Project AC0109 – Future patterns of ammonia emissions across the UK and the potential impact of local emission reduction measures

Appendix 4 - UK mitigation scenarios for 2020 - Critical Loads exceedance

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1. Introduction

This Appendix compares the nitrogen critical load exceedance results for three 2020 mitigation scenarios and the 2020 baseline. Results are presented for UK broad habitats, SACs and SSSIs.

2. Methods

The critical loads of nutrient nitrogen are published as ranges (Bobbink & Hettelingh, 2011), and in the UK single values from within those ranges are used for the calculation of exceedances. These values are referred to as the "UK Mapping Values"; these have only been defined for UK broad habitats, usually where there is UK evidence of nitrogen impacts to inform the value to be used (Hall et al, 2011). For SACs and SSSIs these Mapping Values have been assigned to the designated feature habitats; however, where the feature habitat is not mapped nationally, and no UK Mapping Value is available for the habitat, the mid-range critical load value has been applied in the exceedance calculations presented here (other values may be used in different assessments). The nitrogen deposition data used for each of the scenarios is the sum of wet and dry oxidised and reduced nitrogen; note the FRAME scenarios used in this analysis are not calibrated to CBED deposition and give smaller areas of exceedance than those results based on calibrated FRAME deposition. Further details on the methods used in the UK to calculate critical loads and exceedances for broad habitats and designated sites can be found in Hall et al (2014).

3. Results

3.1 Results for UK Broad Habitats

For broad habitats the following critical load exceedances metrics are calculated:

- Percentage area of habitats exceeding critical loads
- Average Accumulated Exceedance (AAE) calculated as:
  (exceedance * exceeded area) / (total habitat area)
- Exceedance of the 5^{th}-percentile critical loads to produce exceedance maps for all habitats combined. The 5^{th}-percentile critical loads are the values set to protect 95% of the sensitive habitat area in each 1km grid square

The critical load exceedance results for the 2020 baseline scenario and three of the mitigation scenarios are summarised by country in the tables below. The areas exceeded are lowest for all scenarios in Scotland reflecting the lower nitrogen deposition to this region (Table 1). The largest areas exceeded are across England, with the highest exceedances in the Pennines, Cumbria, and Dartmoor; and across Wales, with the highest exceedances in the upland areas of north and mid Wales, and in the valleys in south Wales (Figure 1). The spatial patterns of exceedances are similar

for all scenarios. The most ambitious UK-wide mitigation scenario (Mitig4, see main report and Appendix 1 for details) gives the smallest areas of exceedance of all scenarios for all countries, with the total area exceeded 6% lower than the 2020 baseline, and the AAE 0.6 kg N ha^{-1} $year^{-1}$ lower than the 2020 baseline (Table 1). There is little difference in the critical load exceedance results for the other two mitigation scenarios (Scenario Mitig4 applied in variable buffer zones around SACs and SSSIs, respectively, see main report and Appendix 1 for details).

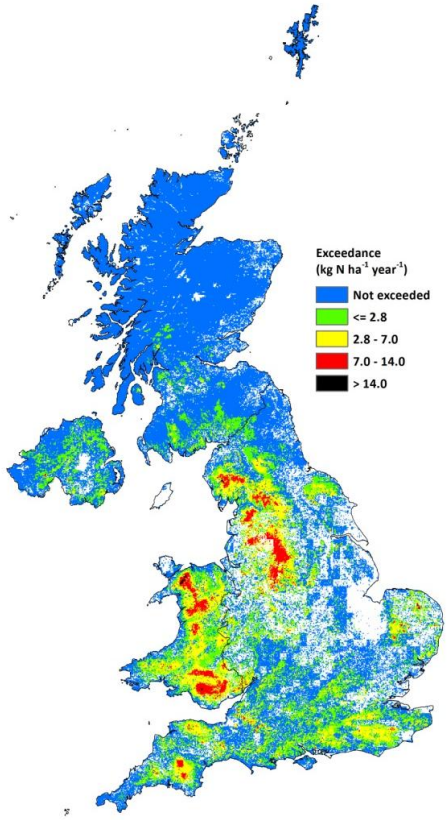

Figure 1: Exceedance of the 5th-percentile nutrient nitrogen critical loads by nitrogen deposition for the 2020 baseline scenario. (Note: 5th-percentile critical loads are the values set to protect 95% of the sensitive habitat area in each 1km grid square).

