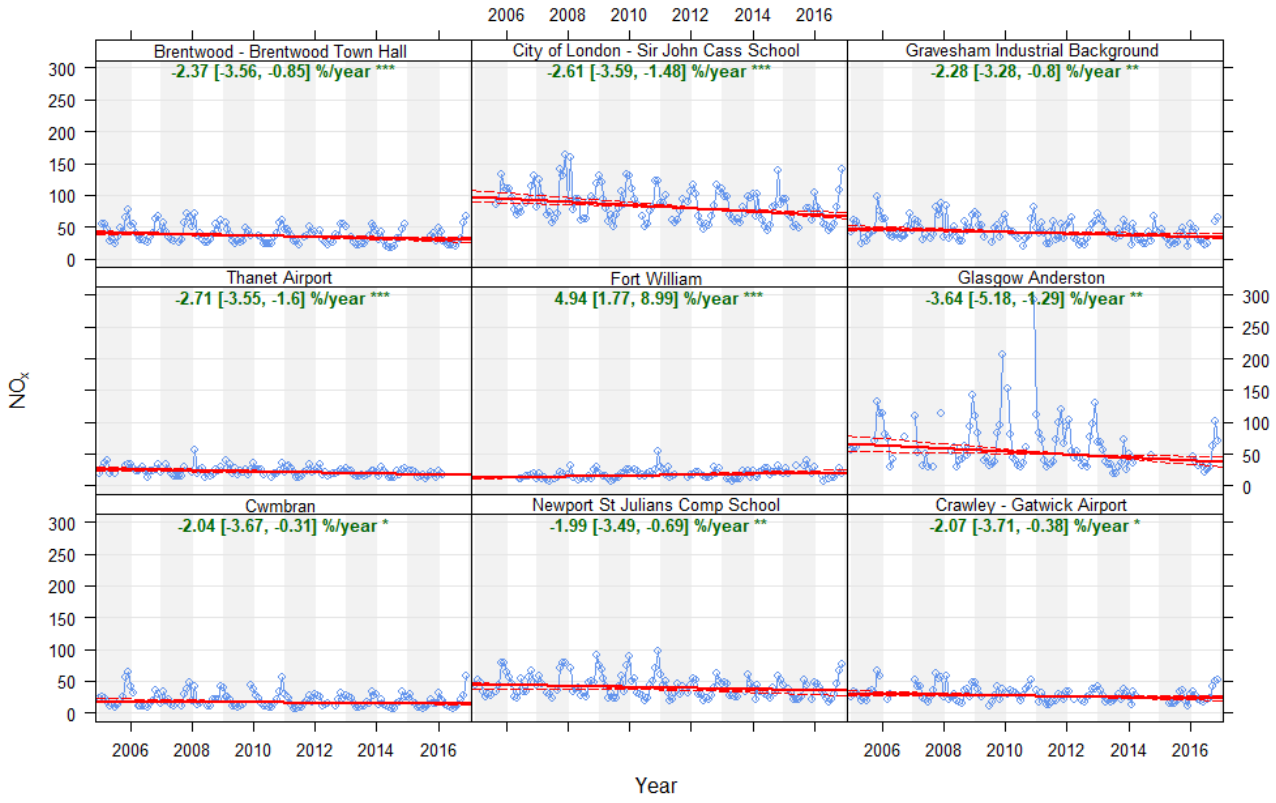

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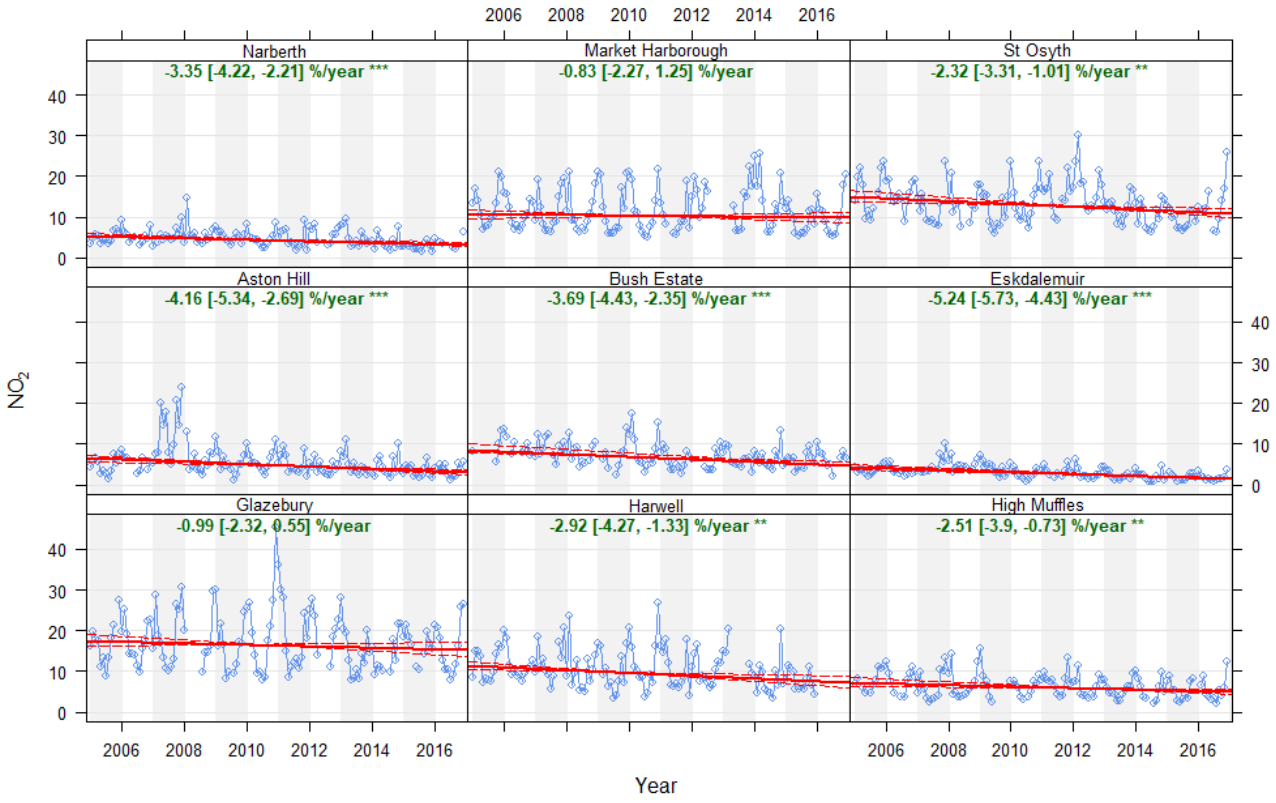


