Countryside Survey 2000 Module 2: Freshwater Studies

R&D Technical Report E1-038/TR1

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Statement of Use
This document presents the findings of the freshwater studies conducted during Countryside Survey 2000 compare these with results of a similar survey conducted in 1990. The results indicate the changes that are taking place in the biological condition of streams and quantify the relationships between stream condition and the habitat quality of river corridors. Concurrently collected data on riparian and catchment land cover provide opportunities to examine and model some of the relationships between land use and stream condition. The results are relevant to the Water Framework Directive and the development of catchment management plans. The data also form part of a long-term survey of changes in the GB Countryside of relevance to other environmental issues such as climatic change and atmospheric depositions and eutrophication.

Keywords
Countryside Survey, Land Classes, Environmental Zones, Broad Habitats, Rivers and Streams, aquatic macro-invertebrates, RIVPACS, biological condition, biodiversity, River Habitat Survey, habitat quality, land cover, temporal change.

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EXECUTIVE SUMMARY

The overall objectives of Countryside Survey 2000 were:

- to record the stock of countryside features associated with the wider countryside, including information on land cover, landscape features, terrestrial and freshwater habitats and species, in 1998
- to determine change by comparison with earlier surveys
- to maintain and refine the base line set down in 1990 to ensure the survey data continue to be relevant to current policy needs
- to develop the data-base of countryside information following the 1990 Survey so that a range of data outputs, relevant to the reporting frameworks used by Central Government and its Agencies and the needs of research and the academic community, can be derived, with the first results available in 2000

Within these overall objectives, a sub-set of more detailed objectives have been developed for the survey of freshwater habitats. These are as follows:

- to provide information on the status, distribution and recent changes in freshwater habitats in Great Britain: to include assessments of freshwater biota, river habitats and water chemistry. The survey work will be integrated with the survey of widespread habitats and landscape and will be compatible with the survey and monitoring procedures used by the Environment Agency
- to provide information on the status and distribution of the macro-invertebrate fauna of streams and rivers in Great Britain.
- to determine and evaluate change by comparison with 1990 survey data relating to the same sites
- to determine the habitat structure and degree of modification of river corridors
- to undertake a limited diagnostic survey of the chemical character of the watercourses to help interpret the results of macro-invertebrate and river habitat surveys
- to investigate the relationship between the habitat quality and modification of river corridors, the ecological quality of the watercourse and the condition of the surrounding countryside
- to derive indicators relating to status and change in watercourse and river habitat quality

In order to meet these objectives, aquatic macro-invertebrate fauna and habitat quality of river corridors of a single watercourse were surveyed in each 1km square in which an appropriate watercourse was present. Single chemical samples were also taken at each site. Opportunistic surveys of diatoms, macrophytes and chironomid pupal exuviae were also undertaken but these samples have not yet been analysed. A total of 425 watercourses were surveyed for their river habit quality, of which 404 were flowing at the time of visit and were also sampled biologically and chemically. All surveys were undertaken in 1998.

The biological condition of each sampling point was assessed using the same standard quality indices widely applied by the water industry. Two further indices, the Habitat Quality Assessment (HQA) and Habitat Modification Index (HMI) were used to assess the condition of the river corridor.

Macro-invertebrate samples collected during CS2000 were compared with samples collected from 354 matched sites also sampled during CS1990. Comparisons showed a widespread increase in taxon richness, with an average of 24.3 taxa (mainly species) per sample in 1998, compared with 16.5 in 1990. Mean gains were greater in the uplands than the lowlands and greater in Scotland than England and Wales. However, the mean number of taxa per site remained slightly higher in England and Wales than in Scotland.

The increase in mean taxa per site was accompanied by an increase in the frequency of distribution of most taxa. Of the 473 taxa recorded in 1998, 329 (70%) were more frequent in that year than in 1990, 106 (22%) were less frequent and 38 (8%) showed no change. These 473 taxa included a total of three that had Red Data Book status and 30 that were categorised as being Nationally Scarce.

There was a tendency for the greatest gains in frequency to be made by taxa associated with fast flow conditions. Conversely, taxa making the least increase or the greatest decrease in frequency tended to be those associated with slow-flow conditions or standing water. The changes in frequency of individual taxa were significantly correlated with their known flow preferences, as categorised in the Lotic invertebrate Index for Flow Evaluation (LIFE).

Increases in number of taxa also occurred at family level. The number of relevant families is present in a sample (NTaxa) is one of the two indices of biological condition of sites derived from the Biological Monitoring Working Party (BMWP) Score system for the purposes of this study. The other is the Average Score Per Taxon (ASPT). ASPT is a measure of the average organic pollution tolerance of the taxa present in a sample.

A general increase in the number of scoring taxa per site and of ASPT values led to apparent improvment in the biological condition of Countryside Survey sites in 1998 compared to their condition in 1990. These improvements occurred in all six

Environmental Zones recognised in Countryside Survey 2000 but were most marked in Scotland.

RIVPACS (River Invertebrate Prediction and Classification) was used to compare the grades of biological condition of sites in 1990 and 1998. Analyses showed that 25.1% of sites in GB showed a significant increase in their biological grade between 1990 and 1998, whilst only 2.0% showed a significant decline. The respective figures for Scotland were 33.0% (significant improvement) and 1.1% (significant decline). In England and Wales the corresponding values were 17.2% and 2.9%. The general improvement in biological condition of Countryside Survey streams was matched but an equivalent annual rate of improvement between the National Rivers Authority's 1990 River Quality Assessment and their 1995 General Quality Assessment.

Values of the Habitat Quality Assessment were, on average, higher in Scotland than in England and Wales, where the lowest mean value per Environmental Zone was recorded in the "Easterly lowlands". However, the highest recorded mean value was in the "Uplands" of England and Wales.

Conversely, Habitat Modification Scores were lower in the uplands than the lowlands and in Scotland rather than England and Wales. Low values signify little channel management and are considered desirable. The lowest mean value of this idex was in the "True uplands" of Scotland, indicating minimal management practices. Conversely, the highest mean value was in the "Easterly lowlands" of England and Wales, where channel straightening and dredging are commonplace.

In all Environmental Zones, except the "Uplands" of England and Wales, one or both of the biotic index values derived from the BMWP Score system were significantly correlated with one or both of the two indices of habitat quality and modification derived from River Habitat Survey. This confirms expectations that the biological condition of streams tends to be highest in stretches that are of good habitat quality and subject to little channel management.

