# Work Package 1:

# Critical loads and Dynamic Modelling

# Work Package 1 Task 1:

# Evaluation and application of empirical and mass balance critical load approaches to soils and vegetation systems, and support of the national critical loads mapping programmes


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# DEFRA Terrestrial Umbrella Annual Report

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## Introduction

This report briefly summarises progress in each of the major components of our contribution to the programme, identifying key conclusions to date and major areas of work planned over the next year. The sections of the report indicate the Work Package to which they contribute

## WP1: Critical Loads

Aim

The main objective of this contribution is to contribute to the revision of empirical critical loads of nitrogen within UN/ECE, to recommend mapping values of empirical critical loads for the U.K., and to contribute to the formal DEFRA review of U.K. critical loads

Summary of Work

Prof. Ashmore is a member of a five–person team currently drafting a new background document proposing new empirical critical loads of nitrogen, under the leadership of Dr. Roland Bobbink (University of Utrecht). Prof. Ashmore attended a meeting at the end of April in Utrecht to plan the document. The first draft for his sections (on bogs, moorland and tundra) has been completed, and currently a complete first draft for all sections is awaited. Prof. Ashmore has also ensured that all authors have available to them the latest reports from the work under the Terrestrial Umbrella programme, to ensure this research properly influences the revised critical load values.

Prof. Ashmore has also acted as the liaison between Dr. Bobbink and two other important contributions from the U.K. The first of these is active collaboration with Jane Hall and her colleagues at the UK National Focal Centre, who have proposed the use of the EUNIS classification scheme in identifying and mapping receptor communities. The second is liaison with Mark Sutton, of CEH Edinburgh, who will be contributing on assessing the quality of information on nitrogen deposition in the control treatment of critical field experiments and in field studies

Key Conclusions and Future Developments

Although it is not possible to provide details of the proposed revised values of critical loads until a second draft of the document is completed at the end of July, it is already clear that a substantial revision of the current empirical critical loads of nitrogen will be proposed for consideration at the UN/ECE Bern workshop in November. These revised values will have implications for the current values used in mapping critical loads of nitrogen in the U.K..

In order to facilitate discussion and revision of U.K. mapping values in the context of the UN/ECE revision, Prof. Ashmore will draft a discussion document on the implications for U.K. mapping values and procedures of the proposed international revision, for circulation within the Umbrella and to other key researchers. He will also organise a small workshop in early October to discuss the proposed U.K. values and to make provisional recommendations prior to the Bern workshop. This process will eventually lead to revised U.K. maps of empirical critical loads and their exceedance early in 2003.

## WP5: Impact of Atmospheric Nitrogen Deposition on Lichens and Bryophytes

### Overview

Aims

The research on lichen and bryophytes has three major aims:- to assess the response of the lichen and bryophyte flora in major field experiments under the programme; to undertake additional experiments to support interpretation of the observed responses; and to contribute to analysis of changes in lichen and bryophyte distributions using national databases.

Progress to date

Research to date has focussed on monitoring of the experimental manipulation experiments. Detailed data have been obtained from two experiments (Little Budworth Common and Wardlow Hay Cop) and are described in further detail below. These two sites were given priority because of the planned management interventions later in 2002. At Wardlow Hay Cop, a decision was made that monitoring should focus on the calcareous rather than the acid plots, as a preliminary survey indicated a much richer bryophyte flora with species atypical of calcareous sites.

Future plans

Surveys of Ruabon and Thursley Common are planned for the autumn of 2002, and all surveys will be repeated to assess change in the final year of the programme. An experiment will be set up in August 2002 to examine the interaction between nitrogen supply and light as a cause of the observed response at Little Budworth Common. Methods of analysis of the national bryological database will be established by the end of 2002.

### Results from Field Manipulation Experiments

#### *(a). Lowland Heathland (Little Budworth Common)*

Aim

The aim of this study was to determine the impact of elevated nitrogen deposition levels, in the form of ammonium nitrate, on lichen and bryophyte frequency of occurrence in a lowland, *Calluna-Deschampsia* dominated heath.