Table 1: Summary of the nitrogen critical load exceedance results for UK habitat areas sensitive to eutrophication, for the 2020 baseline scenario and three mitigation scenarios for 2020.

Country	Percentage habitat area exceeding critical loads and (in brackets) the AAE (kg N ha^{-1} $year^{-1}$)			
	2020 baseline	Mitig4 (UK-wide)	Variable size targeted buffer zones around SACs	Variable size targeted buffer zones around SSSIs
England	78.1 (4.41)	66.5 (2.81)	75.3 (3.98)	73.8 (3.67)
Wales	84.3 (4.29)	76.8 (3.05)	82.1 (3.83)	81.6 (3.74)
Scotland	4.8 (0.09)	2.3 (0.03)	4.4 (0.08)	4.1 (0.07)
Northern Ireland	46.7 (2.03)	30.8 (1.03)	41.4 (1.75)	39.7 (1.56)
UK	33.8 (1.73)	27.8 (1.11)	32.4 (1.55)	31.7 (1.45)

3.2 Results for SACs and SSSIs

For SACs and SSSIs the following exceedance metrics are calculated:

- The percentage of sites with exceedance of the nitrogen critical load for one or more feature habitats (DWI).
- The percentage area of sites with exceedance of the nitrogen critical load for one or more feature habitats. These calculations are based on the assumption that all feature habitats occur across the entire site area because currently digital data are not available to provide the location and area of each feature habitat within a site. However, the feature habitat critical load may not necessarily be exceeded across the entire site, because deposition may vary across the site for those that cross the boundaries of the 5km deposition grids. The results use the maximum exceeded area of any feature on a site to avoid double counting the areas exceeded. This metric is referred to as AWI-2 elsewhere in the report.
- Maximum AAE (of any feature habitat) per site or per country.

Exceedances have been calculated for all four 2020 scenarios.

Table 2: Summary exceedance results for SACs based on (a) only those SACs with critical load values assigned to one or more feature habitats; (b) UK Mapping Value critical loads.

Country	No. sites with critical loads	Exceedance metric[#]	Deposition scenarios			
			2020 baseline	Mitig4 UK-wide	SAC buffer zones	SSSI buffer zones
England	197	% sites exceeded	84.8	77.2	83.2	82.2
		max % area exceeded	90.9	86.0	89.4	89.3
		max AAE (kg N ha^{-1} yr^{-1})	5.2	3.8	4.7	4.5
Wales	85	% sites exceeded	88.6	88.6	88.6	88.6
		max % area exceeded	73.8	71.5	72.6	72.8
		max AAE (kg N ha^{-1} yr^{-1})	6.1	5.1	5.7	5.6
Scotland	236	% sites exceeded	20.9	13.4	19.9	19.4
		max % area exceeded	3.3	2.6	3.2	3.1
		max AAE (kg N ha^{-1} yr^{-1})	0.1	0.1	0.1	0.1
Northern Ireland	54	% sites exceeded	90.0	84.0	88.0	90.0
		max % area exceeded	80.0	56.7	73.6	70.2
		max AAE (kg N ha^{-1} yr^{-1})	2.0	1.0	1.5	1.4
England/Wales border[##]	7	% sites exceeded	100	100	100	100
		max % area exceeded	-	-	-	-
		max AAE (kg N ha^{-1} yr^{-1})	-	-	-	-
England/Scotland border[##]	2	% sites exceeded	50	50	50	50
		max % area exceeded	-	-	-	-
		max AAE (kg N ha^{-1} yr^{-1})	-	-	-	-
UK	536	% sites exceeded	61.9	55.8	60.8	60.4
		max % area exceeded	49.1	45.7	48.1	47.9
		max AAE (kg N ha^{-1} yr^{-1})	2.9	2.2	2.6	2.5

[#]The maximum AAE shown here is the maximum AAE calculated for each country, not the maximum AAE for any site.

[##]Results only for percentage of sites exceeded for those sites that cross the country borders; for the area and AAE calculations the site area has been assigned to the individual countries.

