Atmospheric nitrogen theme plan

Developing a strategic approach for England's Natura 2000 sites

'Improvement Programme for England's Natura 2000 Sites – Planning for the Future'

www.gov.uk/government/publications/improvement-programme-for-englands-natura-2000-sites-ipens

Preface

IPENS and theme plans

The Improvement Programme for England's Natura 2000 (IPENS), supported by European LIFE+ funding, is enabling Natural England, the Environment Agency, and other key partners to plan what, how, where and when to target their efforts on Natura 2000 sites and the areas surrounding them. As part of the IPENS programme, Site Improvement Plans (SIPs) and themed action plans are being developed. SIPs provide an overview of the issues affecting features at the site level and the actions required to address them. Theme plans are high-level plans which aim to improve the way in which we manage a range of key issues on the Natura 2000 site series as a whole. Theme plans can provide an over-arching direction, recommendations or outline approaches to achieve target conservation status of Natura 2000 sites in England, to complement work already underway on individual sites. The plans do not have a legal status, and do not constitute a systematic evidence review, but are based on evidence and expert opinion. They are to inform action and initiatives of Natural England and its partners to help achieve the objectives of Natura 2000.

It is anticipated that Natural England and others, working with stakeholder and partners, will all play a role in implementing the theme plans. In the process of developing the theme plans Natural England has approached key partners and delivery bodies to seek input and agreement on the roles in delivering the improvements, although in some cases these discussions have not yet been concluded. Recommended actions and next steps identified in the theme plans are not necessarily committed or resourced but aimed at informing future resource decisions. Implementation of the theme plan recommendations will be via local prioritised delivery plans and coordinated through the IPENS After-Life Steering group, working with national and local delivery partner organisations.

Audience

This document is the atmospheric nitrogen theme plan. It is aimed at those that play a key role in taking forward the approach set out in this plan, in particular Defra, Natural England, Highways England, Environment Agency, JNCC, local authorities and relevant sector representatives.

Executive summary

There is a wealth of evidence that atmospheric nitrogen deposition is changing ecosystems, including sensitive habitats protected under the Habitats Directive. 80% of Special Areas of Conservation in England are estimated to receive amounts of atmospheric nitrogen above their critical loads. The pressure of nutrient loading can lead to loss of species and irreversible change.

The Habitats Directive offers a high degree of protection to Natura 2000 sites. For sites that are affected by atmospheric nitrogen, there is the significant challenge for Natural England and its partners to ensure that adequate measures are put in place to maintain the integrity of the sites and that a Favourable Conservation Status for the habitat can be achieved.

The issue of atmospheric nitrogen impacts on protected sites is linked to wider air pollution and the use of nitrogen in the economy. Measures for protected sites are likely to have wider benefits beyond biodiversity and improved ecosystem services.

Although nitrogen emissions have been significantly reduced over the past decades, atmospheric nitrogen deposition is likely to remain above critical loads for many sites in the foreseeable future. Nitrogen deposition on protected sites comes both from long distance sources and from local diffuse and point sources. Three interrelated approaches are needed to achieve the long term targets along an achievable trajectory:

- National and international measures which reduce the background deposition,
- Locally targeted measures that reduce nitrogen emissions close to protected sites, or that intercept deposition to the site,
- Habitat restoration measures that mitigate the impact of historic and on-going deposition.

This theme plan proposes to trial the development of 'Site Nitrogen Action Plans' (SNAPs) to integrate these approaches at a site level, as a remedy for affected sites. SNAPs would document:

- The current status of the site in terms of nitrogen deposition and attribution of this nitrogen to identify the most significant sources,
- The expected future decline in background deposition at the site as a result of existing national and international measures,
- Coordinated locally targeted measures to reduce the contribution of local sources where feasible and appropriate,
- Habitat restoration and management measures that mitigate the impact of atmospheric nitrogen.

The intention is that SNAPs would demonstrate what appropriate measures are in place to secure the integrity of the Natura 2000 sites and would coordinate possible future local measures.

By providing a timetabled trajectory towards favourable condition status, future SNAPs can have the potential to clarify what 'headroom' might be available for future developments, thereby providing a firmer basis for habitats regulations assessments. They can also help to inform a balanced and proportionate approach to reduction measures across different emission source sectors.

Establishing SNAPs is likely to require partnership working with the relevant authorities and intensive stakeholder engagement to raise awareness of the issue, to identify appropriate measures and to support implementation along feasible timescales. It is recommended to trial this approach for a limited number of sites initially. A national task group should oversee the development of SNAPs.

Delivering measures

Delivering measures to reduce atmospheric nitrogen impacts on protected sites can be challenging, in particular for reducing diffuse agricultural emissions. Whilst a wide range of good potential measures and techniques exists, comprehensive mechanisms to deliver packages of these measures to protect sites have been lacking. Some agri-environment agreement options under the Rural Development Programme for England can contribute to reducing ammonia emissions and deposition. This voluntary mechanism could provide an important way of reducing atmospheric nitrogen impacts on Natura 2000 sites.

Funding to promote the uptake of low-emission techniques is limited, and the timescales for adoption depend inter-alia on investment cycles, co-benefits and trade-offs with other objectives. Local targeting of available measures close to sensitive sites is therefore considered a cost-effective approach to reducing atmospheric nitrogen impacts on protected sites, given the spatial variability of atmospheric nitrogen deposition at a landscape scale. The development of SNAPs can assist in the appropriate targeting of local measures to reduce atmospheric nitrogen impacts on Natura 2000 sites, taking account of local constraints to implementation, co-benefits and trade-offs, for example with water pollution measures.

In addition to locally targeted measures, there are wider opportunities to reduce atmospheric nitrogen impacts on protected sites, by making better use of existing mechanisms and emission sector initiatives. We will investigate the merits of establishing a national task group with sector partners to further identify and harness this potential.

There are key gaps in evidence and capability that should be addressed to facilitate the approach envisaged in this theme plan and to demonstrate the effectiveness of its implementation. These include uncertainties in the sensitivity of some Natura 2000 features and the effectiveness of some mitigating measures; availability of information about local emission sources and local trends in deposition; skills and tools for local officers to assess and address atmospheric nitrogen impacts.

Contents

1. Introduction to atmospheric nitrogen and Natura 2000

Atmospheric nitrogen (N) deposition is a major pressure on biodiversity in the UK and across Europe (ROTAP 2012, Dise and others 2011, EEA 2014). The impacts are well recognised in international scientific literature and a substantial body of evidence demonstrates that the consequences for semi-natural habitats in the UK and in Europe have been significant and widespread (see for example Emmett and others 2011; Stevens and others 2011; RoTAP 2012). The negative impacts include: loss of sensitive species, changes to habitat structure and function, the homogenisation of vegetation types, changes in soil chemistry, and an increased sensitivity to abiotic and biotic stresses (such as pests and climate). Nitrogen deposition adds nutrients to low-nutrient ecosystems, favouring a few plant species within any given vegetation community at the expense of the other species present, resulting in a change in the characteristic species assemblage, and often a decline in the overall species richness of the habitat. Figure 1 shows a reduction in species richness of acid grasslands with increasing N loading in EU countries.

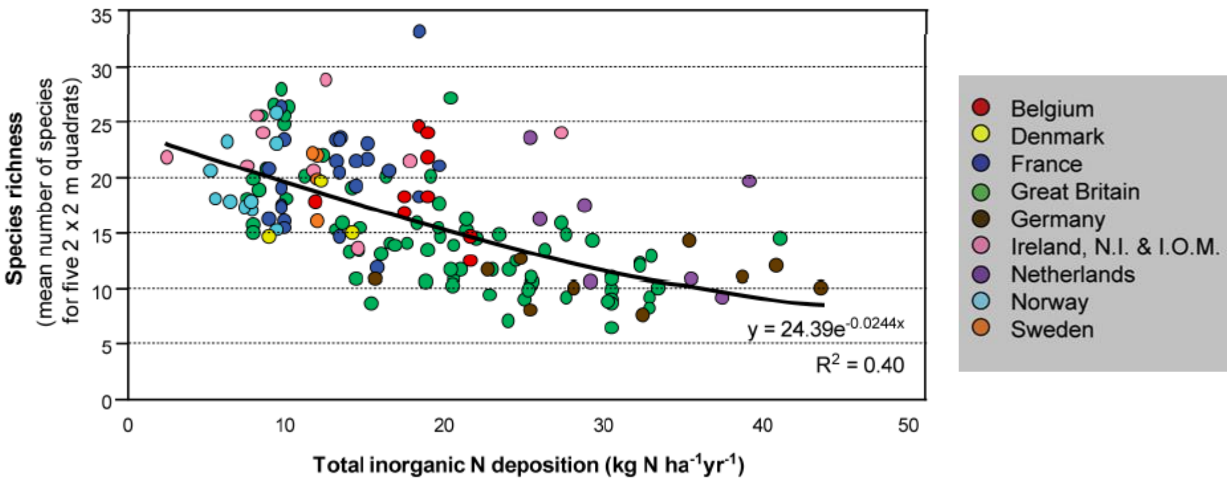

Figure 1. The curvilinear relationship between N deposition and species richness of acid grasslands surveyed in the Atlantic Biogeographic region of Europe (mean number of species in five 2 by 2 m quadrats per site against total inorganic N deposition for each of the countries surveyed. Stevens and others 2010.

In recognition of these effects, internationally agreed critical loads (CL)[1] have been set for the protection of habitats. The exceedance of these critical loads indicates where there is the potential for harmful effects. On-going nitrogen deposition tends to accumulate in the ecosystem so that even small nitrogen inputs can eventually impact on species communities that are adapted to low nutrient conditions. Despite acknowledged uncertainties in CLs and exceedance estimates, CL exceedance mapping currently represents the best available evidence of where the impacts of nitrogen deposition are likely to occur.

The proportion of sensitive ecosystems which exceed critical loads for eutrophication is expected to fall to 94% in

[1] Defined as "A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge" (Nilsson & Grennfelt 1988).

England in 2020 with the implementation of existing and planned policies (down from 97% in 2006-2008) (Defra 2011).

More than 80% of sensitive Special Areas of Conservation (SACs) and 70% by area of sensitive Special Protection Areas (SPAs) in England are estimated to exceed the CL for one or more of their protected features (Figure 2). The estimates for 2020 are similar (Sutton 2014). The level of exceedance varies widely between sites, ranging from 0.1 kg N/ha/y above the lowest CL threshold to over 50kg N/ha/y (for comparison: 50-100kg N/ha/y is typically applied to maintain high productivity hill pasture (JNCC 2011).

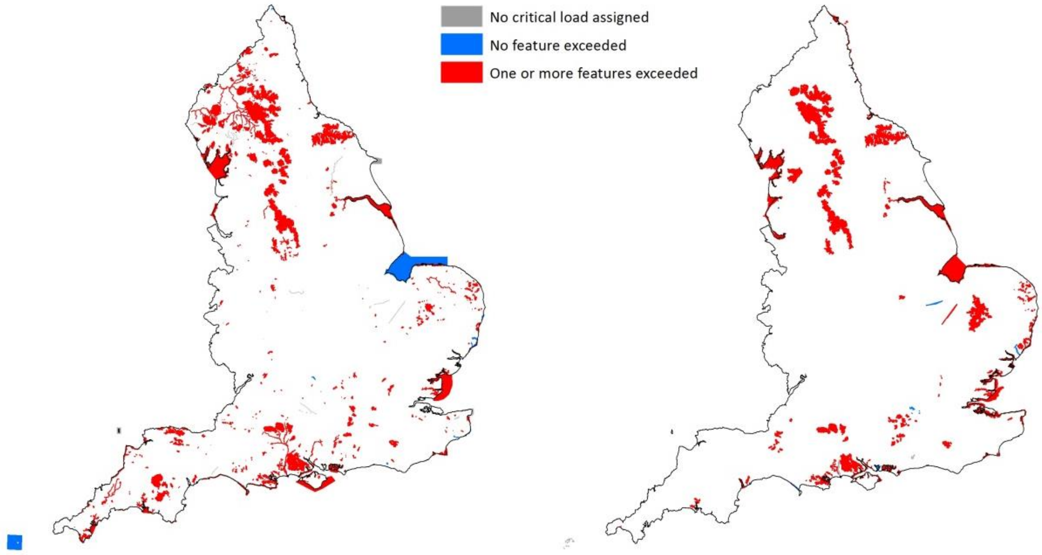

Figure 2. Exceedances of nitrogen site relevant critical loads for SACs (left) and SPAs (right) in the UK, based on recommended critical loads (http://www.apis.ac.uk/indicative-critical-load-values) and deposition data for 2011-13. Source: Maps generated for Natural England by CEH, March 2015.

Habitats that are designated under the Habitats Directive are of particular concern, not only because of their sensitivity and international importance, but also due to the legal protection that applies to them. The Birds and Habitats Directives require Member States to take appropriate steps to avoid the deterioration of habitats and to establish the necessary conservation measures that correspond to the ecological requirements of the Natura 2000 sites[2].There is also a long term obligation to achieve the Favourable Conservation Status of the habitats and species for which Natura 2000 sites are designated.

