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ÉCLAIRE

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RE	Restricted to a group specified by the consortium (including the Commission Services)	☐
CO	Confidential, only for members of the consortium (including the Commission Services)	☐

1. Executive Summary

- The aim of this study is to assess the uncertainty of the calculations of exceedance of critical loads for nitrogen (CLN) carried out at the European scale as a result of the spatial resolution used (50 × 50 km^2)
- In order to assess this uncertainty, critical load exceedances have been calculated for the Netherlands and Scotland using nitrogen deposition data at different resolutions, which were then compared to the exceedance calculations using the deposition data at a resolution of 50 × 50 km^2
- In addition, an evaluation at a high spatial resolution at the landscape scale was also carried out using data from two landscapes located within the two countries
- Critical loads were calculated for all habitats in the two national domains using the model VSD+, where inputs were available. For the remaining sites, the empirical critical loads for nitrogen were used (only necessary for the Scottish domain)
- Land-cover specific nitrogen deposition was estimated using the EMEP4UK chemical transport model applied at three spatial resolutions: 1 × 1 km^2, 5 × 5 km^2 and 50 × 50 km^2
- For the Netherlands, critical loads were estimated to be exceeded within all of the 50 × 50 km^2 grid squares, for all three spatial resolutions of deposition data. However, exceedances were, on average, 15% higher when the 50 × 50 km^2 deposition data were used compared with the calculations done using the 1 × 1 km^2 deposition data
- For Scotland, critical loads were estimated to be exceeded in 62% of the 50 × 50 km^2 grid squares when the 50 × 50 km^2 deposition data were used compared with 91% when the 1 × 1 km^2 deposition data were used. For grid squares where the critical load was estimated to be exceeded, exceedances were, on average, 20% higher when the 50 × 50 km^2 deposition data were used compared with the calculations done using the 1 × 1 km^2 deposition data
- For the Dutch landscape, mean exceedances also increased with a decreasing spatial resolution of nitrogen deposition data, again as a result of an increasing nitrogen deposition to the landscape habitats
- For the Scottish landscape, mean exceedances calculated using the 1 × 1 km^2 EMEP4UK deposition data were at least an order of magnitude smaller than those calculated using 25 × 25 m^2 deposition data from a local-scale atmospheric dispersion model, highlighting the importance of using high spatial resolution modelling for assessing critical load exceedances in “hot-spot” areas

2. Objectives:

The overall objective of this activity is to assess the uncertainty of the calculations of exceedance of critical loads for nitrogen (CLN) carried out at the European scale as a result of the spatial resolution used (50 × 50 km^2). Since the European-scale assessments use critical load data at the highest available resolution at this scale, this uncertainty will arise from the spatial resolution of the nitrogen deposition data (50 × 50 km^2). In order to assess this uncertainty, critical load exceedances have been calculated using nitrogen deposition data at different resolutions, which were then compared to the exceedance calculations using the deposition data at a resolution of 50 × 50 km^2. At the regional scale this has been done at a spatial resolution of 5 × 5 km^2 for a domain covering both the United Kingdom (UK) and the Netherlands and at a spatial resolution of 1 × 1 km^2 for Scotland and the Netherlands, separately. At the landscape scale, the assessment has been done at 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2 for the Dutch landscape Noordelijke Friese Wouden (NFW) and at 25 × 25m^2, and 1 × 1 km^2 for the Scottish landscape (Burnsmuir). Burnsmuir is evaluated at a higher resolution since the landscape is smaller than NFW.

3. Activities:

3.1. Critical load modelling

Critical loads for acidification and eutrophication were calculated using a steady-state solution of the VSD+ model (Bonten et al., 2015) applied to the soil and vegetation database compiled in Task 17.1 (see Deliverable D17.1).

The following paragraphs describe the calculation process for each of the modelling domains.

The Netherlands:

- A map of EUNIS level 2 habitat classes was created at a spatial resolution of 250 × 250 m^2 for the Netherlands, based on the national nature target map, which is a combined national soil and vegetation map at a resolution of 25 × 25 m^2
- Relationships between habitat type and critical limits for pH and N availability were used to derive the critical loads for acidity (CLmaxN) and eutrophication (CLnutN) for the whole of the Netherlands using the model VSD+ at a spatial resolution of 250 × 250 m^2
- The minimum of the two parameters (CLmaxN and CLnutN) was taken as the critical load (CLN) in order to take into account impacts from both acidification and eutrophication, with a minimum threshold value of 300 eq ha^{-1} yr^{-1}.

Scotland:

- Similarly to the Netherlands, input data for VSD+ were prepared for EUNIS level 2 habitat classes, but at a coarser spatial resolution of 1 × 1 km^2 (the finest available)
- Only the habitat classes for which acidity modelling has been done in the UK were included (EUNIS classes: D1,E1.7,E3.5,E4.2,F4.11,F4.2,G1 and G3)
- Relationships between habitat type and critical limits for pH and N availability were used to derive CLmaxN and CLnutN for the whole of the UK using VSD+ at a spatial resolution of 1 × 1 km^2
- As with the Netherlands, the minimum of the two parameters (CLmaxN and CLnutN) was taken as the critical load (CLN) in order to take into account impacts from both acidification and eutrophication, with a minimum threshold value of 300 eq ha^{-1} yr^{-1}
- For the UK habitats not included in the VSD+ simulations (EUNIS classes: A2.5, B1.4, E1.26, G1.6, G1.8, G3.4 and G4), data from the UK empirical critical loads database were used (Hall et al., 2015).

NFW Landscape (The Netherlands):

- Critical N loads were calculated with the same method as that applied to the Netherlands as a whole. The critical loads were calculated for the habitats at a resolution of 25 × 25 m^2. These high resolution CLN data were up-scaled to a 50 × 50 m^2 grid by taking the 5th percentile critical loads (in fact the minimum of the four underlying 25 × 25 m^2 cells).

Burnsmuir Landscape (Scotland):

- Relationships between habitat type and critical limits for pH and N availability were used to derive CLmaxN and CLnutN using VSD+ for the relevant habitats in the land cover map developed in Task 17.1 (see Deliverable D17.1).
- The minimum of the two parameters (CLmaxN and CLnutN) was taken as the critical load (CLN) in order to take into account impacts from both acidification and eutrophication, with a minimum threshold value of 300 eq ha-1 yr-1
- For the habitats not included in the VSD+ simulations, due to a lack of critical limits for pH and N availability, empirical critical loads derived for similar habitats were used.

Note that the methods for deriving critical loads and exceedances for Scotland and the Scottish landscape area may differ from the national methods applied in the UK; for information on the UK methods for calculating critical loads and exceedances please refer to www.cldm.ceh.ac.uk

3.2. Nitrogen deposition modelling

Scotland and the Netherlands

At the regional scale, the EMEP4UK model (Vieno et al., 2014) was used to estimate annual atmospheric nitrogen deposition for the target year (2008) at three different spatial resolutions, 1 × 1 km^2, 5 × 5 km^2 and 50 × 50 km^2 (see Deliverables D8.3 and D17.2). Model outputs of wet deposition and dry deposition to coniferous woodland, deciduous woodland and semi-natural land cover were used in the exceedance calculations (see 3.3 below). Two additional deposition datasets at spatial resolutions of 5 × 5 km^2 and 50 × 50 km^2 were produced by aggregating the 1 × 1 km^2 deposition data in order to look at the effect of changing the resolution of the deposition data whilst keeping the total deposition to the domain constant.

