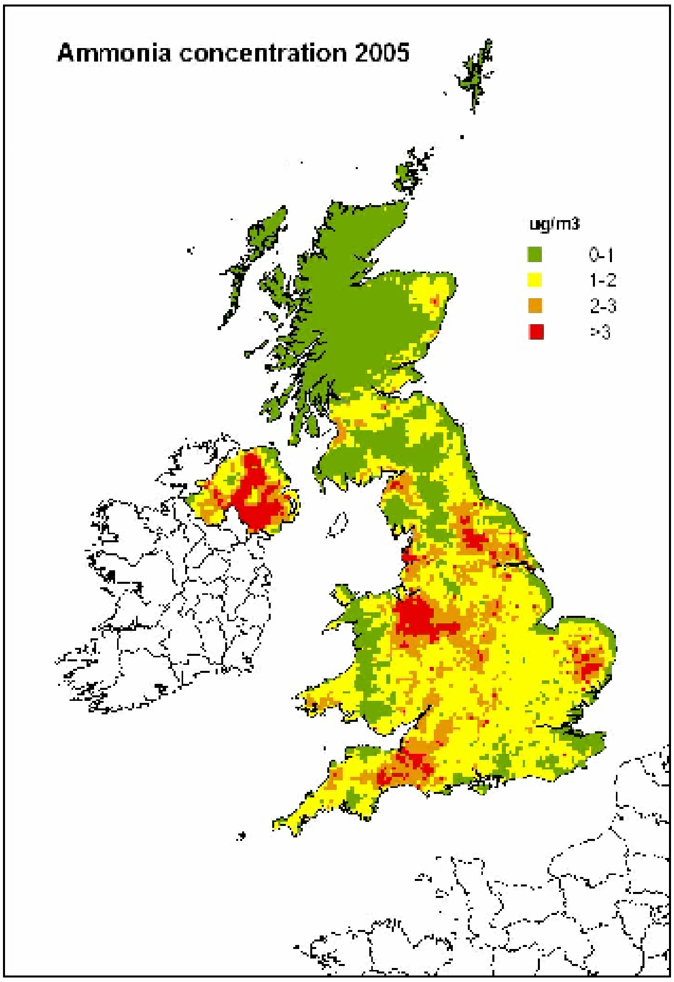
Ammonia and nature conservation

Agriculture is the main source of ammonia emissions to the atmosphere. In 2008, agriculture contributed about 90% of the 281 kilo-tonnes released in the UK. Of this, cattle are the major contributor, releasing approximately 47% of the UK total. Pigs and poultry contribute about 18% of the UK total. The ammonia arises mainly from the decomposition of animal wastes.

Ammonia emissions from all sources have declined by about 23% since 1990, mainly as a result of reductions in animal numbers (declines of 15% in cattle, 55% in pigs and 31% in sheep). As a result, it is likely that the UK will just meet its obligation to reduce emissions of ammonia to below 285 kilo-tonnes by 2010 set in the National Emissions Ceilings Directive.



While animal numbers have declined in general, some sectors have seen an increase (e.g. poultry by 22%). Air concentrations show a very large spatial variability, reflecting the combination of the large number of ground-level sources, primarily related to livestock farming, and the very reactive nature of gaseous ammonia (See Fig. 1). Overall, concentrations appear to have declined only by a small amount since the establishment of the current ammonia monitoring network in 1990.

Impacts of ammonia on ecosystems

Close to an intensive livestock unit, air concentrations of ammonia can be very high, leading to significant local effects. The nitrogen component of ammonia settles out (known as 'nitrogen deposition') on land causing a fertilising effect. This leads to an increase in nitrogen-loving plant species. These species out-compete species more characteristic of the natural environment, especially those which are sensitive to increased nitrogen.

Fig. 1. Estimated air concentration of ammonia in the UK. (From Dragosits et al [1998] Modelling the spatial distribution of ammonia emissions in the UK. Environmental Pollution, Nitrogen Conference Special Issue)

Nitrogen deposition can also lead to acidification of land and water, which can have an impact on plants and animals by making conditions unsuitable for their survival. The overall effect leads to a general loss of plant diversity.

Ammonia can lead to acute toxicity to plants. For example, some species of mosses and lichens cannot tolerate increased ammonia in the air, and are often lost close to major ammonia sources such as intensive farms. Conversely, some species are nitrogen loving, and may increase in abundance close to livestock farms. An example is the orange lichen Xanthoria parietina which is a good indicator of increased ammonia around some pig and poultry units.

The combination of these effects leads to changes to ecosystem structure and function. Some of the most significant problems resulting from ammonia and nitrogen deposition are found at nature conservation sites located in intensive agricultural landscapes.

