

# The Allt a' Mharcaidh-the UK's first sub-arctic Environmental Change Network (ECN) site

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**Abstract.** The first sub-arctic site in the Environmental Change Network (ECN) has been established in the catchment of the Allt a' Mharcaidh, on the western slopes of the Cairngorm Mountains in Scotland. The ECN is a UK-wide integrated network established to monitor environmental change, by collecting, analysing and interpreting long-term data sets on a number of key physical, biological and chemical variables, which are considered to drive and/or respond to environmental change. There are 54 ECN sites, 12 terrestrial and 42 freshwater, representing a wide range of habitats from uplands to lowlands, and moorland to chalk grassland, along with both large and small rivers and lakes.

*Key-words:* environmental change, networks; mountains; sub-arctic; Cairngorms; Scotland

## Introduction

During the 1980s, a series of major changes to the earth's environment, including increases in CO<sub>2</sub> levels and the hole in the ozone layer, were detected. The recognition of a lack of rigorous, comprehensive, quantitative long-term information on the state of the environment came to the fore, and the need for national and international programmes to monitor environmental change became accepted by both politicians and the general public.

To establish just such a long-term programme, the then UK Government launched, in January 1992, the concept of a network of sites to monitor environmental change – the Environmental Change Network. The existence of a number of field stations, where environmental monitoring and experiments had been on-going for some time, meant that the Network could, at least initially, be set up fairly quickly, with relatively little effort and cost.

The ECN is a UK-wide integrated network established to monitor environmental change. It is designed to collect, store, analyse and interpret long-term data sets on a number of key physical, biological and chemical variables, which are considered to drive and/or respond to environmental change.

The Network consists of a series of both freshwater and terrestrial sites. At the beginning of 1999 there were 53 sites, 11 terrestrial and 42 freshwater, representing a wide range of habitats from uplands to lowlands, and moorland to chalk grassland, along with both large and small rivers and lakes. (Appendix 1).

The aims of the ECN are:

- to provide for the integration and analysis of these data sets so as to identify environmental changes and to improve understanding of the causes of change;
- to make these long-term data sets available as a basis for research and prediction of possible future changes;
- to provide, for research purposes, a range of representative sites where there is good instrumentation and reliable environmental information.

The data collected from the ECN sites will therefore be used to:

- identify and quantify man-induced factors;
- distinguish short-term fluctuation from long-term trends;
- provide data to assist in the prediction of future changes.

The Network co-ordinated by the Natural Environment Research Council (NERC) and the Central Co-ordination Unit (CCU) based at the Centre for Ecology and Hydrology (CEH), Merlewood, Cumbria. The policy of the Network is determined by a Steering Committee of experts from various disciplines and agencies. A fuller description of the organisation and management of the ECN as well as the rationale behind its establishment can be found in Sykes and Lane (1996) and on the ECN web page ([www.nmw.ac.uk/ecn](http://www.nmw.ac.uk/ecn)).

## Data collection

Fundamental to the ECN programme is the use of agreed standard protocols for measuring the key environmental variables. These, the Core Measurements, are summarised under the following headings:

Meteorology	Surface water drainage
Surface water chemistry	Precipitation chemistry
Atmospheric chemistry	Soil chemistry
Soil solution chemistry	Soil biology
Vertebrates	Invertebrates
Vegetation-semi natural and managed	

The protocols for collection were produced and

agreed by a number of experts in each field and are detailed in Sykes and Lane (1998).

### Selection of sites

The sites were selected to be representative of a variety of habitats throughout the UK, most frequently being associated with existing, long-established research stations.

An examination of the distribution of the 11 terrestrial sites in 1996 showed that there were important gaps, especially in the northern and western parts of Scotland and the high mountains (Conroy and Johnston 1996). The ITE Land Use Classification of Great Britain (Bunce *et al.* 1996a) showed that four sites were dominated by arable land classes, two by pastoral land classes, two by upland classes and one by marginal upland classes. The absence of a site in the arctic-alpine zone was conspicuous.

### The Cairngorms

While the Cairngorms area is recognised to cover a wide area (see Conroy *et al.* 1990), the critical area of interest for ECN is the core mountain area. This is essentially land above the former natural tree line (ca 600m). It is the most striking example of sub-arctic montane within the UK. The area differs from other expanses of high ground in the UK with extensive areas of high plateaux and high altitude lakes. It also has deep glaciated valleys and bogs with unusually variable and extensive heathland. The high Cairngorm mountains have been described as the most outstanding area in Britain for geomorphology, providing important evidence for interpreting the evolution of the landscape and environmental changes during and since the ice ages (Sugden 1981; Thompson *et al.* 1994; Brazier *et al.* 1966; Bayfield and Conroy 1996).