NFW Landscape (The Netherlands)

The depositions in the NFW due to the landscape NH_3 emissions were calculated by the combination of the two models INITIATOR and OPS (see Kros et al., 2011). The emissions from (i) housing and storage (point sources) and (ii) animal manure application, fertilizer use and grazing (area sources) were initially calculated at a 50 × 50 m^2 resolution with the INITIATOR model. Subsequently these emissions were aggregated to 1 × 1 km^2 and 5 × 5 km^2. For all three spatial resolutions NH_3 deposition was calculated with the OPS model.

In order to calculate critical load exceedances, the total N deposition to the habitats was calculated by combining the NH_3 deposition described above with estimates of deposition of NO_x and NH_3 from sources outside the NFW, including the contribution from non-agricultural sources. The NO_x emissions/deposition and NH_3 emissions/deposition from outside the NFW were based on the 1 × 1 km^2 estimates calculated with the OPS model using the 1 × 1 km^2 emission source files for 2008 from the RIVM (pers. comm J. Aben). All agricultural NH_3 emissions within the NFW domain were removed from these simulations to avoid double counting. The background deposition was calculated only at 1 × 1 km^2 and 5 × 5 km^2. Total N deposition at the three resolutions was calculated by adding the 1 × 1 km^2 background deposition to both the 50 × 50 m^2 and 1 × 1 km^2 resolution landscape NH_3 deposition and the 5 × 5 km^2 background deposition to the 5 × 5 km^2 landscape NH_3 deposition.

Burnsmuir Landscape (Scotland)

The Local Area Dispersion and Deposition (LADD) model was used to simulate annual NH_3 concentrations and dry deposition rates, as described by Vogt et al. (2013). Ammonia emission data were calculated by applying a combination of UK average emission factors (as used in the national inventory) and specific emission factors, to account for agricultural practice and mitigation measures, to detailed agricultural activity data obtained through farm visits and surveys. Land cover/use data were obtained through aerial photographs of the landscape supplemented by information from farm visits, and wind statistics were calculated from data collected for 30-min-intervals during 2008 at a continuous measurement site near the centre of the study area. LADD was applied for the target year 2008 at 25 × 25 m^2 resolution over an area of 7 × 7 km^2, with the model domain extended by 500 m on all sides to limit possible edge effects. Annual average NH_3 concentrations at 1.5 m height above ground level and total dry deposition rates were simulated. The model output was calibrated to eliminate systematic model bias using mean annual NH_3 concentration measurements made at 31 locations within the landscape. The calibrated modelled dry deposition estimates were then combined with the less spatially variable wet deposition of reduced N and the dry and wet deposition of oxidised N calculated using the EMEP4UK model run for 2008 at a 1 × 1 km^2 resolution.

3.3. Critical load exceedance estimates at different spatial resolutions

The average accumulated exceedance (AAE) was used as the indicator for the exceedances of the CLN, (Posch et al., 1999), following the recommendations of the ICP Mapping Manual (CLRTAP, 2004). In European integrated assessments all critical load functions within a grid cell have to be considered simultaneously, and each ecosystem contributes with its area: A_i, i=1,...,N (N=number of ecosystems in the grid cell). Let $Ex_i(N_{dep},S_{dep})$, i=1,..,N, be the exceedance function for ecosystem i as defined above, then we define the accumulated exceedance as:

$$AE(N_{dep}) = \sum_{i=1}^{N} A_i Ex_i(N_{dep}) \qquad (1)$$

For a given deposition rate, AE is the total amount of N (in mol yr^{-1}) that is deposited in excess of the critical loads within the grid cell in a given year. This function is thus strongly determined by the total ecosystem area in a grid cell. In order to minimize this dependence we define the average accumulated exceedance by dividing the AE function by the total ecosystem area:

$$AAE(N_{dep}) = AE(N_{dep}) / \sum_{i=1}^{N} A_i \qquad (2)$$

For the national scale assessments, the AAE of each 50 × 50 km^2 grid cell was calculated using the habitat and CLN data (described above in 3.1) that occur within the grid cell plus the corresponding land-cover specific N deposition estimate from the EMEP4UK model (either coniferous, deciduous or semi-natural). For the UK data set, the actual habitat areas were used in the calculations, whereas for the Dutch data, the habitat was assumed to occupy the entire 250 × 250 m^2 grid square. For each domain, three calculations were made for each of the deposition spatial resolutions, although the calculation unit (the 50 × 50 km^2 grid square) remained the same. For the landscape-scale assessments, the AAE was calculated from the high resolution CLN data described above and the high resolution deposition estimates from the relevant models (INITIATOR and OPS for the Dutch landscape and LADD and EMEP4UK for the Scottish landscape). The areas of the grid squares were used as the habitat areas for the AAE calculations.

4. Results:

4.1. Critical load calculations

Figure 1 shows the 5^{th} percentile critical loads for the 1 km grid cells in the Dutch and Scottish domains and Figures 2 and 3 shows the critical loads for the Dutch and Scottish landscapes, respectively.

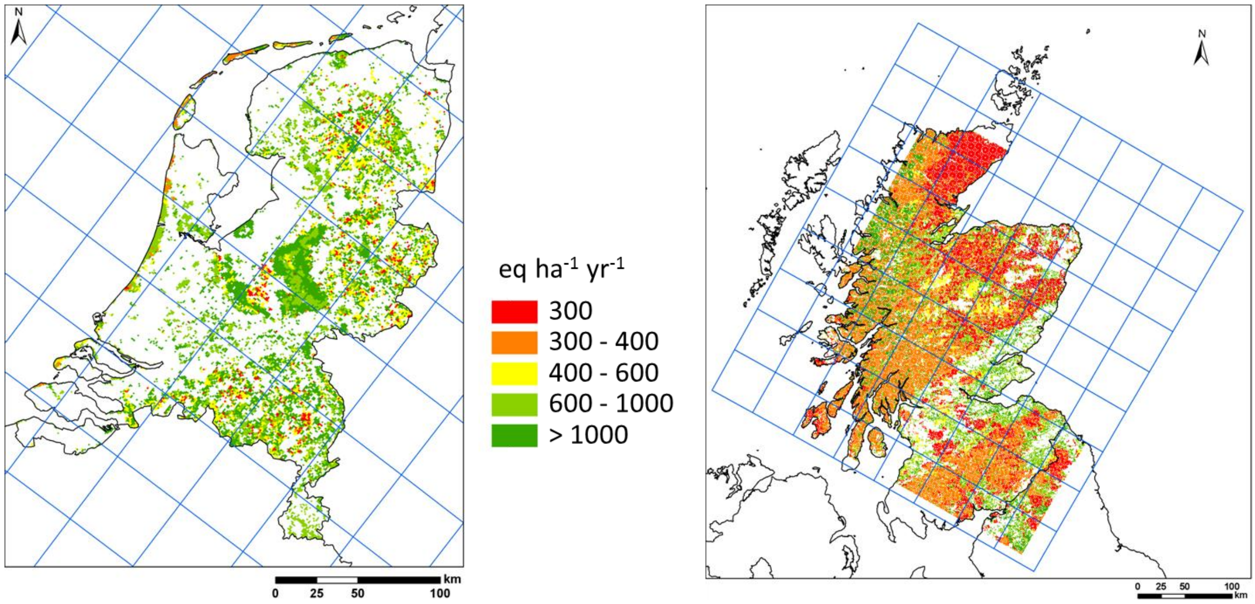

Figure 1: 5th percentile critical loads for the 1 km grid cells in the Dutch and Scottish domains. The blue grid shows the EMEP 50 × 50 km^2 grid squares.