Strong significant relationships were also observed between riparian Broad Habitat type and indices of river corridor condition. Some significant relationships between Broad Habitat type and the biological condition were also recorded, although these were fewer and weaker than with the RHS indices. In particular, corridor and in-stream biological condition were negatively correlated with the frequency of the "Arable and horticulture" Broad Habitat. Positive correlations were strongest with "Broadleaved, mixed and yew woodland" and, to a lesser extent, with "Coniferous woods".

The extent of habitat modification was significantly and positively correlated ($p<0.001$) with the extent of "Arable and horticulture", "Improved grassland" and "Built up areas

& gardens". Significant negative correlations ($p<0.001$) between extent of individual Broad Habitats and Habitat Modification Score occurred with "Acid grassland" and "Bog. At the $p<0.05$ level, additional negative correlations were with "Broadleaved, mixed and yew woodland", "Coniferous woods", "Dwarf shrub heath and "Fenland, marsh and swamp".

Possible explanations for the improvement in the biological condition of the CS2000 watercourses between 1990 and 1998 were considered. The possibility that they resulted from the differential performance of the field surveyors was discounted. The previous experience of the 1990 and 1998 field teams and the pre-survey training that each group received were well matched. Other possible explanations included:

- differences in flow conditions
- improved water chemistry
- reduction in pollution incidents
- increase in the development of vegetated riparian strips (buffer zones), managed separately from the rest of the adjacent field

Whilst the presence of unmanaged, tall vegetation was correlated with good in-stream biological condition, results from other modules of CS200 suggest that this form of vegetated riparian strip is also associated with reduction of botanical diversity. Management procedures for "buffer zones" that consolidate the improvement of in-stream conditions, without reducing the diversity of streamside vegetation, are desirable.

Three research programmes are proposed, in order to examine the results of CS200 in more detail. These are:

- How is the improvement in the quality of freshwater habitats related to management, use and structure of the river corridor and adjacent catchment land cover?

- How can the multiple sources of ecological information collected during CS2000 be best used to indicate the nutrient status of small watercourses?

- How are changes in the biological condition of upland streams related to changes in land management and climate?

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1 INTRODUCTION

1.1 Background

1.1.1 The principles of Countryside Surveys

The Countryside Surveys are inventories of the state of the British landscape and of the diversity of the flora and elements of the fauna, which it supports.

They are designed to provide detailed information about the habitats and landscape features that are important elements of the countryside. They provide estimates of the 'stock' of these resources, and where they are to be found, and give insights into their condition based on the variety and abundance of the plant species associated with them. Using information from previous surveys, an understanding can be gained of how the stock and condition of these habitats and landscape features are changing over time. From this, a balance sheet or an account of natural assets in the UK countryside can be developed.

1.1.2 The history of Countryside Surveys

The 1978 Survey of Great Britain

The first national survey in the series that is now generically entitled Countryside Surveys was undertaken in 1977 and 1978 (abbreviated to 1978 in subsequent text) and was an internally funded research programme of the Institute of Terrestrial Ecology (ITE).

The 1984 Survey of Great Britain

The second survey, again funded by the ITE, was carried out in 1984.

The 1990 Countryside Survey of Great Britain

It was the 1990 survey that attracted the title Countryside Survey. This programme, known in full as Countryside Survey 1990 (CS1990), had a more complex funding arrangement involving a primary partnership between ITE and IFE (representing the Natural Environment Research Council - NERC) and the Department of the Environment (DOE). Additional funding, for specific elements of the overall programme was supplied by the National Rivers Authority, British National Space Centre, the Department of Trade and Industry and the Nature Conservancy Council. The findings of this survey are summarised in Barr *et al.* (1993).

The Countryside Survey of Northern Ireland

In 1986, a similar form of Countryside Survey was first introduced into Northern Ireland. This was conducted by the University of Ulster, on behalf of the Department of the Environment (Northern Ireland) and has been reported upon by Murray *et al*. (1992) and by Cooper *et al.* (1997).

The 1998 Countryside Survey of Great Britain

The most recent field survey, of which this document forms part of the reporting process, was conducted in 1998 and 1999. The major findings of the survey were first published in 2000 in the form of a "launch report" entitled "Accounting for Nature: assessing habitats in the UK countryside" (Haines-Young *et al.* 2000).

In the knowledge that publication would take place in the millennial year the 1998 survey was named **Countryside Survey 2000** and commonly abbreviated to **CS2000**.

Countryside Survey 2000 was primarily funded by the Natural Environment Research Council (NERC) and a consortium of government departments and agencies that included the Department of the Environment, Transport and the Regions (DETR), the Ministry of Agriculture, Fisheries and Food (MAFF), the National Assembly for Wales, the Scottish Executive, the Environment Agency, Scottish Natural Heritage (SNH) and the Countryside Council for Wales (CCW). It was undertaken on their behalf by NERC's Centre for Ecology and Hydrology (CEH).

The 1998 Countryside Survey of Northern Ireland

As in 1990, the 1998 survey of Great Britain was matched by an equivalent survey in Northern Ireland. This was now formally entitled Northern Ireland Countryside Survey 2000 (NICS2000). This was sponsored by the Environment and Heritage Service (Northern Ireland), whilst the Department of Agriculture and Rural Development for Northern Ireland contributed additional funding in support of the production of a satellite imagery based land cover map of Northern Ireland.

1.1.3 Freshwater studies in Countryside Surveys

Neither of the first two Countryside Surveys, of 1978 and 1984, included studies of the aquatic fauna of fresh waters. Attention was merely paid to the stock of freshwater features, including numbers of ponds and larger standing water bodies, and to the flora of the streambank and the associated additional in-stream aquatic plants.

The involvement of the National Rivers Authority in the 1990 survey of Great Britain heralded the introduction of studies of aquatic fauna into Countryside Surveys. In this survey these studies were primarily of the macro-invertebrate fauna of watercourses, although an associated study of the fauna, and particularly the aquatic Coleoptera, of standing water bodies was also undertaken. However, no freshwater studies were included in the Northern Ireland version of the survey.

The principal reported findings of the running-water studies in CS1990 were:

- clear, progressive and inter-linked changes occurred in the environmental features and faunal composition of sites passing from upland, through upland marginal and pasture to arable landscapes.
- upland and upland marginal sites were least prone to visible human influences and visible signs of organic pollution were most frequent in pastural landscapes but sites in arable landscapes had the highest frequency of occurrence of channel modifications such as bank maintenance, weed cutting, channel straightening, dredging and construction of weirs
- the poorest ecological quality, as determined by RIVPACS, occurred at sites in arable landscapes with successive improvements through pastural and marginal uplands to upland sites.
- when only sites of good ecological quality were considered, the highest biodiversity occurred in arable sites which were marginally richer than those in pastural landscapes but biodiversity decreased markedly in marginal upland sites and again between marginal upland and upland sites.