The **results for the SACs** are similar to those for the broad habitats, with the less exceedance in Scotland than other parts of the UK for all scenarios (Table 2, Figure 2). For England, Wales and Northern Ireland the percentage of sites exceeded and maximum percentage area exceeded are

generally in the range 70-90%, with the lowest values, as expected, for the most ambitious UK-wide mitigation scenario (Mitig4). This scenario results in 6.1% fewer sites exceeded, 3.4% less area exceeded, and an AAE 0.7 kg N ha^{-1} $year^{-1}$ lower than the baseline results. The other two scenarios (variable buffer zones around SACs and SSSIs) give results closer to the baseline; the scenario based on spatially targeted mitigation in buffer zones around the SACs does not appear to give greater protection to the SACs than the scenario with buffering around SSSIs, probably because there are more SSSIs and therefore deposition is reduced over a larger area for that scenario.

Results for SSSIs are (not surprisingly) similar to those for SACs (and broad habitats), with the UK-wide mitigation scenario (Mitig4) giving the lowest exceedances (Table 3). The scenario with buffer zones around SSSIs results gives marginally less exceedance than the scenario with buffer zones around SACs; but the results of both of these scenarios are similar to one another and to the baseline. The smallest exceedances are for Scotland, and the largest for Wales (Table 3, Figure 3) with the maximum AAE 6.9 kg N ha^{-1} $year^{-1}$ for the baseline and 1.1 kg N ha^{-1} $year^{-1}$ lower with the most ambitious UK-wide scenario (Mitig4).

Table 3: Summary exceedance results for SSSIs based on (a) only those SSSIs with critical load values assigned to one or more feature habitats; (b) UK Mapping Value critical loads.

Country	No. sites with critical loads	Exceedance metric[#]	Deposition scenario			
			2020 baseline	Mitig4 UK-wide	SAC buffer zones	SSSI buffer zones
England	2593	% sites exceeded	74.2	66.3	72.6	71.2
		max % area exceeded	85.1	77.1	82.9	82.1
		max AAE (kg N ha^{-1} yr^{-1})	4.9	3.5	4.4	4.2
Wales	686	% sites exceeded	89.4	81.3	87.0	87.5
		max % area exceeded	88.6	85.7	87.2	87.6
		max AAE (kg N ha^{-1} yr^{-1})	6.9	5.8	6.5	6.4
Scotland	935	% sites exceeded	24.9	17.1	24.6	23.6
		max % area exceeded	13.4	9.4	13.0	12.6
		max AAE (kg N ha^{-1} yr^{-1})	0.3	0.2	0.2	0.2
Northern Ireland	188	% sites exceeded	69.1	55.3	66.5	64.9
		max % area exceeded	80.6	67.7	76.8	74.7
		max AAE (kg N ha^{-1} yr^{-1})	2.9	1.4	2.5	2.0
UK	4762	% sites exceeded	66.5	58.4	65.0	64.0
		max % area exceeded	53.9	48.1	52.5	52.0
		max AAE (kg N ha^{-1} yr^{-1})	3.0	2.2	2.7	2.6

[#]The maximum AAE shown here is the maximum AAE calculated for each country, not the maximum AAE for any site.