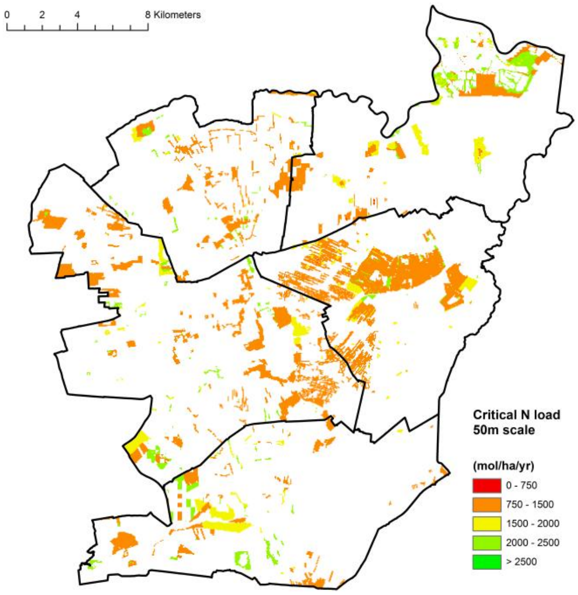

Figure 2: Critical loads for the NFW domain at a spatial resolution of 50 × 50 m^2

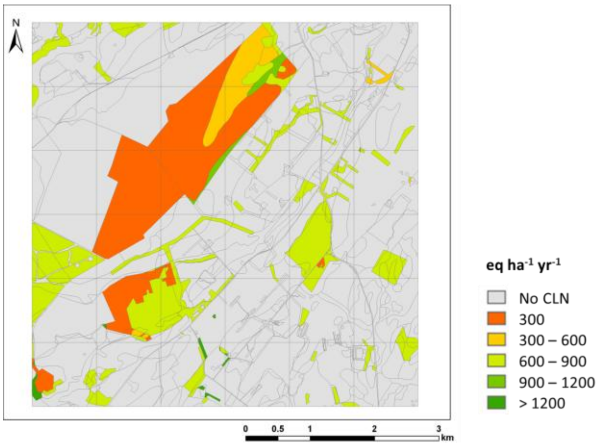

Figure 3: Critical loads for the Burnsmuir landscape at a spatial resolution of 25 × 25 m^2.

4.2. Nitrogen deposition estimates

The impacts of spatial resolution on nitrogen deposition estimates are shown by presenting two approaches: (i) aggregating emissions and calculating the deposition with EMEP4UK at the different resolutions (so deposition is assessed with up-scaled emissions) and (ii) calculating the deposition with EMEP4UK at the highest resolution (1 × 1 km^2) and then aggregating the deposition data to the lower resolutions (5 × 5 km^2 and 50 × 50 km^2). Figure 4 shows the annual estimated nitrogen deposition rates to coniferous forests (as an example) in the Netherlands, at the three different spatial resolutions. These values are per unit area of forest and so are not dependent on the amount of forest in each grid square. Mean land-cover dependent deposition rates to all habitat sites shown in Figure 1 are 21.8, 22.6 and 22.5 kg N ha^{-1} yr^{-1}, for the spatial resolutions of 1 × 1 km^2, 5 × 5 km^2 and 50 × 50 km^2, respectively. Figure 5 shows the deposition maps at resolutions of 5 × 5 km^2 and 50 × 50 km^2 aggregated from the 1 × 1 km^2 data (also shown). For these aggregated data, mean deposition rates to the habitats are 21.8, 22.1 and 22.4 kg N ha^{-1} yr^{-1}, for the spatial resolutions of 1 × 1 km^2, 5 × 5 km^2 and 50 × 50 km^2, respectively. Figure 6 shows the annual estimated nitrogen deposition rates to coniferous forests in Scotland, at the three different spatial resolutions. Mean deposition rates to the habitat sites shown in Figure 1 are 5.1, 5.5 and 5.4 kg N ha^{-1} yr^{-1}, for the spatial resolutions of 1 × 1 km^2, 5 × 5 km^2 and 50 × 50 km^2, respectively. Figure 7 shows the deposition maps for Scotland at resolutions of 5 × 5 km^2 and 50 × 50 km^2 aggregated from the 1 × 1 km^2 data (also shown). For these aggregated data, mean deposition rates to the habitats are 5.1, 5.1 and 5.2 kg N ha^{-1} yr^{-1}, for the spatial resolutions of 1 × 1 km^2, 5 × 5 km^2 and 50 × 50 km^2, respectively.

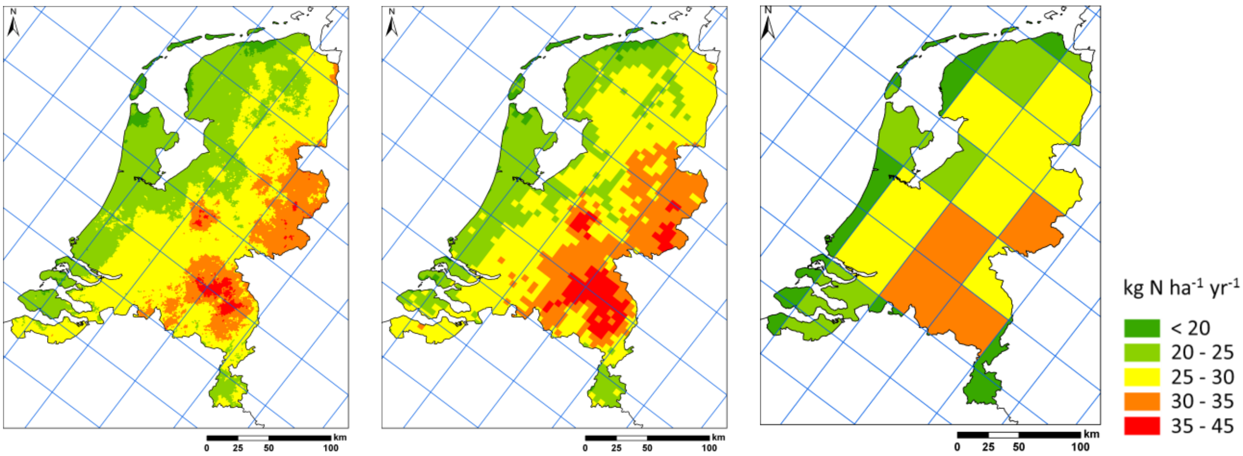

Figure 4: Estimated annual nitrogen deposition rates to coniferous forests in the Netherlands at the three spatial resolutions, left: 1 × 1 km^2; centre: 5 × 5 km^2 and right: 50 × 50 km^2 (5 × 5 km^2 and 50 × 50 km^2 data are based on up-scaling 1 × 1 km^2 emission data).

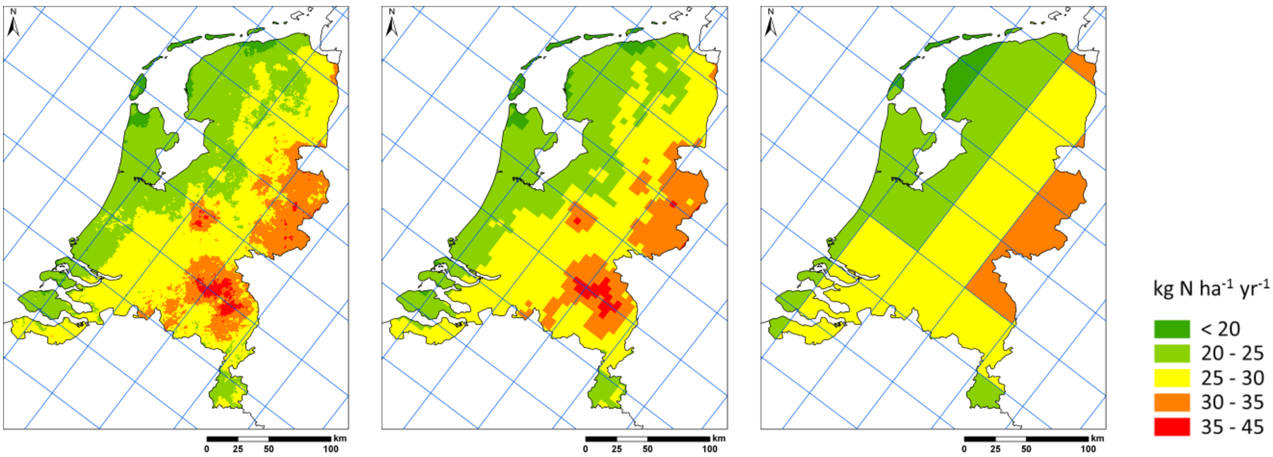

Figure 5: Estimated annual nitrogen deposition rates to coniferous forests in the Netherlands at the three spatial resolutions, left: 1 × 1 km^2 (same data as Figure 4); centre: 5 × 5 km^2 and right: 50 × 50 km^2 (5 × 5 km^2 and 50 × 50 km^2 data are both aggregated from the 1 × 1 km^2 data).