England's Biodiversity 2020 strategy includes targets to achieve favourable and unfavourable recovering conditions on SSSIs and a priority action to reduce air pollution impacts on biodiversity (Defra 2011). Work under this theme plan will contribute to meeting objectives under the Biodiversity 2020 Strategy.

There is widespread evidence of atmospheric nitrogen impacts on semi-natural habitats from experiments and from landscape-scale studies. However, it can be extremely difficult to determine the effects of atmospheric nitrogen on habitats at an individual site level due to the complex interactions between pollution impacts, management and abiotic influences. As a result, both the identification of the impacts of atmospheric nitrogen and the attribution of these impacts as being due to atmospheric nitrogen are considered to be substantially under-

[2] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. See http://ec.europa.eu/environment/nature/legislation/habitatsdirective/

reported as a reason for unfavourable condition on protected sites in England[3]. Work led by JNCC in response to requirements by the inter-agency Chief Scientist Group is considering changes to the protected sites monitoring and reporting methodology to improve our ability to link changes in site condition to impacts from air pollution. For Natura 2000 sites where CLs are exceeded, it cannot be readily assumed that the impacts of atmospheric nitrogen are absent.

Where atmospheric nitrogen deposition is considered to be contributing to unfavourable condition at a site or placing favourable condition at risk, adequate measures need to be put in place. This theme plan proposes that 'Site Nitrogen Action Plans' (SNAPs) are adopted as a remedy for affected Natura 2000 sites. The experience in other countries shows that the lack of a comprehensive approach to address atmospheric nitrogen impacts on Natura 2000 sites may make it difficult to demonstrate that adequate mitigation measures are in place or that sufficient 'headroom' exists to accommodate increased emissions from future economic developments in the areas surrounding these sites (de Bruin & de Groot 2011).

Addressing atmospheric nitrogen impacts on Natura 2000 sites will also have beneficial effects for habitat condition across a wider area of the countryside; thereby potentially making a significant contribution towards meeting the UK's Biodiversity 2020 targets, and to achieving favourable condition of Sites of Special Scientific Interest (SSSIs) as required by the Wildlife and Countryside Act 1991 (as incorporated by the Countryside and Rights of Way Act 2000).

For Natura 2000 sites specifically, there is a significant challenge to reduce deposition to prevent further habitat deterioration and to maximise the potential to achieve the conservation objectives for the sites. Given the historic high levels of atmospheric nitrogen at many sites, it is likely that emission reduction measures will need to be accompanied by habitat restoration measures where feasible (Stevens and others 2013; Smits & Bal 2012).

In addition to the impacts on biodiversity and the functioning of ecosystems, atmospheric nitrogen pollution has major consequences for human health and also impacts on soil quality, water quality, and contributes to greenhouse gas balances (Sutton and others 2011). Addressing atmospheric nitrogen pollution on Natura 2000 sites can therefore have wider benefits, beyond biodiversity conservation.

[3] http://jncc.defra.gov.uk/page-3520. Common Standards Monitoring for Designated Sites: First Six Year Report.

2. Nitrogen sources and potential measures

2.1 Sources of atmospheric nitrogen

There are two main forms of reactive atmospheric nitrogen:

- Oxides of nitrogen (NO_x), which are derived mostly from processes involving combustion (power stations, factories, vehicle engines, etc.) (Figure 3),
- Ammonia (NH_3), which originates mostly from agricultural sources (livestock, the storage and spreading of manure or slurry and fertiliser usage). Lesser quantities of NH_3 (~20% of total UK emissions) are also emitted from a range of non-agricultural sources, including waste, horses, wild animals/birds and early models of vehicular catalytic converters (Figure 4).

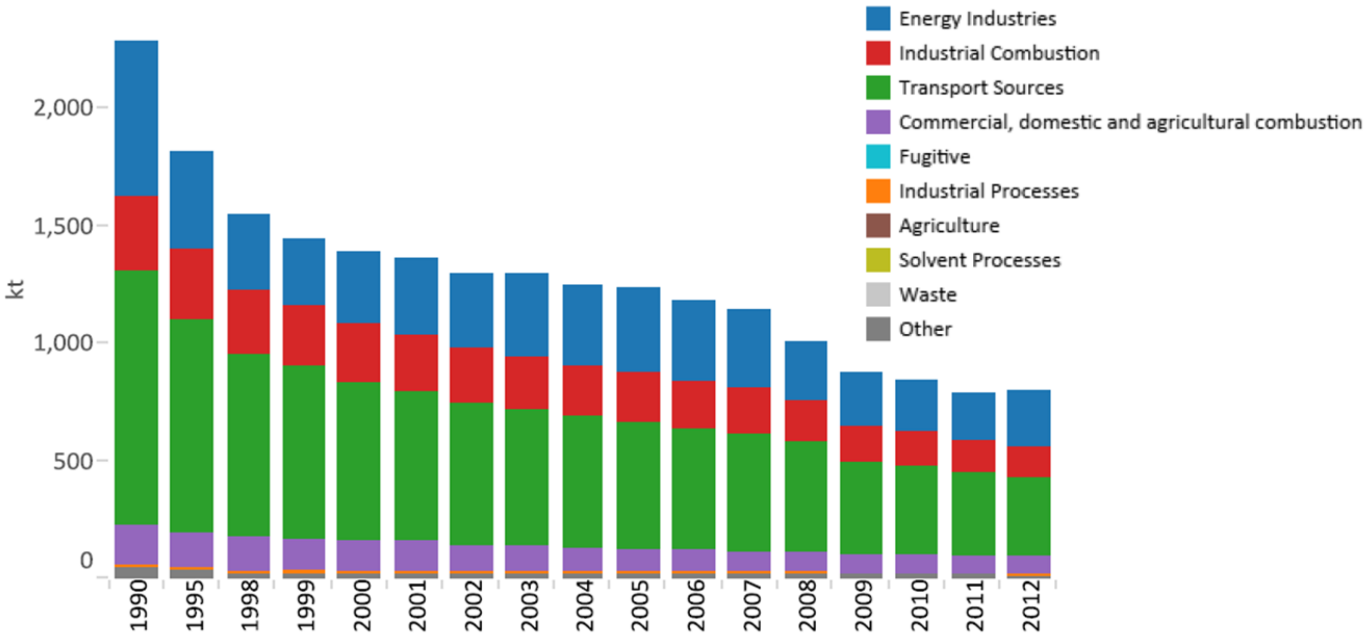

Figure 3. England NO_x emissions by sector, 1990-2012. Source: Adapted from Salisbury and others 2014.

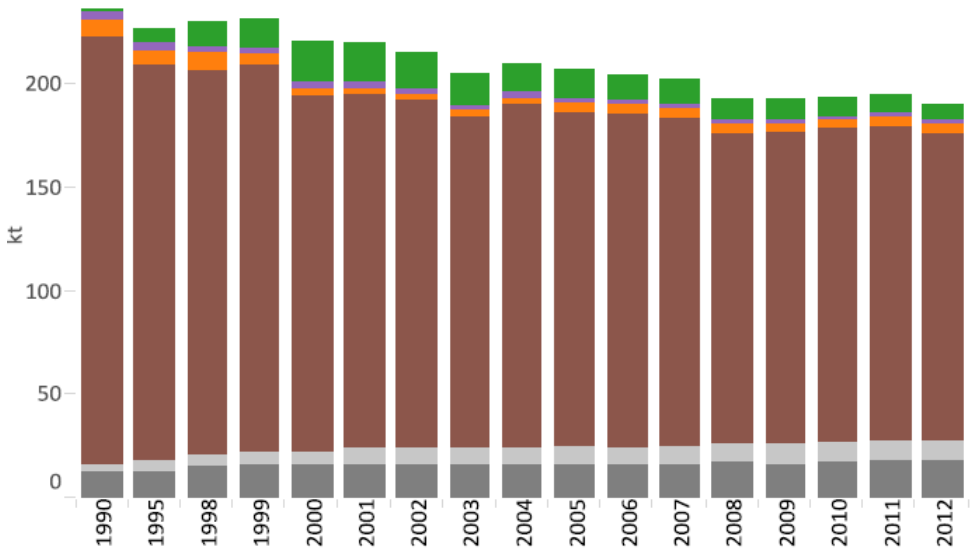

Figure 4. England ammonia emissions by sector, 1990-2012. (Key is as per Figure 3 above). Source: Salisbury and others 2014.

2.2 Sources of atmospheric nitrogen deposition vary between sites

At the UK level, these two forms of N each contribute about 50% of the total nitrogen emissions, but their contribution to nitrogen deposition on Natura 2000 sites varies between sites (Figure 5). Close to urban areas, large combustion sources or along motorway corridors, NO_x is the dominant contributor; whilst NH_3 dominates in more rural areas, especially those with intensive livestock production. Nitrogen deposition at coastal sites may be more heavily influenced by sources from other countries and international shipping; whereas general background deposition (from both national and international sources) is the dominant factor for remote upland sites.

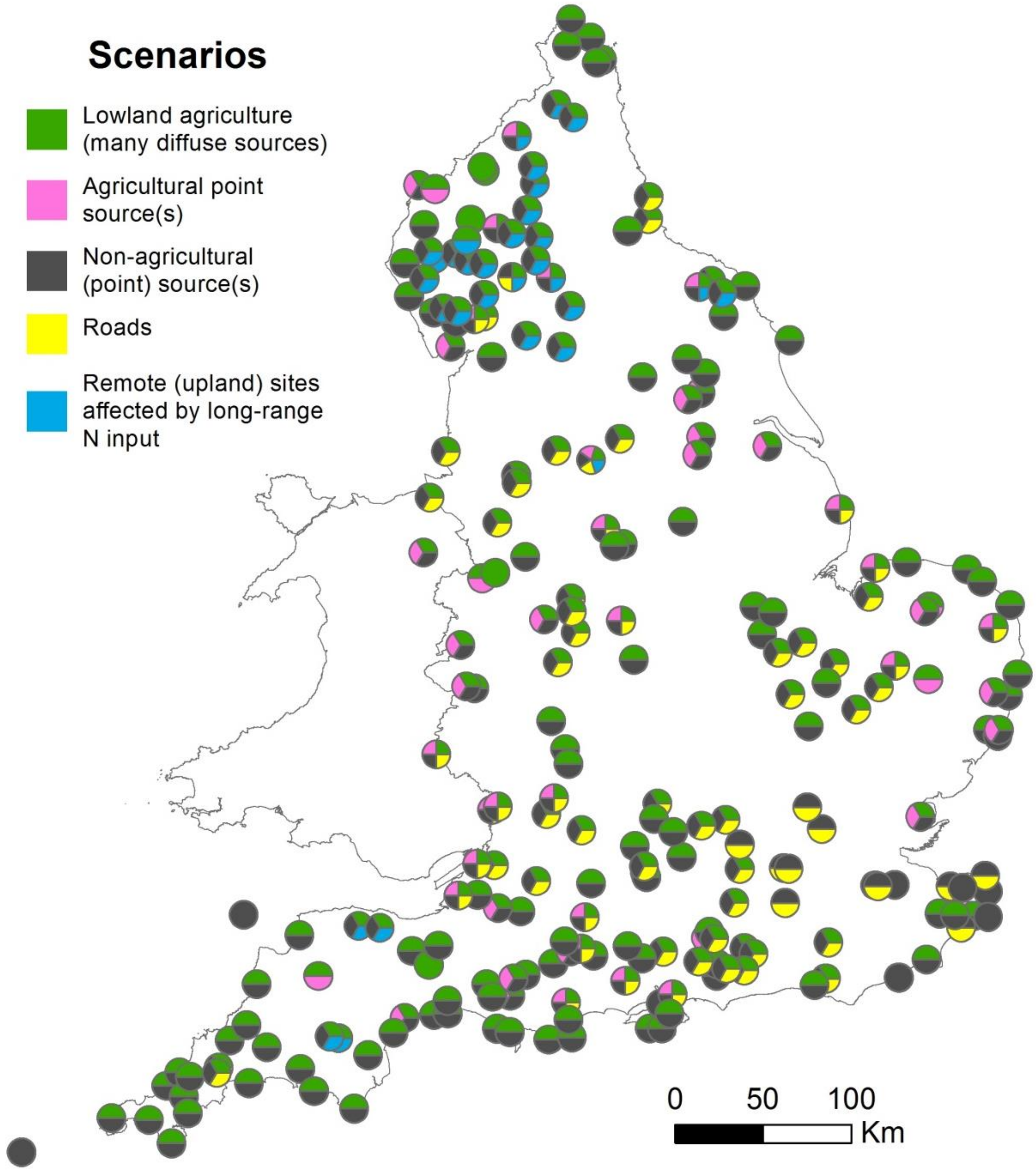

Figure 5. Source attribution scenarios for SACs. This shows the variation in nitrogen sources for the 5km grid squares in which the sites occur. Source: CEH 2005 source attribution data, reformatted by CEH for Natural England (Dragosits and others 2014b).

