Woodland Trust Technical Advice Note 1

Assessing air pollution impacts on ancient woodland - ammonia

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Ancient woodlands are being detrimentally impacted as a result of increasing concentrations of ammonia in the air and levels of nitrogen deposition. This is one of the greatest threats to ancient woodlands in the UK. New developments should not lead to further degradation of ancient woodland sites resulting from significant increases in atmospheric ammonia concentrations and total nitrogen deposition. In recent years, the Woodland Trust has seen an increase in planning applications for ammonia-emitting developments, such as intensive livestock units, in close proximity to ancient woodland sites. Evidence continues to strengthen concerns about nitrogen air-pollution impacts on ancient woodland ecosystems. This technical advice note provides a clear decision-making process for assessing the significance of new developments, where there is potential for ammonia air-pollution impacts on nearby ancient woodland sites.

Ammonia emitting developments such as intensive poultry and livestock units can impact on nearby ancient woodlands
(Photo: Alastair Hotchkiss)

Nitrogen (N) deposition refers to the process of reactive nitrogen pollutants emitted to the atmosphere being transferred to land and water bodies. Emissions of nitrogen oxides (NO_x) mainly come from transport and power stations, whereas the main source of ammonia (NH_3) is from agriculture. The UK has made some improvements in air quality since the 1970s, with the recent 'State of The Environment: Air Quality' reporting that nitrogen oxide (NO_x) emissions have reduced by 72%. However, emissions of ammonia continue to increase[1]. In 2016, agriculture accounted for 88% of all UK ammonia emissions, with the largest contributor being livestock[2], especially from cattle and from the growing pig and poultry industry. Much of these agricultural emissions are currently unregulated, but new intensive livestock developments require planning permission, and larger developments require an environmental permit.

This technical advice note focuses on how to assess the ammonia air pollution impacts on ancient woodland sites, from new developments, such as intensive livestock and poultry units. Other reactive nitrogen pollutants will be considered separately, for example assessing the impacts of NO_x from transport. For intensive livestock and poultry developments, there is an established application, decision-making and consultation process, which involves modelling the dispersal and deposition of pollutants.

Evidence clearly demonstrates the impact of high nitrogen deposition on ecosystems, over a range of spatial and temporal scales. The effects include observable species loss, changes in soil chemistry and habitat degradation resulting from nutrient enrichment, acidification, or direct damage (toxicity) - see box 1 (impacts on ancient woodland). In 2014, 90% of the internationally important habitat in Special Areas of Conservation (SACs) in England and Wales received excessive levels of nitrogen[3]. The situation is probably even worse for ancient woodlands as a whole, with critical loads for nitrogen exceeded for 92-98% of all UK woodlands[4].

Impacts on ancient woodland

There is substantial and wide-ranging evidence of the impacts of nitrogen deposition on ancient woodland communities. Impacts are widespread and directly affect many woodland plants and fungi, with implications for wider ecosystem functioning, resilience and services.

Some of these are described below:

- Nitrogen levels in UK woodlands are increasingly leading to a greater abundance of nitrogen-tolerant plant species which out-compete and impact on many characteristic ancient woodland plants[5,6] and mosses[7,8], degrading the ecological integrity of ancient woodland sites. The knock-on effects for all animal species associated with nitrogen sensitive components are likely to be significant; for example, where essential larval food plants of woodland butterflies, moths and other insects are impacted[9].
- Trees can be directly impacted, and at very high gaseous concentrations can suffer bleaching, leaf discoloration and increased susceptibility to damage from drought, frost and diseases, reducing overall health and vigour[3]. The deteriorating mineral nutrition of trees (e.g. foliar phosphorous) is linked to nitrogen deposition, with consequences for ecosystem functioning and climate-change response[10]. There are also links being made between nitrogen pollution and tree diseases such as acute oak decline[11,12].
- Many woodland fungi have been shown to be sensitive to nitrogen deposition, and there is particular concern about impacts on ectomycorrhizal species (associated with tree roots), and the subsequent impacts on tree health[12,13]. The loss of these woodland fungi also results in soil carbon release to the atmosphere, with climate change implications[14]. This important group of life-supporting fungi has been shown to recover in parts of the Netherlands, where the Government actively put measures into place to reduce ammonia and nitrogen deposition over the past decade or more[15].
- Lichens are powerful indicators for the biological monitoring of air pollution impacts. Many woodland lichen species and communities evolved and developed in naturally low levels of atmospheric nitrogen and are highly sensitive to change (e.g. lungworts *Lobaria* spp. and beard lichens *Usnea* spp.). Lichens on trees provide shelter, food, and vital microhabitats for invertebrates, and are considered to contribute to wider ecosystem services, for example in carbon cycling, water retention[16], and medicine[17].