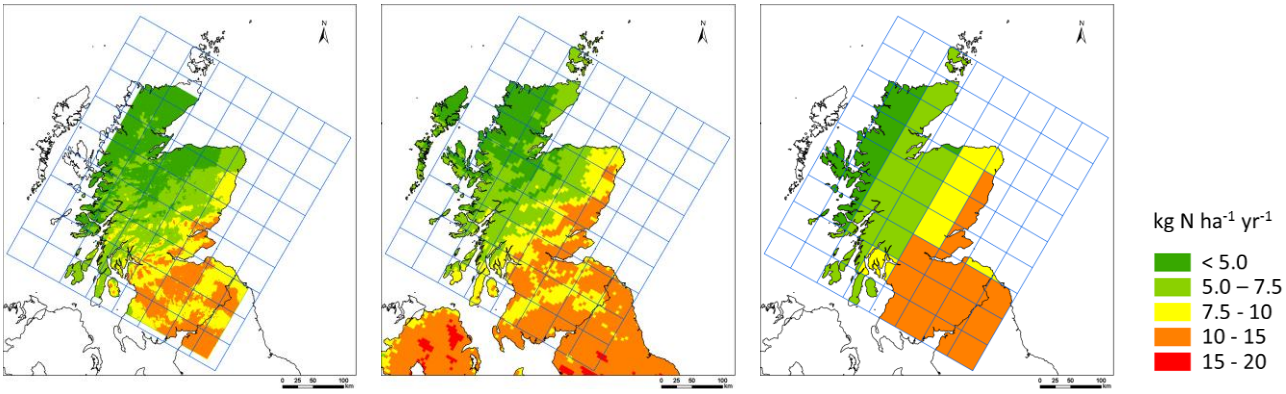

Figure 6: Estimated annual nitrogen deposition rates to coniferous forests in Scotland at the three spatial resolutions, left: 1 × 1 km^2; centre: 5 × 5 km^2 and right: 50 × 50 km^2 (5 × 5 km^2 and 50 × 50 km^2 data are based on up-scaling 1 × 1 km^2 emission data).

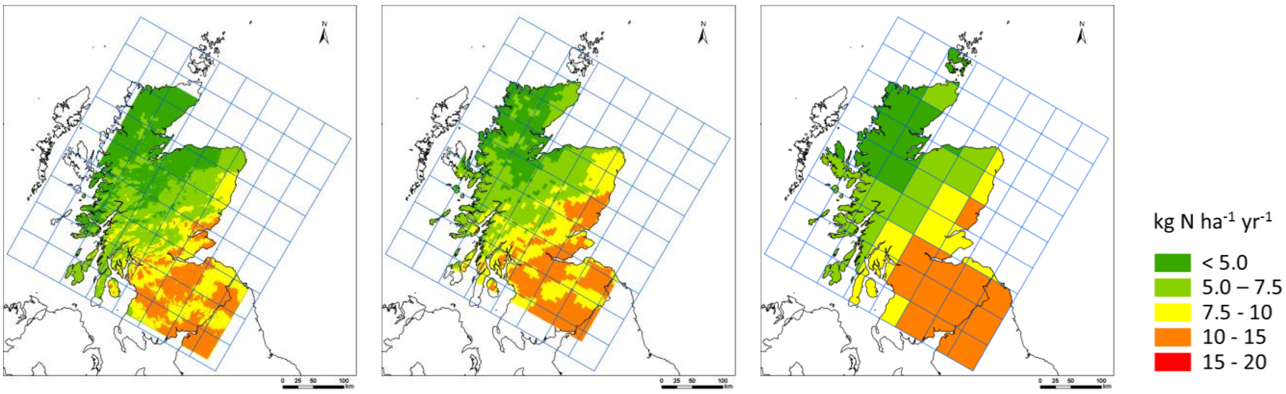

Figure 7: Estimated annual nitrogen deposition rates to coniferous forests in Scotland at the three spatial resolutions, left: 1 × 1 km^2 (same data as Figure 6); centre: 5 × 5 km^2 and right: 50 × 50 km^2 (5 × 5 km^2 and 50 × 50 km^2 data are both aggregated from the 1 × 1 km^2 data).

Figure 8 shows the annual estimated nitrogen deposition rates to the NFW landscape at the three spatial resolutions, 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2 and Figure 9 shows the annual estimated nitrogen deposition rates to the Burnsmuir landscape at two spatial resolutions, 25 × 25 m^2 and 1 × 1 km^2.

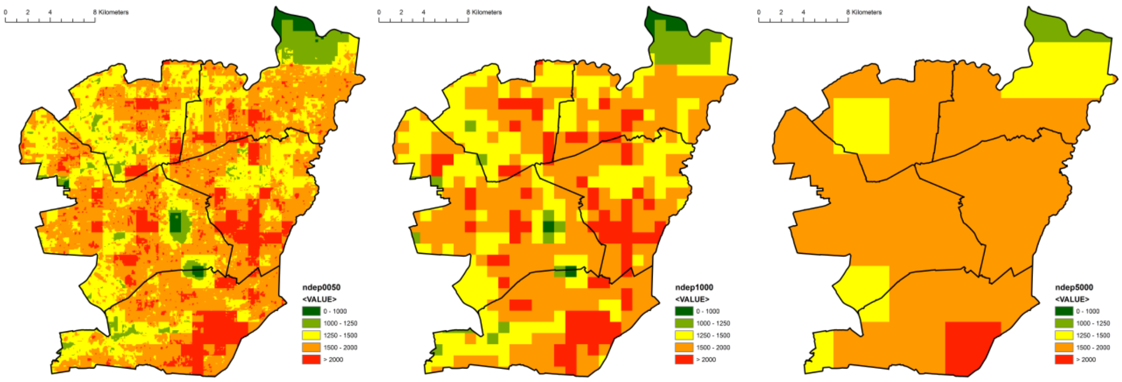

Figure 8: Total nitrogen deposition for the NFW landscape at a resolution of 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2.

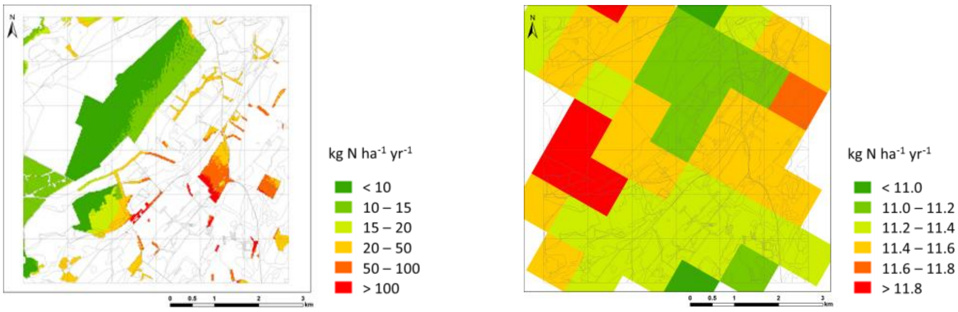

Figure 9: Total nitrogen deposition to grid squares with habitats present for the Burnsmuir landscape at a resolution of 25 × 25 m^2 and 1 × 1 km^2. Note: the different deposition ranges of the two maps.