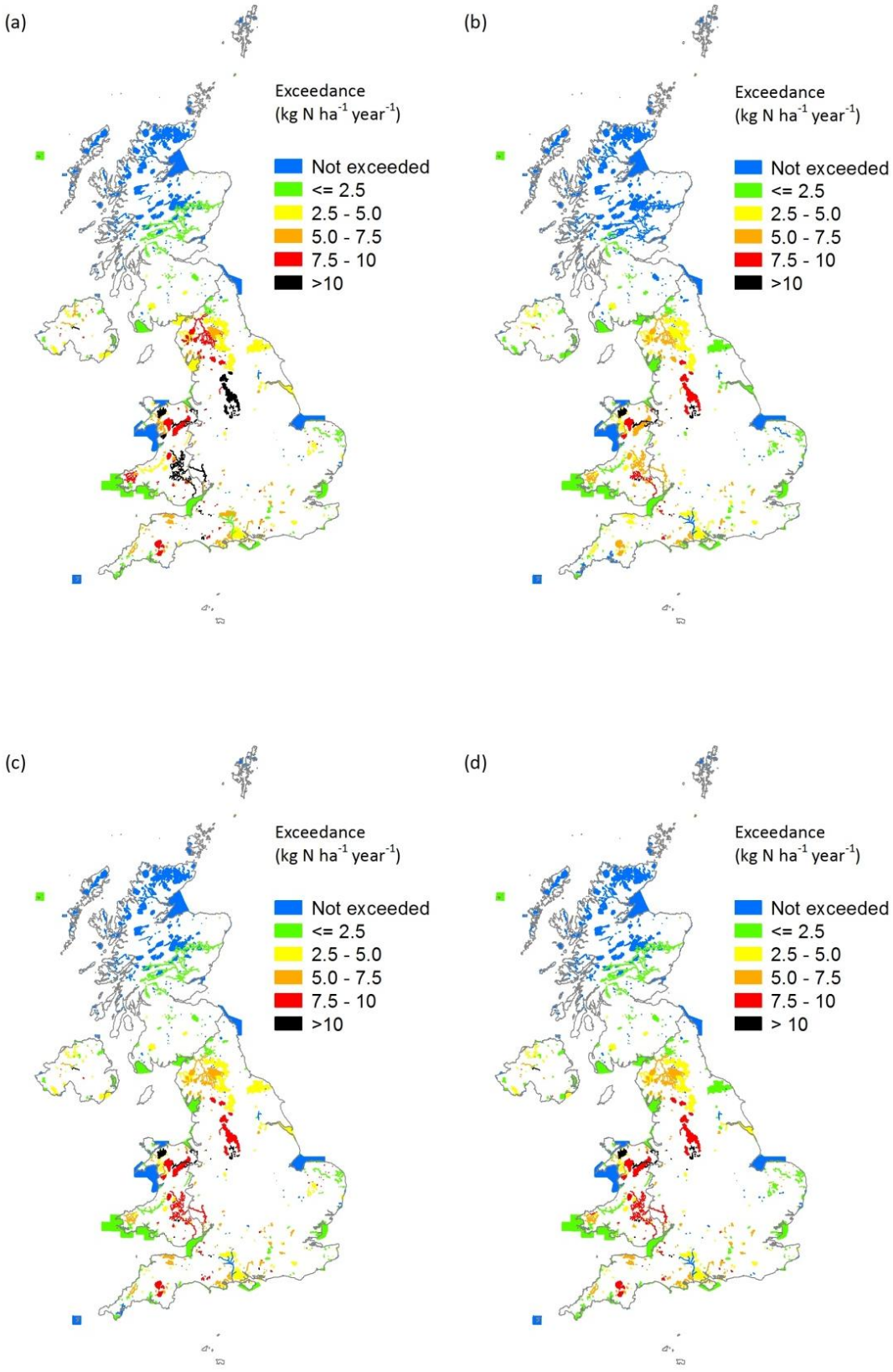

Figure 2. Maximum Average Accumulated Exceedance (AAE) of nitrogen critical loads for each SAC across the UK by nitrogen deposition for (a) 2020 baseline; (b) Mitig4 UK-wide scenario; (c) Mitig4 in targeted buffer zones around SACs; (d) Mitig4 in targeted buffer zones around SSSIs.

