Environment and Rural Affairs Monitoring & Modelling Programme (ERAMMP)

ERAMMP Report-66: Ammonia Critical Level Exceedance in Wales Using the CMAQ Model

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Abbreviations Used in this Report

CMAQ	Community Multiscale Air Quality Model
EPA	Environmental Protection Agency (US)
ERAMMP	Environment and Rural Affairs Monitoring & Modelling Programme
N	Nitrogen
netCDF	Network Common Data Form
NFC	UK National Focal Centre
NH3	Ammonia (Hydrogen nitride)
PM	Particulate Matter
UKCEH	UK Centre for Ecology & Hydrology

Abbreviations and some of the technical terms used in this report are expanded on in the programme glossaries: https://erammp.wales/en/glossary (English) and https://erammp.cymru/geirfa (Welsh)

Contents

1 Introduction

CMAQ (Community Multiscale Air Quality) is a 3-D Eulerian model developed by the US Environmental Protection Agency (EPA) calculating pollutants' concentrations such as ozone, particulate matter (PM) and a variety of air toxics and the deposition of these pollutants[1].

The UK National Focal Centre (NFC) for modelling and mapping exceedances of critical levels and critical loads was asked to calculate exceedance statistics on the basis of CMAQ outputs for these different scenarios:

- **Baseline-2018:** 2018 NH3 data is largely based on emissions inventories. These are in turn supported by existing national and international reporting frameworks, which utilise observed emissions in many cases.
- **Baseline-2030:** Data sources are generally the same as for 2018. The 2030 baseline emissions were created by scaling the 2018 emissions according to country specific factors.
- **Core-2030:** This scenario focuses on planned changes as described in the Clean Air Plan or other policy documents.
- **Additional-2030:** Based on the measures that are being seriously discussed and have a realistic chance of being included in current policy development.
- **Ambitious-2030:** Based on the measures that have been discussed/modelled but are not currently included in any policy development.

[1] https://www.epa.gov/cmaq/cmaq-models-0

2 Methods

Atmospheric model outputs were received in netCDF format in a 2 x 2 km grid from CMAQ. Datasets from the model were regridded to a 1 x 1 km resolution for critical level exceedance calculations for all the scenarios, and stored as geoTIFF raster files.

Exceedances of critical levels (1 and 3 $\mu g \cdot m^{-3}$) for ammonia were calculated for Wales and for N-sensitive habitats in Wales. Exceedances calculated using CMAQ data for different scenarios were compared.

3 Results

Ammonia concentrations and critical levels exceedance

The overall land area in Wales where NH3 critical level is not exceeded is increased from Baseline-2030 scenario to Additional-2030 and increased further in Ambitious-2030. Whereas, areas where critical levels exceeded (both 1 and 3 $\mu g \cdot m^{-3}$) reduced considerably from Baseline to Ambitious-2030 model calculations Table 3.1 and Figure 3.1.

For further details, the spatial patterns of critical level exceedance obtained using the modelled data for five scenarios is shown in Figure 3.2.

Table 3.1. Land areas in Wales where ammonia concentrations exceeded the critical levels of 1 $\mu g \cdot m^{-3}$ and 3 $\cdot \mu g\ m^{-3}$, as calculated by the CMAQ model. Land areas are shown in km^2, and as percentages of the total land area of Wales.

Exceedance class	Baseline 2018	Baseline 2030	Core 2030	Additional 2030	Ambitious 2030
Not exceeded (<1 $\mu g \cdot m^{-3}$ NH_3)	11,092 (53 %)	11,016 (53%)	11,717 (56%)	12,502 (60%)	13,557 (65%)
Exceeded only for sensitive bryophytes and lichens (1 - 3 $\mu g \cdot m^{-3}$ NH_3)	8,851 (43 %)	8,981 (43%)	8,491 (41%)	7,858 (38%)	7,054 (34%)
Exceeded for vascular plants (>3 $\mu g \cdot m^{-3}$ NH_3)	818 (3.9 %)	764 (3.8%)	553 (2.7%)	401 (1.9%)	150 (0.7%)