Such has been the importance of the area that it has been subject to many national and international conservation/natural heritage designations.

### The Cairngorms assets

The Institute of Terrestrial Ecology (ITE) was commissioned by Scottish Natural Heritage (SNH) to collate and summarise the extensive range of monitoring and research being undertaken in the area. These are fully described in Conroy *et al.* (1994). A further study coordinated by ITE and commissioned by the Cairngorms Partnership, examined a wider range of features including those relating to environmental, socio-economic and cultural feature. In this report, potential indicators of change were also described (Bayfield and Conroy 1996).

Conroy *et al.* (1994) and Conroy and Johnston (1996) described in detail ten of the most important features in the area likely to be affected by environmental change.

These were:

Climate	Soils	Vegetation & Grazing
Deer	Birds	Woodlands
Moorland & Peatland	Freshwaters	Fish
Pollution		

### The case for the Cairngorms being included as an ECN site

The extensive research and monitoring programmes undertaken throughout the Cairngorms, some lasting several decades, have clearly highlighted the environmental significance of the area and its rare flora and fauna (in some instances species absent from elsewhere in the UK). The area is also a prime centre for pollution monitoring, while even small changes in temperature might have serious implications for the local environment (Bunce *et al.* 1996b).

The high mountains of the Cairngorms were thus ideal for inclusion in the ECN. Any site would contribute the following:

- a sub-arctic site with a mixture of continental and oceanic climates;
- a site with a wide altitudinal range;
- wide diversity of habitats from native woodlands and open moorland through scrub and remnants of a forest-line to montane and sub-arctic habitat;
- an unusual assemblage of plants and animals, some at the edge of their UK range e.g. snowbed communities, montane heaths, tree lines etc; many likely to be susceptible to environmental change;
- associations with a number of national and international scientific research programmes. Environmental changes expected to occur in the area include:

1. **Climate change.** Long-term changes or variations in climate would have significant impacts on the mountain environment and the adjacent regions. Predictions for changes in climate in the UK include, for example a general warming over the next 50 years (Houghton *et al.* 1990), the implication of which could be serious (Bunce *et al.* 1996b).
2. **Anthropogenic pollution.** The high Cairngorms are among the most vulnerable areas of the UK to atmospheric pollution from anthropogenic sources within the UK and throughout Europe (UKAWRG 1988). Changes in soil, river and lake chemistry have already been found, and this has important impacts on a range of features of the area e.g. fish populations, lichen and bryophyte communities (see Mason 1990).
3. **Land use change.** Recent years have seen dramatic changes in the land use of the area, and these are likely to

continue as the conservation importance of the area is more and more realised, e.g. the designation of the area as a National Park and a World Heritage Site.

For example, a major problem in many parts of the Cairngorms in both the open hill ground and in the woodlands has been the heavy grazing of the vegetation by red deer (*Cervus elaphus* L.) and sheep. It is only in recent years, following significant increases in the cull of red deer in many estates, that there has been evidence of increasing natural regeneration of native woodland, e.g. in the Northern Corries of Cairn Gorm and Inshriach (Miller 1985; Watson 1990). The role of red deer, including details of culls, has been reviewed in a number of papers (Mitchell *et al.* 1977; Youngson and Stewart 1996).

The moorlands of the Cairngorms change from ground dominated by heather (*Calluna vulgaris* (L.) Hull) on the eastern slopes of the main massif, to grass land dominated on the western slopes. Management of these moors over the years has resulted in unusual vegetation types, habitats and animals. The open habitat has flushes, mires and blanket bogs that maintain a high biodiversity. However, as a result of air pollution, climate change, grazing pressures, drainage and the natural consequences of the growth in richness of the peat blanket, the total area of heather-dominated moorland had decreased dramatically over the past 50 years (Sydes and Miller 1988).

Details of land-use changes since the 1940s have already been published (Gauld *et al.* 1991), and these should form, a solid base line against which to determine further change.