4.3. Critical load exceedance estimates at different spatial resolutions

Scotland and the Netherlands:

Figure 10 shows the AAEs for the 50 × 50 km^2 grid squares that make up the Netherlands calculated using the three different spatial resolutions of nitrogen deposition data and Figure 11 shows them for calculations using the 1 × 1 km^2 deposition data aggregated to 5 × 5 km^2 and 50 × 50 km^2. Figures 12 and 13 show similar maps for the Scottish domain. Besides small differences between the individual AAE values for a particular 50 × 50 km^2 grid square, mean exceedances increase slightly going from 1 × 1 km^2 to 50 × 50 km^2 (from 458 to 525 eq ha^{-1} yr^{-1} for the Netherlands and from 23 to 27 eq ha^{-1} yr^{-1} in Scotland) in line with the increasing mean N deposition estimates (from 21.8 to 22.4 kg N ha^{-1} yr^{-1} in the Netherlands and from 5.1 to 5.4 kg N ha^{-1} yr^{-1} in Scotland).

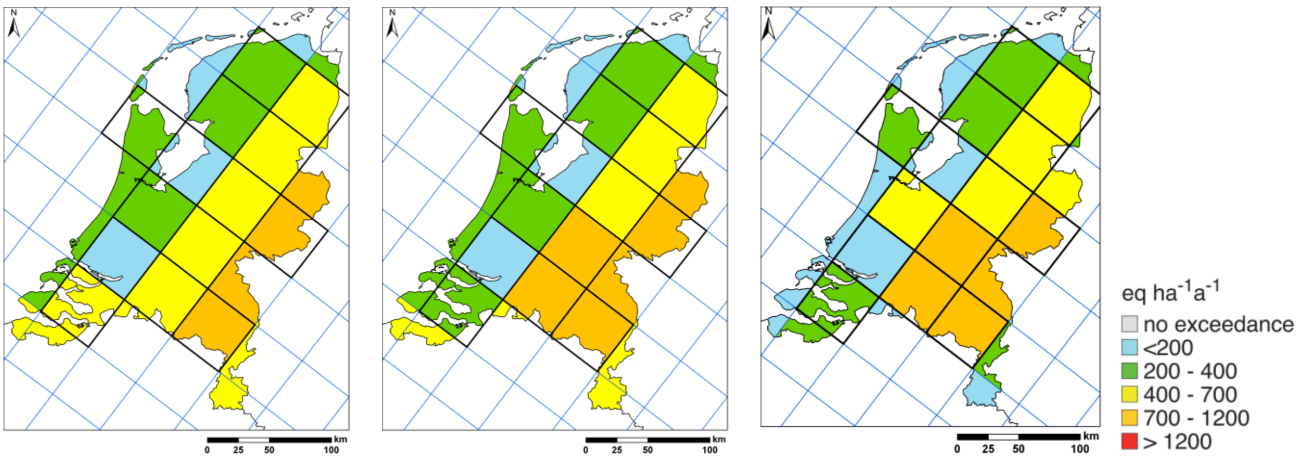

Figure 10: Average accumulated exceedances for 50 × 50 km^2 grid squares in the Netherlands calculated using nitrogen deposition data at the three spatial resolutions shown in Figure 4, left: 1 × 1 km^2; centre: 5 × 5 km^2 and right: 50 × 50 km^2 (5 × 5 km^2 and 50 × 50 km^2 data are based on up-scaling 1 × 1 km^2 emission data).

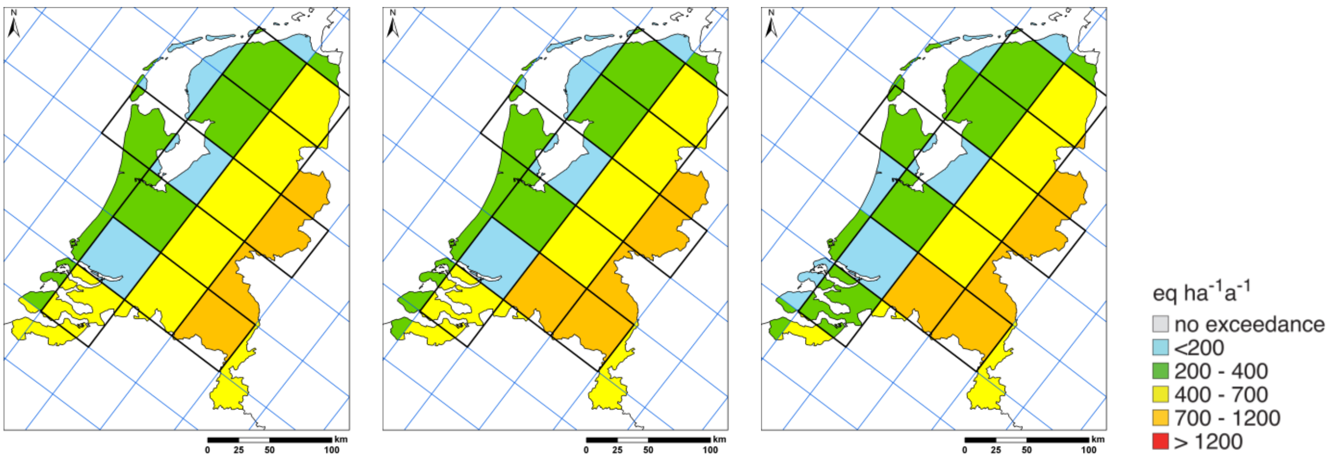

Figure 11: Average accumulated exceedances for 50 × 50 km^2 grid squares in the Netherlands calculated using nitrogen deposition data at the three spatial resolutions shown in Figure 5: left: using 1 × 1 km^2 data (same data as Figure 10); centre: using 5 × 5 km^2 aggregated data and right: using 50 × 50 km^2 aggregated data.

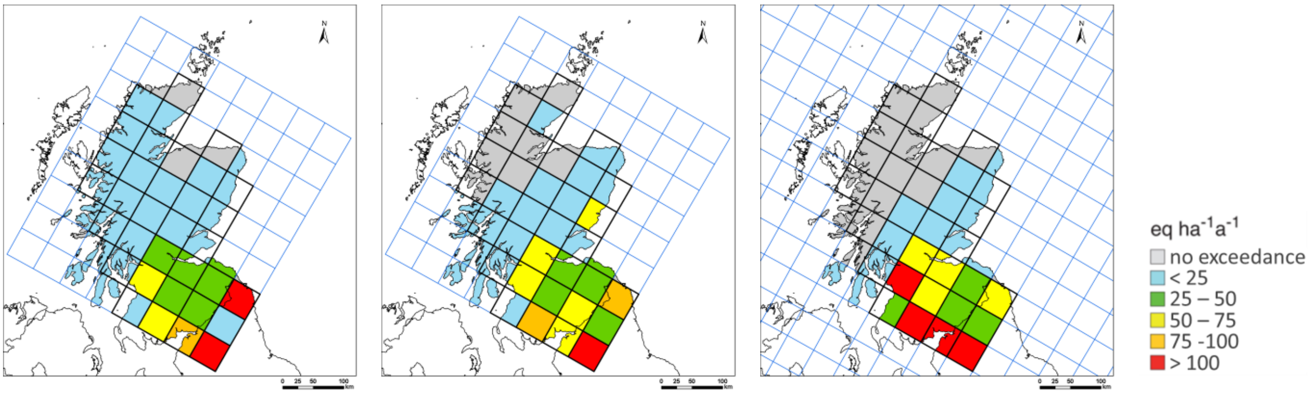

Figure 12: Average accumulated exceedances for 50 × 50 km^2 grid squares in Scotland calculated using nitrogen deposition data at the three spatial resolutions shown in Figure 6: left: 1 × 1 km^2; centre: 5 × 5 km^2 and right: 50 × 50 km^2 (5 × 5 km^2 and 50 × 50 km^2 data are based on up-scaling 1 × 1 km^2 emission data). Note: different exceedance range to the Dutch maps.