2.3 Local sources

There is a high degree of spatial variability of nitrogen deposition and concentrations at a local scale (Figure 6), especially for ammonia (Vogt and others 2013). An individual emission source such as a slurry lagoon immediately upwind of a protected site may be a larger contributor to atmospheric deposition at a particular site than a larger emission source further away and downwind. Locally targeted measures that take account of this spatial variability are therefore seen as a cost-effective strategy to reduce atmospheric nitrogen impacts on protected sites. Taking measures close to protected sites can be up to seven times more cost effective than non-targeted measures, when taking account of the spatial variability of concentrations and deposition of ammonia (Sutton, 2014).

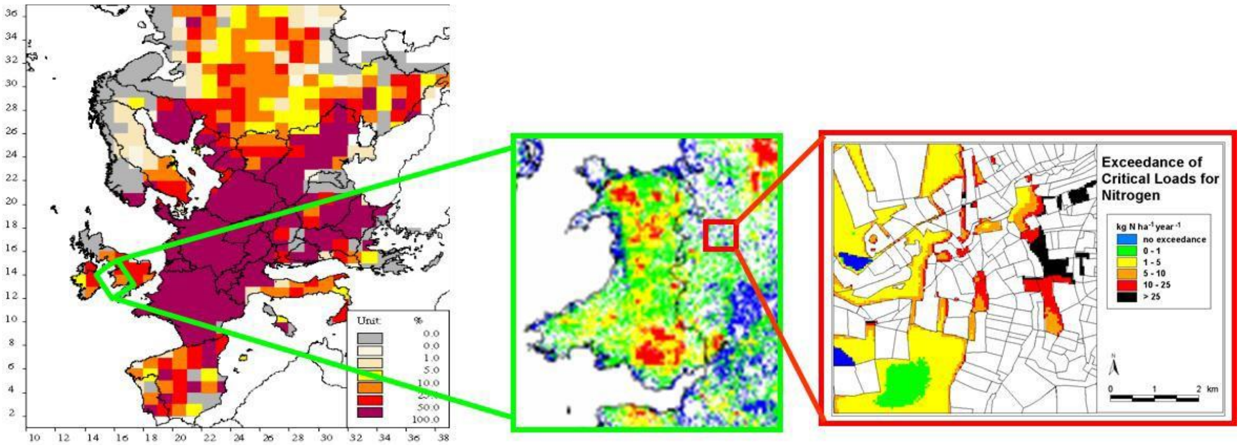

Figure 6. Spatial variability at international, regional and local scale. Source: modified from Dragosits 2014a.

2.4 Long range sources

Although the most obvious effects often occur close to emission sources (i.e. within a few km), both NO_x and NH_3 are also transported over medium/longer distances by the prevailing winds, especially from large point sources with tall chimneys. This long range transport (including pollution imported from elsewhere in Europe and further afield) is a major source for many sites and can by itself cause CL exceedance[4]. National and international measures which reduce background N deposition are therefore required alongside locally targeted measures where appropriate. Existing measures and emission reductions, such as under the Gothenburg Protocol to the Convention on Long-range Transboundary Air Pollution, will contribute to a decline in deposition on protected sites, but their contribution to the reductions necessary to achieve site conservation objectives over the long term will need to be closely monitored.

2.5 Measures to tackle NO_x

Measures and policies to reduce NO_x emissions have resulted in significant reductions in emissions over recent decades (60% fall in the UK since 1970 (Defra 2013)). For vehicles, combustion and industry sources, which are subject to regulatory frameworks, these measures are expected to further reduce NO_x emissions in the UK by 55% by 2020 compared to 2005 levels (Defra 2013). Threats to protected sites from (non-agricultural) point sources are associated mainly with NO_x emissions from combustion plants, especially in the electricity supply industry. Large combustion plants are regulated through the Industrial Emissions Directive. Medium size combustion plants may also have scope for retrofitting secondary techniques to control emissions, where economically feasible.

[4] See for example North York Moors SAC where up to 15-18 kg N/ha/y is derived from long range deposition whereas the lowest critical load is 5-10 kg/ha/y (Dragosits and others 2014b).

Adoption of low emission vehicle techniques (through EURO standards) has had considerable success in reducing the contribution from the transport sector to NO_x emissions (Defra 2013). Targeted mitigation measures may be possible where roads pose an immediate threat to protected sites (mostly limited to sites in very close proximity to roads). Potential measures include the use of buffer zones or tree belts, traffic management measures (adjusting speed levels, reducing congestion, promoting green driving, diverting the most polluting traffic) or the installation of roadside barriers to divert or re-capture pollution (Smithers and others 2014).

2.6 Measures to tackle ammonia

In contrast to NO_x, ammonia emissions in the UK, have remained relatively constant (20% fall since 1980) and are expected to decrease by only another 8% by 2020 (Defra 2013). Agricultural sources accounted for 82% of the ammonia emissions in the UK (in 2012) (Defra 2013), and this sector has the largest potential for emission reduction with cost effective measures (Sutton 2014). Industry led initiatives to promote improved nutrient management (such as Tried & Tested[5]) have led to an increased awareness of possible 'win-win' solutions, and trends in emissions are moving in the right direction (Mitchell 2014). Nitrogen use efficiency of major crops has increased steadily over the past decades and an increasing proportion of farmers now work with nutrient management plans (60% in 2014[6]). However, a large proportion of the emission reductions achieved to date are due to reductions in livestock numbers rather than large-scale implementation of emission reduction measures.

The main groups of potential measures to reduce NH_3 emission are (in order of cost-effectiveness):

- Low-emission manure (solid and slurry) application techniques and mineral fertiliser application techniques,
- Application of low-emission manure storage,
- Modifications to agricultural livestock housing (including low-emission livestock buildings for newbuilds) and diet.

It should be noted that a considered combination of measures is likely to be most effective because (for example) measures such as minimising nitrogen loss 'upstream' (e.g. during manure storage) can increase emissions during spreading.

Landscape management measures can be effective close to protected sites:

- Buffer zones of low/ no fertiliser input,
- Conversion to semi-natural vegetation,
- Establishing of tree belts around sensitive sites or local point sources.

Buffer zones around a site may also have co-benefits in terms of increasing a site's resilience (connectivity, pollination, external buffering), whereas tree belts may improve a farm's privacy, landscape amenity or provide odour mitigation and contribute to carbon sequestration.

Many of the options for mitigating ammonia measures have successfully been applied elsewhere in the EU. However, in England comprehensive delivery mechanisms for these measures close to protected sites are currently lacking, in particular in relation to tackling existing diffuse sources (see section 3).

[5] http://www.nutrientmanagement.org/home/
[6] ibid

2.7 Habitat management and landscape measures

The effectiveness of on-site habitat management in reducing atmospheric nitrogen deposition impacts was reviewed in a study commissioned by Natural Resources Wales on behalf of all the Statutory Nature Conservation Bodies (Stevens and others 2013). For all habitats covered in the study, management techniques with the potential to mitigate nitrogen deposition impacts were identified. Potential measures include:

- additional grazing or mowing;
- sod cutting, turf stripping or topsoil removal;
- hydrological management; and
- liming.

However, not all the techniques may be suitable for all the habitats and they need to be applied with care to avoid unintended consequences.

Recognising that nitrogen deposition levels are likely to remain high at many sites in the coming decades, recovery strategies for sensitive habitats have been developed in the Netherlands to support a Programmatic Approach to Nitrogen (Smits & Bal 2012). These include habitat restoration measures at the regional/landscape level and at the habitat/field level. For example, for some habitats the acidifying impacts of atmospheric nitrogen can be mitigated by restoring the hydrological functioning of a site, which increases the pH and base saturation of acidified habitats. Restoration measures may enable the mitigation of some of the adverse impacts of excess nitrogen while atmospheric nitrogen deposition remains above the CL. This would contribute to help stabilise conditions and alleviate deterioration of the habitat quality, pending further future reductions in deposition through the implementation of local, regional and international measures.

On-site management and landscape scale measures can help to mitigate impacts and may enable habitat quality improvements within a context of declining future N deposition (assuming targets are met). However, habitat restoration measures alone are unlikely to fully mitigate the long term impacts of nitrogen deposition at all sites. Some management interventions may only be effective under specific conditions or can only be applied once per decade (Stevens and others 2013). Therefore, a strategy to address atmospheric nitrogen impacts must consider deposition reduction alongside the potential for habitat management measures to mitigate impacts.

3. Delivery mechanisms and gaps in current approaches

A range of current drivers and delivery mechanisms are relevant to atmospheric nitrogen deposition on protected sites. These relate to national and international regulatory instruments to control emissions and standards for air quality, as well as incentive and advice schemes, some of which can have co-benefits for atmospheric nitrogen despite having originally been designed for other purposes (e.g. water or soil). There is scope to further develop instruments that are currently not targeted at reducing atmospheric nitrogen impacts at protected sites, such as advice and incentive schemes. Annex 2 provides an overview of mechanisms that are relevant to reducing atmospheric nitrogen deposition on protected sites.

Until now, preventing or reducing atmospheric nitrogen impacts on protected sites has largely relied on three separate approaches:

- **National and international policy measures** to reduce nitrogen emissions and related deposition (e.g. cleaner technologies for cars and energy production, codes of agricultural practice).
- Protection of sites from significant impacts of new developments through **regulation and assessment of projects and plans** (e.g. planning permissions and environmental permitting).
- **On-site habitat management** in response to observed changes in site condition (usually aimed at tackling more recognisable issues such as under-grazing or scrub encroachment that may be exacerbated by atmospheric nitrogen).

These three approaches have not (yet) resulted in the full protection of designated sites from atmospheric nitrogen impacts, as demonstrated by the current (and forecasted) widespread occurrence of critical loads exceedance and associated likely impacts on habitats:

- Current **national and international policy measures** will further reduce the deposition at most protected sites, but this is unlikely to bring the deposition levels at sites down to levels that provide certainty that sites are not affected. Available measures that are relevant to protected sites are not coordinated across different sectors to achieve an integrated approach for a sensitive locality.
- **Regulated sources form only a small part** of the total N deposition on Natura 2000 sites and there is no programmed approach to reduce diffuse air pollution for protected sites (compared to, for example, diffuse water pollution). Whilst technically and economically feasible measures are available to substantially reduce NH_3 emissions from agriculture, there is currently no systematic programme of delivery mechanisms to put these measures in place.
- On site **habitat management measures are often not sufficient** to address the effects of on-going deposition and the legacy of accumulated nitrogen. The complexity of recognising nitrogen impacts means that current on-site habitat measures are usually not directed at this aim. Funding for restoration measures is limited and the effect may only be temporary.

Whilst the threat of atmospheric nitrogen impacts on protected sites may be due to a range of different emission sources at different spatial scales; measures that are planned or are in place are currently not integrated to ensure they jointly deliver effective protection locally.

Where Natura 2000 sites are at risk of being impacted by nitrogen deposition there is a degree of certainty required that the appropriate measures are being taken:

- to avoid deterioration of habitats; and
- to (be able to) reach favourable condition and meet the conservation objectives in the long term.

The challenge for Natural England and its partners is either to show that the existing measures are adequate, or to take additional measures where appropriate and feasible. This theme plan therefore focusses on the practical steps that Natural England and its partners *can* take to reduce and mitigate atmospheric nitrogen impacts at Natura 2000 sites. While policy gaps may remain, significant progress can be, and should be, made for Natura 2000 sites at a local level. Site Nitrogen Action Plans need to be developed to serve as evidence that appropriate steps are being taken to fulfil the requirements of the Habitats Directive for Natura 2000 sites.

4. Strategic approach to Natura 2000 and atmospheric nitrogen

Three categories of measures are jointly needed to address atmospheric nitrogen impacts on Natura 2000 sites:

- **Reducing the background deposition** through ongoing national and international efforts.
- **Reducing the contribution of local emission sources** to the nitrogen deposition on the site through locally targeted measures.
- Putting in place **effective habitat management and restoration measures** to mitigate and reduce nitrogen impacts on habitats and increase habitat resilience to on-going N deposition while delivery mechanisms are being developed and measures are being implemented, and to reduce the impacts of legacy N deposition.

Given the contributions needed from various sectors (e.g. energy, agriculture, transport) and the measures required at different scales (national, international, local-landscape, on site habitat) an integrated approach is pivotal. The significant spatial variability in atmospheric N deposition and the fact that the sources of emission vary greatly between individual sites, mean that measures are likely to be most cost-effective when integrated at a local level for a site or a group of sites and taking into account the relationship between the Natura sites, other protected sites and their spatial location in the landscape. At the same time, national initiatives can contribute to reducing atmospheric nitrogen impacts on protected sites.

