Defra project AQ0834 - Identification of Potential "Remedies" for Air Pollution (nitrogen) Impacts on Designated Sites (R.A.P.I.D.S.)

Appendix 2 - Background and data sources for source attribution

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Table of Contents

Summary

- This appendix describes sources of information and data, models and tools required for identifying and quantifying N threats for a robust assessment of sites, including a discussion of limitations and gaps in the available data.

1. Introduction

Pollution sources contributing to the atmospheric nitrogen (N) input at individual nature conservation sites (or habitats more generally) may be located in the immediate vicinity of a site or a considerable distance away, and potentially also arriving from other countries (transboundary pollution). This document focuses on providing information on available datasets and other information, including models and tools for identifying and quantifying sources of atmospheric N pollution, which may pose a threat to sensitive habitats and species at a specific location (e.g. nature conservation site or habitat). The N pollution threats may originate from gaseous concentrations (NO_x, NH_3) or atmospheric deposition of different forms of N, the latter by either wet or dry deposition[1]. This identification of sources and quantification of their contributions ('*source*

[1] Dry deposition is the transfer of gases and particulates to surface vegetation, whereas wet deposition refers to the transfer of materials from the atmosphere to hydrometeors (could and fog droplets, rain and snow) and then to the ground through precipitation events.

attribution') can then inform remedial action choices to protect the sites in question, and the appropriate targeting of measures.

This document is intended to provide:

- a summary of information required to carry out a robust assessment for a site/sites, including the level of detail in information needed for the assessment (e.g. spatial and source category resolution)
- a review and evaluation of existing datasets and tools for the quantification of N deposition and NH_3/NO_x concentrations at a site/sites and identification of contributing emission sources, including any limitations and gaps (with reference to developments under way).

N.B. Step-by-step guidance on how to carry out source attribution assessments using the range of tools currently available are provided in ***Appendix 10****.*

2. Information required for identifying and quantifying N threats

To enable conservation agency staff to carry out comprehensive source attribution assessments for a site/habitat, national-scale datasets, models and tools as well as local knowledge/assessment (or access to local expertise) are required. Upon completion of source attribution assessments, structured targeting of measures could then be carried out, as required. The need for local targeting of measures will depend on the type of source indentified, their location(s) relative to the site being assessed, and the instruments available at the local, regional, national and international level.

Depending on the nature of the assessment and the complexity and size of the site, the effort may range from semi-automated national-scale assessment to detailed local assessment. National scale assessments may involve combining 5 km grid resolution mapped datasets with point data for Industrial Emissions Directive (IED)[2] sources and line source for data major/busy roads for initial assessments, followed by detailed assessment of individual N emission sources and dispersion/deposition in the local area. To enable the implementation of locally targeted and cost-effective measures with minimal side effects, detailed information on source types needs to be assessed (up to 2 km distance). For the agricultural sector, this includes knowledge of agricultural practice/operations taking place in the vicinity, such as livestock grazing, manure and fertiliser applications, animal houses and manure/slurry storage facilities etc, including information on any mitigation measures already in place. This assessment needs to take account of the relative spatial location of sources and the designated site (inc. prevailing winds and topography), as well as local suitability for application of candidate measures.

Supporting data on UK-scale annual deposition for critical loads exceedance assessment are typically based on at least 3-year average estimates (available annually from Defra funded projects – see Section 3 for further details), while source attribution modelling output is based on periodic updates (previous version based on 2005 data –implemented in APIS, new analysis currently under discussion with the APIS Steering Group).

For quantitative assessments, measurement data of atmospheric concentrations from the national networks may be utilised at the designated site (or in close proximity, < 1 km) where available. For assessing typical trends at a site and temporal variability, one full year's data are required at a minimum, to be informative, however datasets over multiple years are preferred. For a detailed ecosystem impacts assessment of N deposition, monthly time resolved monitoring is typically sufficient – while continuous hourly data on air concentrations can optionally be useful to better

[2] Industrial Emissions Directive: includes large pig and poultry farms (formerly known as the Integrated Pollution Prevention and Control (IPPC) Directive).

understand pollution exposure characteristics, in combination with local meteorological measurements of wind speed and direction.