Sensitive habitats

Certain habitats are more sensitive to ammonia than others, and experience the severest changes to ecosystem structure. This is especially the case in habitats which are usually nutrient poor, or cannot tolerate increased acidity. The most sensitive habitats in England and Wales are heathlands, bogs, woodland and grasslands (Fig. 2). These habitats are a characteristic and intrinsic part of our landscape and natural heritage.

Certain species are also more sensitive than others. Lower plants, namely lichens and mosses, are the most sensitive group, with ammonia having an effect on them at much lower concentrations than others, such as grasses and flowering plants.

Lichens and mosses grow in a wide range of habitats, are susceptible to ammonia to different degrees, and can be used to monitor and map pollution. They act as an indicator of ecological change which can be linked to ammonia and nitrogen deposition.

To protect our natural heritage, certain areas of the landscape in England and Wales have been identified as nature conservation sites. They usually contain high species diversity characteristic of a natural and healthy ecosystem, or species which are particularly vulnerable and/or sensitive that do not occur in many other places. They are offered protection from development and other activities which could result in damage to their structure or function. They receive protection under various pieces of legislation.

Fig. 2. Semi-natural grassland habitat in foreground, with agricultural fields in the distance.
(Photo credit Natural England)

Evidence that ammonia changes our natural environment

Work has been done to study the impacts of ammonia and nitrogen deposition on natural habitats, both at a local and regional scale. There is growing evidence that nutrient enrichment through nitrogen inputs is one of the main forces driving changes to the natural vegetation in England and Wales, and across Europe as a whole.

Acute effects are observed close to ammonia sources. In Figs 3 and 4, ammonia was released to simulate the effects of a pig or poultry farm on a bog habitat. Initially damage was observed close to the ammonia source but with time, damage was seen further away. Damage was observed when the amount of nitrogen depositing to the land was around 8 to 10 kg per hectare per year. To put this into context, the current average deposition in UK is double this figure, estimated at 20 kg of nitrogen per hectare per year.

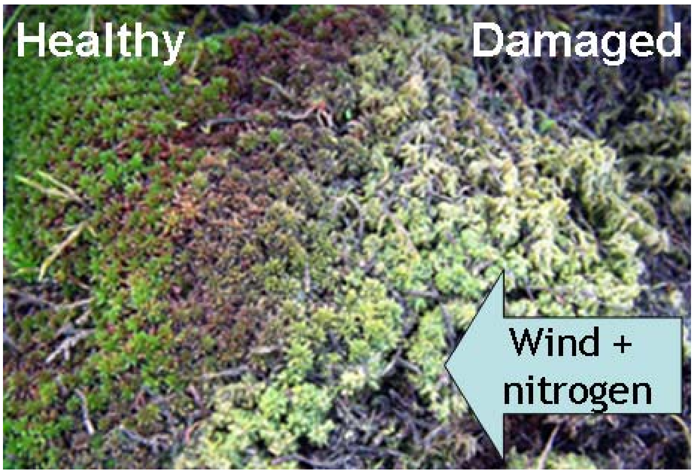


Fig. 3 (left). Damage to a moss (Sphagnum) commonly found in bogs.
(Photo credit Ian D Leith, CEH)

Fig. 4 (right). Damage to a lichen (Cladonia) commonly found in heathlands. The main photo shows a healthy lichen, whereas the insert shows a bleached effect, and algae overgrowing the main structure of the lichen, leading to significant damage.
(Photo credit Ian D Leith, CEH)

Effects of ammonia can be seen downwind of intensive pig and poultry farms, as illustrated in Figs. 5 and 6. Fig. 5 shows an algal slime growing on a tree in immediately downwind of an intensive farm as a result of nutrients from the farm. Fig. 6 shows a nitrogen-loving lichen, Xanthoria parietina, which is found in abundance around some pig and poultry units. These signs provide an initial indication that increased ammonia is causing ecological change.

Fig. 5 (left). Algal slime growing on tree bark downwind of an intensive livestock farm.
(Photo credit Mark A. Sutton, CEH)

Fig. 6 (right). A nitrogen loving lichen, Xanthoria parietina, commonly found growing adjacent to intensive poultry farms. (Photo credit Ian D Leith, CEH)

One of the key findings at an experimental plot in a heathland site in North Wales was an overall reduction in sensitive mosses, liverworts and lichens through nitrogen addition experiments to simulate nitrogen deposition (Fig. 7). Other findings over this 20 year study period were a speeding up of the life-cycle of heather, increased cold-stress sensitivity and an increase in soil acidity.