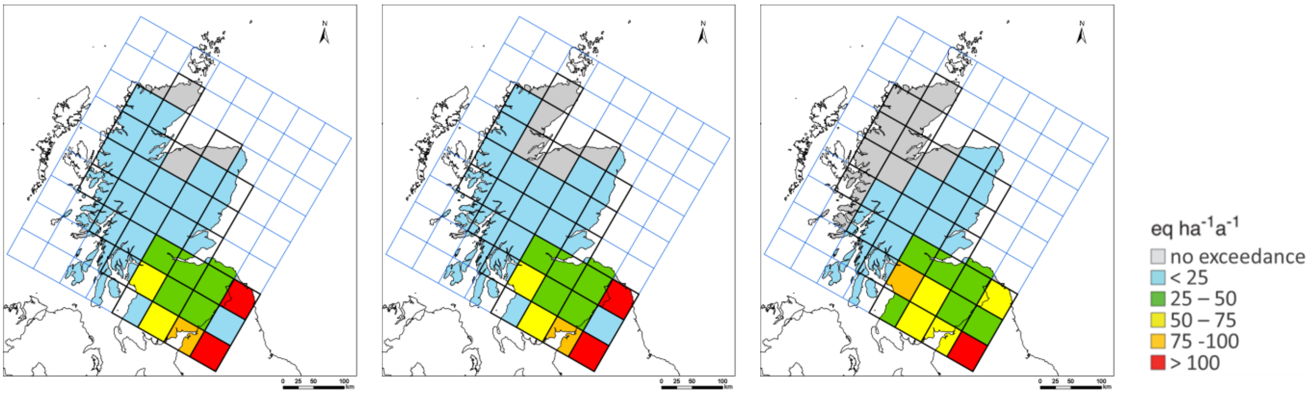

Figure 13: Average accumulated exceedances for 50 × 50 km^2 grid squares in Scotland calculated using nitrogen deposition data at the three spatial resolutions shown in Figure 7: left: using 1 × 1 km^2 data (same data as Figure 12); centre: using 5 × 5 km^2 aggregated data and right: using 50 × 50 km^2 aggregated data. Note: different exceedance range to the Dutch maps.

Figure 14 shows the cumulative frequency plots of the AAEs for the Netherlands, both for the calculations using the EMEP4UK deposition data at the three spatial resolutions and for those using the aggregated deposition data. These calculations were only carried out for those 50 × 50 km^2 squares for which the Netherlands occupies more than 50% (those highlighted with black borders in Figures 10 and 11), in order to reduce the influence of non-representative grid squares. These data show that the frequency distributions of AAEs are similar for all deposition datasets although there is less variability when the aggregated deposition data are used. Figure 15 shows similar results for the Scottish domain.

A preliminary statistical analysis of the AAE calculations shows that for the Netherlands, the AAE estimates calculated using the 50 × 50 km^2 EMEP4UK deposition dataset are, on average, approximately 15% higher than those calculated using the 1 × 1 km^2 EMEP4UK deposition dataset. By contrast, the AAE estimates calculated using the 50 × 50 km^2 deposition dataset aggregated from the 1 × 1 km^2 data are, on average, 7% higher. For Scotland, the use of the 50 × 50 km^2 EMEP4UK deposition dataset, estimates exceedance in 62% of the grid squares compared with 91% when the 1 × 1 km^2 EMEP4UK dataset is used. When the 50 × 50 km^2 deposition dataset aggregated from the 1 × 1 km^2 data is used, the proportion of exceeded squares increases to 74%. Comparing only those squares where exceedance is estimated at both resolutions, the AAE estimates calculated using the 50 × 50 km^2 EMEP4UK deposition dataset are, on average, 20% higher than those calculated using the 1 × 1 km^2 EMEP4UK deposition dataset. By contrast, the AAE estimates calculated using the 50 × 50 km^2 deposition dataset aggregated from the 1 × 1 km^2 data are, on average, 8% lower.

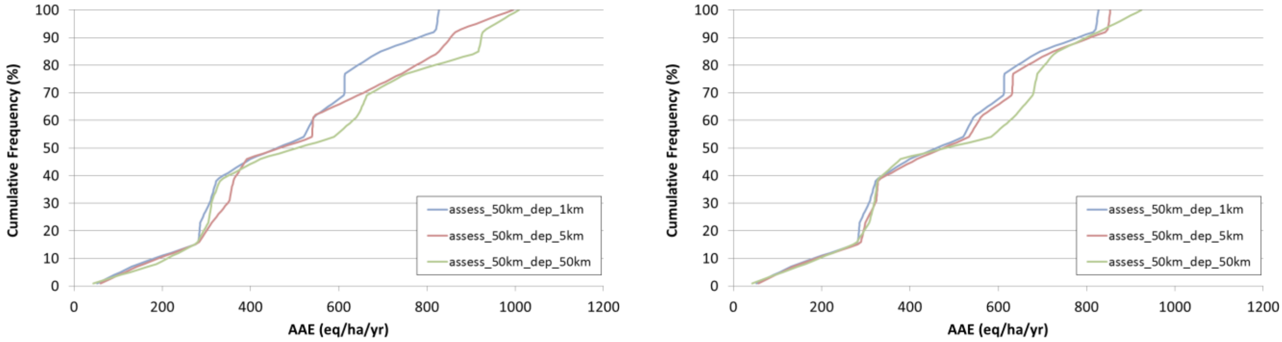

Figure 14: Cumulative frequency distributions for the Netherlands of the exceedances calculated using (left) EMEP4UK nitrogen deposition data at the three spatial resolutions and (right) deposition data aggregated from the 1 × 1 km^2 EMEP4UK deposition dataset.

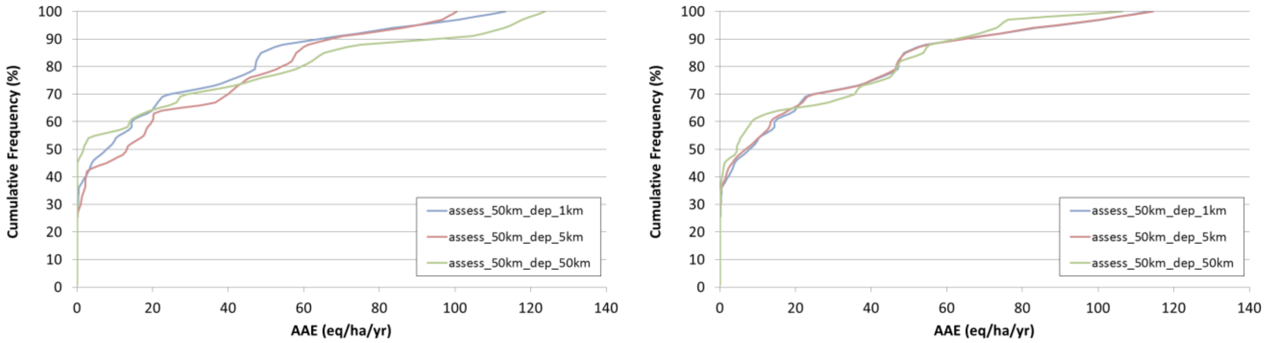

Figure 15: Cumulative frequency distributions for Scotland of the exceedances calculated using (left) EMEP4UK nitrogen deposition data at the three spatial resolutions and (right) deposition data aggregated from the 1 × 1 km^2 EMEP4UK deposition dataset.