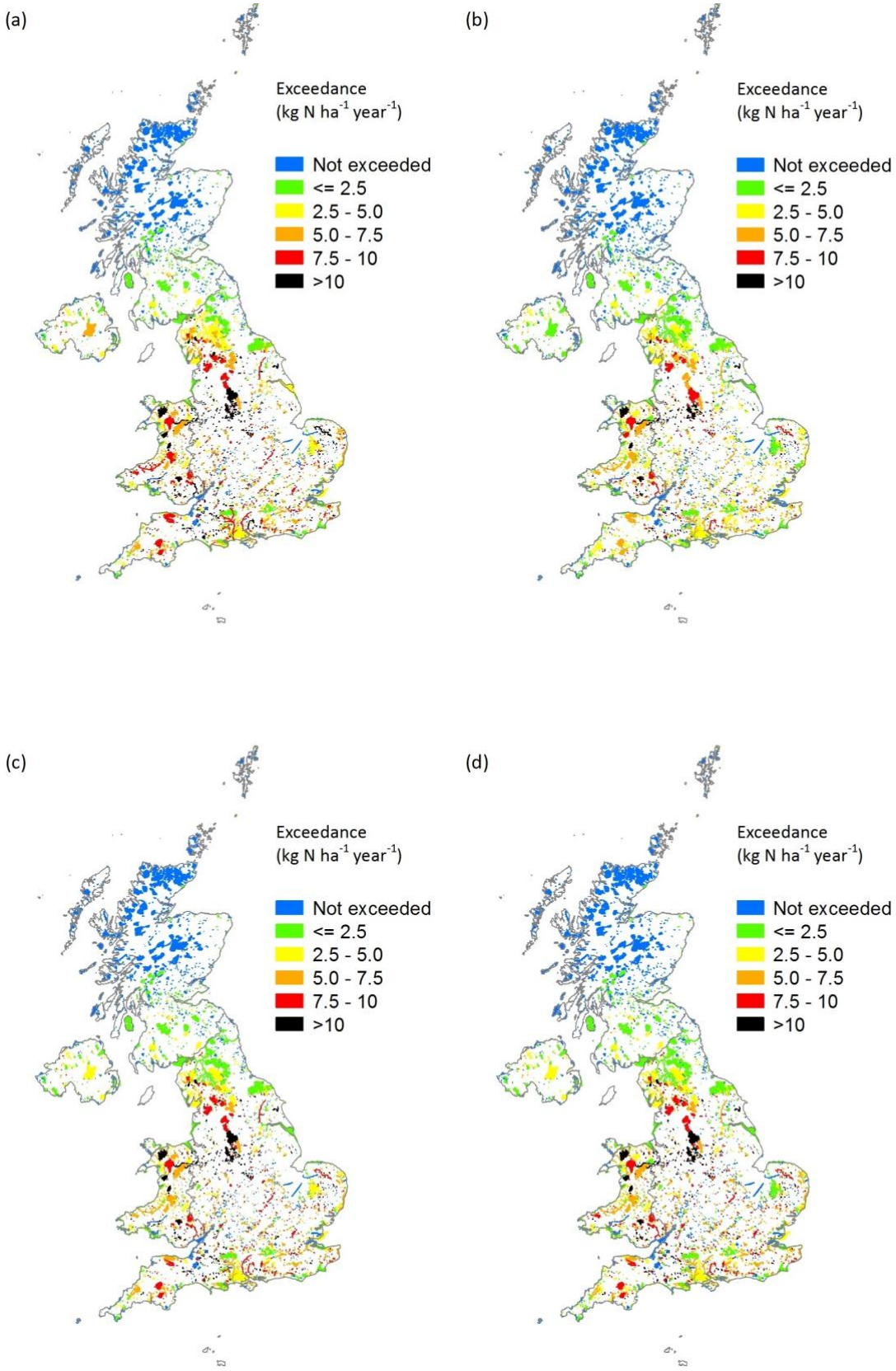

Figure 3. Maximum Average Accumulated Exceedance (AAE) of nitrogen critical loads for each SSSI across the UK by nitrogen deposition for (a) 2020 baseline; (b) Mitig4 UK-wide scenario; (c) Mitig4 in targeted buffer zones around SACs; (d) Mitig4 in targeted buffer zones around SSSIs.

References

Bobbink, R. & Hettelingh, J.P. (eds) 2011. Review and revision of empirical critical loads and dose-response relationships. Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM). http://wge-cce.org

Hall, J., Emmett, B., Garbutt, A., Jones, L., Rowe, E., Sheppard, L., Vanguelova, E., Pitman, R., Britton, A., Hester, A., Ashmore, M., Power, S. & Caporn, S. 2011. UK Status Report July 2011: Update to empirical critical loads of nitrogen. Report to Defra under contract AQ801 Critical Loads and Dynamic Modelling. http://cldm.defra.gov.uk

Hall, J., Curtis, C., Dore, T. & Smith, R. 2014 (in press). Methods for the calculation of critical loads and their exceedances in the UK. Report to Defra under contract AQ0826 (will be published at http://cldm.defra.gov.uk