The strategic approach envisaged in this theme plan comprises of two main aspects:

1) Trialling Site Nitrogen Action Plans for affected sites (see sections 4.1-4.5).
2) Promoting some national scale initiatives to better address the issue (see sections 4.6-4.7).

4.1 Site Nitrogen Action Plans as a new remedy for protected sites

A new approach is proposed here to develop and implement Site Nitrogen Action Plans (SNAPs) for Natura 2000 sites that are considered at risk from excess N deposition. These plans would aim to:

- **Achieve a decline in atmospheric nitrogen deposition** on sensitive habitats[7], through spatially targeted source and landscape-scale measures, while taking account of trends in background N deposition at a site level.
- **Ensure habitat restoration measures are in place** where feasible that help mitigate (historic and on-going) nitrogen deposition impacts and secure improvement of habitat quality while N deposition remains above CL.

A SNAP for a protected site (or group of protected sites) would describe:

- Current status of atmospheric N input (deposition/concentration/CL exceedance, source attribution – local vs. regional vs. transboundary).
- Predicted future trends of nitrogen deposition as a result of existing emission reduction measures at international, national or regional scale.

[7] Speed of reduction must be sufficient to avoid further deterioration and retain the capacity to restore habitats to favourable condition over the long term.

- Coordinated local-scale measures for all relevant sources to reduce N deposition within feasible timescales.
- Habitat restoration measures that help mitigate the impact of atmospheric N for specific habitats.

By being an integrated plan, covering measures in different sectors and across different spatial scales, a SNAP could provide the evidence to demonstrate:

- whether sufficient measures are already in place to adequately address the risk or impact of atmospheric N deposition, or
- whether the integrity of the Natura 2000 site is (likely to be) maintained if the identified local and wider-ranging measures are implemented.

The SNAP could also document the progress of the implementation of these measures. By demonstrating that adequate mitigation measures were in place, the SNAP could support the Habitats Regulations Assessment process; thereby enabling decision-makers to determine with confidence whether proposed future developments could be carried out in compliance with the Habitats Regulations. For this to be effective, the plan would need to be accompanied by commitment to action over relevant timescales.

The SNAPs integrated approach to addressing nitrogen deposition on protected sites across different sectors could also help to inform a balanced approach to different sectors (e.g. measures proportionate to the relative contribution to N deposition; or based on relative costs and benefits) and allows measures to take account of co-benefits, local constraints and trade-offs such as those with water pollution measures. It would reduce the instances where permitting or authorisations appear to be unduly constraining new regulated developments (e.g. Environmental Permits, housing or roads projects, Local Plans,) while existing or unregulated sources are not addressed. SNAPs can demonstrate that atmospheric N reductions are being sought as appropriate from all sectors, through an integrated plan.

Although SNAPs would be a new way of dealing with atmospheric nitrogen issues, comparable approaches exist for other threats to protected sites, such as Diffuse Water Pollution Plans and Nutrient Management Plans for rivers. In other countries, programmed approaches have been developed for nitrogen deposition on Natura 2000 sites. Site based action plans, which encompass a more integrated or programmed approach were recommended at the International Biogeographic Workshop on this topic (JNCC 2014, see http://jncc.defra.gov.uk/page-5954). A framework for site action plans has been developed by CEH (Carnell and others 2014) and the required analysis steps have been tested and further refined through evidence projects funded through the IPENS project[8]. It was concluded from these projects that, for the case study sites tested, the framework was feasible and allowed a reliable identification of the main (local) nitrogen source groups, which in turn enabled a relatively clear initial assessment of likely mitigation measures. Catchment Sensitive Farming was identified as an example of a good potential route by which to deliver agricultural measures, where there is synergy with water pollution and other benefits/cost savings for farmers.

[8] IPENS 49 site categorisations for nitrogen measures (Dragosits and others 2014b); IPENS 50 case studies for ammonia measures (Misselbrook and others 2014).

Steps proposed for establishing Site Nitrogen Action Plans (SNAPs)

It is suggested that SNAPS would be developed for protected sites where it is identified that atmospheric nitrogen deposition has an impact. Establishing SNAPs would therefore be preceded by an investigation into the nitrogen impacts on the site's conservation objectives. SNAPs can integrate various types of measures (national measures, local off-site source and landscape measures, on-site management measures) in a coordinated plan that, alongside measures to address other impacts, ensures the integrity of the site is maintained and/or that deterioration is prevented. Establishing SNAPs would require a range of steps:

1) Identifying the location and sensitivity of habitats and analysing the current nitrogen deposition and concentration levels for the site, including source attribution and critical loads assessment.

2) Analysing the expected reduction in background N deposition at the site as a result of national and international measures.

3) Identifying local emission sources and potential local and regional measures to further reduce nitrogen emissions, concentrations and deposition.

4) Detailing on-site habitat management measures and analysing the restoration measures that mitigate remaining (and legacy) nitrogen impacts.

5) Agree the delivery of appropriate actions (local emission reduction measures and habitat management and restoration measures) along a feasible timescale to secure the site integrity (in conjunction with measures to address any other issues affecting the site); along with the delivery mechanisms and the bodies responsible for their implementation.

6) Perform an ecological audit, to confirm that the expected reduction in N deposition together with the programmed habitat measures is likely to lead to achievement of the conservation objectives for the site.

4.2 Trialling the SNAP approach

The robust approach to addressing atmospheric nitrogen issues at protected sites though SNAPs would be a new process for England. The novelty of this mechanism requires it to be piloted by developing SNAPs for a limited number of sites in the first instance, in order to test their value, feasibility and to further develop the approach. The effectiveness of these pilot SNAPs will need to be monitored and evaluated to inform wider roll-out. This also fits with the limited available budgets in the foreseeable future for implementing measures on the ground.

An initial indication of sites with good potential for local agricultural ammonia measures is provided in Annex 3. Pilot SNAPs can best be developed for those sites where they can build on existing well-developed delivery initiatives and stakeholder relationships. In order to inform the test phase, the selection of pilot sites should also reflect the range of circumstances and nitrogen sources that can be encountered across England.

It is therefore proposed to consider the following sites as potential pilots for trialling the development and implementation of SNAPs (*initial selection for further consideration within Natural England and with partners, subject to available resources*):

- Culm Grassland SAC;
- Fenn`s, Whixall, Bettisfield, Wem and Cadney Mosses SAC;
- Walton Moss SAC;
- Epping Forest; and
- South Pennine Moors SAC.

IPENS Natura 2000 Site Improvement Plans provide an indication of the sites where a Site Nitrogen Action Plan is considered to be beneficial in the long term, but this needs to be evaluated based on the application of a more robust assessment of atmospheric nitrogen impacts on protected sites (forthcoming JNCC framework for the attribution of Nitrogen deposition as a cause of unfavourable condition). SNAPs are likely to be most valuable for sites that are likely to be impacted by atmospheric nitrogen and where there is potential for local measures to make a difference. See Annex 3 for an initial assessment of SACs.

4.3 Partnership working and stakeholder engagement in SNAPs

Given the need for various authorities and sectors to be involved, it is proposed to develop SNAPs in close partnership through a collaborative approach. Implementations of measures will rely on existing, mostly voluntary mechanisms (e.g. agri-environment agreements); meaning that intensive stakeholder engagement is needed to increase awareness, to identify realistic and achievable measures and to set timescales of implementation that tie-in with the economics of business development. As SNAPs have a primary focus on protected sites, Natural England would have a role in coordinating their establishment, whilst support would be sought from, for example, the Environment Agency and Local Authorities as key delivery partners and in collaboration with local sector and stakeholder representatives. It is suggested that interdisciplinary working groups should be established for sites or groups of sites in England where SNAPs would be developed.

The development of SNAPs in each local geographic area would need to be supported by a comprehensive communications strategy across all relevant sectors and stakeholders, both nationally and locally, to ensure that their role and status and the linkages to other plans and initiatives is clear. It is recommended that a national steering group involving stakeholders should oversee the development of the SNAPs, while the exact process of developing them is best agreed at a local level, with early stakeholder engagement.

4.4 Status of SNAPs and links to other plans

There is no statutory requirement to develop SNAPs and as such, they are not intended to have a statutory or legal status in themselves. SNAPs would be a way for relevant authorities to coordinate their actions to address nitrogen impacts on protected sites (in discharging their statutory duties with regard to SSSIs and the Habitats Directive). SNAPs are proposed to function as a potential 'remedy' for those protected sites (Natura 2000 sites initially and potentially other SSSIs in the future) where nitrogen deposition is identified as having an impact on those sites (see Natural England's SSSI standard for explanation of 'remedies'). The status of SNAPs may therefore be comparable to that of for example Diffuse Water Pollution Plans.

Because the purpose of SNAPs is to show that the appropriate steps are being taken to address nitrogen impacts on protected sites, they can document which measures from different relevant plans and initiatives contribute to resolving the issue. SNAPs can therefore link to other plans, coordinating integrated delivery for atmospheric nitrogen issues. Where the existing measures may not yet be sufficient, SNAPs can specify which additional measures are needed that can reasonably be taken within the remit of the authorities involved and agree feasible timescales for their implementation.

4.5 Coordinating the delivery of measures

SNAPs could coordinate measures to ensure their (cost-) effectiveness for an individual Natura 2000 site or group of sites through the appropriate spatial targeting of their implementation. The measures within the SNAPS would be likely to be delivered through a range of schemes including:

- The **spatial targeting of voluntary ammonia mitigation measures** and the programming of delivery support through advice, capital items and land management options under the new Countryside Stewardship Scheme and Countryside Productivity Schemes (currently being developed).
- The **planning and 'nitrogen proofing' of habitat restoration measures on sites**, delivered through existing instruments (e.g. Higher Level Stewardship, Conservation Enhancement Scheme, National Nature Reserve management, LIFE, etc.) and their successors.
- The **consideration of environmental permit conditions** (both bespoke and standard rule permits) where a SNAP indicates that site-specific permitted sources are making a significant impact and where such impacts may need to be considered cumulatively.
- The **programming of traffic management measures** taken by local authorities. Proposals for such measures should take account of Air Quality Plans for the zone under the Ambient Air Quality Directive (Directive 2008/50/EC) and local Air Quality Management Plans.
- Informing the Habitats Regulations Assessments of proposed new plans and projects.

4.6 New delivery mechanisms for local measures

Atmospheric nitrogen deposition has historically often been regarded by conservation officers as an intractable issue that can only be addressed through national policy intervention. However, a wider set of tools is now emerging that can enable local partners to make tangible steps towards reducing atmospheric nitrogen impacts on protected sites.

In tandem with developing this theme plan, IPENS has provided inputs to the development of elements within the Countryside Stewardship Scheme and the Countryside Productivity Scheme to include and target measures that are relevant to reducing ammonia impacts as well as other benefits such as improvement of water quality or nutrient use efficiency. Measures that are being considered include:

- options that reduce the nutrient inputs to grassland and arable fields close to protected sites (Countryside Stewardship);
- establishing tree belts to screen emission sources or sensitive sites (Countryside Stewardship); and
- using nutrient management techniques to improve N use efficiency which also reduce emissions to air (Countryside Productivity).

Implementing these measures needs thorough consideration locally of the benefits, risks and potential trade-offs. The likely funding constraints for these schemes mean that their availability is likely to be limited in scale, at least initially, so their deployment needs to be strictly targeted. Expectations of uptake and the pace at which these measures could be implemented needs to be realistic in light of the investment cycles in the different emission sectors and other potential barriers to implementation. This theme plan proposes to use Site Nitrogen Action Plans to help coordinate the concerted deployment of these options at the sites where action is most needed, although the measures could be deployed more widely.

4.7 Making better use of existing delivery mechanisms through targeting action at sensitive sites

There are opportunities to deploy existing delivery mechanisms to further reduce atmospheric nitrogen impacts on protected sites. Options for further discussion with stakeholders might include:

- **Seeking inclusion of mitigation measures to address the impacts of major roads on designated sites** in the roll out of the Department for Transport's Roads Investment Strategy, which identifies designated funds for improving biodiversity (including SSSI condition and Nature Improvement Areas) and air quality alongside other environmental interventions. 'Priority sites' that are highly sensitive to nitrogen deposition and experience a high exposure to NO_x from road traffic have been identified by Natural England. Further work is needed in partnership with Highways England to verify these sites and identify and implement specific locally targeted mitigation measures where feasible.
- The contribution of local roads to the deposition at a site could be reduced by consideration of sensitive sites in the **programming of traffic management measures** taken by local authorities (e.g. through Air Quality Management Plans). The need for this could be indicated in SNAPs.
- **Farm advice** delivered as part of Catchment Sensitive Farming, industry led initiatives or Environment Agency farm visits could consciously consider and recommend possible action that might be taken to reduce ammonia emissions, in particular where farming operations are within a zone of 2-3 km around sensitive sites.
- For **regulated industry**, site specific measures beyond Best Available Techniques (BAT) could be considered where this will contribute to the reduction of overall N deposition at Natura 2000 sites that are impacted by nitrogen deposition.
- In considering **planning permissions**, relevant authorities can make use of SNAPs to take account of cumulative impacts, supported by more comprehensive inventories of current and planned activities.