In addition, local screening tools (such as SCAIL) can be useful for providing fast quantitative assessments on likely contributions from local IED farms, especially if high-resolution assessments are required. However local diffuse agricultural sources are more difficult to quantify without expert knowledge and or local scale dispersion and deposition model estimates at better than 100 m resolution, due to the high spatial variability of ammonia.

3. Data sources for quantifying N sources affecting protected sites

Currently, there are a number of datasets and interactive tools available, as well as data portals for downloading model outputs and measurement data (most freely available), to help identify and quantify N pollution sources for individual designated sites. The emission/concentration/deposition datasets and associated models (in yellow), key model input and monitoring data (in blue) and portals (in green) shown in Figure 1 are described briefly in the sections below, followed by an evaluation of their advantages and disadvantages.

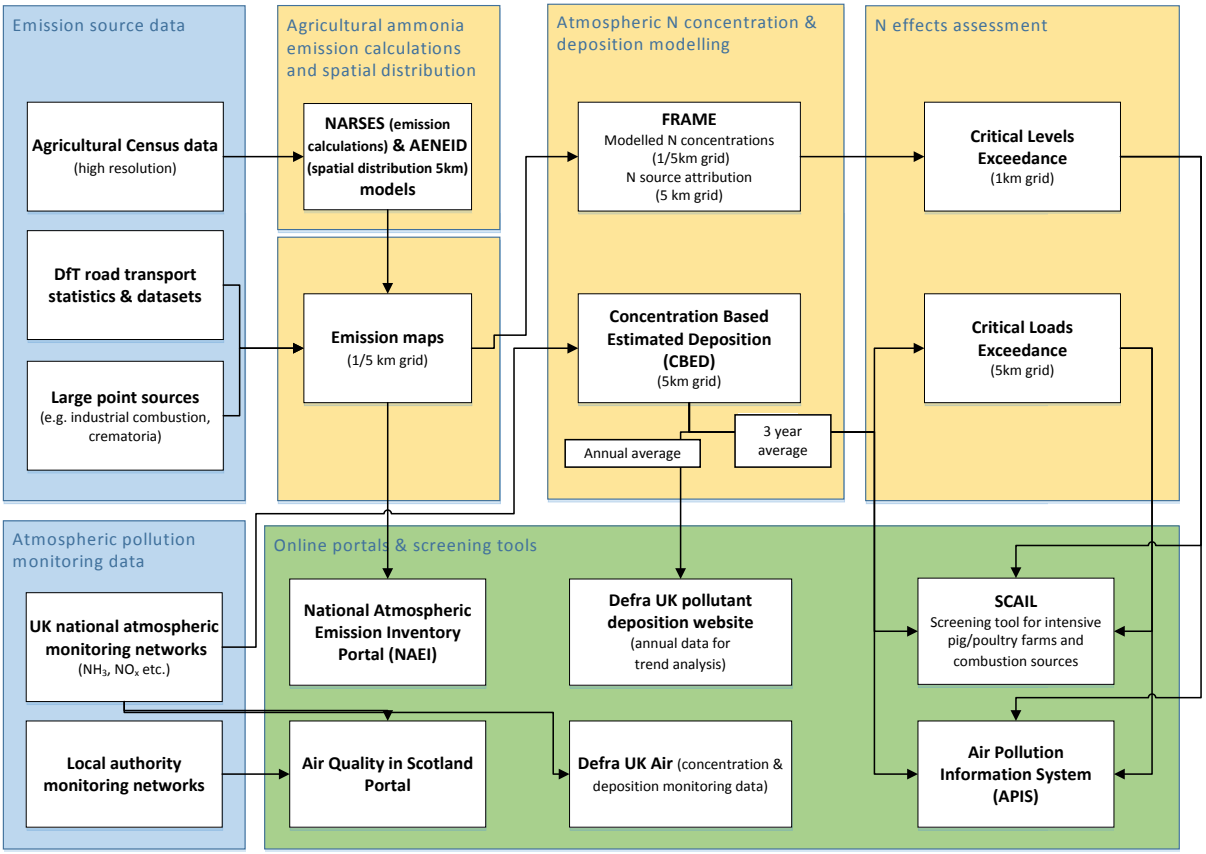

Figure 1 – overview of UK emission/concentration/deposition datasets and associated models (in yellow) for atmospheric N assessment of sensitive habitats and sites, key model input and monitoring data (in blue) and portals (in green).