The aquatic macro-invertebrate sampling undertaken in 1990 was repeated in 1998 and further extended to include River Habitat Surveys (Raven *et al*. 1997) and indicative chemical surveys. Other sampling (see Section 2.2.3) was also undertaken on a voluntary basis, by CEH but the results of these additional surveys have not yet been analysed. No sampling of the fauna of standing water bodies occurred in 1998 but streamside botanical sampling and stock assessment of the freshwater Broad Habitats, including numbers of ponds, were retained as important components of the survey. An additional survey of lowland ponds, which included botanical and water quality assessements, also took place in 1996 (Williams *et al.* 1998).

Once again the Northern Ireland survey was conducted by the University of Ulster and, like the 1990 survey, contained no studies of the freshwater fauna.

In the current thematic freshwater report, attention is paid to the results of the freshwater studies in CS2000 and to the changes that have taken place in the period between the last two surveys, CS1990 and CS2000, the only ones to include freshwater faunal studies. Its scope of reference includes the aquatic invertebrate fauna and the condition of the river corridor (River Habitat Surveys).

The condition of the streamside flora is reported upon in separate thematic reports on the flora of the wider countryside (CEH in preparation). Information on the stock of aquatic Broad Habitats, including numbers of ponds, is also published separately (CEH in preparation).

1.2 Objectives

The overall objectives of Countryside Survey 2000 are:

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Within these overall objectives, a sub-set of more detailed objectives have been developed for the survey of freshwater habitats. These are as follows:

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- to provide information on the status and distribution of the macro-invertebrate fauna of streams and rivers in Great Britain.
- to determine and evaluate change by comparison with 1990 survey data relating to the same sites
- to determine the habitat structure and degree of modification of river corridors
- to undertake a limited diagnostic survey of the chemical character of the watercourses to help interpret the results of macro-invertebrate and river habitat surveys
- to investigate the relationship between the habitat quality and modification of river corridors, the ecological quality of the watercourse and the condition of the surrounding countryside

- to derive indicators relating to status and change in watercourse and river habitat quality

1.3 Policy Context

1.3.1 General

The two most recent Countryside Surveys, CS1990 and CS2000 were designed to inform Government departments and their agencies, Non-Governmental Organisations and others involved in the formulation of countryside strategies and policies. They offer a mechanism for government to assess the effectiveness of current policies for managing the countryside and for shaping the policies for the future.

For example, the results of the 1990 Countryside Survey, indicated that 49,000km (± SE 12,000km) of hedgerows in Great Britain had been lost between 1984 and 1990. This information was provided to government in advance of the summary report (Barr *et al.* 1993) and was critical to the development of policies to protect hedges and encourage their management.

Subsequently, departments have started to use Countryside Survey data to help fulfil obligations in relation to:

- UN Rio Declaration and Agenda 21 UK Sustainable Development Strategy (UK Government 1994a); Indicators of Sustainable Development (1996)
- UN Convention on Biological Diversity (Biodiversity: The UK Action Plan (UK Government 1994); UK Biodiversity Steering Group Report (UK Biodiversity Steering Group 1995); Species/Habitat Actions Plans)
- EU Reform of Common Agriculture Policy (Agri-environment schemes, ESA's, Countryside Stewardship)
- UK Environment White Paper 1990
- UK Rural White Papers of 1995 and 1999.

1.3.2 DEFRA policy relevance

The UK Sustainable Development Strategy, at the time of the 1998 survey, incorporated the following aims, objectives and indicators, as abstracted from the contemporary DETR website:

wwwdetr.gov.uk/environment/epsim/indics/isdtheor.htm [8th May 2001]

<table>
<tr><th>Broad aims</th><th></th><th>Key objectives and issues</th><th>Key indicators</th></tr>
<tr><td rowspan="4">Damage to the carrying capacity of the environment and the risk to human health and biodiversity from the effects of human activity should be minimised.</td><td>Freshwater quality</td><td>To sustain and improve water quality and the aquatic environment.

Surface water and groundwater quality
Control of pollution
Waste water treatment
Recreational use of water</td><td>River quality - chemical and biological
Nitrates in rivers and groundwater
Phosphorus in rivers
Pesticides in rivers and groundwater
Pollution incidents
Pollution prevention and control
Expenditure on water abstraction, treatment and distribution
Expenditure on sewage treatment</td></tr>
<tr><td>Wildlife and habitats</td><td>To conserve as far as reasonably possible the wide variety of wildlife species and habitats in the UK, and to ensure that commercially exploited species are managed in a sustainable way.

Extent and quality of habitats
Populations and ranges of key species</td><td>Native species at risk
Breeding birds
Plant diversity in semi-improved grassland
Area of chalk grassland
Plant diversity in hedgerows
Habitat fragmentation
Lakes and ponds
Plant diversity in streamsides
Mammal populations
Dragonfly distributions
Butterfly distributions</td></tr>
<tr><td>Land cover and landscape</td><td>To protect the countryside for its landscape and habitats of environmental value while maintaining an efficient supply of good quality food and other products.

Rural land cover
Protection of landscape and habitats of environmental value
Agricultural productivity
Nitrogen and pesticide usage.
Land management.</td><td>Rural land cover
Designated and protected areas
Damage to designated and protected areas
Agricultural productivity
Nitrogen usage
Pesticide usage
Length of landscape linear features
Environmentally managed land</td></tr>
<tr><td>Soil</td><td>To protect soil as a limited resource for the production of food and other products and as an ecosystem for vital organisms.</td><td>Soil quality
Heavy metals in topsoils</td></tr>
</table>

Since then, the data have also provided the basis of two of the Government's Quality of Life Counts indicators that are used as metrics for assessing progress towards sustainable development in the UK (Government Statistical Service 1999, Haines-Young *et al.* 2000).

The following objectives and indicators provide a sub-set of the DETR's Quality of Life Counts, relating to their Sustainable Development Strategy (SDS), for which Countryside Surveys have immediate relevance. They have been abstracted from http://www.sustainable-development.gov.uk/sustainable/quality99/annexa.htm [22nd[th] October 2002]. Objectives and indicators for which the freshwater module of Countryside Surveys have special relevance are given in bold.