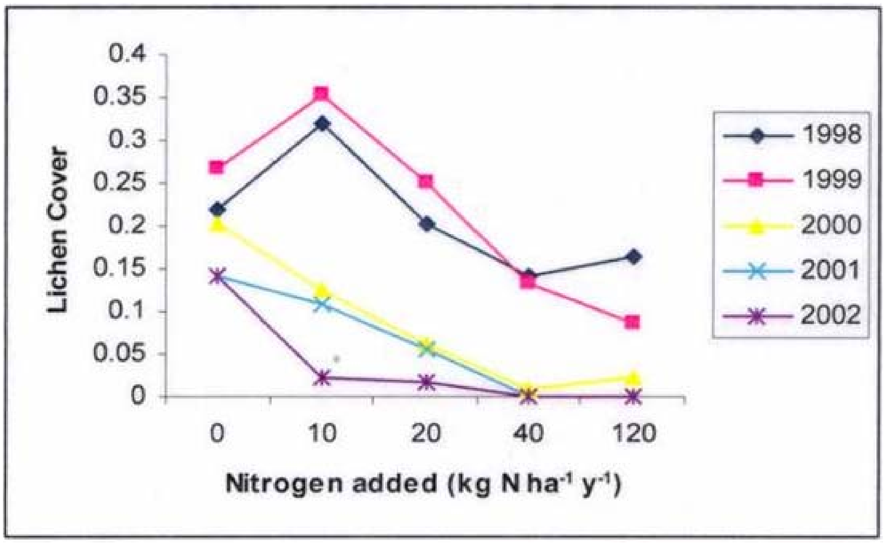


Fig. 7. Effects of nitrogen on lichen cover in experimental plots at Ruabon Moor, North Wales. No invasion of other plants was observed, but heather remained dominant (Figure courtesy of Dr Mike Pilkington)

Damage and change to species cover does not only occur to the most sensitive species of mosses and lichens. Evidence downwind of poultry farms has shown the different effects that nitrogen deposition can have on the abundance of higher plants, such as grasses, flowering plants, and ferns. A change in abundance of two species is illustrated in Fig. 8. The grass species Holcus lanatus can be seen to increase in abundance closer to the farm as it is more tolerant of nitrogen, whereas the less nitrogen-tolerant fern species Dryopteris dilatata can be seen to decrease in abundance.

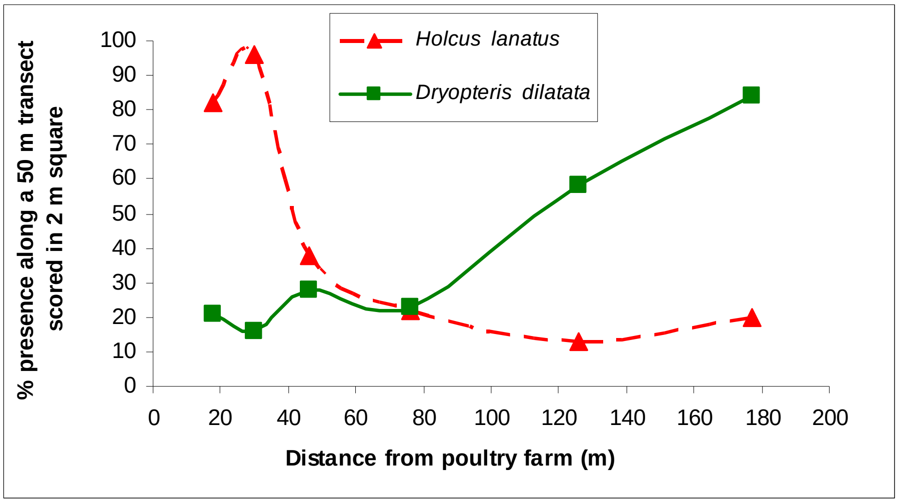


Fig. 8. Changes in percentage cover of two species downwind of a poultry farm. (From Pitcairn et al [2003] Bioindicators of enhanced nitrogen deposition. Environmental Pollution)

Nitrogen deposition effects can also drive a change in species or community composition on a large scale. Work has been done to look into these effects. The New Atlas of the British and Irish Flora describes vegetation changes between 1930-69 and 1987-99, compiling nine million records. The results (Fig. 9) show that across the UK, plants associated with low soil fertility have decreased, while those characteristic of soils with higher nutrient levels have increased. This result is found in all regions except the Scottish Highlands, where nitrogen deposition is low.