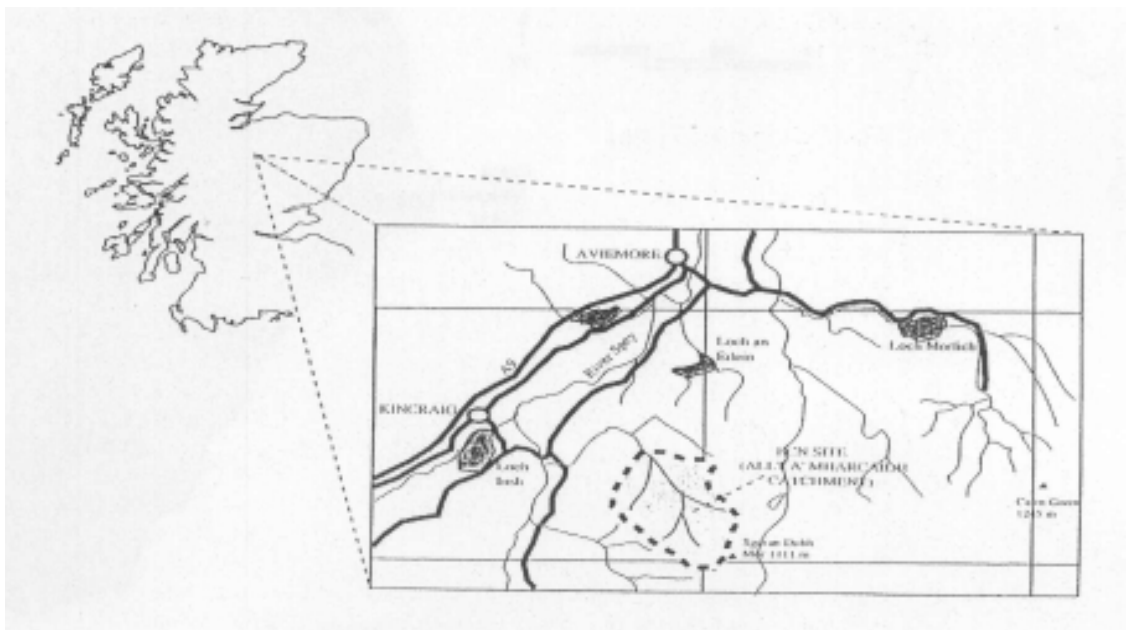
## The choice of site

After an examination of the available information, it was decided that the most suitable site would be the Allt a' Mharcaidh catchment (Figure 1). This lies on the western flank of the Cairngorms and is a tributary of the river Feshie. It has a high altitudinal range (800 m) and already supports a wide range of environmental monitoring programme from the climate and snow packs to the soils and vegetation. The catchment has been classified as traditional i.e. it has a pH of around 6.0, but is subject to acute acidic shocks associated with high flow events generated by snow melt and rainfall. Detailed research began in the early 1980s and had been carried out primarily by the Institute of Hydrology (IH), MLURI, Scottish Office Agriculture Fisheries and Environment Department (SOAFED), the ITE and a number of universities and other research institutes.

In addition it lies in an area which has experienced major changes in rainfall over the past 60 years (Mayes 1996; Harrison 1997); increases of between 15 and 20% during the summer and an average decrease of 15% during the winter. Within the catchment, the exceedance of the critical load of acidity in the soils is 0.2-0.5 kg H<sup>+</sup>ha<sup>-1</sup>year<sup>-1</sup> and is close to an area where it exceeds 1 (Cannel, Fowler and Pitcairn 1997; CLAG Mapping and Modelling 1996).

The catchment has also been part of several important international studies. These include:

- The Surface Water Acidification Programme (see Mason 1990);
- UK Acid Waters Monitoring Programme;
- UN-ECE Programme on integrated monitoring;



**Fig. 1.** Location of the Allt a' Mharcaidh catchment

- EU ENCORE Programme;
- EU ECOMONT Programme;
- ECN Freshwater site.

There already exists an extensive monitoring programme for the area, e.g. details of soil and vegetation (Figure 2). Within the catchment.

there are already data from 13 of the 26 variables identified as part of the ECN terrestrial site-monitoring programme, in some instances collected over more than ten years. The catchment is already a ECN freshwater site, managed by the Scottish Environment Protection Area (SEPA).