Objective	**Ref no.**	**Indicators**
Landscape and wildlife		
Reverse the long-term decline in populations of farmland and woodland birds	H13	Populations of wild birds
	S3	**Trends in plant diversity**
Reverse the decline in UK wildlife and habitats	S4	**Biodiversity action plans**
Protection for individual landscape features such as hedges, dry stone walls and **ponds**	S5	**Landscape features -** hedges, stone walls and **ponds**
Protecting the wider landscape	S7	Countryside quality
Contextual indicator	S9	Native species at risk
Freshwater		
Improving river quality	H12	**Rivers of good or fair quality**
	Q1	**Nutrients in water**

1.3.3 Environment Agency policy relevance

The Environment Agency also set out a number of long term objectives for providing a better environment (Environment Agency 2001). Information collected during Countryside Surveys can contribute to this process.

The results of the freshwater module of CS2000 are most relevant to the following objectives. The intended outcomes and summary strategy for delivery of these objectives are are also given.:

Long-Term Objective:

- Habitats will improve in their extent and quality to sustainable levels for the benefit of all species
- Everyone will understand the importance of safeguarding biodiversity

The outcomes* [the Environment Agency] *will help achieve:

- Degraded habitats, especially rivers, estuaries and wetlands, will have been restored
- Wildlife corridors and their associated habitat will be of high quality, with no artificial barriers to wildlife movement
- The UK's Biodiversity Action Plan will have been successfully delivered and priority species will no longer be under threat
- Rivers, estuaries, lakes and canals will all support appropriate fish communities.
- Urban and rural land-use practices will encourage the protection and restoration of habitats, species and natural processes
- The management of land for wildlife and landscape benefits will be accepted and supported as a normal activity of rural life.

What the Agency will do:

- The Agency will ensure that its activities and those it authorises do not threaten key species and habitats
- It will work with many partners at local, regional and national levels to safeguard and enhance biodiversity

LONG-TERM OBJECTIVE:

- Our rivers, lakes and coastal waters will be far cleaner
- They will sustain diverse and healthy ecosystems, water sports and recreation such as boating and fishing, and those uses needed by a thriving and healthy community

The outcomes* [the Environment Agency] *will help achieve:

- The causes of water pollution, eutrophication, and acidification will have been fully controlled
- Surface waters will sustain a diverse variety of habitats and wildlife

What the Agency will do:

- The Agency will work to clean up polluted waters and to reduce the risk of further pollution

1.3.4 Scottish Natural Heritage policy relevance

The Scottish Natural Heritage's corporate strategy, "A Natural Perspective" as previously published on their website: www.snh.org.uk/about/ab-frame.htm. [8th May 2001], includes many specific objectives whose achievement may be promoted by the information gathered during Countryside Survey. Of particular relevance to the freshwater module of Countryside Surveys is the aim "to achieve a strategic and catchment-based approach to fresh waters which safeguards features of interest, restores ecological functions, and fosters sustainable use and recreational pursuits".

1.3.5 Other policy applications

Other applications of the results of Countryside Surveys (Haines-Young *et al.* 2000) are assisting in the design and evaluation of agri-environment schemes and, in the context of climate change evaluations, for helping calculate levels of carbon storage in ecosystems.

2 METHODS

2.1 The General Approach

2.1.1 The forms of survey

CS2000 can be divided into two complementary forms of data collection: field survey and satellite imagery (Figure 2.1). Only the former is of immediate relevance to the current report and no further information on remotely-sensed data will be given here.