NFW Landscape (The Netherlands)

Figure 16 shows the AAE maps and Figure 17 the frequency distribution of exceedances for all three spatial resolutions. Analysing the AAE data within the NFW for the grid squares for which there are habitat data, critical load exceedance is predicted in 69%, 79% and 94% of the grid squares when calculated at resolutions of 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2, respectively. Median exceedance for the domain is 208, 187 and 304 mol ha^{-1} yr^{-1} for the spatial resolutions 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2, respectively (Table 1).

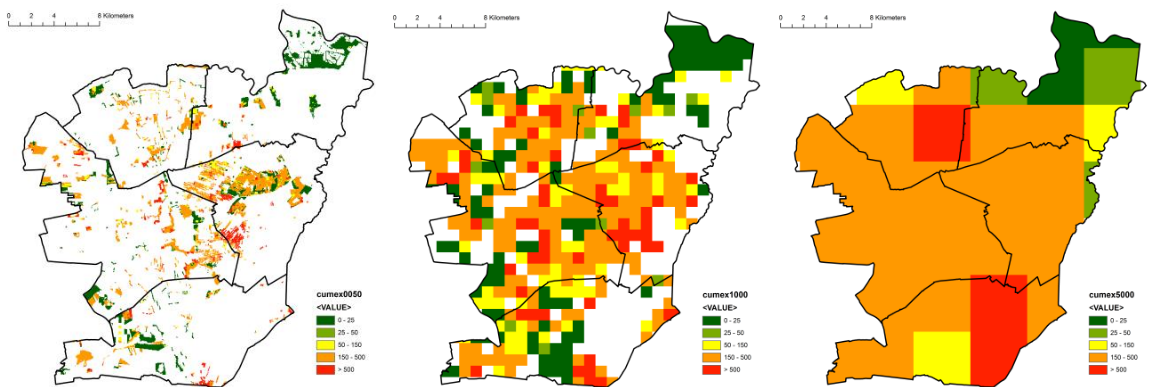

Figure 16: AAE based on total N deposition for the NFW at a resolution of 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2 data.

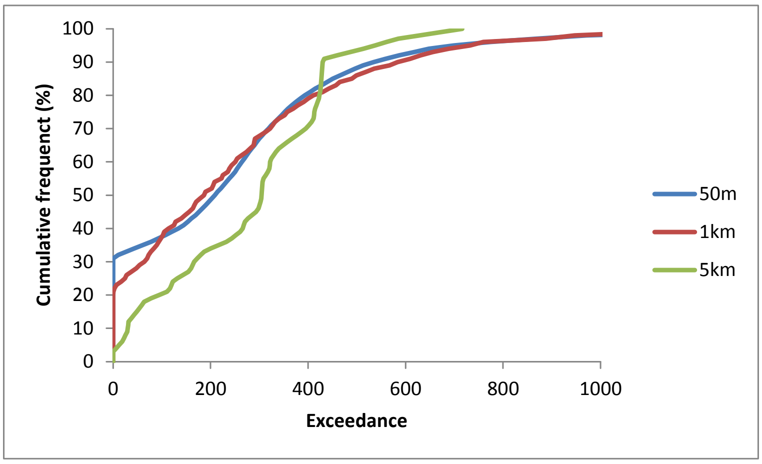

Figure 17: Cumulative frequency distribution of the AAE based on total N deposition at a resolution of 50 × 50 m^2, 1 × 1 km^2 and 5 × 5 km^2 for the NFW.

Table 1 shows that the mean AAE increases with increasing grid size, from 240 (50 × 50 m^2) < 242 (1 × 1 km^2) < 278 (5 × 5 km^2) mol ha^{-1} yr^{-1}. This is partly due to the increasing N deposition for the habitats, which increases from 1528 mol ha^{-1} yr^{-1} at a 50 × 50 m^2 resolution to 1634 mol ha^{-1} yr^{-1} at 5 × 5 km^2 resolution. Contrary to the N deposition for the habitats the mean N deposition for the whole NFW domain barely changes with cell size.

Table 1: Selected percentiles and mean AAE and total N deposition, both for the whole domain and habitats only, for the NFW using deposition at an increasing grid size (based on aggregated emissions)

	AAE (mol ha^{-1} yr^{-1})			N dep (whole domain) (mol ha^{-1} yr^{-1})			N dep (for habitats only) (mol ha^{-1} yr^{-1})		
Cell size	50m	1km	5km	50m	1km	5km	50m	1km	5km
# cell	30620	428	34	415625	1400	56	30620	428	34
Mean	240	242	278	1655	1641	1649	1528	1584	1634
0%	0	0	0	623	585	830	772	774	1035
5%	0	0	12	1176	1105	1343	1113	1125	1322
25%	0	24	132	1453	1455	1550	1348	1397	1529
50%	208	187	304	1603	1606	1666	1466	1541	1646
75%	352	357	413	1793	1790	1755	1660	1736	1744
95%	699	732	537	2329	2335	1982	2076	2155	1884
100%	9187	1342	716	35102	3226	2105	10587	2742	2101

Burnsmuir Landscape (Scotland)

Figure 18 shows the spatial distribution of AAEs calculated using the high resolution nitrogen deposition data and assessed at two different spatial resolutions. For comparison, Figure 19 shows the spatial distribution of AAEs using the EMEP4UK 1 × 1 km^2 deposition data and both the landscape habitat data and the habitat data used for the national estimates.

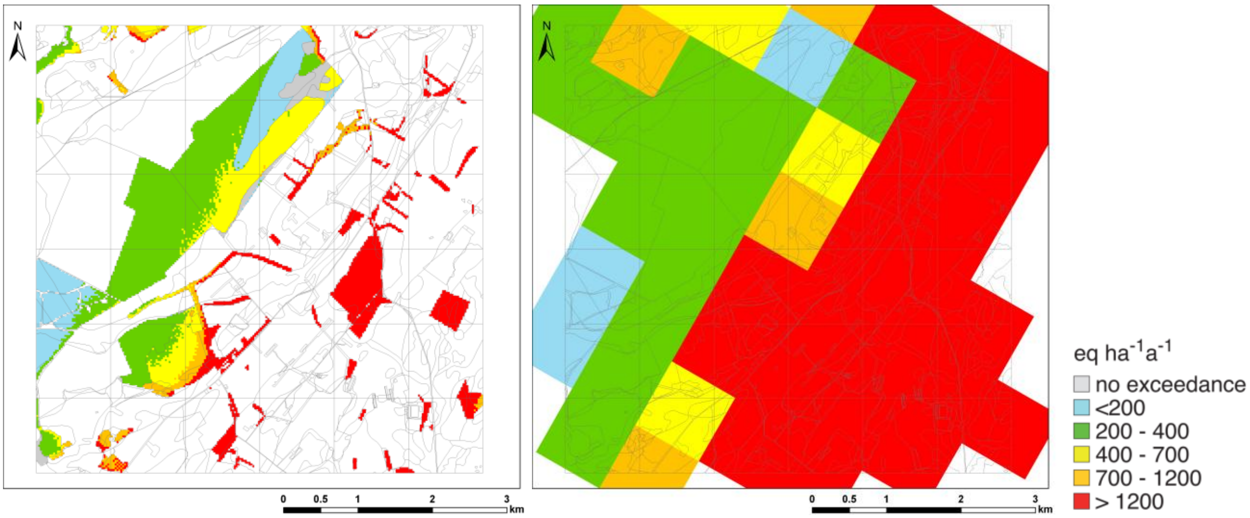

Figure 18: Average accumulated exceedances for the Burnsmuir landscape assessed for (left) 25 × 25 m^2 grid squares and (right) 1 × 1 km^2 grid squares, using nitrogen deposition data at a spatial resolution of 25 × 25 m^2.