3.1. UK national emission, concentration and deposition datasets

- **UK atmospheric emission inventories and maps** are produced annually for a wide range of pollutants, including ammonia (NH_3) and nitrogen oxides (NO_x). These maps are available at a 1 km grid resolution, separately by SNAP Sector, i.e. agriculture, waste, energy production, road transport, industrial processes etc. These maps are based on a range of models and data sources

to construct the spatial distribution for these different sources. For example, the maps include inputs from national/devolved administration pollution registers for point sources, such as combustion plants or industrial processes. For agricultural NH_3 emissions, for example, the NARSES model[3] produces detailed (non-spatial) tables of emissions from livestock and fertiliser application data, other activity data (such as agricultural practice, mitigation methods already in place etc) and emission source strength estimates (emission factors). The model is updated annually and produces a consistent time series back to 1990. The annual data are then spatially distributed with the AENEID model[4] which uses high-resolution disclosive agricultural census data (under license from the data providers – see Section 3.2 for more detail), land cover and agricultural practice information to produce non-disclosive maps of NH_3 emissions. The NO_x and NH_3 maps for all sources are produced on an annual basis and used as input data in the national concentration/deposition modelling including source-attribution modelling. Detailed data tables for the UK and devolved administrations, are also available for much more detailed source categories, which are freely accessible via the National Atmospheric Emission Inventory portal (NAEI, www.naei.org.uk).

- **UK atmospheric concentration and N deposition maps** are produced through modelling. As shown in Figure 1, these data are used for a variety of purposes in the UK, in particular for the assessment of critical loads and critical levels exceedance, and the related publicly accessible data and information portals. The UK datasets are produced through two main methods:
  - **Statistical modelling based on concentration measurements** from the UK monitoring networks , with no activity data used (CBED model)[5] at a 5 km grid resolution. The CBED model provides both single-year and 3-year average data annually, under Defra contracts. The single-year data are used for assessing temporal variation and long-term trends, whereas the three-year average data are used for critical loads exceedance assessment.
  - **atmospheric transport and deposition models** such as the FRAME model[6] which uses the emission inventory maps as a key input, and performs chemical transformations as well as

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[3] Webb, J., and Misselbrook, T. H. (2004). A mass-flow model of ammonia emissions from UK livestock production. *Atmospheric Environment* **38**, 2163-2176.

[4] Hellsten S., Dragosits U., Place C.J., Vieno M. and Sutton M.A. (2008) Modelling and assessing the spatial distribution of ammonia emissions in the UK. *Environmental Pollution* **154**, 370-379.

Dragosits U., Sutton M.A., Place C.J. and Bayley A.A. (1998) Modelling the Spatial Distribution of Agricultural Ammonia Emissions in the UK. *Environmental Pollution* **102** (S1) p.195-203.

[5] Smith R.I., Fowler D., Sutton M.A., Flechard C. and Coyle M. (2000) Regional estimation of pollutant gas deposition in the UK: model description, sensitivity analyses and outputs. *Atmospheric Environment*, **34,** 3757–3777

[6] Dore A.J., Kryza M., Hall J.R., Hallsworth S., Keller V.J.D., Vieno M. and Sutton M.A. (2008) The influence of model grid resolution on estimation of national scale nitrogen deposition and exceedance of critical loads. *Biogeosciences*, **9**, 1597–1609.

Dore A.J., Bealey W., Kryza M., Vieno M. and Sutton M.A. (2010) Modelling the Individual Contributions of Gaseous Emissions Sources to the Deposition of Sulphur and Nitrogen in the UK. In: Steyn D.G.; Rao S.T., (eds.) *Air pollution modelling and its application XX.* Dordrecht, Netherlands, Springer, 207-211. (NATO Science for Peace and Security Series B-Physics and Biophysics).