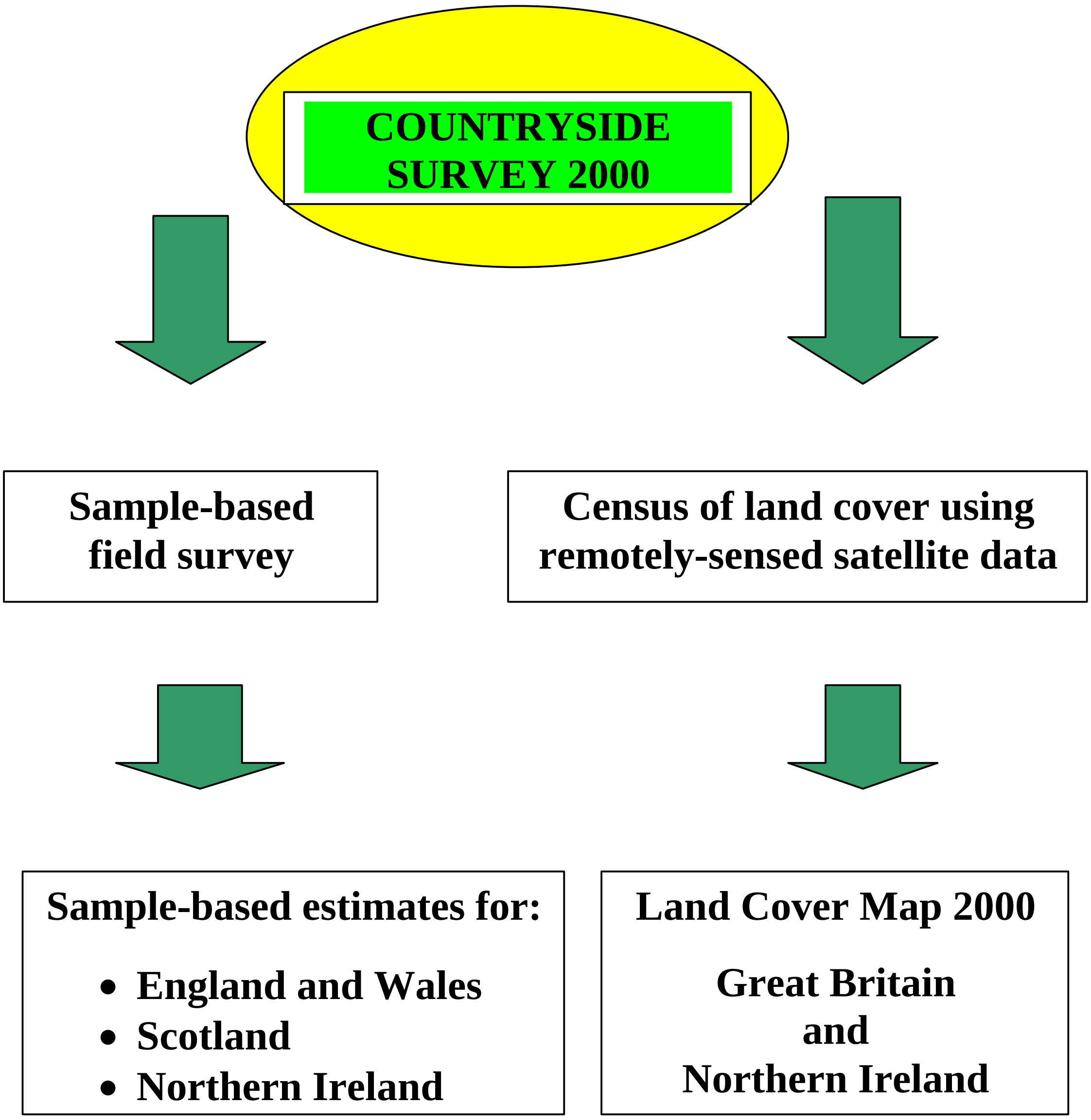

Figure 2.1 The overall structure of the survey

2.1.2 The ITE Land Classification

The sample-based component of the survey relies on the division of Great Britain into a series of 40 land classes (Haines-Young *et al.* 2000). These classes were developed by ascribing attribute values to a series of geographical, climatic, geological and edaphic entities for each 1km square in GB that is wholly or partially comprised of land.

The Land Classification of Great Britain was initially developed by ITE for their 1978 survey and other research programmes. The first classification comprised 32 distinct end groups (land classes). Classification was achieved by Two-way Indicator Species Analysis (TWINSPAN). The initial classification was modified for CS1990 and this classification was subsequently further amended and extended prior to CS2000.

The CS2000 re-classification ensured that each of the 40 new land classes was entirely confined to a single country. This allowed sample-based estimates of single country land cover data to be derived entirely from data collected within that country. This had not been possible before CS2000.

2.1.3 The CS2000 Environmental Zones

In order to present a less complex structure than individual land classes for reporting on CS2000, the 40 classes were aggregated into a series of six Environmental Zones (Figure 2.2). Of these zones, three were exclusively in Scotland and the other three covered the combined area of England and Wales. Northern Ireland is represented by a single, seventh environmental zone for reporting at the UK level.

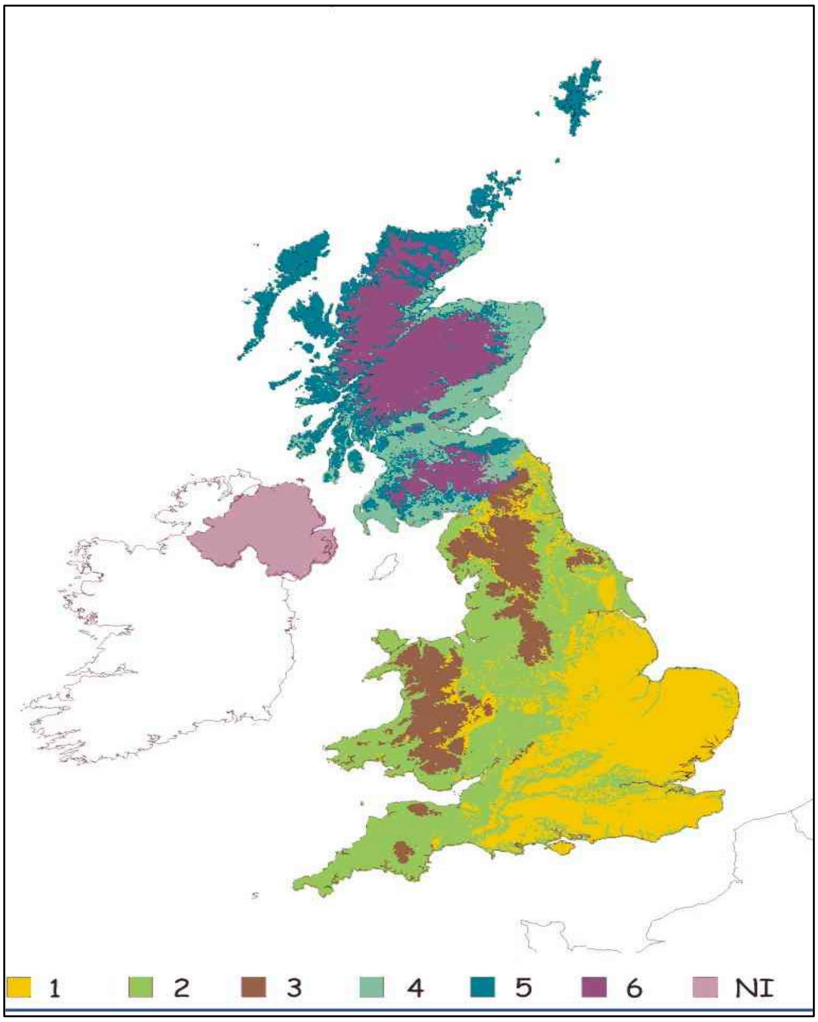

Figure 2.2 The seven CS2000 environmental zones of the United Kingdom

Although it is difficult to find simple names to define these mathematically derived environmental zones (i.e. aggregates of land classes), Haines-Young et al. (2000) developed the following approximate terms:

Environmental Zone	1	Easterly lowlands of England and Wales
Environmental Zone	2	Westerly lowlands of England and Wales
Environmental Zone	3	Uplands of England and Wales
Environmental Zone	4	Lowlands of Scotland
Environmental Zone	5	Intermediate uplands and islands of Scotland
Environmental Zone	6	True uplands of Scotland
Environmental Zone	7	Northern Ireland

2.1.4 The CS2000 Country Units

Although a primary framework for reporting on CS2000, the Environmental Zones represent just one possible approach to sub-dividing the United Kingdom for analytical purposes.

Another of the many approaches, and one commonly used in this document, is country-level reporting. In this approach, because of the relatively few samples collected in Wales, England and Wales are treated as a single unit, with Scotland and Northern Ireland then each treated independently. These three administrative areas are termed "Country Units" in the following text.

2.1.5 The UK Biodiversity Action Plan (BAP) Broad Habitats

In the light of the importance of the UK Biodiversity Action Plan (BAP), and the Government's requirement to report on biodiversity at the turn of the Millennium, the results of CS2000 are also being presented in terms of the system of BAP Broad Habitats (Table 2.1).

Table 2.1 A list of the BAP Broad Habitats included in Countryside Survey 2000 and the Northern Ireland Countryside Survey 2000

Arable and horticultural	Calcareous grassland	Inland rock
Improved grassland	Acid grassland	Standing water and canals
Neutral grassland	Bracken	Rivers and streams
Boundary and linear features	Dwarf shrub heath	Built-up areas and gardens
Broadleaved, mixed and yew woodland	Fen, marsh and swamp	*Supralittoral rock*
	Bog	*Supralittoral sediment*
Coniferous woodland	Montane habitats	*Littoral sediment*

This report presents the data collected on just one of these Broad Habitats, "Rivers and Streams". Further information on botanical plots surveyed in 10m long by 2m wide quadrats, laterally centred on the stream/bank interface of "Rivers and Streams", and on the standing stock and changes in stock of "Standing Water and Canals" is given in other thematic reports (CEH in preparation).