4.8 Wider initiatives that would contribute to reducing atmospheric nitrogen impacts

Raising greater awareness about atmospheric nitrogen and its impacts is needed among conservation practitioners and sector stakeholders, in particular how to recognise symptoms at sites. Activities driven by other objectives (e.g. reducing diffuse water pollution, nutrient efficiency, human health) will already contribute to reductions and these achievements need to be disseminated and recognised in local and national assessments. Improved communication of technical solutions through existing guidance represents a potential route for further improvements. Opportunities for these wider initiatives identified at the IPENS stakeholder workshop[9] as meriting further exploration and discussion include:

- engagement and capacity building with the agricultural livestock housing supplier industry on low-emission housing solutions;
- exploration of the potential role of/ links with Environment Agency sector action plans;
- adaptation of standard rules in environmental permitting for atmospheric nitrogen; and
- identifying how the ring fenced investment funds announced with the Roads investment Strategy can be used to "strike a balance between increasing road capacity and mitigation the impact of roads on neighbouring communities and the environment". This can include consideration of how the funds might

[9] IPENS workshop on atmospheric nitrogen deposition and Natura 2000, August 2014 Peterborough. http://publications.naturalengland.org.uk/publication/5748422325829632?category=6285310547722240

contribute to IPENS.

- facilitation of early consideration of air pollution in new developments through guidance (e.g. environment plan for dairy farming);
- update of the Design Manual for Roads and Bridges;
- improvement of the knowledge base of site managers to recognise atmospheric nitrogen impacts;
- extending the system of Air Quality Management Areas (see annex II) to encompass designated sites; and
- revision of the Codes of Good Agricultural Practice, RB209 fertiliser manual, and Inventory of mitigation measures.

These possibilities need to be further considered. There may be a value in establishing a national Task Group with sector partners (transport, agriculture, energy) to harness these potential pathways. This could be the same group that oversees the development of SNAPs.

4.9 Evidence and capability

There are some key challenges in relation to evidence and data requirements as well as in the capability and skills required to make the approach set out above a success.

a) Key evidence gaps

- The **sensitivity of Natura 2000 features** to atmospheric nitrogen is sometimes uncertain, in particular for habitats and species where critical loads are currently based on expert judgment or based on analogy to similar habitats; whilst the critical loads applied to SPA birds are based upon the critical loads for their most frequent supporting habitat and may not always be appropriate to a specific SPA. Further research is required to address these gaps.
- The **location and extent of sensitive habitats within sites**, in particular for Annex I habitats and the habitats of European species and birds. Currently this information is fragmented. Local or national datasets informed by structured monitoring would be invaluable to identify habitats at risk and explicitly flag/exclude those thought not to be at risk.
- **Effectiveness of on-site habitat management measures to mitigate atmospheric nitrogen** impacts is not fully established. There are outstanding evidence gaps to demonstrate that restoration measures can lead to long term habitat quality improvement in situations where nitrogen deposition critical loads continue to be exceeded.

b) Improvements to data and tools

- **Information on local emission sources**, in particular diffuse agricultural sources, is needed to reliably estimate local emissions and their contribution to deposition on sensitive sites. This requires information on which measures are already applied at which locations. This information is not systematically gathered at a high resolution, with only national estimates currently existing for established measures. The uptake of technologies that reduce ammonia emissions and landscape measures can also inform the national emission inventory which currently relies on these average implementation rates.
- **Fine resolution deposition modelling** would significantly help the local targeting of measures. The spatial resolution at which deposition data is available is currently 5km. There is large spatial variability of deposition at a local scale. Finer resolution deposition modelling would support the identification of locations where N impacts are likely (or exclusion of areas where impacts are not likely) and would enable

proper consideration of background levels and other sources of N emissions in determining the impacts of proposed new emission sources under the planning system.

- The approach would be supported by developing a **web tool to enable the assessment of the contribution of multiple spatially separate sources** and the effect of potential measures. Experience in other countries has shown that the availability of a user friendly deposition and assessment tool can also significantly reduce the costs of impact assessment for developers (see for example: www.aerius.nl/en) and facilitate cumulative impact assessments for authorities. This can also be linked to a web-based decision support tool with information on potential measures and their effectiveness.
- **Historic and future deposition trends** as a result of (inter)national measures need to be established for individual sites. This is essential information for the overall assessment of whether the measures for protected sites are adequate. It also provides the context in which the contribution of local measures can be identified.

c) Capability and skills

- The likely impact of atmospheric nitrogen on Natura 2000 sites needs to be reflected in the **condition assessments of protected sites**. The systems currently used for site monitoring and condition assessments do not adequately capture threats and impacts from atmospheric nitrogen and therefore do not adequately drive actions to put measures into place. A task and finish group established under the Chief Scientist Group is developing a framework for attributing atmospheric nitrogen deposition as a threat or reason for adverse condition. The outcomes of this work will need to be applied to all Natura 2000 sites in due course, as updated assessments proceed. Site Nitrogen Action Plans can subsequently be used as a remedy for unfavourability where adverse impacts are identified.
- Protected sites staff will need **training** in the recognition of atmospheric nitrogen impacts on sites where this is possible, as well as in the identification of potential measures (on-site habitat management and off-site input reduction measures). It is recommended that practical tools are developed for recognising the symptoms of atmospheric nitrogen impacts.
- **Conservation objectives for Natura 2000 sites** reflect air quality as one of the supporting processes on which many European features rely, with reference to critical loads and levels as reference values. However, N deposition is likely to remain above critical loads at some sites even in the long term. The topic of setting conservation objectives in relation to critical loads was discussed at an international workshop (Whitfield & McIntosh 2014), which recommended considering ways to set meaningful nature conservation objectives for sites, building on an understanding of historical nitrogen impacts and how cumulative effects of nitrogen deposition will influence structure & function of these sites and their future prospects. There may be a merit in considering an approach to setting interim milestones for atmospheric nitrogen deposition at site level.

5. Wider benefits of the approach

While SNAPs would be primarily targeted at protecting sites from the impacts of atmospheric nitrogen pollution, there are wider benefits of the SNAP approach and the associated processes identified above. The associated benefits for biodiversity and ecosystem services mean that these steps can also deliver significant benefits for:

- Agricultural measures which reduce NH_3 emissions from manure management have the potential to increase the fertiliser nitrogen value of the manures/slurry, thereby reducing costs of mineral N fertilisers for farmers. Amounts will vary, but could typically save 5-25 kg N/ha/yr, depending on location.
- Some agricultural measures that reduce NH_3 emissions may also have the benefit of reducing diffuse water pollution, reduction of odour and particulates. Conversely, certain measures implemented for water quality through Catchment Sensitive Farming have been shown to reduce air pollution. Through SNAPs, the spatial targeting of these measures can be optimised to deliver multiple benefits and pollution-swapping can be avoided.
- Measures to reduce emissions from road transport can result in substantial co-benefits by reducing fuel use and other associated pollutants, and can also help to minimise traffic noise.
- Decreased local nitrogen emissions resulting from the SNAPs' proactive approach can contribute to reaching national emissions ceiling targets, deliver health benefits and contribute to climate change mitigation.

6. Actions

The table 6.1 below outlines the priority actions for implementing this theme plan. It indicates the next steps required to progress the approach outlined in the theme plan. The actions table should not be seen as a fully funded, committed-to implementation plan. It is aimed at informing future resource decisions of the delivery bodies involved. Implementation of the actions will be via local prioritised delivery plans and coordinated through the IPENS After-Life Steering Group, working with national and local delivery partner organisations.

The actions table is not an exhaustive list of measures needed to address atmospheric N impacts on protected sites. As the actions below have not yet been agreed and funded, the table should be seen as proposals that need to be agreed and further specified within and between the relevant delivery organisations and with partners. It is likely that Natural England will provide the lead for many of these actions, with Defra or EA as key partners, though depending on resources and priorities other bodies may take a lead, for example in data collection.

Table 6.1 priority actions for implementing this theme plan

Action no.	Action description	Suggested delivery bodies
Actions to develop SNAPs		
1	Establish a national Task and Finish Group to oversee the development and communication of SNAPs and to harness wider options to reduce atmospheric nitrogen impacts on protected sites	Defra, Natural England
2	Establish an interdisciplinary working group for the local geographical areas where SNAPs will be developed	Natural England
3	Create a specification for SNAPs and establish supporting tools to develop SNAPs for trial sites/groups of sites	Natural England
4	Develop and evaluate individual Site Nitrogen Action Plans for up to 6 sites	Natural England
5	Develop a programme of SNAPs (depending on evaluation results)	Natural England, Environment Agency
6	Roll out a programme of SNAPs (depending on available budget)	Natural England
Wider initiatives to support the approach		
7	Assess the effectiveness of on-site habitat restoration measures in the context of on-going nitrogen impacts	Natural England
8	Analyse future N deposition trends at individual sites	Defra
9	Consider an approach to setting interim milestones for reducing atmospheric N impacts as part of site level conservation objectives.	Natural England
10	Promote further investigation of the sensitivity of Natura 2000 features for which no reliable CL exists.	TBC
11	Create a map of Natura 2000 habitats at sensitive	Natural England
12	Apply the framework for site condition assessment of nitrogen impacts to all Natura 2000 sites in England	Natural England
13	Develop tools and train NE staff to identify nitrogen impacts on sites	Natural England
14	Consider the potential benefits of finer resolution modelling and developing of a web based decision support tool (ideally UK-wide rather than for England only)	Defra
15	Consider the potential benefits of structured information gathering about the application and uptake of agricultural technologies.	Defra

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Annex 1. Overview of potential measures

This table provides an overview of potential NH_3 and NO_x mitigation measures. This is not a comprehensive list of all potential measures, but represents the most promising measures that may be relevant to SNAPs and for which robust evidence of effect exists. Data have been compiled by Centre for Ecology & Hydrology from the most relevant and up to date existing sources.

Pollutant	Method	Description	Source	mitigation effect (%)
NO_x	Selective catalytic reduction (SCR)	A secondary (end-of-pipe) technology to reduce NO_x following combustion. A reducing agent (such as ammonia) is injected upstream of a catalyst and NO_x is reduced on the catalyst surface at temperatures of 170 - 510 °C	Combustion	70–95
NO_x	Selective non catalytic reduction (SNCR)	A secondary (end-of-pipe) technology to reduce NO_x following combustion. A reagent (such as ammonia, urea, caustic ammonia) is added following combustion to reduce NO_x at high temps (850 and 1100 °C)	Combustion	30-50
NO_x	Combustion modification	A primary measure of reducing NO_x that involves the modification of the operational or design parameters of combustion installations, in order to reduce NO_x formation. Measures include flue-gas recirculation and reducing the level of oxygen available in the combustion zone.	Combustion	10-70
NO_x	Introduction of demand management technique (e.g. congestion charge or low emission zones (LEZs)).	A local traffic management measure, which should reduce vehicle numbers and encourage motorists to switch to greener vehicles. The London Congestion Charge is such a measure and has been shown to alleviate congestion and modify the driving mode in which the vehicles are operated.	Vehicular exhaust	?
NO_x	Minimising the use of nitrates in furnaces	The use of alternative oxidising agents to nitrates (e.g. sulphates, arsenic oxides, cerium oxide), in order to reduce NO_x emissions	Combustion	?
NO_x	Installation of bunds/screens	The use of vegetation or a barrier to divert pollution away from sensitive areas or provide a greater distance for dispersion.	Vehicular exhaust	?
NO_x	Installation of NOxer barrier	The use of a photo-catalytic barrier next to the road, to recapture NO_x emissions from vehicular exhausts. The barrier is coated with a titanium dioxide catalyst, which oxidises NO	Vehicular exhaust	?
NO_x	Realignment of roads	Ensuring the optimal placement of a transport link, in order to minimise emissions to site. Realigning a road away from a site by as little as a few tens of metres (or placing it on an embankment or in a cutting) can have a significant impact on deposition to the site. Other considerations include: The direction of prevailing wind (ideally orientating the road downwind of the site) The placement of traffic intersections near sensitive areas (intersections tend to produce more emissions than free flowing traffic) The placement of other sources of elevated emissions (e.g. tunnels)	Vehicular exhaust	N/A