Healthy communities of lungwort lichens (left) and beard/horsehair lichens (right) on trees in Lochaber, Scotland, where ammonia pollution is very low (Photo: Alastair Hotchkiss)

Trees covered with slimy algal 'gloop' due to ammonia pollution at Woodland Trust's Coed Gwernafon in Powys, Mid-Wales (Photo: Sam Bosanquet)

Woodland Trust Assessment Process for Ammonia Emitting Developments and Ancient Woodland

Stage 1 – Is the development >5km from an ancient woodland site?

Yes – Most developments considered unlikely to result in significant detrimental impact on ancient woodland **– No Response**

No – Modelling information is required to assess development. For smaller developments >2km this could be an initial screening modelling (e.g. SCAIL).

Stage 2 - Does modelling suggest that the Process Contribution (PC) will be <1% of the Critical Level & Load at the closest Ancient Woodland receptor. Always considered to be 1µg-NH_3/m^3 and 10kg N/ha/y (1% = 0.01µg-NH_3/m^3 and 0.1kg N/ha/y).

Yes – Emissions considered to be insignificant with negligible impact on ancient woodland – **No Objection.**

However, other aspects may need to be considered e.g. Is there any information on the spreading of manure resulting from development?

Yes – consider the measures proposed in resubmitted application and updated modelling

No

Objection - Stage 3 - Can the proposal/development be amended to include measures which would reduce the PC to <1%?

This could be achieved through re-siting, better technology, reduction in numbers of animals, capture/buffering from tree planting etc. Further detailed modelling will be required along with information on measures included.

At this stage, consider supporting the planting of tree belts as mitigation and ammonia capture option, but only when in combination with other control measures to demonstrably reduce PC from development on ancient woodland.

No – application demonstrates that significant measures have been incorporated to reduce PC, but PC still = >1%

Stage 4 - Are the background levels of ammonia or nitrogen deposition already exceeding the critical levels and/or load (1µg-NH_3/m^3 and 10kg N/ha/y) at the ancient woodland site (use APIS www.apis.ac.uk/)

Yes, one or both exceeded

Objection – Development as proposed is not considerered acceptable at this location. Only if it can be demonstrated that background levels of ammonia / nitrogen depostion can be reduced may this position change.

No, neither exceeding

Is the PC <4% of the critical level/load (=0.04µg-NH_3/m^3 or 0.4kg N/ha/y) and, in combination with background levels, will not result in an exceedance of critical levels/