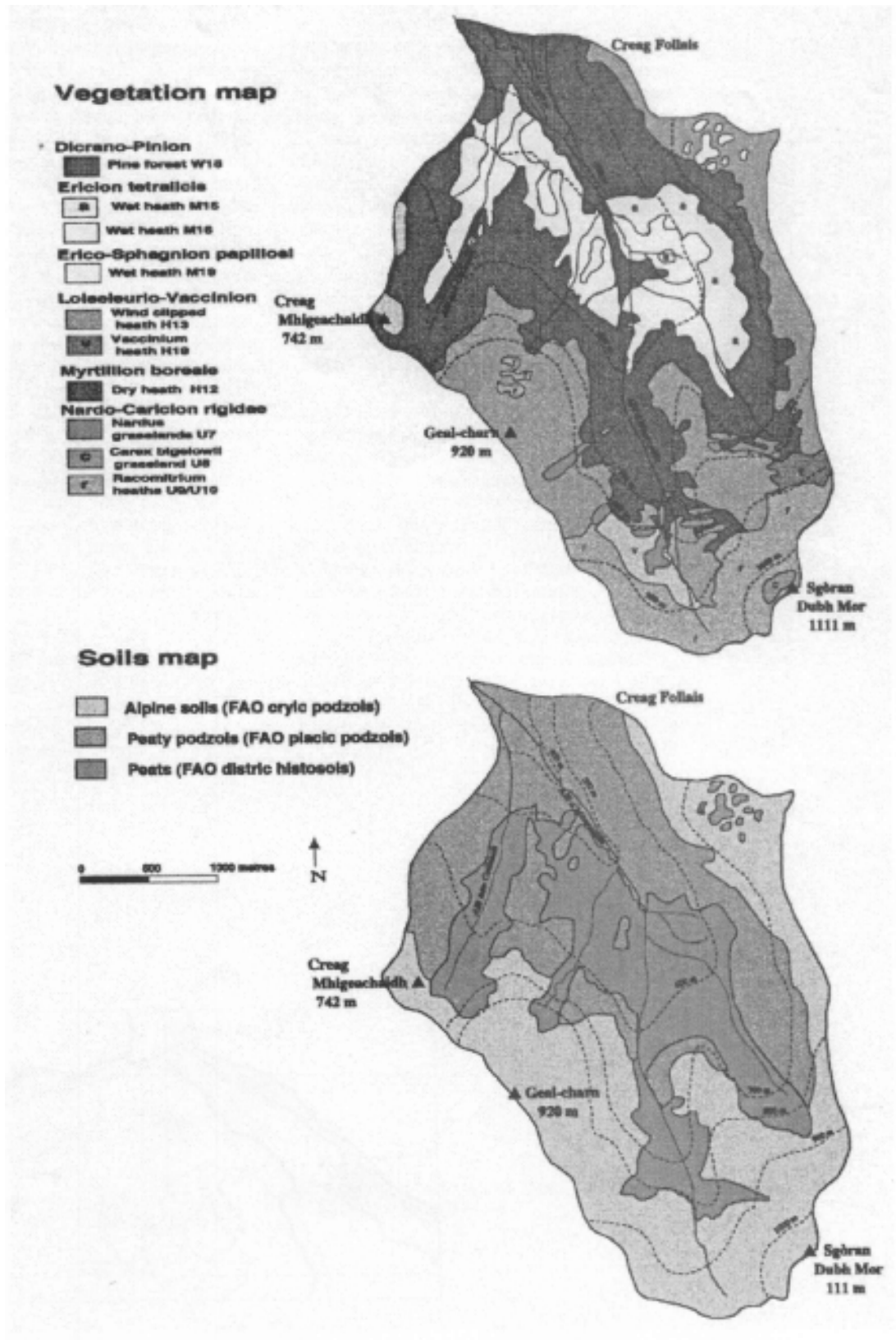


Figure 2. Simplified map of the Allt a' Mharcaidh catchment

In 1999, the Centre of Hydrology (CEH), part of NERC and SNH accepted the environmental importance of the Allt a' Mharcaidh catchment and agreed to jointly sponsor the site. The Cairngorms ECN site as it is known was established during the summer of 1999 and is the first site in the UK's sub-arctic zone and the first joint terrestrial/freshwater ECN site.

A small group from ITE, SNH, MLURI and SEPA was established to set up the site. They developed a management strategy for the site and established the various experimental sites within the catchment. It is hoped that by declaring the area and ECN site, it will encourage others to develop their research interests in the area, and the integrated monitoring programme, an integral part of the ECN philosophy, can be expanded.

