

Biological Diversity and Ecosystem Function in Soil

Soil Biodiversity

NERC Thematic Programme



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BIODIVERSITY IN SOIL

A central question in ecology is whether there is a necessary link between biological diversity and ecosystem function. Biogeochemical cycles are among the most fundamental of the functions performed in ecosystems, and many critical processes in these cycles (eg decomposition, nitrogen transformations, trace gas generation) occur in soil and are mediated by soil organisms. The role of these organisms in biophysical processes (eg hydrological cycling, energy balances) is unclear, but almost certainly profound. Soil communities are currently exposed to a wide range of impacts, including erosion, agricultural intensification and the deposition of acidic and nitrogenous pollutants, with poorly documented effects on diversity of the soil biota, and virtually unknown effects on ecosystem processes.

FUNDING

£6 million has been allocated by NERC for research into the relationship between soil biodiversity and the function of the components of the soil ecosystem. The programme will be closely directed and integrated, with the aim of producing data and insights of wider generality than the chosen ecosystem, an upland grassland at Sourhope, near Kelso, Scotland.

TIMING

34 full bids are currently under peer review. The first of the awards will be made in September 1998.

AIMS OF THE PROGRAMME

To achieve simultaneously an understanding of biological diversity of the soil biota and the functional roles played by soil organisms in key ecological processes

OBJECTIVES

- Quantify diversity of key soil biota in a single grassland ecosystem, as a basis for experiments to determine the role of biodiversity in ecosystem functional processes.
- Extend taxonomic understanding of the soil biota, by using novel isolation and molecular techniques to examine hitherto poorly characterised groups.
- Characterise roles of all major groups in the soil biota (including root-microbe associations) in key ecological processes of the carbon and nitrogen cycles in soil, to determine the pathways, sinks and carbon flux rates in soil food webs.
- Determine how depauperation of soil biota may reduce their ability to perform ecosystem functions, eg coping with anthropogenic inputs.
- Conduct parallel manipulations of major taxa of soil biota in mesocosms and in the Ecotron to manipulate the soil microbiota.
- Investigate the extent to which indicators of biodiversity are measures of soil resilience relevant to land use management.

Website: <http://mwnta.nmw.ac.uk/soilbio>

SHORTLISTED PROPOSALS & LEAD PRINCIPAL INVESTIGATORS

- 1** Dr M Blaxter University of Edinburgh
Title: Development of a molecular barcode system for soil nematode identification
- 2** Dr DMcL Roberts Natural History Museum
Title: Protozoan diversity and ecosystem function in soil
- 3** Dr AS Ball University of Essex
Title: Role of actinomycetes in the pattern and extent of C and N mineralisation in a grassland
- 4** Prof JPW Young York University
Title: Function and taxonomic diversity of mycorrhizas in grassland
- 5** Dr P Millard MLURI, Aberdeen
Title: Mangement of field experiments at Sourhope
- 6** Dr LL Handley SCRI Invergowrie
Title: N fluxes through diverse or depauperate microbial soil communities
- 7** Dr CH Robinson King's College
University of London
Title: Biodiversity of saprotrophic fungi of grassland in relation to their function
- 8** Prof AG O'Donnell University of Newcastle
Title: Microbial community interactions in the cycling of carbon, nitrogen and phosphorous in upland soils and their importance to ecosystem stability
- 9** Dr PJ Murray IGER North Wyke
Title: Biodiversity of invertebrate root feeders and their impact on soil microbial communities
- 10** Dr HIJ Black ITE Merlewood
Title: Scaling up from point samples to the field scale: the effect of scale on the relationship between soil biodiversity and carbon and nitrogen cycling
- 11** Dr P Ineson ITE Merlewood
Title: Soil faunal biodiversity and carbon cycling
- 12** Dr IM Head University of Newcastle
Title: Effects of soil improvement treatments on bacterial community structure and function
- 13** Dr JR Leake University of Sheffield
Title: The effects of mycorrhizal mycelium on the diversity, biomass and functioning of soil microbial communities and its role in carbon and nutrient cycles
- 14** Prof JI Prosser University of Aberdeen
Title: The influence of land-use management practices on species and functional biodiversity of nitrite-oxidising bacteria and nitrification and denitrification processes
- 15** Prof JH Lawton NERC Centre for Population Biology
Title: Soil biodiversity, carbon and nitrogen fluxes in replicate, model Sourhope ecosystems: an Ecotron experiment
- 16** Dr DL Jones University of Wales (Bangor)
Title: Role of soil biodiversity in plant C turnover and N mineralization
- 17** Dr S Spiro University of East Anglia
Title: Bacterial diversity and molecular ecology of denitrification in soils at Sourhope
- 18** Dr A Meharg ITE Monks Wood
Title: Dynamics of the quality of rhizosphere carbon flow as regulated by symbiotic and non-symbiotic rhizosphere organisms
- 19** Prof JM Anderson University of Exeter
Title: Diversity, functionality and resilience in saprotrophic communities in relation to land use management practices
- 20** Dr K Bruce University of Liverpool
Title: The impact of soil fauna on bacterial diversity and nitrogen cycling in ecosystems modelled on Sourhope
- 21** Dr LA Glover University of Aberdeen IMS
Title: What is the link between microbial diversity and soil resilience?
- 22** Dr NJ Talbot University of Exeter
Title: Use of monoclonal antibody and nucleic acid-based technologies to quantify the population dynamics of fungi during the transformation of pollutants in soil
- 23** Prof DA Davidson University of Stirling
Title: Interactions of soil biodiversity, micromorphology, structure and organic matter
- 24** Dr PF Cannon CABI Bioscience
Title: Molecular and cultural assessments of saprobic fungal diversity in Sourhope soil
- 25** Dr D Hopkins University of Dundee
Title: Earthworm diversity and the integration of physical, biochemical and microbiological functions
- 26** Dr BJ Finlay IFE Windermere
Title: Soil protozoan diversity and its role in carbon and nitrogen turnover
- 27** Dr LA Glover University of Aberdeen IMS
Title: Bacterial diversity in upland pastures: What is the biological and functional significance of the culturable vs. uncultured population?
- 28** Dr HIJ Black ITE Merlewood
Title: How important is inter- and inter-specific genetic diversity in enchytraeids (Oligochaeta; Enchtraeidae) for ecosystem function? A case study in a Scottish upland grassland ecosystem.
- 29** Dr R Bardgett University of Manchester
Title: The relationship between diversity, biomass and function of soil microarthropod communities
- 30** Dr RA Sanderson University of Newcastle
Title: Modelling biodiversity of Collembolan predators and tritrophic level interactions in the soil
- 31** Prof K Killham University of Aberdeen
Title: Fungal diversity and function in acidic grassland soils - effects of habitat patchiness and N-inputs
- 32** MJ Bailey NERC IVEM
Title: Establishing the link between functional and total bacterial diversity, its response to perturbation and effect upon carbon flux to other trophic levels
- 33** Prof ID Hodkinson Liverpool John Moores University
Title: Soil microarthropods: biodiversity and community function
- 34** Dr E Wellington University of Warwick
Title: Assessment of chitin decomposer diversity: the role of actinomycetes and other bacteria in C and N cycling in limed and unlimed grasslands.