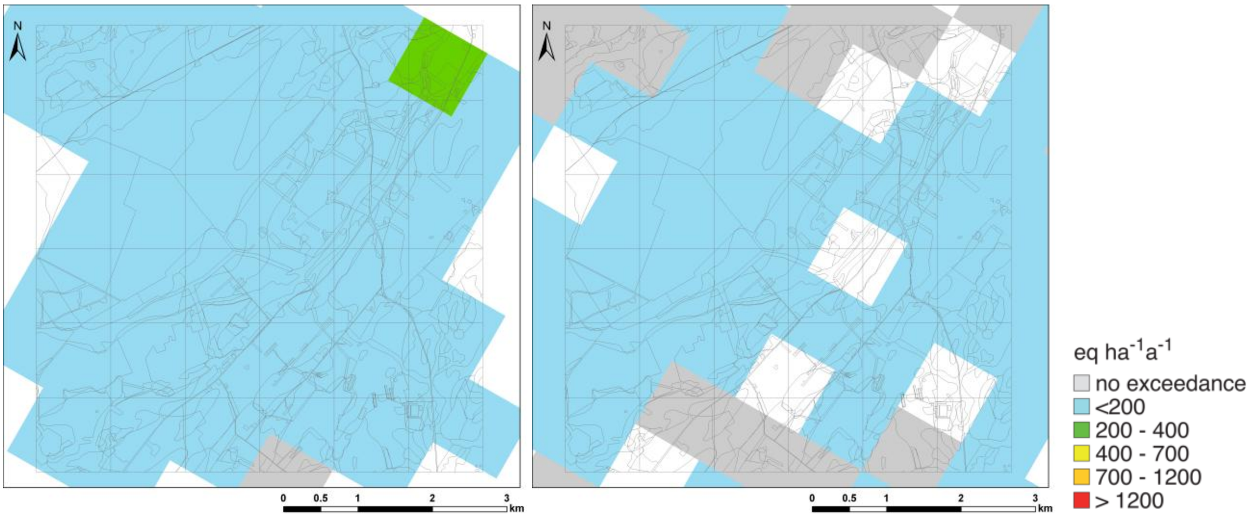

Figure 19: Average accumulated exceedances for the Burnsmuir landscape assessed for 1 × 1 km^2 grid squares using nitrogen EMEP4UK nitrogen deposition data at a spatial resolution of 1 × 1 km^2 and using (left) the landscape habitat data and (right) the national scale habitat data.

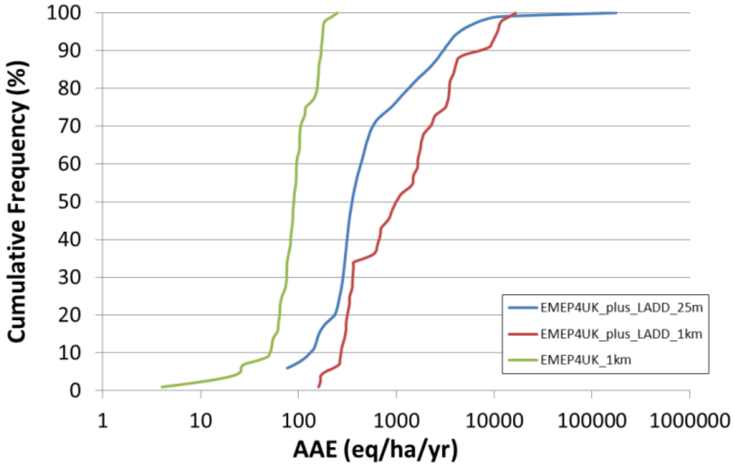

Figure 20: Cumulative frequency distribution of the AAE for the Burnsmuir landscape using the landscape habitat data and nitrogen deposition data at a spatial resolution of 25 × 25 m^2 and assessed for (blue) 25 × 25 m^2 grid squares, (red), 1 × 1 km^2 grid squares and (green) using the EMEP4UK 1 × 1 km^2 deposition and assessed for 1 × 1 km^2 grid squares. Note: logarithmic scale used for AAE.

5. Milestones achieved:

- MS76: Critical threshold and exceedance modelling complete for regional and landscape scales
- MS77: Uncertainty assessment complete and peer-review article submitted

Note: Three peer-review articles are being prepared as a result of this work but none have been submitted at the time of writing.

6. Deviations and reasons:

The completion of this deliverable has been delayed by four months as a result of delays in the previous stages of the project. However, time has been made up in the last year of the project reducing these delays and making it possible for this work to be completed within the timeframe of the project.

7. Publications:

Three publications are planned from this work:

- Theobald , M.R., U. Dragosits, M. Vieno, E. Rowe, G.J Reinds, J Kros and W. de Vries. Impact of spatial resolution on calculated critical load exceedances at national scale
- U. Dragosits, M.R. Theobald , E. Rowe, M. Vieno, G.J Reinds, J Kros and W. de Vries. Impact of spatial resolution on calculated critical load exceedances at landscape scale
- Kros, J. and W. de Vries, 2015. Impact of spatial resolution of input data on nitrogen losses to air and water from a rural landscape.

8. Meetings:

The work plan for completing this deliverable has been developed through teleconferences involving participants of WP17 in June 2012 and July 2013, June 2014 and December 2014 and during the sessions held at the annual project meetings.

9. List of Documents/Annexes:

None

10. References

Bonten, L.T.C., Reinds, G.J. and Posch, M., 2015. A simple model to calculate effects of atmospheric deposition on soil acidification, eutrophication and C-sequestration. Environmental Modelling and Software: (submitted).

Hall, J.; Curtis, C.; Dore, T.; Smith, R. 2015. Methods for the calculation of critical loads and their exceedances in the UK. http://www.cldm.ceh.ac.uk/content/methods-calculation-critical-loads-and-their-exceedances-uk

Kros, J., Frumau, K.F.A., Hensen, A. and De Vries, W., 2011. Integrated analysis of the effects of agricultural management on nitrogen fluxes at landscape scale. Environmental Pollution, 159(11): 3171-3182.

Posch, M., de Smedt, P.A.M., Hettelingh, J.P. and Downing, R.J., 1999. Calculation and mapping of critical thresholds in Europe. CCE Status Report 1999. RIVM report 259101009, Coordination Center for Effects, National Institute of Public Health and the Environment, Bilthoven, The Netherlands.

CLRTAP, 2004. Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads & Levels and Air Pollution Effects, Risks and Trends. http://www.umweltbundesamt.de.

Vieno, M., Heal, M. R., Hallsworth, S., Famulari, D., Doherty, R. M., Dore, A. J., Tang, Y. S., Braban, C. F., Leaver, D., Sutton, M. A., and Reis, S.: The role of long-range transport and domestic emissions in determining atmospheric secondary inorganic particle concentrations across the UK, Atmos. Chem. Phys., 14, 8435-8447, doi:10.5194/acp-14-8435-2014, 2014.

Vogt E., Dragosits U., Braban C.F., Theobald M.R., Dore A.J., van Dijk N., Tang Y.S., McDonald C., Murray S., Rees R.M., Sutton M.A., 2013. Heterogeneity of atmospheric ammonia at the landscape scale and consequences for environmental impact assessment. Environmental Pollution 179, 120-131.