### References

- Birse, E.L., Dry, F.T. and Robertson, L. 1970: Assessment of Climatic Conditions in Scotland and Macaulay Institute of Soil Research, Aberdeen.
- Bayfield, N.G. and Conroy, J.W.H. 1996: The Cairngorm As sets. Cairngorms Partnership, Aviemore.
- Brazier, V., Gordon, J.E., Hubbard, A. and Sugden, D.E. 1996: The geomorphology evolution of a dynamic landscape: the Cairngorm mountains, Scotland. *Botanical Journal of Scotland*, **48**, 13-30. (Environmental History of the Cairngorms. Ed J. McConnell and J.W.H. Conroy.)
- Bunce, R.G.H., Barr, C.J., Clarke, R. T., Howard, D.C. and Lane, A.M.J. 1996a: ITE Merlewood land classification of Great Britain. *Journal of Biogeography*, **23**, 625-634.
- Bunce, R.G.H., Watkins, J.W., Gillespie, M. K. and Howard, D.C. 1996b: The Cairngorms environment and climate change in a European context. *Botanical Journal of Scotland*, **48**, 127-136. (Environmental History of the Cairngorms. Ed J. McConnell and J.W.H. Conroy.)
- Cannell, M.G.R., Fowler, D. and Pitcairn, C.E.R. 1997: Climate change and pollutant impacts on Scottish vegetation. *Botanical Journal of Scotland*, **49**, 301-314. (Scottish Vegetation: Plant Ecology in Scotland. Ed J. Proctor.)
- CLAG Mapping and Modelling 1966: Mapping and Modelling Environmental Acidification in the United Kingdom. Report to the Critical Loads Advisory Group, Sub-group on Mapping and Modelling. Department of the Environment, London.
- Conroy, J.W.H. and Johnston, R. 1996: The Cairngorms in relation to the UK Environmental Change Network (ECN). *Botanical Journal of Scotland*, **48**, 137-154. (Environmental History of the Cairngorms. Ed J. McConnell and J.W.H. Conroy.)
- Conroy, J.W.H., Staines, B.W. and Watson, A. 1994: The Environmental Change Network: The Cairngorms as a Potential Site. Institute of Terrestrial Ecology, Banchory.
- Conroy, J.W.H., Watson, A. and Gunson, A.R. (eds.) 1990: Caring for the High Mountains - Conservation of the Cairngorms. Centre for Scottish Studies, University of Aberdeen, Aberdeen.
- Gauld, J.H., Bell, J.S., Towers, W. and Miller, D.R. 1991: The Measurement and Analysis of Land Cover Changes in the Cairngorms. MLURI, Aberdeen.
- Harrison, S.J. 1997: Changes in the Scottish climate. *Botanical Journal of Scotland*, **49**, 287-300. (Scottish Vegetation; Plant Ecology in Scotland. Ed J. Proctor.)
- Houghton, J.T., Jenkins, G.J. and Ephraums, J.J. (eds.) 1990: Climate Change. The IPCC Scientific Assessment. Policy makers summary. Pp. vi-xxiv. Cambridge University Press, Cambridge.
- Mason, B.J. (ed.) 1990: The Surface Water Acidification Programme. Cambridge University Press, Cambridge.
- McClatchey, J. 1966: Spatial and altitudinal gradients of climate in the Cairngorms observations from climatological and automatic weather stations. *Botanical Journal of Scotland*, **48**, 31-50. (Environmental History of the Cairngorms. Ed J. McConnell and J.W.H. Conroy.)
- Mayes, J. 1996: Spatial and temporal fluctuations of monthly rainfall in the British Isles and variations in mid-latitude westerly circulation. *International Journal of Climatology*, **16**, 585-596.
- Miller, D.R. 1985: Ecological Considerations in Management of Cairngorms Estate. Institute of Terrestrial Ecology, Banchory.
- Mitchell, B., Staines, B.W. and Welch, D. 1977: Ecology of Red Deer. A Research Review Relevant to their Management in Scotland. Institute of Terrestrial Ecology, Cambridge.
- Sugden, D. 1981: Landforms. In: The Cairngorms (eds. D. Nethersole-Thompson and A. Watson), pp. 210-221. The Melven Press, Perth.
- Sydes, C. and Miller, G.R. 1988: Range management and nature conservation in the British uplands. In: Ecological Changes in the Uplands. (ed. M.B. Usher and D.B.A. Thompson), pp. 323-342. Blackwell Scientific Publications, Oxford.
- Sykes, J.M. and Lane, A.M.J. 1996: The United Kingdom Environmental Change Network: Protocols for standard measurements at terrestrial sites. The Stationary Office, London.
- Thompson, D.B.A., Horsfield, D., Gordon, J.E. and Brown, A. 1994: The environmental importance of the Cairngorms massif. In: The Cairngorms - Planning Ahead. (ed. A. Watson and J.W.H. Conroy), pp 15-14. Kincardine and Deeside District Council, Stonehaven.
- UKAWRG 1988: Acidity in United Kingdom Freshwaters. Department of Environment, London.
- Watson, A. 1990: Human impact on the Cairngorms environment above timber line. In Caring for the High Mountains Conservation of the Cairngorms. (eds. J.W.H. Conroy, A. Watson and A.R. Gunson), pp 61-82. Centre for Scottish Studies, University of Aberdeen, Aberdeen.
- Youngson, R.W. and Stewart, L.K. 1996: Trends in red deer populations in the Cairngorms core area. *Botanical Journal of Scotland*, **48**, 111-116. (Environmental History of the Cairngorms. Eds. J. McConnell and J.W.H. Conroy.)