RATIONALE FOR A SINGLE SITE: SOURHOPE

The programme will combine detailed taxonomic description with an experimental approach designed to utilise that description, to test hypotheses about the functional role of biodiversity. It will be based on an intensive study of a single site. Diluting the effort over a range of sites would preclude proper investigation of functional links between taxonomic diversity and function. Intensive studies at a range of sites would be prohibitively expensive.

The research will focus on a grassland system at MLURI's Sourhope Research Station in the Cheviot Hills, which is part of the UK Environmental Change Network and the most thoroughly studied site in the SOAEFD MicroNet programme. Sourhope has extensive areas of upland grassland (*Agrostis Festuca*; National Vegetation Classification U4), for which data on microbial diversity are already becoming available. Faunal data are limited and will be augmented by research from the Soil Biodiversity Programme.

DESIGN OF EXPERIMENTAL PLOTS

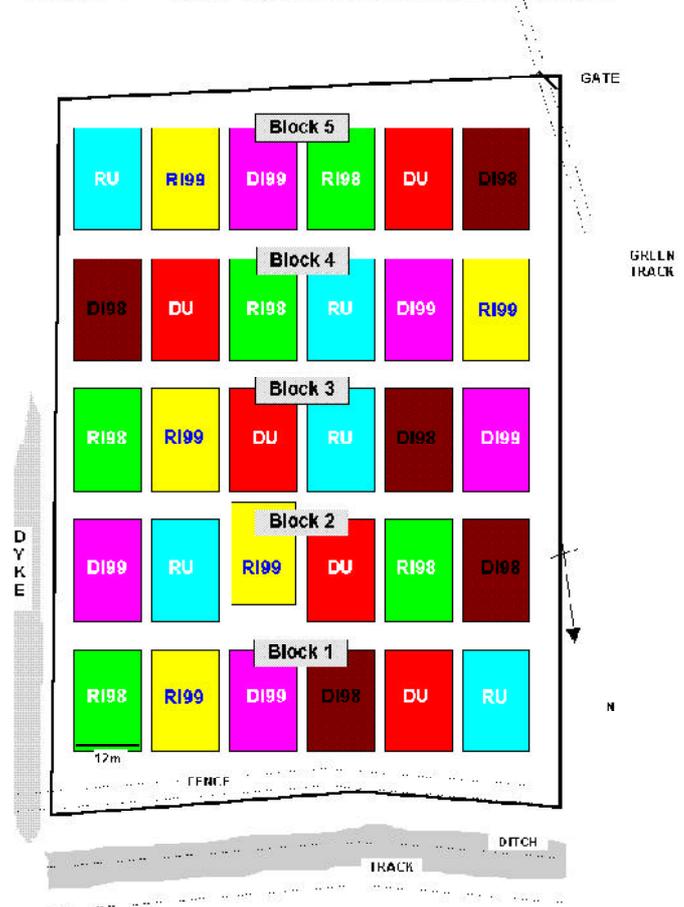
The plots are located at the Rigg Foot site at Sourhope. The design has five randomised blocks, each containing six plots (see figure 1), incorporating combinations of the following treatments: 'Improved (I)', 'Unimproved (U)', 'Cutting with disposal of clippings off-site (D)' and 'Cutting with return of clippings to the plots (R)'. Surface spreading of lime + P is the improvement treatment, with treatments imposed in two phases 'Improved '98' and 'Improved '99' to allow the research teams utilising these treatments alternative starting dates.