Hallsworth S., Dragosits U., Dore A.J., Bealey W.J., Vieno M., Tang Y.S., Hellsten S. and Sutton M.A. (2011) Quantifying the threat of atmospheric ammonia to UK Natura 2000 sites at 1 km resolution. In: Hicks W.K., Whitfield C.P., Bealey W.J., Sutton M.A. (eds.) *Nitrogen deposition and Natura 2000: Science and practice in determining environmental impacts.* COST Office-European Cooperation in Science & Technology, 281-285.

dispersion and deposition calculations. The FRAME model operates at a 1 km and 5 km grid resolution. The model is also used to periodically update the UK source attribution dataset under Defra contracts. Source attribution is estimated by performing a large number of model runs (>100), to determine the contribution of each source categories (and individual large point sources) to N deposition, across each 5 km by km grid square of the UK. The source attribution model includes all known sources in the UK for which emissions have been included in the NAEI, and trans-boundary input from the EMEP model[7]. The most recent source attribution dataset is for the year 2005, which is now considerably out of date.

3.2. Other relevant data sources for source attribution and related work

There is a wide variety of **other data sources** that may provide further high-resolution details on N emission sources. These data sources may be useful for quantifying and spatially locating emission sources, for assessing the potential for local targeting of measures. Examples include the locations and emissions from large point sources covered by environmental permitting, agricultural census data, animal registration systems for veterinary purposes, Rural Payments Agency data, Highway Agency monitoring data (http://www.highways.gov.uk/), road traffic count data from the Department for Transport (http://www.dft.gov.uk/traffic-counts/), shipping vessel monitoring systems, the European Pollutant Release and Transfer Register (E-PRTR[8]), etc. Some of these data sources, such as the **DfT traffic counts**, are freely available, whereas the high resolution agricultural datasets (such as the animal registration systems, e.g. Cattle Tracing System (CTS), Poultry Register; the IACS rural payments data and holding-level agricultural census/survey data) have disclosure limitations placed on them (for data protection purposes) and are only available under very restricted licensing. Some of these data sources described above may be available under license to authorised government agencies and public bodies. However their use for further work would be governed by any data agreements negotiated, to satisfy the data providers who are responsible for safeguarding the data. The datasets deemed most useful for designated site assessments under a RAPIDS-type framework are discussed further below:

- **Locations and emissions from large point sources** covered by environmental permitting under the IED, which includes pig and poultry farms above defined size limits. These are spatially located at the site of the operations, i.e. the emission source is well defined, with very little spatial uncertainty. Some of the data related to this database source (location, estimated emission for each relevant pollutant) are freely available, e.g. from the Environment Agency's '*What's in your backyard?*' tool[9] for England and Wales, or SEPA's *Scottish Pollutant Release Inventory* (SPRI)[10]. However, there is no single database at a national scale. Further details, such

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Dragosits U., Dore A.J., Sheppard L., Vieno M., Tang Y.S., Theobald M.R. and Sutton M.A. (2008) Sources, dispersion and fate of atmospheric ammonia. In: Hatfield, J.L.; Follett, R.F., (eds.) *Nitrogen in the Environment - Sources, Problems, and Management.* Academic Press, 333-393, 61pp.

[7] The EMEP model domain covers Europe, northern Africa, west-central Asia and the NE Atlantic Ocean http://emep.int/publ/reports/2013/EMEP_status_report_1_2013.pdf

[8] http://www.eea.europa.eu/data-and-maps/data/member-states-reporting-art-7-under-the-european-pollutant-release-and-transfer-register-e-prtr-regulation-8

[9] http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683.0&y=355134.0&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=pollution

[10] http://www.sepa.org.uk/air/process_industry_regulation/pollutant_release_inventory.aspx

as the type of animals/birds and populations at each location, may be available under license from the different data owners for use in site assessments.

- The **DfT traffic count data** are used in the production of the 1 km grid emission inventory maps, however the gridded inventory maps do not give real gradients away from roads or distance information for designated sites (road proximity), which is the key information to help determine the actual threat rather than the average threat for the grid square. Combining the traffic count data with detailed maps of the locations of roads and designated sites could be useful for identifying sites where roads may pose a high risk in terms of N input. (N.B. This approach has been further refined and implemented under the IPENS-049 project by Natural England).
- The **agricultural census/survey** data provide annual livestock counts and crop/grass areas for each farm holding, with the data spatially located by post code or similar address markers. However, these data do not provide any further information on agricultural practice, such as livestock housing or manure/slurry storage systems, manure/fertiliser applications etc. Information of this nature is collected for a sample of UK farms through Defra's Farm Practice Surveys (FPS), Farm Business Surveys (FBS) and the British Survey of Fertiliser Practice (BSPF), but no comprehensive dataset for individual UK farms exists, nor any spatially distributed information. The high-resolution **agricultural census/survey data** are one of the key input datasets for the annual emission inventory maps for the NAEI produced in collaboration between CEH and Rothamsted Research North Wyke for the NAEI (see also Section 3.1 above). However due to disclosivity rules for the use of these data, the agricultural emission maps can only be published at a 5 km grid resolution, as no output unit can contain information from less than five holdings. This is achieved in the spatial emission model AENEID through a statistical approach that distributes ammonia emissions on an area basis using high resolution land cover data rather than representing farms as point data. A similar approach could be used to calculate non-disclosive emission densities and a local agricultural sector split in emissions for areas surrounding each designated site, by aggregating the underlying data in a way that at least 5 holdings contribute to each piece of information. This would be subject to permission from the data holders (e.g. Defra for England), to use the data for this purpose[11].