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Name	Location	Sponsoring Agency
<b>a. Terrestrial sites</b>		
Alice Holt	Surrey	Forestry Commission
ADAS Drayton	Warwickshire	Ministry of Agriculture, fisheries and Food
Glensaugh	Aberdeenshire	Scottish Office/MLURI
Hillsborough	Northern	Ireland Department of Agriculture for Northern Ireland
Moor House & Upper Teesdale	Cumbria & Durham	NERC and English Nature (EN)
North Wyke	Devon	Biotechnology and Biological Sciences Research Council (BBSRC)
Porton	Wiltshire	Ministry of Defence
Rothamsted	Berkshire	BBSRC
Sourhope	Scottish Borders	Scottish Office/MLURI
Wytham	Oxfordshire	NERC and Oxford University
Y Wyddfa/ Snowdon	North Wales	Countryside Commission for Wales and Welsh Office
<b>b. Freshwater sites-rivers</b>		
River Eden	Cumbria	Environment Agency (North West Region)
River Esk	North Yorkshire	Environment Agency (North East Region)
River Coquet	Northumberland	Environment Agency (North East Region)
River Exe	Devon	Environment Agency (South West Region)
River Frome	Dorset	Environment Agency (South West Region)
River Wye	Gwent (Wales)	Environment Agency (Welsh Region)
River Lathkill	Derbyshire	Environment Agency (Midlands Region)
Bradgate Brook	Leicestershire	Environment Agency (Midlands Region)
Cringle Brook	Lincolnshire	Environment Agency (Anglian Region)
River Bure	Norfolk	Environment Agency (Anglian Region)
River Coln	Gloucestershire	Environment Agency (Thames Region)
River Lambourn	Berkshire	Environment Agency (Thames Region)
River Eden	Kent	Environment Agency (Thames Region)
Trout Beck	Cumbria	NERC and EN
Old Lodge	S E England	Department of the Environment, Transport and the Regions (DETR)
River Stinchar	Strathclyde	SEPA (West Region)
Lower Clyde	Strathclyde	SEPA (West Region)
River Cree	Dumfries & Galway	SEPA (West Region)
Allta' a' Mharcaidh	Highland	SEPA (North Region)
River Spey/ Fochabers	Morayshire	SEPA (North Region)
River Ewe	Highland	SEPA (North Region)
River Tweed/ above Galafoot	Borders	SEPA (East Region)
River Eden	Fife	SEPA (East Region)
River Faugan	Northern Ireland	Department of the Environment for Northern Ireland (DoE/NI)
River Garvary	Northern Ireland	DoE/NI
River Bush	Northern Ireland	DoE/NI
<b>c. Freshwater sites-lakes</b>		
Upton Broad	Norfolk	Environment Agency (Anglian Region)
Hickling Broad	Norfolk	Environment Agency (Anglian Region)
Wroxham Broad	Norfolk	Environment Agency (Anglian Region)
Windermere	Cumbria	NERC
Esthwaite Tarn	Cumbria	NERC
Loch Leven	Tayside	NERC
Scoat Tarn	Cumbria	DETR
Llyn Llagi	North Wales	DETR
Lochnagar	Aberdeenshire	DETR
Loch Lomond	Strathclyde	SEPA (West Region)
Loch Katrine	Central Scotland	SEPA (East Region)
Loch Davan	Aberdeenshire	SEPA (North Region)
Loch Kinord	Aberdeenshire	SEPA (North Region)
Lough Neagh	Northern Ireland	Department of Agriculture for Northern Ireland
Lough Erne	Northern Ireland	Department of Agriculture for Northern Ireland

**Appendix 1.** Detail of the ECN sites in the UK and their sponsors.