2.1.6 The Rivers and Streams Broad Habitat

The summary definition of the Rivers and Streams Broad Habitat is "rivers and streams from bank top to bank top; where there are no distinctive banks or banks are never overtopped, it includes the extent of the mean annual flood. This includes the channel that may support aquatic vegetation and water fringe vegetation".

2.2 The Freshwater Sampling Programme

2.2.1 Strategy for training and surveying

Eight casual and four full-time employees of IFE were therefore trained to undertake freshwater surveying. Each was already accredited as a River Habitat Survey (RHS) surveyor and had had previous experience of the collection of water samples for analytical purposes. However, none of these surveyors had previous experience of macro-invertebrate sampling. Their additional training comprised a one-week course organised by IFE and held at its Dorset River Laboratory between 1st and 5th June 1998.

The training received in aquatic macro-invertebrate sampling was identical in theory to that received by the surveyors responsible for macro-invertebrate sampling in the 1990 survey. Each course was of the same duration and content as that provided in 1990 and was supervised and directed by the same, widely experienced NERC staff member. The previous lack of experience of macro-invertebrate sampling was common to both the 1990 and 1998 surveyors. The teams of surveyors and their experience and training were considered to be well matched in the two surveys.

Two additional IFE staff members, with no previous experience of aquatic macro-invertebrate sampling, later joined the survey teams, largely to ensure double-manning for health and safety purposes. Neither of these surveyors undertook RHS but each assisted with supervised biological sampling after receiving appropriate training from the other surveyors.

Surveyors were each issued with a freshwater survey field handbook (Furse *et al*. 1998) outlining the techniques used during the study and other issues of relevance.

2.2.2 Site Selection

The agreed work programme was that a freshwater survey would be carried out in each of 508 survey squares from Countryside Survey 1990, plus any additional squares selected for CS2000, that were known, or believed, to have a perennial or intermittent flowing watercourse of an appropriate size (see below).

Additional squares included:

- thirty squares selected by NERC and the other project sponsors for improving single country estimates
- replacement squares for two squares previously sampled on the Isle of Man in 1990, but excluded from the 1998 survey for logistical reasons
- thirty squares selected by NERC and MAFF for obtaining improved information on upland squares.

Subsequently, ITE were obliged to replace four of the selected squares where access to all or most of the square was refused. Thus, in total ITE considered 572 squares for potential sampling. Of these, funding for the additional upland squares was provided by MAFF and made no provision for freshwater sampling.

Thus, 542 squares were considered for freshwater sampling. These included 361 squares that had been successfully sampled for aquatic macro-invertebrates in CS1990.

The features of each of the remaining 181 squares were examined on Ordnance Survey maps at the 1:10,000 and 1:50,000 scale. Any square without a marked watercourse on both maps was presumed to be permanently dry. Eliminating these squares left a total of 432 squares that were earmarked for potential freshwater surveying.

Sampling sites on the 361 streams sampled successfully for aquatic macro-invertebrates in 1990 were retained at the same location for CS2000.

In each of the 71 squares that would potentially be sampled for the first time in 1998, the policy for selecting the exact site location was the same as in 1990:

- streams and rivers were sampled in preference to drains, ditches and canals
- drains were sampled in preference to ditches and canals
- ditches were sampled in preference to canals
- third order watercourses were sampled in preference to second order which, in turn had priority over first order

Successively higher order streams (Strahler 1957), where third order is higher than second order etc., are increasingly less frequent than lower orders and this site selection policy therefore tended towards greater equalisation of the number of sites sampled in each order. Streams in excess of third order tend to be deep and potentially unsafe. These were not sampled for health and safety reasons.

The locations of sites in the 71 squares were chosen to maximise the length of River Habitat Survey that could be conducted within the survey square but, within this constraint, to be as close as feasible to the watercourse’s exit point from the square. This tended to maximise the amount of the site’s catchment which lay within the borders of the square and whose land cover was surveyed by ITE.

The 572 squares considered for surveying by ITE were divided into the following categories for the purposes of the freshwater survey:

Flowing watercourse suitable for biological sampling and RHS:	WET
Dry watercourse suitable for River Habitat Survey only*	DRY
Abandoned square with a suitable watercourse for sampling	ABANDONED
Square without any suitable watercourses for sampling	NO STREAM
Square excluded from freshwater survey for various reasons	EXCLUDED

* River Habitat Surveys were carried out at dry sites in 1998 only

The number of squares that fell into each combination of categories for the two survey years (Table 2.2).

Table 2.2 The freshwater module status of the 572 squares incorporated, or considered for surveying by ITE in CS2000.

1998 STATUS	NUMBER OF SQUARES
Wet	404
Dry	21
No stream	104
No stream	4
Abandoned	6
Excluded	33

An abandoned square (Table 2.2) is one in which access is wholly or substantially denied by landowners Exclusions were due to either contractual reasons (i.e. MAFF upland squares) or because the squares were late substitutions in the 1998 terrestrial survey whose selection by ITE was not notified to IFE.

The table (2.2) shows that 425 of the 432 squares containing suitable watercourses were successfully sampled (= 404 “wet” + 21 “dry”). Of the remaining seven squares, six were abandoned because of access difficulties. Three of these were in Scoland and three in England and Wales. The seventh abandoned square was in Wales. It contained a single stream that was flowing in 1990 but which had since been land-filled and no longer existed.

Each of these 425 sites was subject to a River Habitat Survey, irrespective of whether the stream was “wet” or “dry”. Furthermore, each of the 404 “wet” sites was also successfully sampled for aquatic macro-invertebrates.

The relative numbers of sites that were “wet” in 1990 but “dry” in 1998 (3), compared to the number that were “dry” in 1990 but “wet” in 1998 (23) suggests that climatic conditions in 1998 were wetter, or had recently been wetter, than for equivalent conditions in 1990. Closer examination, however, revealed that all “dry” sites in either year were in England and Wales. Any conclusions regarding differential climatic conditions in the two years that can be inferred from comparative instream flow conditions must therefore exclude Scotland.