3.3. UK national portals providing data on atmospheric N concentrations, deposition and critical loads/levels exceedance

Currently, there are a number of interactive tools and data download sites freely available to help identify pollution sources for individual Designated Sites. The main relevant data and information portals at a UK scale are:

- the **UK Air Pollution Information System** (APIS, http://www.apis.ac.uk)
  APIS provides the UK national-scale *source-attribution matrices* at a 5 km grid resolution for assessment of N deposition and Site Relevant Critical Loads (SRCL) exceedance. Results are distinguished for designated features by type, for each SAC, SPA or A/SSSI in the UK. Pie charts are provided showing source-attribution from the main emission source sectors (livestock agriculture, fertiliser use, road transport, domestic combustion, international shipping, transboundary, etc.) for each designated site (see Figure 2 for an example). The source attribution data in APIS are based on national atmospheric transport modelling funded by Defra, using the FRAME model (current data represent 2005 and an associated 2020 projection which is

[11] UPDATE (Nov 2014): Permission has been granted by Defra for this work to be carried out under a separate Natural England project under the IPENS programme, and the results are due to be published shortly (IPENS-049, Dragosits et al. 2014).

now considered out of date) [12]. Discussions with the APIS Steering Group are ongoing regarding funding for an updated dataset. In addition to the source-attribution database, APIS provides also critical loads exceedance data for sites (using the latest up-to-date 3-year average CBED deposition data) and summary overviews of air pollution impacts from a range of angles, by pollutant, impact type, habitat type, as well as various search tools, bio-monitoring information etc.

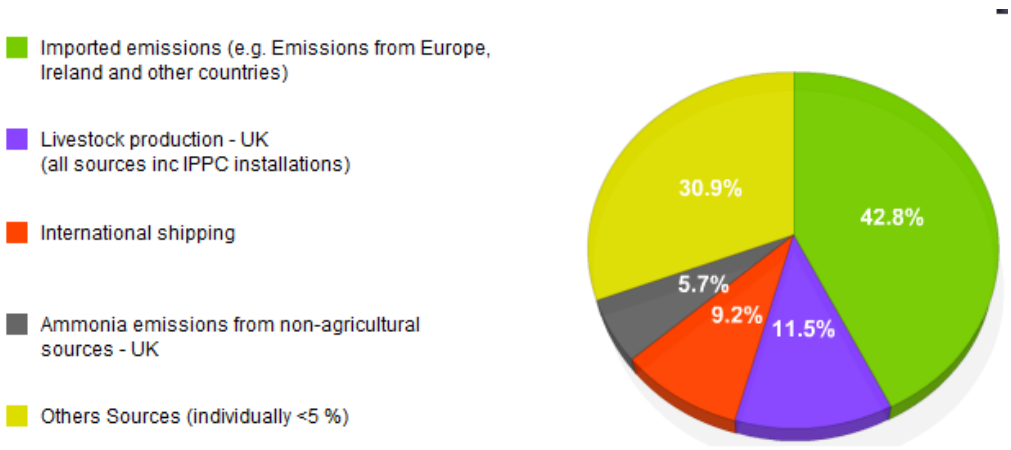

Figure 2: Example source attribution for Nitrogen for a SAC from APIS. (N.B. Not all sources are shown separately in the legend, Note that small sources contributing <5% of the total for this site individually are aggregated to 'other sources' in this figure. This example is for Altnaharra SAC)