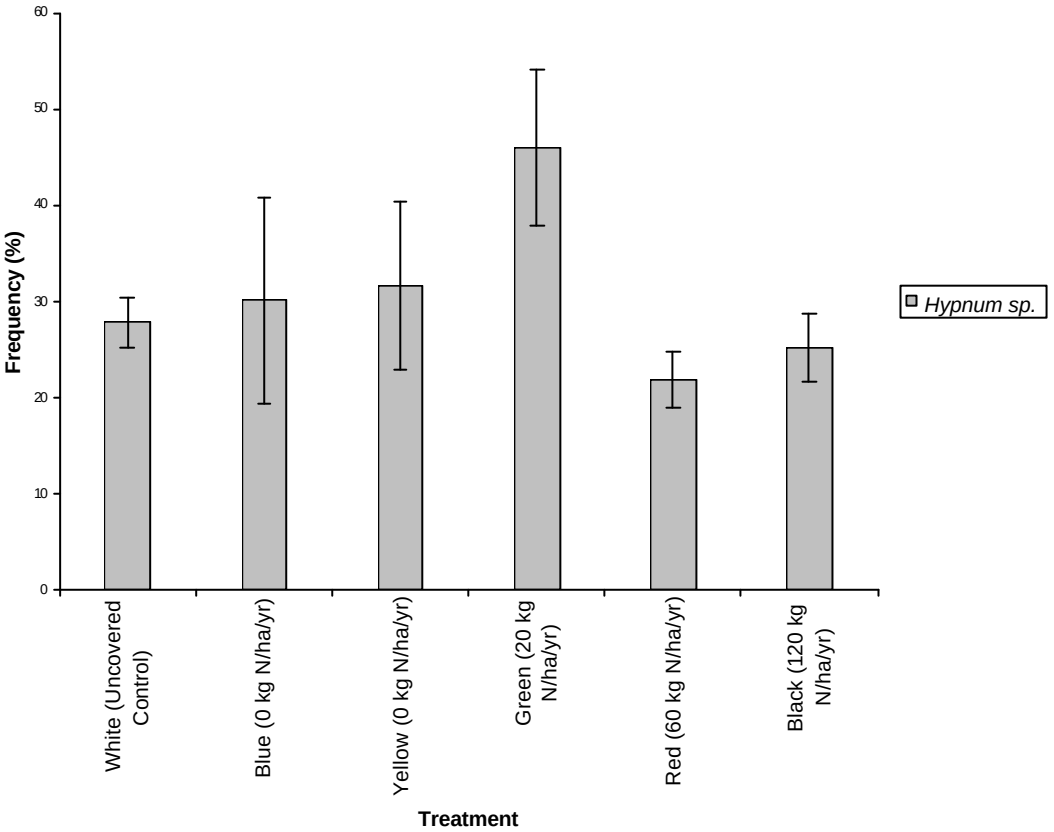
Summary of Preliminary Observations

- There are no lichen species present within the treatment plots (including controls). There are, however, lichens present in the surrounding ecosystem

and between the plots. This suggests that lichens may have been present in the plots but have since disappeared.

- *Hypnum spp.* is the dominant species of bryophyte present and there is a strong indication that *Hypnum spp.* cover is greater in the 20 kg $ha^{-1}$ N plots compared with the untreated and higher N plots (see Figure 1.). It is also interesting to note that the *Hypnum* within the 20 kg $ha^{-1}$ N plots appeared to be in better health than in other plots. Further field and laboratory work will be conducted to clarify these findings.
- Other species of bryophytes are much less abundant with some species only present as one or two stems. No obvious patterns can be observed in relation to N treatment for these species and statistical analysis is unlikely to be useful given the very low frequencies involved.
- Heterogeneity between treatment plots suggests that there may be factors, other than nitrogen, which are influencing bryophyte species distribution.