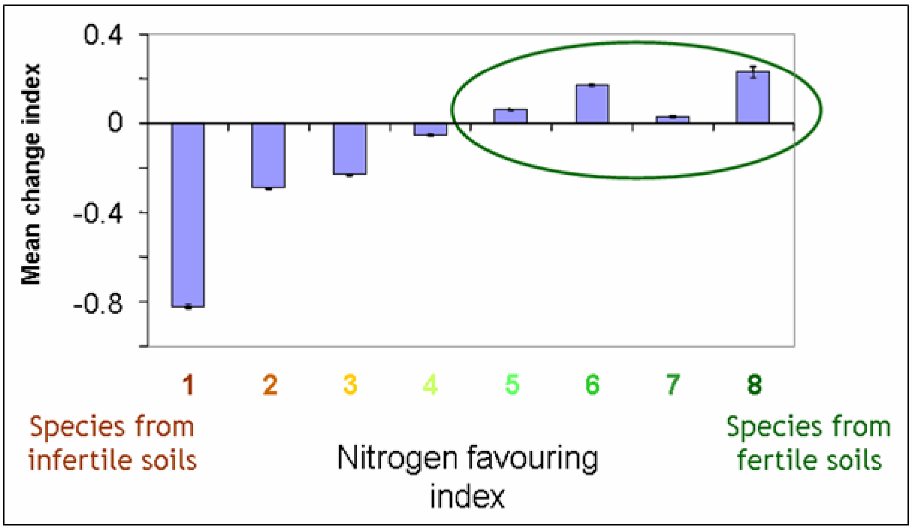


Fig. 9. Increase in occurrence of nitrogen-loving species. (From Preston et al. [2002] New Atlas of British and Irish Flora)

Looking specifically at grassland habitats, a clear negative relationship has been identified between nitrogen deposition and species richness, from a survey of over 68 sites (Fig. 10). One plant species was estimated to be lost with every additional 2.5 kg nitrogen deposited per hectare per year. At average UK nitrogen deposition, it is estimated that 23 per cent of plant diversity is lost.

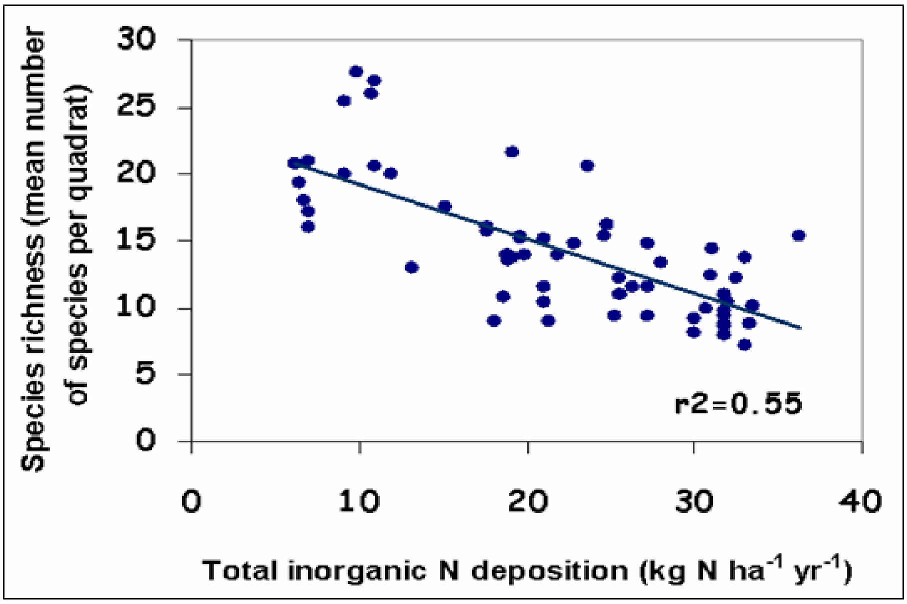


Fig. 10. Species richness decline with increase in total inorganic nitrogen deposition. (From Stevens et al. [2004] Impact of nitrogen deposition on the species richness of grasslands. Science)

Finally, The Countryside Survey has identified large-scale changes in UK vegetation types. The survey is a regular audit of the UK's natural resources and has been taking place since 1978. It has linked this change to fertility scores, which are a measure of nutrient availability for plant species present. Between 1990 and 1998, fertility scores in the UK increased significantly in four out of eight vegetation types, which presents indirect evidence of increasing nutrient availability at a UK scale.

Summary

There is a growing body of evidence available to show that ammonia leads to changes in the natural environment, both locally on nature conservation sites and on a large scale across England and Wales. Damage and loss of the most sensitive species is often the first ecological change identified when ammonia levels increase. At higher levels of nitrogen deposition, species diversity generally reduces, particularly in the most sensitive habitats. This is seen as a shift towards more nitrogen-loving species, and a reduction in sensitive species characteristic of semi-natural habitats in England and Wales.

To help protect the natural environment in England and Wales, nature conservation sites have been identified. Collectively, they play a critical role in the conservation of the UK's natural heritage by providing essential wildlife refuges. Protection of this network of nature conservation sites is essential to ensure wildlife can survive not only within sites, but also that there are sufficient corridors to move between them. They also act as essential buffers to potential impacts from climate change.

The Environment Agency has a general duty to ensure the protection of nature conservation sites through its regulatory activities. Many of these sites are also directly protected through various pieces of legislation. The Environment Agency therefore needs to assess the impact of ammonia on nature conservation sites in the regulation of intensive farms and other ammonia-producing industries.