- the **UK National Atmospheric Emissions Inventory** (NAEI, www.naei.org.uk), with emission maps freely downloadable for NH_3 and NO_2, at a 1 km grid resolution (by SNAP Sector, e.g. agriculture, waste, energy production, road transport, industrial processes etc).
- The **Defra UK Pollutant Deposition** website (http://pollutantdeposition.defra.gov.uk/data) – provides annual 5 km grid N deposition data from UK national scale modelling (using the CBED model). Component N deposition estimates are available separately for oxidised dry/wet deposition and reduced dry/wet deposition, as are ammonia concentrations.
- the **Defra UK AIR** website (http://uk-air.defra.gov.uk/) provides **measured atmospheric concentration (NO, NH_3) and wet deposition data from a number of UK national monitoring networks**, as well as background information on air quality[13]. A number of monitoring sites of the UK National Ammonia Monitoring Network (NAMN) are located within or near designated sites, with monthly data available for viewing and downloading. These can be used to determine atmospheric N concentrations and wet deposition rates at those designated sites which host monitoring sites, to provide local evidence of N input. However, it should be recognised that there can be substantial spatial variability in pollution levels across a single SAC or A/SSSI. Such data can therefore supplement the modelled deposition/ concentration data that are averaged over the surrounding 5 km grid square (from APIS). Some of these sites are co-located with the Environmental Change Network (ECN), which provide further N measurements, such as nutrients in soil water.

[12] Note that estimates of present deposition are provided by the CBED model (Smith et al., 2000) which draws on UK monitoring network data, while future scenarios and source attribution are calculated using the FRAME model (driven by emissions sources). To minimise differences in the scenario estimates, FRAME estimates are normalised to CBED for current conditions.

[13] N.B. The air quality focus of UK AIR is primarily on human health, whereas APIS focuses especially on ecosystem health.

- The **Air Quality in Scotland website and database** www.scottishairquality.co.uk. In addition to data from UK network monitoring sites, the portal also provides data from a large number of local authority sites, which undergo QA/QC to the same standards as national sites, and online viewing and analysis tools.

3.4. Local scale screening tools/models for N concentration/deposition

Local gradients of air pollution (e.g. at 10 m - 5 km scale) away from specific pollution sources, which cannot easily be investigated by the national scale models and measurements, can also be important. Available detailed models such as ADMS or AERMOD could be used for calculating detailed spatial patterns of estimated concentration or deposition estimates at a designated site. For regulated processes, these (or other) models may have been used as part of the permit application, and data may be available from the environment agencies. However as such models need to be set up with detailed data for each emission source and for each site individually, this would require very large resources for a UK-wide assessment. Such tools are therefore typically restricted to specific localities by specialist consultants.

Alternatively, rapid screening tools such as **SCAIL** (Simple Calculation of Atmospheric Impact Limits, http://www.scail.ceh.ac.uk/)[14] enable users to calculate/quantify the *contribution of local sources (focused on pig/poultry and combustion sources) to the N deposition at a nearby habitat*, depending on the relative spatial location and local conditions. SCAIL compares the amount of background pollution and additional NH_3/NO_x concentration and dry N deposition (as dry deposited NH_3 or NO_x) from a defined existing or new (proposed) emission source on a habitat at a given distance, taking account of regional wind patterns. The tool also calculates exceedance of the relevant Critical Load or Critical Level for pig/poultry-related emission sources and combustion plants, with options for conservative or realistic calculations.
To use SCAIL successfully for source-attribution assessments, a number of input parameters are required, however default parameters can be used for all but the basic input. For calculating contributions to N deposition or NH_3 concentrations at a site from nearby pig/poultry farms (options: animal housing, manure storage or spreading), types and numbers of animals, amount of manure stored or spread, and agricultural practice information, such as housing, storage and manure spreading parameters and techniques are required. Multiple sources (e.g. poultry houses) and receptors (designated sites) can be added to a single run, however this is not the same as a full landscape scale model taking account of all sources. For combustion plants, data on stack height, diameter, exit temperature and velocity, emission rates and location need to be specified. The relative spatial location of the source (or multiple sources) and receptor in relation to regional prevailing winds are also taken into account.