2.2.3 The components of the freshwater sampling programme

The contractual freshwater sampling programme contained three components:

- Component 1 A survey of macro-invertebrate assemblages
- Component 2 River Habitat Surveys
- Component 3 An indicative chemical survey

In addition the following types of unfunded samples were collected by CEH on an opportunistic basis. They have not been analysed and are not reported on here:

- Component 4 A survey of diatom assemblages
- Component 5 A survey of chironomid pupal exuviae assemblages
- Component 3 A survey of instream aquatic macrophyte assemblages

Each of these types of survey was attempted in each square with a suitable watercourse (see Section 2.2.2). Biotic samples (components 1, 4, 5 and 6) were only collected at flowing sites and pupal exuviae (component 5) were only collected where the suitable floating debris and scum required for sampling were present. The sampling programme is shown in graphic form in Figure 2.3.

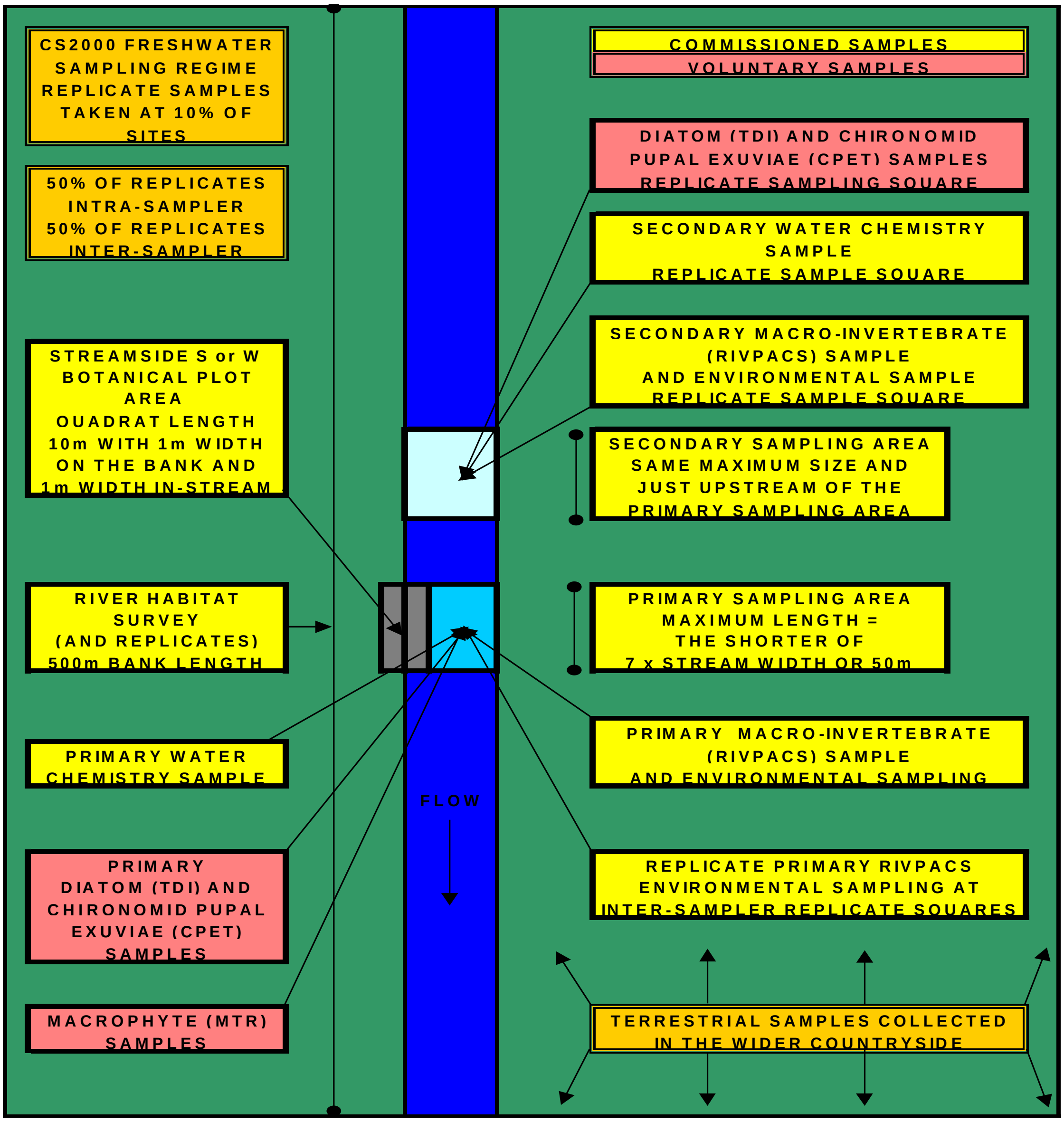

Figure 2.3 **The freshwater sampling programme in each CS2000 square with a suitable flowing watercourse [Note: River Habitat Surveys were also undertaken along dry watercourses.]. See internal figure text boxes for further details.**

At 10% of sites replicate macro-invertebrate, diatom, chironomid pupal exuviae and chemical sampling was undertaken but not macrophyte sampling or River Habitat surveys. Replicate sites were divided into two types:

Type 1 Intra-sampler variation: The same sampler takes macro-invertebrate, diatom, chironomid pupal exuviae and chemical samples at both the primary and secondary sites and records RIVPACS environmental variables at each.

Type 2 Inter-sampler variation: A different (primary) sampler takes the macro-invertebrate, diatom, chironomid pupal exuviae and chemical samples at the primary site to the (secondary) sampler who undertakes these collections at the secondary sites.

The primary sampler records RIVPACS variables at the primary site. The secondary sampler records RIVPACS variables at both sites. At the primary site the two sets of RIVPACS variable values can be compared. At the secondary site, the RIVPACS variable values are used only for RIVPACS invertebrate predictions.

River Habitat Survey audits (repeat surveys) were conducted at 7% of survey sites but these sites were not the same set used for other replicate sampling. No replicate aquatic macrophyte sampling was undertaken.

2.2.4 Freshwater sampling protocols

Macro-invertebrate sampling

The macro-invertebrate sampling protocols are those standard national techniques adopted by the Environment Agency, Scottish Natural Heritage, the Department of The Environment (Northern Ireland), the Centre for Ecology and Hydrology and others in connection with the use of RIVPACS. Full details of these protocols are provided by Murray-Bligh *et al.* (1997) and are summarised in the CS2000 Field Manual for sampling freshwater habitats (Furse *et al.* 1998). Brief details of these techniques are given in the following paragraph but the reader is referred to Murray-Bligh *et al.* (1997) for a full understanding of the protocols used.