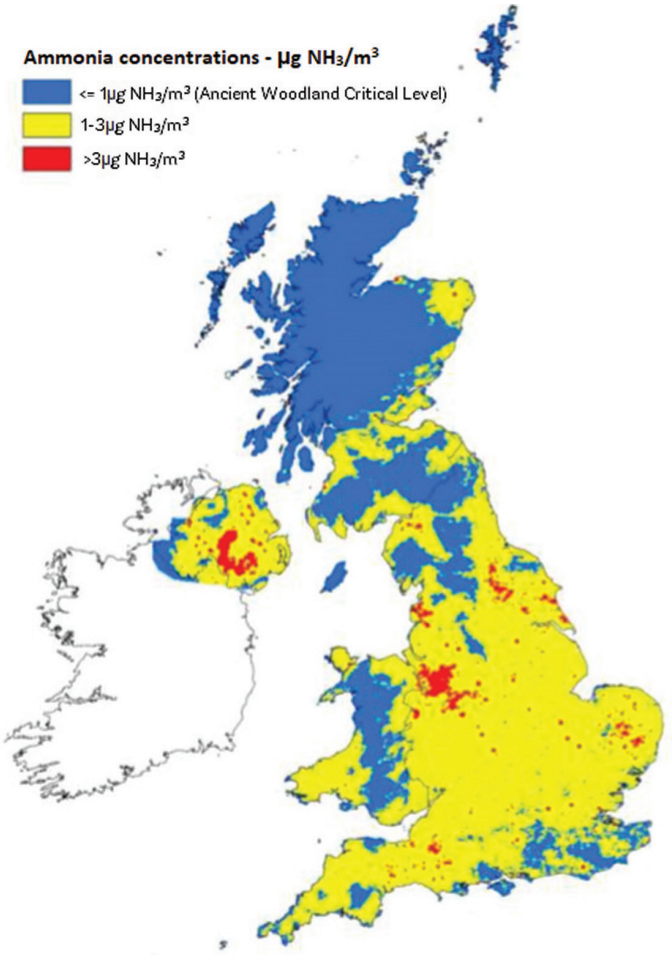
Detailed 'Ancient Woodland Nitrogen Impact Assessment' provides sufficient technical detail to allay any concern about impact of <4% PC from development on sensitive woodland features.

A programme of ecological monitoring may be required to provide further evidence during operational phase of development.

Yes

Holding Objection - Stage 5 – Request a detailed 'Ancient Woodland Nitrogen Impact Assessment' of the ancient woodland of concern. This will need to demonstrate that there will be no deterioration or impacts as a result of the contributions from this development.

Concern arising from the detail provided in 'Ancient Woodland Nitrogen Impact Assessment'.



Adapted from Hall et al. 2017 based on FRAME 1x1km mean ammonia concentrations for 2012-2014.

How to assess ammonia air pollution impacts from developments near ancient woodland sites:

Given the increases, both in terms of the number of cases and the concern and evidence around the impacts, there is a need for clear technical advice on decision making. This defines how the Woodland Trust responds to development proposals for new intensive livestock and poultry units, and other point sources of ammonia emissions. This assessment process will ensure that developments do not result in deterioration of ancient woodland habitats, and can help local planning authorities in their decision making. The assessment and decision-making process is outlined in the flowchart and explained further below.

Stage 1: initial screening

Concentrations of ammonia are highest close to intensive livestock units, which can lead to serious local impacts. The range of impact from ammonia from livestock units is considered to be relatively short compared to some other longer-distance pollutants. However, as an example, ammonia emissions have been detected 2.8km from a 160,000 bird poultry unit, contributing 30% of the total nitrogen load at an upwind conservation site[18]. This resulted in an exceedance of the level at which the ecosystem will deteriorate. The established process for assessing impacts arising from the dispersal and deposition of nitrogen pollutants involves atmospheric modelling. Although this modelling is not without its limitations, without any modelling information, applications cannot be assessed for their impacts. It is therefore expected that modelling information is provided for all ammonia-emitting developments within 5km of an ancient woodland site. Beyond this distance, it may still be necessary to consider some exceptionally large developments. At stage one, this could form a basic screening assessment using the SCAIL online tool (scail.ceh.ac.uk/cgi-bin/agriculture/input.pl), particularly for smaller developments, and where it is more than 2km from an ancient woodland site. However, it is likely that many developments within 0-2km of an ancient woodland site will subsequently require more detailed modelling of dispersal and deposition.

Stage 2: evaluating data and modelling

Much of the decision making at this stage is informed by data presented in more detailed ammonia and nitrogen dispersal and deposition modelling reports. These reports contain a lot of technical language and established ways of presenting information, such as deposition rates and volumes. The key terms are explained below.