A current knowledge gap/model limitation here is that SCAIL only deals with pigs/poultry and combustion plant sources, but only indirectly deals with cattle, which are the largest overall NH_3 source in the UK inventory. At present, the DMRB Screening Method v.1.03[15] is only able to calculate NO_x concentrations, rather than N deposition at a location. In addition, the user has to specify a receptor's location, as unlike SCAIL it is not currently linked to a spatial database sensitive receptors (i.e. designated sites). Another useful extension of SCAIL would be for sensitive habitats in the vicinity of roads (or to include this functionality into the DMRB). In the meantime, a crude conversion of pig emissions into cattle emissions could be developed for screening purposes. This will be investigated under RAPIDS.]

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[14] Theobald M.R., Bealey W.J., Tang Y.S., Vallejo A. and Sutton M.A. (2009) A simple model for screening the local impacts of atmospheric ammonia. *Science of the Total Environment* **407**, 6024-6033.

[15] Design Manual for Roads and Bridges. http://www.dft.gov.uk/ha/standards/guidance/air-quality.htm

4. Limitations of available data and solutions

4.1. UK deposition, concentration and source attribution data

While, on average, **national scale deposition or concentration datasets** (and related tools such as APIS) described above will identify major threats and source allocations for each grid square and any Designated Sites present, they should not be used in isolation for site assessment, but together with relevant local information. The **spatial resolution** of the modelled N deposition maps used in the national critical loads assessments (**5 km grid**) is relatively coarse, resulting in uncertainties[16] at the site-scale. For example, emission source and sink areas are often contained in the same gridsquare, thereby not allowing concentration and dry deposition gradients, which are very spatially variable for NH_3, to be represented at the scales these processes occur in the landscape.

It should be noted that the **spatial resolution of the modelled NH_3 concentration data** has been increased from a 5 km grid to a 1 km grid, following extensive testing of the 1 km grid version of the FRAME model against measurements[17]. The new dataset, which will be used for assessing for Critical Level exceedance for habitats and Designated Sites during spring 2014, will need to be approved before wider release, pending discussions on the disclosivity of these data. However, it is anticipated that the concentration and deposition data should at the very least become available for restricted release by government agencies in due course.

The **source attribution dataset** is updated only periodically due to the resources required for the iterative model runs, for each source category in turn. The currently available data were calculated for 2005 (with associated now out-of-date projections for 2020), but discussions are ongoing in the APIS Steering Group regarding an update. A major drawback of the source attribution dataset cannot currently distinguish whether deposition arriving at a grid square from a source sector (such as agriculture) is due to local, regional or long-range sources. This could be resolved in an updated source attribution model run by changing the model code to output deposition data with more detailed N components (i.e. chemical species), which can be approximated with short/ medium/ long-range deposition.

It is important to be aware that basing the assessment of N threats at a site entirely on these 1/5 km grid national datasets may give a 'false positive' or 'false negative' (terms used in the IPCC uncertainty guidance note [18])result, for various reasons. Some examples are discussed here:

- Large pig or poultry farms with substantial emissions of NH_3 and associated locally enhanced concentrations and dry deposition may be located at one end of a 5 km grid square, with a

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[16] A new JNCC project (started Oct 2014, led by Laurence Jones, CEH) is looking into the uncertainty in deposition data and critical load exceedance.

[17] Hallsworth S., Dragosits U., Dore A.J., Bealey W.J., Vieno M., Tang Y.S., Hellsten S. and Sutton M.A. (2011) Quantifying the threat of atmospheric ammonia to UK Natura 2000 sites at 1 km resolution. In: Hicks, W.K.; Whitfield, C.P.; Bealey, W.J.; Sutton, M.A. (eds.) *Nitrogen deposition and Natura 2000: Science and practice in determining environmental impacts.* COST Office-European Cooperation in Science and Technology, 281-285.

Hallsworth S., Dore A.J., Bealey W.J., Dragosits U., Vieno M., Hellsten S., Tang Y.S. and Sutton M.A. (2010) The role of indicator choice in quantifying the ammonia threat to the 'Natura 2000' network. *Environmental Science and Policy* **13**, 671-687. (doi:10.1016/j.envsci.2010.09.010)

[18] http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note.pdf In this context, a 'false positive' constitutes a site where the gridsquare data may be overestimating the N threat, whereas a 'false negative' would constitute an underestimation of the N threat at a site.

sensitive site several kilometres away, in the same grid square, not necessarily being adversely affected ('false positive').