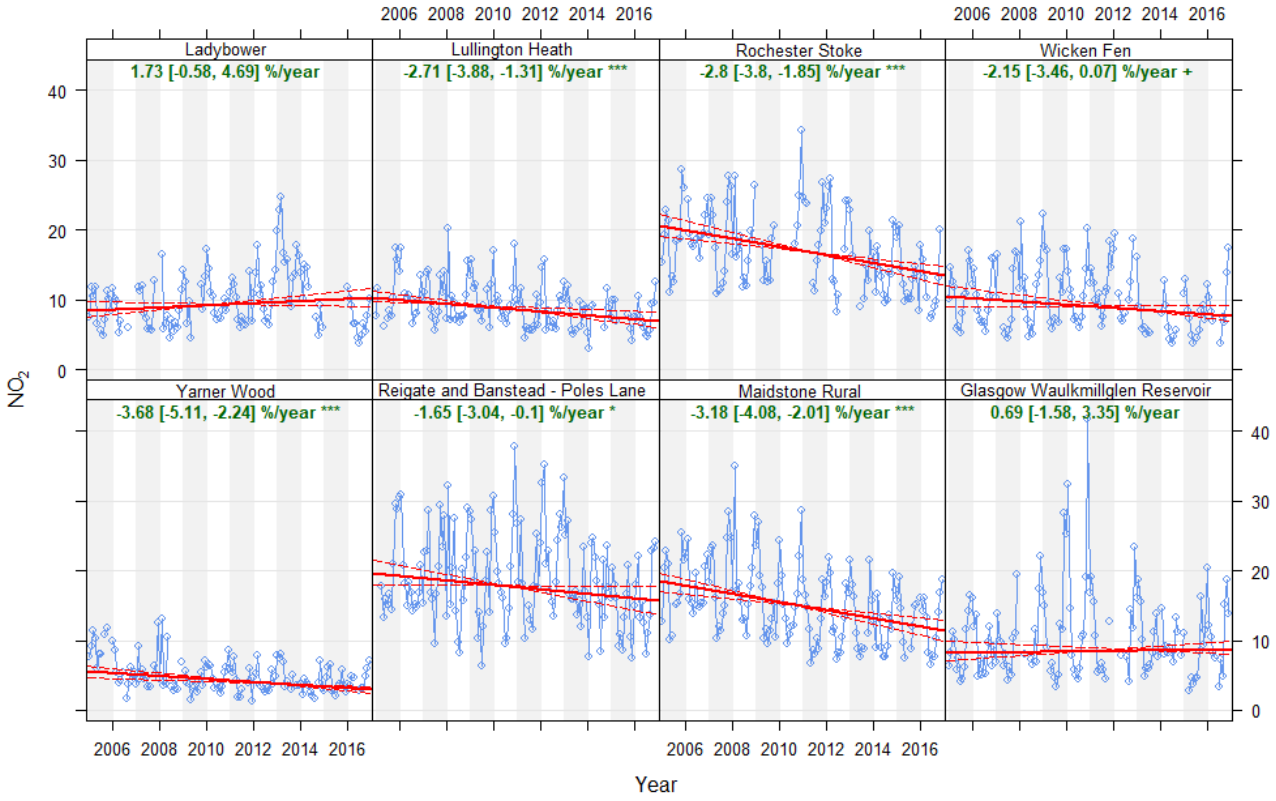

## Rural Sites NOx