Critical levels and critical loads - The process of considering impacts of pollutants on ecosystems relies on the use of critical levels and critical loads, and then understanding the contribution that a development may have on these, as well as the current background levels. The **critical load** relates to the quantity of pollutant **deposited** from air to the ground (in this case, usually as total nitrogen deposition). It is a quantitative estimate of the level below which significant harmful effects do not occur, according to present knowledge. Whereas the **critical level** is the gaseous **concentration** of a pollutant in the air (in this case, ammonia - NH_3). This is the concentration of ammonia in the atmosphere above which direct adverse effects may occur, according to present knowledge. Although these definitions refer to present knowledge, the nutrient nitrogen critical loads, for example, have not been revised since 2010.

Critical load for ancient woodlands - The critical load for woodland habitats in the UK has been defined to be within a wide range of 5–20kg N/ha/y (kilograms of nitrogen per hectare per year), depending on woodland vegetation types[19]. There are more specific critical load ranges where information is available to assign vegetation types (e.g. acidic oak-birch woods, beech or native pine woods) – see www.apis.ac.uk/indicative-critical-load-values. Where information is unavailable to determine woodland vegetation types, the default value for woodland habitats is considered to be **10kg N/ha/y.** However, there is increasing evidence that this figure is not robust enough, and ecologically significant impacts occur at lower figures. The critical load for key components of woodland ecosystems (e.g. the life-support fungi associated with tree roots - ectomycorrhizae) has been proposed to be nearer to 5–6kg N/ha/y[12]. Evidence from a large study of woodlands and forests in mainland Europe[20] revealed that ecologically significant changes occur

at an even lower nitrogen critical load of 2.4kg N/ha/y. The Woodland Trust therefore believes that a precautionary approach must be taken when assessing applications against the current established critical load of 10kg N/ha/y. Furthermore, there is a need to consider revising the critical loads for ancient woodland habitats based on evidence published since the last revision (in 2010).

Critical level for ancient woodlands - For ammonia concentration in air, the critical level for sites where lichens and bryophytes (mosses and liverworts) are an integral part of the ecosystem has been set at **1.0µg NH_3/m^3** (micrograms of ammonia per cubic metre of air) as an annual mean. Bryophytes and lichens form significant communities of epiphytes (organisms that grow on other plants) on tree trunks, branches and twigs. The ground vegetation of ancient woodlands is also strongly characterised by bryophytes. Healthy communities of lichens and bryophytes are therefore a fundamental component of ancient woodland sites, and their ecological integrity. There is evidence[21] that a critical level of 1µg NH_3/m^3 is insufficient to avoid impacts on the most sensitive species, and ecologically significant changes occur at lower levels, such as 0.5µg NH_3/m^3. There is also growing concern about the impacts of acute toxicity on woodland species arising from spikes in ammonia concentrations[22] which are known to occur, and whether annual ammonia mean concentrations are robust as a way of assessing impacts. The Woodland Trust therefore believes that a precautionary approach must be taken when assessing applications against the current established critical level for ammonia of 1.0µg NH_3/m^3. Furthermore, the Woodland Trust argue that there is a need to consider revising the ammonia-critical levels for the most sensitive ancient woodland habitats and species in the UK, as well as a need to ensure that short-term increases in ammonia concentrations are limited.