Pollutant	Method	Description	Source	mitigation effect (%)
NO_x	Improve signage and access to real time traffic information	Providing the driver with information of alternative routes and raising awareness of areas of current (or likely future) areas of congestion. Alternative routes may then be considered to avoid transient conditions and minor roads.	Vehicular exhaust	N/A
NO_x	Implement a dynamic traffic signal system	Alleviating congestion through an intelligent traffic management system that uses real-time data (traffic cameras and counters). The real-time data can also be used to provide real-time bus information which may help to promote public transport.	Vehicular exhaust	N/A
NH_3	Lower crude protein diet	Formulating dairy cattle diets such that protein content does not greatly exceed requirement	Dairy cow manure management	?
NH_3	Increased scraping frequency	Increased frequency of removing manure from the floor of dairy cow cubicle housing	Dairy cow cubicle housing	0-20
NH_3	Grooved floors for dairy cow cubicle housing	Grooved floors allow faster drainage of urine to storage, lowering the potential for NH_3 emission from the dairy house floor.	Dairy cow cubicle housing	25-45
NH_3	Washing down dairy cow collecting yards	Pressure washing (or hosing and brushing) of dairy cow collecting yards immediately following each milking event	Dairy cow collecting yards	50-90
NH_3	Partially-slatted floors for pig housing	A 50:50 void:floor area (compared with traditional 80:20) can further reduce the fouled floor area. Also, a domed lying area will encourage any deposited urine to quickly drain to the below- slat storage.	Pig housing	10-50
NH_3	Frequent slurry removal from pig housing	Frequent and complete slurry removal from the below-slat pit using vacuum system.	Pig housing	?
NH_3	Floating balls on slurry surface	A layer of non-stick balls are floated on the below-slat slurry surface	Pig housing	?
NH_3	Acid scrubbers	Acid scrubbers fitted to air outlets of mechanically ventilated pig or poultry housing	Pig/poultry housing	70-90
NH_3	Air-drying belt-removal systems	Air drying of manure on belt-removal systems for laying hens	Laying hens housing	0-70
NH_3	In-house poultry litter drying	Air drying of manure in broiler and other litter-based poultry housing systems	Litter-based poultry housing	10-50
NH_3	Addition of aluminium sulphate to poultry litter	Regular addition of aluminium sulphate to reduce poultry litter pH	Litter-based poultry housing	?
NH_3	Fit rigid cover to slurry tanks	A tent-like structure is fitted to above-ground slurry tanks to reduce gaseous transfer from the slurry to the atmosphere	Slurry storage	?
NH_3	Floating cover on slurry stores	Floating clay granules or similar to reduce gaseous transfer from slurry surface to the atmosphere	Slurry storage	30-70

Pollutant	Method	Description	Source	mitigation effect (%)
NH_3	Slurry bags	A large bag into which slurry is pumped for storage	Slurry storage	?
NH_3	Sheet cover on FYM/poultry manure heap	Farm yard manure and poultry manure heaps are covered with an impermeable sheet for the duration of storage	FYM/poultry manure storage	30-90
NH_3	Trailing hose slurry application	Apply slurry to land via trailing hoses (band spreading) instead of surface broadcast application	Slurry application	0-50
NH_3	Trailing shoe slurry application	Apply slurry to land via trailing shoe instead of surface broadcast application	Slurry application	20-80
NH_3	Shallow injection slurry application	Apply slurry to land via open-slot shallow injection instead of surface broadcast application	Slurry application	50-90
NH_3	Deep injection slurry application	Apply slurry to land via deep closed slot injection instead of surface broadcast	Slurry application	80-100
NH_3	Rapid incorporation of surface-spread slurry (within 4h)	Surface applied slurry is incorporated into the soil within 4h of application by either plough, disc or tine	Slurry application	30-80
NH_3	Rapid incorporation of surface-spread slurry (within 24h)	Surface applied slurry is incorporated into the soil within 24h of application by either plough, disc or tine	Slurry application	10-50
NH_3	Rapid incorporation of FYM (within 4h)	Surface applied FYM is incorporated into the soil within 4h of application by either plough, disc or tine	Manure application	30-80
NH_3	Rapid incorporation of FYM (within 24h)	Surface applied FYM is incorporated into the soil within 24h of application by either plough, disc or tine	Manure application	10-50
NH_3	Rapid incorporation of poultry manure (within 4h)	Surface applied poultry manure is incorporated into the soil within 4h of application by either plough, disc or tine	Manure application	30-90
NH_3	Rapid incorporation of poultry manure (within 24h)	Surface applied poultry manure is incorporated into the soil within 24h of application by either plough, disc or tine	Manure application	10-50
NH_3	replace urea with ammonium nitrate	Replace urea fertiliser with an equivalent quantity of ammonium nitrate fertiliser (associated with a much lower EF)	Fertiliser application	?
NH_3	replace UAN (urea ammonium nitrate) with ammonium nitrate	Replace UAN fertiliser with an equivalent quantity of ammonium nitrate fertiliser (associated with a much lower EF)	Fertiliser application	?
NH_3	Include urease inhibitor with urea fertiliser	Urease inhibitors slow the hydrolysis of urea to ammonia	Fertiliser application	?
NH_3	Include urease inhibitor with UAN fertiliser	Urease inhibitors slow the hydrolysis of urea to ammonia	Fertiliser application	?
NH_3	convert intensive agricultural land (arable and grass) to unfertilised grassland or semi-natural land cover (inc. woodland) around Designated Sites	change land use from intensive agriculture to unfertilised grass or semi-natural land cover, with no fertiliser of manure applied	Manure and fertiliser application	?

Pollutant	Method	Description	Source	mitigation effect (%)
NH_3	convert intensive agricultural land (arable and grass) to unfertilised grassland or semi-natural land cover (inc. woodland) around Designated Sites, with extensive grazing	change land use from intensive agriculture to unfertilised grass or semi-natural land cover, with no fertiliser of manure applied; with extensive grazing to manage the sward	Manure and fertiliser application	?
NH_3	reduce mineral fertiliser application rates	reduce mineral fertiliser N application rates to below the economic optimum	Fertiliser application	?
NH_3	siting of temporary manure heaps away from Designated Sites	siting of temporary manure heaps in fields away from the vicinity of Designated Sites (at least 500m), also taking account of local topography and prevailing winds	Manure storage	?
NH_3	tree belt next to livestock house	plant tree belt next to livestock house, especially effective if the designated site is downwind (of prevailing direction) from livestock house (N.B. dimensions of tree belt need to be substantially larger than housing)	Poultry or pig houses, cattle sheds, slurry stores	5-50
NH_3	tree belt next to Designated Site	plant tree belt next to designated site, especially effective if the designated site is downwind (of prevailing direction) from livestock house (N.B. dimensions of tree belt need to be substantially larger than housing)	Poultry or pig houses, cattle sheds, slurry stores	5-50
NH_3	tree belt upwind and downwind of slurry storage	Tree belt shelters air flow across the lagoon and also re-captures ammonia downwind of the slurry store (note modelling included the increase in T associated with the sheltering of the slurry	Slurry storage	10-30
NH_3	keeping free range livestock under trees with short backstop tree belt	Making a silvopastoral area in which the livestock (most suitable for poultry but could be applicable to other species). Emissions are mostly recaptured within the woodland canopy rather than released to the atmosphere	Livestock (poultry, pig)	20-60

Annex 2. Overview of drivers and delivery mechanisms

Air quality and legislation

Air quality is controlled in two ways:

1) by emission control; and
2) by setting standards for pollutants in ambient air.

Legislation exists at international, European and national level (Table 1); legislation in bold is particularly relevant for NH_3, NO_x and total N deposition.

	Emissions control	Ambient standards
International	Convention on long-range transboundary air pollution; Gothenburg Protocol MARPOL	Heavy Metals Protocol
European	National Emission Ceilings Directive Industrial Emissions Directive Euro Standards for Vehicles	Ambient Air Quality Directive Fourth Daughter Directive
National	Clean Air Act	Air Quality Strategy Air Quality Standards Regulations Local Air Quality Management

Table 1. Overview of relevant legislative drivers for air pollution.

Emission control:

- The **Convention on Long-Range Transboundary Air Pollution** (CLRTAP) and the accompanying **Gothenburg Protocol** set national emission targets for a number of pollutants including NO_x and NH_3. The most recent amendment sets targets for 2020. They also require signatory parties (such as the UK) to *apply where it considers it appropriate, best available techniques for preventing and reducing ammonia emissions* (article 3, p 8(b)). The UNECE framework code for Good Agricultural Practice for reducing Ammonia Emissions provides a reference document for abatement measures (Bittman and others 2014).
- The **National Emissions Ceiling Directive** 2001/81/EC (NECD) sets emission ceilings for a number of pollutants including NO_x and NH_3 and requires EU member states to draw up a national programme with policies and measures to achieve them. It therewith (partly) implements CLRTAP in Europe. Parts of the Gothenburg Protocol are however not included in the directive, such as the measures to reduce ammonia emissions from agriculture. Similarly, these aspects are not included in UK legislation. NECD is enacted in the UK through the National Emissions Ceiling Regulation 2002. New ceiling targets for 2030 were proposed in December 2013 and are currently under discussion; they include specific requirements to monitor adverse impacts of air pollution on ecosystems. When ceilings for 2030 are established, the UK will subsequently revise its national programme. The current programme largely relies on European measures and the Air Quality Strategy. A specific programme for ammonia measures is not currently in place in the EU or the UK.
- The **Industrial Emissions Directive** 2010/75/EU (IED) consolidates seven existing directives including the Large Combustion Plant Directive (2000/80/EC) which set NO_x emission limit values for large (> 50 MW) combustion plants. IED aims to minimise pollution, from various industrial activities, including air pollution from large combustion (power plants) and large pig and poultry units. It defines Best Available Techniques

(BATs) (as referenced in Best Available Techniques Reference Documents, BREFs) and emission limit values for a range of sectors. It should be noted that compliance with limit values or BATs does not in itself ensure that there is no impact on protected sites. A Medium Combustion Plant Directive was proposed in December 2013 as part of the European Commission's Clean Air Package. The proposed legislation includes a requirement for combustion plants with rated thermal inputs between 1-50MW to meet Emission Limit Values (ELVs) for NO_x.

- IED is implemented through the **Environmental Permitting Regulations** (England and Wales) 2010, in which the assessment of impacts on protected sites is integrated (see below). The Environment Agency and local councils, as competent authorities, have powers to review permissions to control emissions to air via EPR. The Environment Agency regulates the release of pollutants into the atmosphere from large and complex industrial processes, some large-scale food processing factories and large intensive pig and poultry rearing activities. Conditions beyond BAT can be imposed to bring an installation's process contribution to below thresholds of a critical level/load.
- Nitrogen emission sources below IED thresholds (e.g. all cattle farms, pig farms below 2000 fattening pigs or 750 sows and poultry farms below 40,000 places) are not covered by environmental permits. For these activities, the power to review permissions can therefore not be used as a mechanism to promote the update of emission reduction measures (new developments are still subject to planning regulations, see below).
- **Emissions standards for vehicles** (EURO) are established through Directive 70/220/EEC and a range of subsequent amendments. They set increasingly tight limits for exhaust emissions of new vehicles sold in the EU. The standards have significantly reduced the emissions of NO_x from roads (Defra, 2013).

Ambient standards:

- At a European level, air quality limit values are set by the **Ambient Air Quality Directive** 2008/50/EC (AAQD) to ensure human health standards for concentrations of NO_x are not exceeded; there are no concentration limits or measures for NH_3 but the directive includes a NO_x level for the protection of vegetation (30 µg/m3).The Air Quality Strategy (AQS) sets out air quality objectives and policy options to further improve air quality in the UK. It covers the limit values set by the AAQD and introduces a number of more ambitious UK targets. These air quality limit values are transposed into national legislation by the Air Quality Standards Regulations (2010).
- Part IV of The Environment Act 1995 sets provisions for protecting air quality in the UK and for **local air quality management**. Local councils are required to monitor air quality and where limit values are exceeded they must designate air quality management areas (AQMAs), draw up and implement action plans. Local authorities are only required to assess the quality of air at locations which are situated outside of buildings or other natural or man-made structures where members of the public are regularly present. As a result AQMAs have generally been established in urban areas. LAQM does not require local authorities to review exceedance of critical levels at protected sites.

Protection of designated sites from nitrogen impacts

- The **Habitats Directive** (directive 92/43/EEC) and the Birds Directive (directive 2009/147/EC, previously directive 79/409/EEC), implemented through the Conservation of Habitats and Species Regulation 2010, more commonly referred to as the Habitats Regulations, require that an appropriate assessment is made for (new and revised) projects or plans that are likely to have a significant impact on European Protected Sites, in order to ascertain that there are no adverse effects on the integrity of these sites. This requirement is integrated in other decision making processes. Competent authorities must carry out a Habitats Regulations Assessment before deciding to permit a project or plan which is capable of affecting the designated features of a European site. This means considerations of the potential cumulative impacts of atmospheric nitrogen on Natura 2000 sites must be considered, for example in:
- **Environmental permits** issued by the Environment Agency. For example, for large and complex industrial

installations, or for large pig or poultry units (above IED thresholds of 40,000 places for poultry, 2000 places for fattening pigs, 750 places for sows).