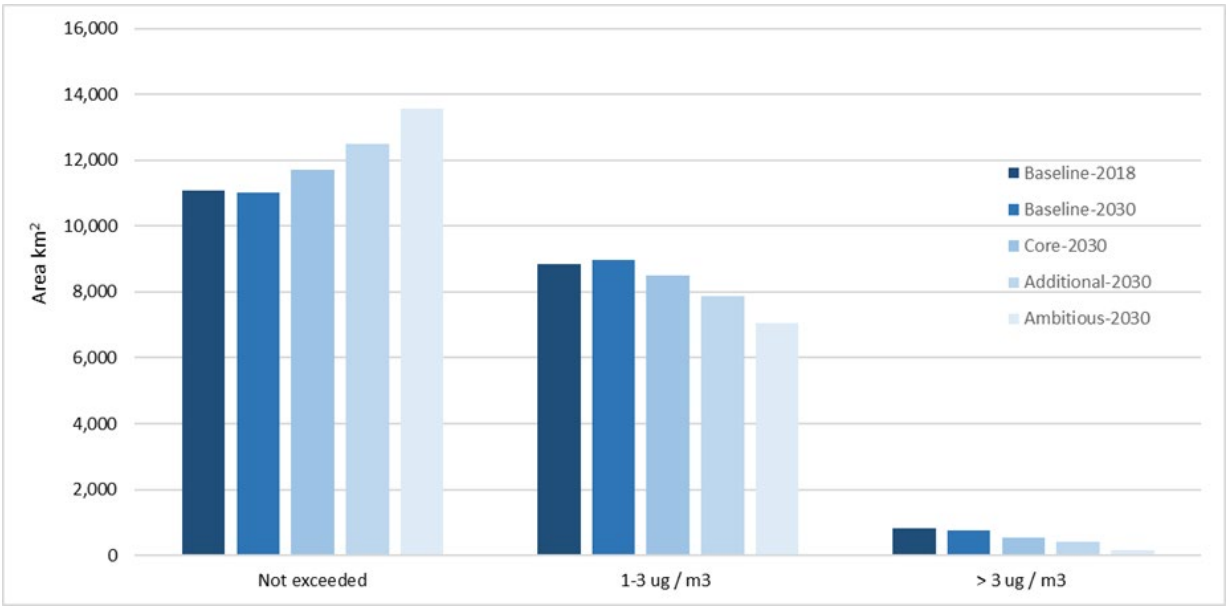

Figure 3.1. Land areas in Wales where ammonia concentrations exceeded the critical levels of 1 $\mu g \cdot m^{-3}$ and 3 $\mu g \cdot m^{-3}$, as calculated by the CMAQ model.