Process contribution (PC) - This is the ammonia released to the air and nitrogen deposited to the ground as a result of a development. The PC should be considered separately for the atmospheric ammonia critical level and the total nitrogen deposition critical load. The PC can be expressed as a percentage of the critical load or critical level for a site. The PC should always be considered for the nearest receptor point (closest boundary/edge) of an ancient woodland site. For example, if the emissions from a development are modelled to result in **0.1kg N/ha/y** being deposited at the closest receptor of an ancient woodland site, then this would equate to a process contribution of 1% to a critical load of 10kg N/ha/y. For the critical level, an increase in the ammonia concentration in an ancient woodland site of **0.01 µg NH_3/m^3** equates to a process contribution of 1% towards the critical level of 1µg NH_3/m^3. Where a process contribution is modelled to be below 1%, then this is considered insignificant, and no objection is required unless there are any other issues. With a PC of <1% of the critical level or load, it is considered unlikely that an emission at this level will make a significant contribution to detrimental air pollution impacts at an ancient woodland site, and is therefore regarded to be inconsequential, both alone and a low likelihood of in-combination effects.

Many statutory organisations and local authorities have defined their own guidance to outline the processes and thresholds for how intensive-livestock developments are considered. Some recent examples (e.g. Shropshire County Council's 2018 planning guidance note[23]) properly consider and account for impacts on ancient woodlands and use a 1% PC threshold for all natural assets (including ancient woodland). Other organisations do not (e.g. Environment Agency, Natural Resources Wales), and set a threshold PC of 100% to the critical level or load of ancient woodland habitats. This PC accepts the fact that an individual development will result in the exceedance of critical levels and loads, and that ancient woodland will deteriorate as a consequence. This is considered out of alignment with current policy. For example, the National Planning Policy Framework (NPPF) in England requires that there is no deterioration of irreplaceable habitats (including ancient woodland), unless there are wholly exceptional reasons. Intensive livestock developments do not fall within the definition of wholly exceptional. Planning Policy Wales (paragraph 6.4.26) also states that ancient woodland should be afforded protection from development which would result in their loss or deterioration unless there are significant and clearly defined public benefits.

Stage 3: considering control measures and capture

This requires that an application sufficiently demonstrates that measures have been included to amend the proposal to try to significantly reduce, capture or/and buffer emissions as far as reasonably possible. Further detailed modelling will be required to quantitatively demonstrate the impacts that specific measures have had in terms of the reduction or capture of emissions.

Stages 4 and 5: background levels

In many areas of the UK, the background levels of ammonia and nitrogen deposition exceed the critical level and load. Stage 5 only applies in those areas where the background levels are not already in exceedance. Information on background levels for a specific location can be obtained from the APIS website (apis.ac.uk/). If the PC of the proposed development is above 4% (0.04µg NH_3/m^3 or 0.4kg N/ha/y), this is sufficient grounds to object to the application at Stage 4. Stage 5 applies in situations where the critical level and load are below 4% and the addition of PC and background levels remains below the critical level/load. In this scenario, an 'Ancient woodland nitrogen impact assessment' should be produced, for which the Woodland Trust can provide further information on the scope of an assessment, as it is likely to be site-specific and range in its technical content. This will require an appropriate qualified ecologist with knowledge and demonstrable experience of air pollution impacts, particularly on lower plants and other sensitive features. There is accepted standard methodology for certain aspects, such as those used to assess the presence and condition of nitrogen-sensitive lichens (apis.ac.uk/nitrogen-lichen-field-manual).

Reducing ammonia from existing sources and current land use

In many parts of the UK, ammonia concentrations and total nitrogen deposition exceed the critical levels and loads for ancient woodland. Where this is the case, the aim should be to reduce emissions from existing sources. It will require a strategic approach to achieve the necessary levels of reductions for all ancient woodland across the UK, but localised actions can make a difference for individual ancient woodland sites. Trees can play a role in the interception and capture of ammonia emissions, and planting of tree belts may buffer ancient woodland sites from existing sources of pollution, such as livestock units and ranging areas.

An online calculator tool is available (farmtreestoair.ceh.ac.uk) to inform the design of tree-belts (width, length, density, etc.) and provide a modelled estimate of the amount of ammonia captured. This tool could be useful to inform the design of planting schemes as well as help new applicants demonstrate effective pollution control The recently published 'Code of Good Agricultural Practice for Reducing Ammonia Emissions' (DEFRA 2018) provides further information on how changes to agricultural practices can reduce emissions.