**Figure 1. *Hypnum* at Little Budworth**
**Average Frequency of Occurrence**




Conclusions

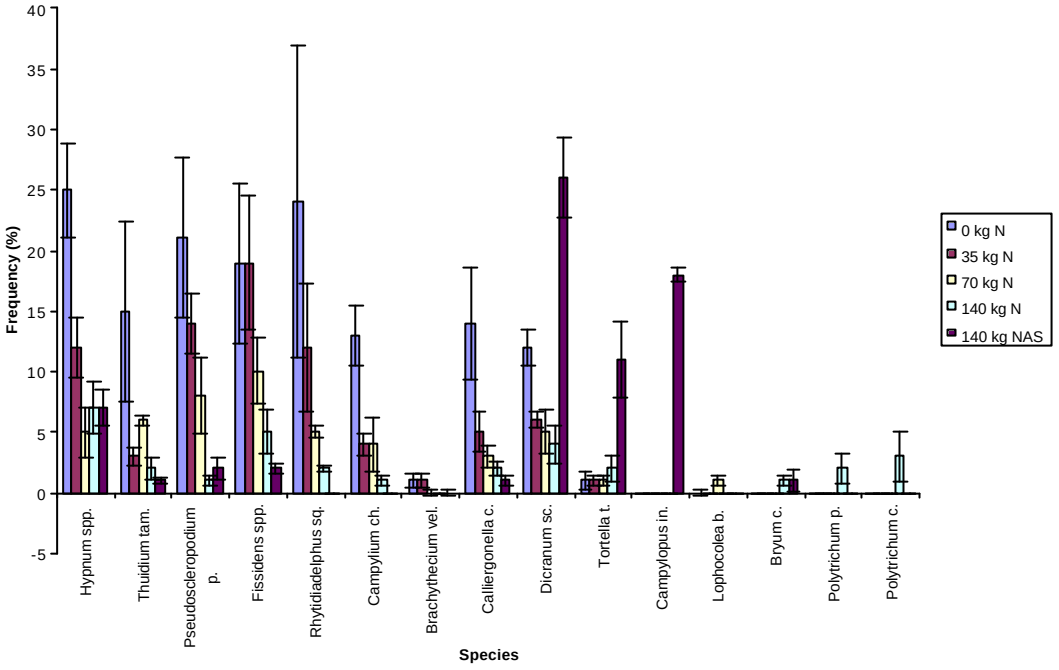
- No firm conclusions can be made at this stage, as further field and laboratory studies, as well as statistical analysis, are required.
- However, results for *Hypnum spp.* suggest that nitrogen may be having a positive impact at relatively low deposition rates (approximately twice background deposition for Little Budworth Common).

### *(b) Calcareous Grassland (Wardlow Hay Cop)*

Aim

The aim of this study was to determine the impact of elevated nitrogen deposition, in the form of ammonium nitrate and ammonium sulphate, on lichen and bryophyte communities of a calcareous grassland by recording the frequency at which each species was occurring.

**Figure 2. Bryophytes at Wardlow Hay Cop**




Summary of Preliminary Observations

- Formal statistical analysis has not yet been completed. However, preliminary observations show a general trend for most species of a decline in abundance with increasing nitrogen concentration (see Figure 2).
- The results from the addition of ammonium sulphate instead of ammonium nitrate suggest a disappearance of some species such as *Rhytidiadelphus squarrosus.* The results for the ammonium sulphate treatment also suggest invasion of other species, such as *Campylopus introflexus*, which are either not present, or present at relatively low frequency in the corresponding ammonium nitrate plots.
- The decline of some acid intolerant (calcicole) species and the appearance of generally acid loving or acid tolerant (calcifuge) species, such as *Polytrichum commune*, with increasing nitrogen concentration, suggests that the high nitrogen treatments plots may be becoming acidic, with implications for species composition.
- As at Little Budworth Common, heterogeneity between treatment plots, such as bare patches of ground or bare limestone rock, suggests that there may be factors other than nitrogen which are influencing bryophyte species distribution.

Conclusions and Policy Implications

- Nitrogen deposition, at the treatments used, is having an impact on bryophyte abundance. It is unclear at this stage whether this is by direct toxicity, or indirectly, e.g. through competitive exclusion or substrate acidification and eutrophication. Indeed, these factors vary in importance between species.
- Nitrogen treatment is also influencing species composition. The appearance of acid-tolerant species suggests acidification of the substrate with increasing nitrogen deposition. The addition of ammonium sulphate has allowed an introduced species to become established where otherwise it would not be found.
- In terms of policy, these observations suggest that bryophyte abundance and composition needs to be taken into consideration when setting critical loads for nitrogen, particularly as these plants are some of the first to show signs of impact.

**WP2 and WP5: Dynamic Modelling**

Aims

To contribute to the evaluation of linked soil-vegetation models for dynamic modelling, and to use a dynamic model to predict the long-term implications of findings from the experimental manipulation studies at moorland and heathland sites.

Progress to date

The contribution under this part of the programme, which involves collaboration with Dr. Power (Imperial College) is through the use of the HEATHSOLUK model, which simulates competition for light and nutrients between ericaceous shrubs and grasses based on carbon and nitrogen fluxes. Work has continued on the development and parameterisation of the model for upland communities in the U.K. using support from the NERC GANE programme, as was originally planned. Realistic simulation outputs have now been obtained for the uplands which demonstrate the importance of grazing pressure and burning frequency on the impacts of nitrogen deposition and on the timescales for recovery.

Future Developments

In the first half of year 2, the GANE-supported development work will continue. A meeting will be held between Dr. Evans, Prof. Ashmore and Dr. Power to compare the structure of HEATHSOLUK with other soil-vegetation models proposed for use in Work Package 2, such as SMART-MOVE. This will provide the basis for agreeing methods of comparing the predictions of HEATHSOLUK, which provides a more process-based description of the vegetation component, with vegetation-soil feedbacks and inter-specific competition, with those of the simpler dynamic models.