- A site may be located relatively close to a large agricultural emission source, but upwind of the general prevailing wind direction and hence be much less affected by that source than it might be, if it was located downwind of the source ('false positive'). This does not mean that a site would not be affected, as prevailing winds are the most common wind direction as a long-term average, and annual or seasonal variability in wind patterns are likely to result in some enhanced concentration or N deposition at the site.
- A small or medium sized source in a relatively low background grid square with associated low average deposition and concentrations of N may be located directly upwind of a sensitive site, with a much higher likelihood of exceeding critical loads or levels ('false negative').
- Given that the most recent update of the APIS source attribution matrices refers to 2005, some larger local/regional sources may have increased or decreased their emissions, may no longer exist or new operations may post-date the 2005 emission input data to APIS ('false negative' or 'false positive').
- A busy road (motorway) in an area with otherwise low emission/ concentrations/ deposition may impact on any site in its immediate vicinity. However this would be averaged out in the 5 km grid assessment in APIS and not necessarily flagged as an issue at this resolution ('false negative').

4.2. Solutions

For the reasons laid out in Section 4.1 above, a **more detailed assessment of the vicinity of designated sites** is required, to ensure that local sources and source/receptor relationships are fully taken into account. For larger sites, such as the Pennines SACs, considerable areas may need to be screened, whereas for smaller sites (e.g. Fenn's, Whixall, Bettisfield, Wem & Cadney Mosses) this will require much less effort (spanning a range of areas in the region of several km^2 to several 10s of km^2 to be screened). If the main emission sources identified for a site consist of a small number of individual point or line (road) sources, or if long-range or transboundary emissions provide the main N input, the range of suitable measures may be identified very quickly. For a large number of more diffuse sources of a diverse nature, the assessment of current practice (e.g. livestock housing, manure storage, manure and fertiliser spreading) will be more time consuming.

Detailed local assessment is especially important for point-source contributions to N threats at sites. For large pig and poultry farms, as well as for other large industrial point sources, up-to-date data from the IED (formerly IPPC) database (described in Section 3.3. above) can be used to supplement the APIS source attribution data, and this work has been carried for all UK SACs and SSSIs under RAPIDS, with flags added to all sites in close proximity to IED farms (<2km) and major roads (<200m) – see the main RAPIDS report and Appendix 5 for further details. It should be noted that agricultural sectors cannot be accounted for separately in the source attribution modelling underlying the APIS database, as the agricultural NH_3 emissions at the sector level (i.e. poultry, pigs, cattle etc) are deemed disclosive at this high spatial resolution (see also Section 3.2 above). The emission modelling cannot currently build in the IED farms as a separate source category, but it is anticipated that work towards this aim will be carried out in the next few years.

To check for **threats from road emissions**, simple cross-checks with maps of the road network across all designated sites can determine the distance of major roads from the site boundaries - the main area under threat from road transport emissions is likely to be a zone of up to around 200m from the roadside edge, with concentrations and deposition decreasing relatively rapidly away from the

roadside edge[19]. This has been carried out under RAPIDS for all SACs and SSSIs. This analysis can be further supplemented with road traffic count data[20] for sites with potential issues[21].

For the assessment of **regional-scale prevailing wind directions**, the SCAIL tool can provide this information. However this needs to be used carefully as regional wind roses do not account for any local context of topographic features and wind systems around each emission source and designated site need to be taken into account. Historic data from individual meteorological stations can be downloaded from the British Atmospheric Data Centre[22].

By combining information and data from the sources described above, a general overview of the N threat at any UK Designated Sites can be derived, in terms of current average atmospheric concentrations and deposition and their sources[23].

[19] Design Manual for Roads and Bridges (DMRB) http://www.dft.gov.uk/ha/standards/dmrb/

[20] http://www.dft.gov.uk/traffic-counts/download.php

[21] UPDATE (Nov 2014): This has been tested for six case studies under the IPENS-049 project commissioned by Natural England.

[22] http://catalogue.ceda.ac.uk/uuid/ea2d5d8bce505ad4b10e06b45191883b

[23] N.B. Future UK projections can only take average national trends into account, and are unable to predict the spatial location of emission sources currently not present; this type of information can only be provided from submitted planning applications or local knowledge.