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References:

1 Environment Agency (2018). *State of the Environment: Air Quality.* July 2018, Environment Agency.
2 DEFRA (2018). *Code of Good Agricultural Practice (COGAP) for Reducing Ammonia Emissions.*
3 Plantlife (2017). *We Need to Talk About Nitrogen.* Plantlife Publications. Salisbury, UK.
4 Dragosits, U. (2006). The potential for spatial planning at a landscape level to mitigate the effects of atmospheric ammonia deposition. *Environmental Science and Policy* 9: 626-638.
5 Kirby et al. (2005). Long-term ecological change in British woodland. EN Research Reports 653. http://www.englishnature.gov.uk/pubs/publication/PDF/653.pdf.
6 Stevens et al., (2011). Changes in species composition of European acid grasslands observed along a gradient of nitrogen deposition. *Journal of vegetation science* 22: 207-215.
7 Sheppard, L.J, et al. (2011). Dry deposition of ammonia gas drives species change faster than wet deposition of ammonium ions: evidence from a long-term field manipulation. *Global Change Biology* 17 (12) 3589-3607.
8 Leith et al. (2008). The influence of nitrogen in stemflow and precipitation on epiphytic bryophytes of Atlantic oakwoods. *Environmental Pollution* 155 (2008), 237-246.
9 Kurze et al. (2018). Nitrogen enrichment in host plants increases the mortality of common Lepidoptera species. *Oecologia.*
10 Jonard et al. (2018). Tree mineral nutrition is deteriorating in Europe. *Global Change Biology* (2015), 21, 418–430.
11 Brown et al. (2018). Predisposition of forests to biotic disturbance: Predicting the distribution of Acute Oak Decline using environmental factors. *Forest Ecology and Management* 407 (2018), 145–154.
12 Van der Linde et al. (2018). Environment and host as large-scale controls of ectomycorrhizal fungi. *Nature.* 558: 243-248.
13 Stankevičienė & Pečiulytė, (2004). Functioning of ectomycorrhizae and soil microfungi in deciduous forests situated along a pollution gradient next to a fertilizer factory. *Polish Journal of Environmental Studies* Vol. 13, No. 6 (2004), 715-721.
14 Averill et al. (2018). Continental-scale nitrogen pollution is shifting forest mycorrhizal associations and soil carbon stocks. *Global Change Biology* (2018), 24:4544–4553.
15 Van Strien et al. (2017). Woodland ectomycorrhizal fungi benefit from large-scale reduction in nitrogen deposition in the Netherlands. *Journal of Applied Ecology* 2017, 1–9.
16 Esseen et al. (2017). Externally held water – a key factor for hair lichens in boreal forest canopies. *Fungal Ecology* 30 (2017), 29-38.
17 Johnson et al. (2011). Degradation of the disease-associated prion protein by a serine protease from lichens. *PLoS ONE* 6(5).
18 Jones et al. (2013). Upwind impacts of ammonia from an intensive poultry unit. *Environmental Pollution.*
19 APIS (2013). Indicative critical load values: Recommended values within nutrient nitrogen critical load ranges for use in air pollution impact assessments - APIS Steering Group July 2013.
20 Giordani et al. (2014). Detecting the nitrogen critical loads on European forests by means of epiphytic lichens. A signal-to-noise evaluation. *Forest Ecology and Management* 311, 29–40.
21 Cape et al. (2009). Evidence for changing the critical level for ammonia. *Environmental Pollution* 157 (2009), 1033–1037.
22 Munzi et al. (2010). Time- and dose-dependency of the effects of nitrogen pollution on lichens. *Ecotoxicology and Environmental Safety* 73 (2010), 1785–1788.
23 Shropshire County Council (2018). *Assessing the impact of ammonia and nitrogen on designated sites and Natural Assets from new and expanding livestock units (LSUs),* Shropshire Council Interim Guidance Note GN2 (Version 1, April 2018).

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