- **Planning permissions** issued by local authorities (district, county or unitary councils) or by the Secretary of State following an appeal or 'call-in'. For example, for new roads, small biomass installations, new livestock housing or slurry lagoons, or for pig or poultry units below IED thresholds.
- **Environmental impact assessments** (EIA) may accompany larger projects, such as housing developments, and can inform appropriate assessments under the Habitats Regulations (see above). Where appropriate assessments are not required, the EIA provides a mechanism to consider (background) nitrogen emissions for activities that are not otherwise covered by emissions regulations. Some activities such as changes in agricultural livestock are not covered by the EIA regulation. However, where impacts on protected sites are likely, an EIA may still be required. **Strategic Environmental Assessments** are an essential tool to consider potential atmospheric nitrogen impacts in regional planning, for example where areas are targeted for agricultural or other development that is likely to lead to increased N emissions.
- **Natural England,** in the role of statutory consultee, provides advice, views and recommendations to other competent authorities when they are carrying out an appropriate assessment, or at the preceding steps (screening for likely significant effects). For projects and plans, the thresholds used for impact assessments allow for small increases in N deposition on sites, even where critical loads are already exceeded. Advice on adverse effects as part of appropriate assessments is given on a case by case basis and can allow for increases in N deposition on parts of the site. Given the large contributions of diffuse and unregulated sources and background deposition, it is often difficult to accurately apportion potential or observed negative impacts from atmospheric nitrogen to individual developments.

Other relevant mechanisms and instruments

- Measures under **Nitrate Action programmes** established for the Nitrates Directive 1991 (91/676/EEC) include low emission spreading of slurry or rapid incorporation into the ground, which reduces ammonia emissions.
- Advice and capital grants provided to farmers through the **Catchment Sensitive Farming** (CSF) (and more recently the countryside stewardship scheme) such as the covering of slurry lagoons and nutrient management plans, provides co- benefits by reducing atmospheric nitrogen emissions. CSF provided advice on ammonia emissions in previous years. Recently Water capital grants have been included in the Countryside Stewardship Scheme some of which can contribute to reducing ammonia emissions (e.g. covers for slurry stores).
- **Land Management Schemes** (under previous Entry Level Stewardship and Higher Level Stewardship Schemes) included options that would limit ammonia emissions, which may be especially relevant close to sensitive sites: permanent grassland with very low inputs; arable reversion to unfertilised grassland; nil-fertiliser supplement. However, these have not been targeted at reducing ammonia deposition on sensitive habitats. New measures and their targeting are currently being considered under the Countryside Stewardship Scheme and the Countryside Productivity Scheme, including potential measures for ammonia emission reductions.
- **Water resources control of pollution** (Silage, Slurry and Agricultural Fuel Oil, SSAFO) regulations 2010 (England) and as amended 2013 define standards design, maintenance and construction of stores. Specific requirements (e.g. coverage of store located within a certain distance of a sensitive site) are currently not included.
- **Land spreading permits** (and standard rule criteria). Landspreading (of waste such as sewage sludge and the residues from anaerobic digestion) is regulated under the Environmental Permitting Regulations. Operators can choose to work under standard rules which aim to achieve the same level of environmental protection as site specific conditions. There may be potential to use specific conditions on permits and the periodic review of standard rules to reduce nitrogen deposition to sensitive protected sites.
- **EIA agricultural regulations** Regulated by Natural England, The Environmental Impact Assessment

(Agriculture) (England) (No.2) Regulations 2006 ('the EIA regulations') aim to consider all environmental impacts in cases where semi-natural or uncultivated land is subject to land use change. There may be potential to increase awareness of potential atmospheric nitrogen emissions close to protected sites within these assessments.

- **Codes of Good agricultural practice.** Farmers maintain land in good agricultural and environmental condition, also as part of the cross compliance principle for receiving financial support under the EU Common Agricultural Policy. In principle, safeguarding protected sites is part of this good practice. In practice there may be scope to improve the consideration of potential atmospheric nitrogen impacts within this, for example in relation to manure management close to sensitive sites (Sutton et al., 2011).

Roles and responsibilities

Given the wide range of activities and sectors associated with atmospheric nitrogen emissions, it is inevitable that many authorities, public bodies and organisations are involved, ranging from national government to local authorities and from nature conservation organisations to the Highways England or port authorities. They have a shared responsibility for addressing the atmospheric nitrogen issue that, by its very nature, can only be addressed in an integrated approach by cooperation between these bodies.

The law places general duties on public bodies to further and protect biodiversity. Specifically for Natura 2000 sites it is relevant that all competent authorities, in addition to the provisions to review consents and assess new projects and plans, also have a general duty to *have regard for* the requirements of the Habitats Directive in the exercise of their statutory functions (regulation 9(3)). The most direct responsibility is borne by Natural England and Defra which have a statutory duty to *secure compliance* with the requirements of the Habitats Directive in the exercise of its function. However, the legal provisions also require that other public bodies have a responsibility to contribute within their power to the reduction of negative impacts on Natura 2000 sites, including potential atmospheric nitrogen impacts.

Annex 3. List of SACs for potential prioritisation of targeted local agricultural ammonia measures (initial assessment)

The table below represents an initial classification of SACs in England into high, medium or low potential significance of local agricultural measures to reduce atmospheric nitrogen deposition at the sites. This table should be used as a preliminary pre-selection of sites for which the development of a SNAP and the targeting of agricultural measures would have the best potential. The assessment is based on:
the **sensitivity of the sites** (based on the critical load (CL, mapping value provided by CEH) of the most sensitive designated feature and the reliability if this CL)
the estimated **level of critical load exceedance** (site based exceedance statistics CBED 2009-2011)
the estimated **relevance of local ammonia emission sources** (agricultural contribution to the deposition, ammonia concentration and deposition and level of local ammonia emissions).
However, there are significant uncertainties in the data used and the table is likely to contain some false positives and false negatives. It should therefore be seen as a provisional indication pending a more profound assessment in line with a framework that is under development by JNCC and the use of site specific intelligence. For more information see van Vliet 2014.

Legend

Sensitivity code		
vs	very sensitive	Reliable or quite reliable CL 5-10 kg N/ha/y
(vs)	potentially very sensitive	Expert judgement CL 5-10 kg N/ha/y or based on species only
s (vs)	sensitive, potentially very sensitive	CL 11-20 kg/N/ha/y, reliable/ quite reliable + expert judgement CL 5-10
s	sensitive	Reliable or quite reliable CL 11-20 Kg N/ha/y
(s)	potentially sensitive	Expert judgement CL 11-20 kg N/ha/y
ls (s)	less sensitive, potentially sensitive	Reliable or quite reliable CL 21-30 kg N/ha/y + expert judgement CL 11-20 kg N/ha/y
ls	less sensitive	Reliable or quite reliable CL 21-30 kg N /ha/y
u (vs)	unknown, potentially very sensitive	No reliable or quite reliable CL, expert judgement CL 5-10 kg N/ha/y
u	unknown	No critical load
n	not sensitive	
Level of CL exceedance		
Very high	CL exceedance > 28 kg N/ha/y	
High	CL exceedance 14-28 kg N/ha/y	
Moderate	CL exceedance >0 – 14 kg N/ha/y	
Not exceeded	Deposition below CL	
Likelihood of nitrogen impacts		
Very likely	e.g. sensitive and high level of CL exceedance	
Likely	e.g. less sensitive and very high level of CL exceedance	
Uncertain	e.g. less sensitive and moderate level of CL exceedance	
Relevance of local agricultural sources		
High relevance	e.g. agricultural deposition > 40%, NH_3 dry deposition > 20 kg N/ha/y , NH_3 emissions within 2-3 km of the site > 10 kg/ha/y	
Medium relevance	e.g. agricultural deposition 20-40%, NH_3 dry deposition 10-20 kg/ha/y, NH_3 emissions within 2-3km of the site 6-10 kg/ha/y	
Low relevance	e.g. agricultural deposition < 20%, NH_3 dry deposition < 10 kg/ha/y, NH_3 emission within 2-3km of the site < 6 kg/ha/y	

SAC name	Sensitivity code	level of CL exceedance	likelihood of N impact	relevance of local agricultural NH_3 sources	potential significance of local agricultural NH_3 measures
Alde, Ore and Butley Estuaries	ls	Not exceeded	uncertain	Medium	Low
Arnecliff and Park Hole Woods	s (vs)	Very High	very likely	Medium	Medium
Arun Valley	n		not	Unknown	Low
Asby Complex	vs	Very High	very likely	Medium	Medium
Ashdown Forest	vs	Moderate	very likely	Low	Low
Aston Rowant	vs	Very High	very likely	Low	Low
Avon Gorge Woodlands	s	High	very likely	Low	Low
Barnack Hills and Holes	s	Moderate	likely	Low	Low
Baston Fen	n		not	Low	Low
Bath and Bradford-on-Avon Bats	s	Very High	very likely	Medium	Medium
Beast Cliff – Whitby (Robin Hood`s Bay)	u		uncertain	Low	Low
Bee`s Nest and Green Clay Pits	s	High	very likely	High	High
Beer Quarry and Caves	s	Moderate	likely	Medium	Medium
Benacre to Easton Bavents Lagoons	ls	Not exceeded	uncertain	Low	Low
Berwickshire and North Northumberland Coast	n		not	Medium	Low
Birklands and Bilhaugh	vs	High	very likely	Low	Low
Blackstone Point	s	Not exceeded	uncertain	Low	Low
Blean Complex	s	High	very likely	Low	Low
Bolton Fell Moss	vs	Moderate	very likely	Medium	Medium
Border Mires, Kielder – Butterburn	vs	High	very likely	Medium	Medium
Borrowdale Woodland Complex	vs	Very High	very likely	Low	Low
Bracket`s Coppice	s	High	very likely	Medium	Medium
Braunton Burrows	s	Moderate	likely	Medium	Medium
Breckland	vs	Very High	very likely	High	High
Bredon Hill	n	High	not	Medium	Low
Breney Common and Goss and Tregoss Moors	vs	High	very likely	High	High
Briddlesford Copses	s	High	very likely	Medium	Medium
Brown Moss	(vs)	High	very likely	High	High
Burnham Beeches	(s)	High	likely	Low	Low
Butser Hill	s	High	very likely	Medium	Medium
Calf Hill and Cragg Woods	(vs)	High	very likely	High	High
Cannock Chase	vs	High	very likely	Medium	Medium
Cannock Extension Canal	(vs)	Moderate	likely	Low	Low
Carrine Common	vs	Moderate	very likely	Medium	Medium
Castle Eden Dene	s	High	very likely	Medium	Medium
Castle Hill	s	Moderate	likely	Low	Low
Cerne and Sydling Downs	s (vs)	High	very likely	High	High
Chesil and the Fleet	ls (s)	Moderate	uncertain	Medium	Low
Chilmark Quarries	(s)	High	likely	Medium	Medium
Chilterns Beechwoods	s	Very High	very likely	Medium	Medium
Clints Quarry	u		uncertain	Low	Low
Cothill Fen	ls	Moderate	uncertain	Medium	Low
Cotswold Beechwoods	s	High	very likely	Medium	Medium
Craven Limestone Complex	vs	Very High	very likely	Medium	Medium
Crookhill Brick Pit	u		uncertain	Low	Low
Crowdy Marsh	s	Moderate	likely	Medium	Medium
Culm Grasslands	vs	High	very likely	High	High
Cumbrian Marsh Fritillary Site	(vs)	Very High	very likely	High	High
Dartmoor	vs	Very High	very likely	Medium	Medium
Dawlish Warren	s	Moderate	likely	Low	Low
Dee Estuary/ Aber Dyfrdwy	s	Moderate	likely	Medium	Medium
Denby Grange Colliery Ponds	u		uncertain	Medium	Low
Devil`s Dyke	s	Moderate	likely	Low	Low
Dew`s Ponds	u		uncertain	Medium	Low