The 'Improved '98' and 'Improved '99' treatments are distributed between the six randomized main plots within each block. The 'Unimproved' treatment is in factorial combination with the cutting treatments. Each main plot is 12 m wide with approx 1 m between plots across the slope. The main plots will be split into 15 (4 m x 4 m) subplots which will be made available for treatments, such as addition of heavy metals, biocides and isotope pulses linked to specific awards.

BASELINE STUDIES

Baseline information on soils and vegetation, together with a detailed plan of the site, are being produced prior to the September meeting of award holders. The data will be made available in a Site Handbook. Four soil cores, 2 for freezing and 2 for drying, will be collected and archived from each of the 30 main plots (5 blocks each with 6 main plots). Samples for future microbial molecular work will be split into small (2–3 ml) aliquots and stored at -80°C. Soil samples will be analysed for a wide range of elements, as baseline data for the award holders.

FIGURE 1 RIGG FOOT EXPERIMENTAL SITE, SOURHOPE



KEY

- D198** Cutting with disposal and improvement in 1998
- D199** Cutting with disposal and improvement in 1999
- DU** Cutting with disposal and no improvement treatment
- R198** Cutting with return to site and improvement in 1998
- R199** Cutting with return to site and improvement in 1999
- RU** Cutting with return to site and no improvement

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ROLE OF SOIL ORGANISMS

Soil organisms control the magnitude and chemical nature of the globally significant C and N fluxes from soils. The role of some bacteria in these transformations is well established, but rates and pathways of soil biological processes are typically studied as functions of environmental rather than biological variables. The roles played by most groups of soil organisms are very poorly known, although a general theoretical and conceptual framework is emerging. Experimental demonstrations of the importance of faunal-microbial interactions are rarely performed in a context where their significance to ecosystem-level processes can be inferred.

MASTER CLASSES

The programme will include a series of master classes. These will be open to students, research assistants and institute staff associated with projects funded under the programme. They will provide short (2 to 5 days) intensive periods of training in selected topics, for example application of isotopic techniques, the use of molecular approaches in taxonomic studies, traditional taxonomy, data models and data protocols. The numbers attending any one class will be restricted to about 10 and the tuition will be provided by leading experts in the field. The classes will be residential and most probably held in university facilities. Details of each master class will be advertised to all award holders, inviting nominations for attendance.

ECOTRON

The programme will also have access to the Ecotron facility, at the Centre for Population Biology (CPB) Imperial College, in which a simplified grassland ecosystem will be created with communities of varying diversity to defined taxonomic specifications. A key element of the field and Ecotron-based parts of the programme will involve the introduction of a large pulse of ^{13}C to the grassland ecosystem and monitoring the progress of this signal through the soil ecosystem, which will be manipulated so as to alter its structure. The ^{13}C pulse will be added to the Ecotron system early in the life of the programme and results from these mesocosm studies will be used to generate predictions about expected responses in the field. The pulse will be added in the field following a period of characterisation and protocol development.

DATES FOR THE DIARY

- 6 Aug** - Peer Review and Steering Committee assessment meeting, Edinburgh.
- 7 Aug** - Steering Committee meeting, Sourhope
- 17/18 Sept** - Protocols discussion and Introduction meetings, University of York

Chairman of the Steering Committee

Professor Michael B. Usher, Chief Scientific Officer, Scottish Natural Heritage, Edinburgh

Members of the Committee

Dr J Curran, Head of Science, SEPA, Stirling

Professor D.A. Davidson, Department of Environmental Science, University of Stirling

Professor A. Fitter, Department of Biology, University of York

Dr M Embley, Principal Scientific Officer, Department of Zoology, Natural History Museum

Dr K Fox, Environmental Modeller, Unilever Research, Port Sunlight

Professor M Hornung, Head of Station, ITE Merlewood, Cumbria

Dr H Lappin-Scott, Department of Biological Sciences, University of Exeter

Dr P Millard, Head of Plant Science Group, MLURI, Aberdeen

Dr P Shaw, Senior Lecturer, School of Life Sciences, Roehampton Institute.

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