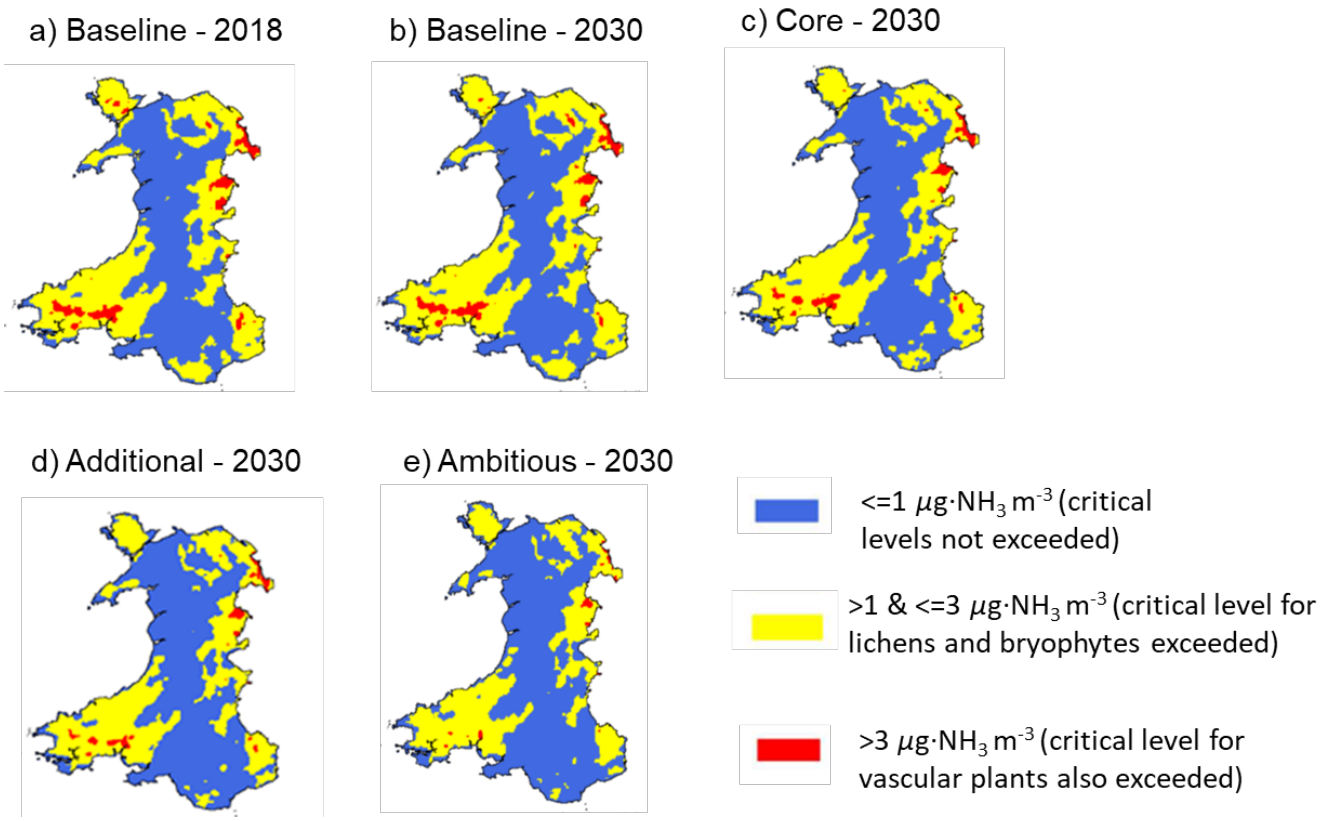

Figure 3.1. Land area in Wales where ammonia concentrations exceeded critical levels of 1 μg·m^{-3} and 3 μg·m^{-3}, according to CMAQ scenarios, a) Baseline-2018, b) Baseline-2030, c) Core-2030, d) Additional-2030 and e) Ambitious-2030.

The percentage area of nitrogen sensitive habitats in Wales that is projected in 2030 to exceed the 1 μg·m^{-3} NH_3 critical level decreased with increasing scenario ambition, for all of the habitat types (Table 3.2).

For acid grassland, the N-sensitive habitat with the largest area (4,443.6 km^2) in Wales, the area projected in 2030 to exceed the 1 μg·m^{-3} NH_3 critical level decreased from 36.5% (Baseline-2030) to 27.3% (Ambitious-2030). Similarly, the area projected in 2030 to exceed the 1 μg·m^{-3} NH_3 critical level set to protect vascular plants decreased with increasing scenario ambition (Table 3.3). For example for Broadleaved woodland, the proportion exceeding 1 μg m^{-3} NH_3 was 11.0 % under Baseline-2030 and 6.4% under the Ambitious-2030 scenario.

Table 3.1. Areas of nitrogen-sensitive habitats in Wales, and percentage of these areas where ammonia critical levels of 1 µg·m^{-3} are exceeded according to CMAQ.

Habitat	Total area (km^2)	% area exceeding 1 µg·m^{-3}				
		Baseline -2018	Baseline -2030	Core -2030	Additional -2030	Ambitious -2030
Acid grassland	4,443.6	34.1	36.5	33.6	31.0	27.3
Calcareous grassland	1.2	61.3	65.2	62.2	54.0	54.0
Dwarf shrub heath	674.6	28.0	29.7	27.1	23.9	20.9
Bog	193.4	6.7	5.5	3.0	2.0	1.4
Montane	17.0	3.3	6.3	21.5	17.4	11.4
Coniferous woodland	1,588.8	33.3	35.8	32.0	28.4	22.8
Broadleaved woodland	274.7	50.2	51.1	47.0	44.4	39.3
Beech woodland	277.8	57.1	55.8	51.7	46.7	42.2
Acidophilous oak woodland	1,557.7	44.7	45.8	43.0	38.6	34.6
Mixed woodland	123.6	46.3	46.9	43.0	37.4	32.8
Dune grassland	78.8	55.0	52.2	45.3	38.7	34.5
Saltmarsh	115.7	54.8	54.0	51.6	47.9	43.9

Table 3.2. Areas of nitrogen-sensitive habitats in Wales, and percentage of these areas where ammonia critical levels of 3 µg·m^{-3} are exceeded according to CMAQ.

Habitat	Total area (km^2)	% area exceeding 3 µg·m^{-3}				
		Baseline -2018	Baseline -2030	Core -2030	Additional -2030	Ambitious -2030
Acid grassland	4,443.6	2.3	2.2	1.8	1.5	1.2
Calcareous grassland	1.2	28.5	5.5	5.5	5.5	5.5
Dwarf shrub heath	674.6	5.0	4.1	2.1	1.6	0.7
Bog	193.4	0.0	0.0	0.0	0.0	0.0
Montane	17.0	0.0	0.0	0.0	0.0	0.0
Coniferous woodland	1,588.8	1.9	2.0	1.7	1.5	1.1
Broadleaved woodland	274.7	10.2	11.0	9.1	8.1	6.4
Beech woodland	277.8	4.4	3.4	3.4	2.3	1.3
Acidophilous oak woodland	1,557.7	6.4	6.2	5.2	4.2	2.4
Mixed woodland	123.6	6.6	6.8	5.8	4.8	3.4
Dune grassland	78.8	6.0	1.4	0.8	0.1	0.1
Saltmarsh	115.7	5.5	6.5	5.8	4.4	3.3

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