Dixton Wood	n	High	not	Medium	Low
Dorset Heaths	vs	Very High	very likely	Medium	Medium
Dorset Heaths (Purbeck and Wareham) and Studland Dunes	vs	High	very likely	Low	Low
Dover to Kingsdown Cliffs	s	Moderate	likely	Low	Low
Downton Gorge	(s)	High	likely	Low	Low
Drigg Coast	s	Moderate	likely	High	Medium
Duddon Mosses	vs	Moderate	very likely	Medium	Medium
Duncton to Bignor Escarpment	(s)	High	likely	Low	Low
Dungeness	s	Moderate	likely	Low	Low
Durham Coast	u	Moderate	uncertain	Low	Low
East Devon Pebblebed Heaths	vs	Moderate	very likely	High	High
East Hampshire Hangers	s	Very High	very likely	Medium	Medium
Ebernoe Common	s	High	very likely	Low	Low
Eller`s Wood and Sand Dale	(s)	Moderate	uncertain	Medium	Low
Emer Bog	s	Moderate	likely	Low	Low
Ensor`s Pool	u		uncertain	Low	Low
Epping Forest	vs	Very High	very likely	Low	Low
Essex Estuaries	ls	Moderate	uncertain	Medium	Low
Eversden and Wimpole Woods	(s)	High	likely	Low	Low
Exmoor and Quantock Oakwoods	s (vs)	High	very likely	Medium	Medium
Exmoor Heaths	vs	High	very likely	Low	Low
Fal and Helford	ls (s)	Moderate	uncertain	Medium	Low
Fen Bog	s	Moderate	likely	Low	Low
Fenland	ls (s)	Moderate	uncertain	Medium	Low
Fenn`s, Whixall, Bettisfield, Wem and Cadney Mosses	vs	High	very likely	High	High
Fens Pools	u		uncertain	Low	Low
Flamborough Head	u		uncertain	Low	Low
Folkestone to Etchinghill Escarpment	s	Moderate	likely	Low	Low
Fontmell and Melbury Downs	s	High	very likely	High	High
Ford Moss	vs	Moderate	very likely	Low	Low
Gang Mine	vs	Moderate	very likely	Medium	Medium
Godrevy Head to St Agnes	vs	Moderate	very likely	Medium	Medium
Great Yews	s	High	very likely	Medium	Medium
Grimsthorpe	s	Moderate	likely	Medium	Medium
Hackpen Hill	s	Moderate	likely	Medium	Medium
Harbottle Moors	vs	Moderate	very likely	Low	Low
Hartslock Wood	s	High	very likely	Low	Low
Hastings Cliffs	u		uncertain	Low	Low
Hatfield Moor	vs	Moderate	very likely	Medium	Medium
Helbeck and Swindale Woods	(s)	High	likely	Medium	Medium
Hestercombe House	(s)	Very High	likely	High	Medium
Holme Moor and Clean Moor	ls (s)	Very High	likely	Medium	Medium
Holnest	u		uncertain	High	low
Humber Estuary	s	High	very likely	Medium	Medium
Ingleborough Complex	vs	Very High	very likely	Medium	Medium
Isle of Portland to Studland Cliffs	s	Moderate	likely	Medium	Medium
Isle of Wight Downs	vs	Moderate	very likely	Low	Low
Isles of Scilly Complex	(s)	Not exceeded	uncertain	Low	Low
Kennet and Lambourn Floodplain	u		uncertain	Low	Low
Kennet Valley Alderwoods	n		not	Medium	Low
Kingley Vale	s	Very High	very likely	Medium	Medium
Kirk Deighton	u		uncertain	Low	Low
Lake District High Fells	vs	Very High	very likely	Medium	Medium
Lewes Downs	s	Moderate	likely	Medium	Medium
Little Wittenham	u		uncertain	Medium	Low
Lower Bostraze and Leswidden	u		uncertain	Medium	Low
Lower Derwent Valley	ls	Moderate	uncertain	High	medium
Lundy	n		not	Low	Low
Lydden and Temple Ewell Downs	s	Moderate	likely	Low	Low

Lyppard Grange Ponds	u			uncertain	Medium	Low
Manchester Mosses	vs	Moderate		very likely	Medium	Medium
Mells Valley	s	Very High		very likely	High	High
Mendip Limestone Grasslands	vs	Very High		very likely	Medium	Medium
Mendip Woodlands	(s)	Very High		likely	High	Medium
Minsmere to Walberswick Heaths and Marshes	vs	High		very likely	Medium	Medium
Mole Gap to Reigate Escarpment	vs	Very High		very likely	Low	Low
Moor House – Upper Teesdale	vs	Very High		very likely	Medium	Medium
Morecambe Bay	s	High		very likely	High	High
Morecambe Bay Pavements	vs	Very High		very likely	High	High
Mottey Meadows	ls	Moderate		uncertain	High	medium
Mottisfont Bats	(s)	High		likely	Low	Low
Naddle Forest	vs	Very High		very likely	Medium	Medium
Nene Washes	u			uncertain	Low	Low
Newham Fen	ls	Not exceeded		uncertain	Medium	Low
Newlyn Downs	vs	Moderate		very likely	High	High
Norfolk Valley Fens	vs	High		very likely	High	High
North Downs Woodlands	s	High		very likely	Low	Low
North Meadow and Clattinger Farm	ls	Not exceeded		uncertain	Medium	Low
North Norfolk Coast	s	Moderate		likely	Low	Low
North Northumberland Dunes	s	Moderate		likely	Medium	Medium
North Pennine Dales Meadows	s	High		very likely	Medium	Medium
North Pennine Moors	vs	Very High		very likely	Medium	Medium
North Somerset and Mendip Bats	s	Very High		very likely	Medium	Medium
North York Moors	vs	High		very likely	High	High
Oak Mere	s (vs)	Moderate		likely	High	Medium
Orfordness – Shingle Street	s	Moderate		likely	Low	Low
Orton Pit	u			uncertain	Low	Low
Ouse Washes	u			uncertain	Low	Low
Overstrand Cliffs	u			uncertain	Low	Low
Ox Close	s	Very High		very likely	Medium	Medium
Oxford Meadows	ls	Not exceeded		uncertain	Medium	Low
Parkgate Down	s	Moderate		likely	Low	Low
Paston Great Barn	(s)	High		likely	Low	Low
Pasturefields Salt Marsh	u			uncertain	Low	Low
Peak District Dales	vs	Very High		very likely	High	High
Penhale Dunes	s	Moderate		likely	Medium	Medium
Peter`s Pit	u	Moderate		uncertain	Low	Low
Pevensey Levels	n			not	unknown	Low
Pewsey Downs	s	Moderate		likely	Medium	Medium
Phoenix United Mine and Crow`s Nest	s	High		very likely	High	High
Plymouth Sound and Estuaries	ls (s)	Moderate		uncertain	Medium	Low
Polruan to Polperro	vs	Moderate		very likely	Medium	Medium
Portholme	ls	Not exceeded		uncertain	Medium	Low
Prescombe Down	s (vs)	Moderate		likely	Medium	Medium
Quants	(vs)	High		very likely	Medium	Medium
Queendown Warren	s	High		very likely	Low	Low
Rex Graham Reserve	s	Moderate		likely	Medium	Medium
Richmond Park	n	High		not	Low	Low
River Avon	u	Moderate		uncertain	Medium	Low
River Axe	u			uncertain	High	low
River Camel	vs	Very High		very likely	High	High
River Clun	u			uncertain	Low	Low
River Dee and Bala Lake	u (vs)	Very High		very likely	Medium	Medium
River Derwent	u			uncertain	Medium	Low
River Derwent and Bassenthwaite Lake	u (vs)	Very High		very likely	Medium	Medium
River Eden	u (vs)	Very High		very likely	High	High
River Ehen	u			uncertain	Medium	Low
River Itchen	u (vs)	Moderate		likely	Medium	Medium
River Kent	u			uncertain	Medium	Low

River Lambourn	u		uncertain	Low	Low
River Mease	u		uncertain	High	low
River Tweed	u		uncertain	Medium	Low
River Wensum	u	Moderate	uncertain	High	low
River Wye/ Afon Gwy	s	Very High	very likely	Medium	Medium
Rixton Clay Pits	s		uncertain	Low	Low
Rochdale Canal	(vs)	Moderate	likely	Medium	Medium
Rodborough Common	s	Moderate	likely	Medium	Medium
Roman Wall Loughs	u		uncertain	Low	Low
Rook Clift	(s)	Moderate	uncertain	Low	Low
Rooksmoor	s (vs)	High	very likely	High	High
Roudsea Wood and Mosses	vs	High	very likely	Medium	Medium
Roydon Common and Dersingham Bog	vs	Moderate	very likely	Low	Low
Salisbury Plain	vs	Very High	very likely	Medium	Medium
Saltfleetby–Theddlethorpe Dunes and Gibraltar Point	s	Moderate	likely	Low	Low
Sandwich Bay	s	Moderate	likely	Low	Low
Sefton Coast	s	High	very likely	Medium	Medium
Severn Estuary/ Môr Hafren	ls	Moderate	uncertain	Medium	Low
Shortheath Common	vs	High	very likely	Medium	Medium
Sidmouth to West Bay	(s)	High	likely	Medium	Medium
Simonside Hills	vs	Moderate	very likely	Low	Low
Singleton and Cocking Tunnels	(s)	High	likely	Low	Low
Skipwith Common	vs	Moderate	very likely	High	High
Solent and Isle of Wight Lagoons	ls	Not exceeded	uncertain	Low	Low
Solent Maritime	s	High	very likely	Medium	Medium
Solway Firth	s	High	very likely	Medium	Medium
South Dartmoor Woods	vs	High	very likely	Medium	Medium
South Devon Shore Dock	(s)	Not exceeded	uncertain	Low	Low
South Hams	vs	High	very likely	Medium	Medium
South Pennine Moors	vs	Very High	very likely	Medium	Medium
South Solway Mosses	vs	Moderate	very likely	High	High
South Wight Maritime	u	Moderate	uncertain	Low	Low
St Albans Head to Durlston Head	s	Moderate	likely	Low	Low
St Austell Clay Pits	u	Moderate	uncertain	Low	Low
Staverton Park and The Thicks, Wantisden	(vs)	High	very likely	Low	Low
Stodmarsh	u		uncertain	Low	Low
Strensall Common	vs	High	very likely	High	High
Subberthwaite, Blawith and Torver Low Commons	s	High	very likely	Medium	Medium
Tarn Moss	s	High	very likely	Low	Low
Thanet Coast	n		not	Low	Low
The Broads	s	Moderate	likely	High	Medium
The Lizard	vs	Moderate	very likely	High	High
The Mens	(s)	High	likely	Medium	Medium
The New Forest	vs	High	very likely	Medium	Medium
The Stiperstones and The Hollies	vs	Very High	very likely	High	High
The Wash and North Norfolk Coast	ls	Not exceeded	uncertain	Medium	Low
Thorne Moor	vs	Moderate	very likely	High	High
Thrislington	s	Moderate	likely	High	Medium
Thursley, Ash, Pirbright and Chobham	vs	High	very likely	Medium	Medium
Tintagel–Marsland–Clovelly Coast	vs	Very High	very likely	Medium	Medium
Tregonning Hill	u	Moderate	uncertain	High	low
Tweed Estuary	ls	Not exceeded	uncertain	Low	Low
Tyne and Allen River Gravels	s	Moderate	likely	Low	Low
Tyne and Nent	s	Moderate	likely	Low	Low
Ullswater Oakwoods	(vs)	Very High	very likely	Low	Low
Walton Moss	vs	Moderate	very likely	High	High
Wast Water	(vs)	Moderate	likely	Medium	Medium
Waveney and Little Ouse Valley Fens	ls ( )	High	likely	High	Medium
West Dorset Alder Woods	s (vs)	Very High	very likely	High	High
West Midlands Mosses	s (vs)	Very High	very likely	High	High

Wimbledon Common	vs	High		very likely	Low	Low
Windsor Forest and Great Park	s (vs)	High		very likely	Medium	Medium
Winterton – Horsey Dunes	s	Moderate		likely	Low	Low
Witherslack Mosses	vs	Moderate		very likely	Medium	Medium
Woolmer Forest	vs	Moderate		very likely	Low	Low
Wormley Hoddesdonpark Woods	(s)	High		likely	Medium	Medium
Wye and Crundale Downs	s	High		very likely	Medium	Medium
Wye Valley and Forest of Dean Bat Sites	s	High		very likely	Medium	Medium
Wye Valley Woodlands	s	Very High		very likely	Medium	Medium
Yewbarrow Woods	vs	High		very likely	Low	Low

Annex 4. List of IPENS theme plans

IPENS has produced several thematic action plans or 'Theme Plans', some of which relate to issues discussed in this theme plan. The full list of theme plans can be found below:

Theme plan	Weblink
Atmospheric nitrogen	http://publications.naturalengland.org.uk/publication/6140185886588928?category=5605910663659520
Climate change	http://publications.naturalengland.org.uk/publication/4954594591375360?category=5605910663659520
Diffuse water pollution	http://publications.naturalengland.org.uk/publication/5848526737113088?category=5605910663659520
Grazing	http://publications.naturalengland.org.uk/publication/4839898496368640?category=5605910663659520
Habitat Fragmentation	http://publications.naturalengland.org.uk/publication/5004101806981120?category=5605910663659520
Hydrological functioning	http://publications.naturalengland.org.uk/publication/6400975361277952?category=5605910663659520
Inappropriate coastal management	http://publications.naturalengland.org.uk/publication/6371629661683712?category=5605910663659520
Invasive species	http://publications.naturalengland.org.uk/publication/6130001713823744?category=5605910663659520
Lake restoration	http://publications.naturalengland.org.uk/publication/5583022327857152?category=5605910663659520
Public access and disturbance	http://publications.naturalengland.org.uk/publication/6621454219083776?category=5605910663659520
River Restoration	http://publications.naturalengland.org.uk/publication/5478339747774464?category=5605910663659520

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Natural England is here to secure a healthy natural environment for people to enjoy, where wildlife is protected and England's traditional landscapes are safeguarded for future generations.

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