One of the most serious problems facing groundwater dependent terrestrial ecosystems (GWDTEs) in England and Wales is pollution from nutrients (nitrate, and especially nitrogen). Atmospheric nitrogen inputs to GWDTEs have often been studied in isolation from terrestrial inputs such as groundwater and surface water. This report aims to bridge that gap by considering both atmospheric and terrestrial sources of nitrogen using a phased approach to develop a methodology to identify sources of nutrients.

The findings from this project will enable regulatory and conservation bodies to protect GWDTEs.

Background
Phase 1 involved a desk-based review of available information on atmospheric and terrestrial nutrient loading at GWDTEs in England and Wales. Initial analysis was made using national modelled atmospheric source apportionment from the UK Air Pollution Information System (www.APIS.ac.uk). The review identified a need to study the problem at a site scale and to develop a methodology to define nutrient sources from both atmospheric and terrestrial nutrients.

Methodology
The project aimed to develop a methodology for data collection and appraisal that could be applied to any wetland site. Atmospheric and terrestrial nitrogen inputs were measured for 12 months at 3 sites:

- Wybunbury Moss Site of Special Scientific Interest (SSSI) in Cheshire (part of West Cheshire Meres and Mosses Special Area of Conservation)
- Newbald Beckeries SSSI in east Yorkshire
- Cors Bodelio SSSI in North Wales (part of the Anglesey and Llŷn Fens Special Area of Conservation)

A good conceptual understanding and a monitoring network exist for all 3 wetlands. Field data collection included a range of chemical and hydrological monitoring, nitrogen and oxygen isotopes and age dating. Atmospheric deposition was calculated from measurements of ammonia and nitrogen dioxide concentrations using diffusion tubes.

National air quality modelling was combined with these field data to establish whether GWDTE impact assessments can be undertaken with modelled data or it is important to gather site-specific field data.

In a separate linked project (SC160010), catchment nutrient modelling was performed using both modelled and measured atmospheric data.

Results and conclusions
The study’s main results and conclusions at these sites.

- Measured atmospheric deposition monitoring was in broad agreement with national models.
- Site-specific atmospheric monitoring is required under certain conditions.
- Site-specific water quality monitoring is essential because natural loss of nitrogen occurs in many wetlands and regional monitoring alone could overestimate the loading.
- Combined site-specific monitoring can confirm the loading reaching receptors and the dominant pathways.
- National-scale modelling shows that atmospheric nitrogen is a significant problem at many sites. Site-specific investigations should take into account atmospheric contributions to ensure that the measures chosen during modelling are both correctly targeted and cost-effective.
- Rough calculations based on modelled outputs suggest that atmospheric inputs are likely to make up at most one-fifth of the load coming from agricultural inputs.
The report examines different approaches and methods of carrying out atmospheric monitoring and makes recommendations for practitioners to ensure robust and accurate data quality.

**Recommendations**

Further work is required to:
- refine the input estimates made during the project
- develop an improved approach for quantifying the load to groundwater from atmospheric inputs
- assess the relative importance of atmospheric versus terrestrial inputs in causing ecological damage.

This summary relates to information from project SC130039, reported in detail in the following outputs:


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