The *sample area* in each stream, from which aquatic macro-invertebrates were collected for CS2000, was a single area of stream-bed whose major habitat types can be sampled within the recommended sampling period of 3 minutes of active sampling supplemented, where circumstances permit, by two forms of manual search (Figure 2.4). This area normally varied from 5 to 15m according to stream width. Each sample was collected using a standard FBA pond-net of the type provided.

The objective of sampling was to obtain the widest range of animals possible from within the sample area by sampling all accessible habitats in proportion to their relative areas of cover (Figure 2.4). Note that, because pond-netting was used for all sample collecting, main sampling method C varies from that given in their Figure 6.1 by Murray-Bligh *et al.* (1997).

On completion of sampling, the sample was emptied into a medium gauge, 18" x 12" polythene bag as provided. Forty per cent formalin solution was added to the sample bag until the fluid in the bag was equivalent to 4% aqueous formaldehyde. Samples were returned to the Centre of Ecology and Hydrology’s (formerly Institute of Freshwater Ecology) Dorset laboratory for standard sorting and identification by a small team of suitably experienced and qualified staff.

1st part: MANUAL SEARCH

Seek and collect individual animals from the water surface.

Spend a total of 1 minute on the manual search, split between parts 1 and 3

?

2nd part: MAIN SAMPLE

Collect by either A, B or C

A - shallow/wadeable

3 minute active pond-net sample collected by a combination of kicking and sweeping, depending on the nature of the substratum, current and habitats, for benthos and free-swimming animals.

All habitats sampled in proportion to their cover.

B - too deep to kick sample whole site, but possible to sample at least some of the main channel with a long handled pond-net

3 minute active pond-net sample collected by a combination of kicking and sweeping for benthos and free-swimming animals.

Attempt to sample all habitats in proportion to their cover, although this may not be possible for habitats in the main channel

C - impossible to sample material from the main channel using a long-handled pond-net

3 minute sweep with pond-net to collect free-swimming animals and those from vegetation, *but not the benthos*.

?

3rd part: MANUAL SEARCH

Search and collect individual animals from submerged rocks, logs or vegetation.

Spend a total of one minute on the manual search, split between parts 1 and 3

Figure 2.4 Summary of the CS2000 macro-invertebrate sampling procedures (modified from Murray-Bligh *et al*., 1997).

Environmental data

At each site at which biological sampling was undertaken, a suite of environmental data was collected using the standard protocols outlined by Murray-Bligh *et al.* (1997). These field-measured data were complemented by a series of additional items of information on each site derived either from maps or from procedures contained within RIVPACS. Once again, the reader is referred to this manual for full details of the information collected and the manner of collection. The data collected comprised the following:

Time invariant (map based data)	**Time variant (field-measured data)**
Latitude	Stream width
Longitude	Stream depth
Mean air temperature	Mean particle size (of the stream bed)
Air temperature range	% cover of boulders & cobbles
Altitude	% cover of pebbles & gravel
Distance from source	% cover of sand
Slope	% cover of silt and clay
Discharge or velocity	

Chemical sampling

A single chemical sample was taken at each site at which biological sampling was undertaken. Replicate chemical samples were collected from most sites where replicate biological sampling was undertaken (see Figure 2.3). Chemical analyses were undertaken by CEH using standard laboratory protocols. The following determinands were analysed for: pH, total alkalinity, conductivity and soluble reactive phosphate.

RIVPACS

RIVPACS is a software package used to evaluate the biological condition of watercourses based on their aquatic macro-invertebrate assemblages (Wright *et al*. 1993). It is a standard procedure adopted by the Environment Agency and the Scottish Environment Protection Agency for national surveys of the biological condition of rivers.

In order to apply RIVPACS macro-invertebrate and environmental data are collected and analysed using standard field and laboratory procedures described above. In addition to these the RIVPACS prediction option used in CS2000 also utilised the total alkalinity data collected from each site.

The taxa collected in a sample are used to generate a set of biotic indices using a system known as the BMWP (Biological Monitoring Working Party) System (Armitage *et al.*

1983). In this system each family of invertebrates is scored according to tolerance to environmental stress. The two most commonly used forms of BMWP indices are the total number of scoring taxa present (NTaxa) and the average individual score of the taxa present (ASPT or Average Score Per Taxon).

RIVPACS uses a set of reference sites to predict the expected BMWP index values from knowledge of the recorded environmental conditions at a site. The reference sites were chosen to represent, as far as possible, the best achievable biological conditions at sites of their environmental type. Each set of predictions is site specific.

The ratio of the observed index values and the expected (predicted) values is called the EQI (Ecological Quality Index) (Sweeting *et al*. 1992). EQI's are a measure of the extent to which the fauna of a site matches expectations. A good site has an EQI of about unity. As the biological condition of a site deteriorates, the values of EQI's fall towards zero. From an experimental knowledge of the errors associated with the collection, processing and evaluation of biological and environmental data from sites RIVPACS III+ can be used to evaluate the probability that a site has genuinely improved or declined in quality.

River Habitat Survey

River Habitat Survey (RHS) is an assessment procedure for evaluating the physical structure of freshwater streams and rivers, based on a standard 500m survey section (Environment Agency 1997; Raven *et al*. 1998). Account is taken of both in-stream and riparian features. The technique does not require specialist botanical or geomorphological expertise but consistent recognition of features included on the field proforma is essential. The reader is referred to the Environment Agency field manual (Environment Agency 1997) for full methodological details, which are too complex to provide here. To ensure consistency of recording, all surveyors must be accredited.

Two forms of index are derived from RHS. The first is the Habitat Quality Assessment (HQA), which is a measure of the diversity and suitability of the riverine habitat for biological assemblages. The index is normally expressed as an absolute value but procedures are under development for comparing the observed HQA values with expected values, derived from benchmark (reference) sites, in a manner akin to RIVPACS. HQA values increase with increasing habitat quality.

The second index is the Habitat Modification Score (HMS), which is a measure of the extent that the natural characteristics of the survey section have been modified by man. An HMS value of zero indicates no significant anthropogenic modification. HMS values increase with increasing levels of modification.

RHS is a standard procedure adopted by the Environment Agency and the Scottish Environment Protection Agency for national surveys of river habitat quality.

Other procedures

In addition to the contracted sampling, diatoms, chironomid pupal exuviae and aquatic and riparian macrophytes (including mosses) were also taken on the same day as the macro-invertebrate sample was collected in a square. Macrophyte samples were collected for Mean Trophic Rank (MTR) analyses and mosses were collected for trace metal analyses.
These data can be used to categorise the environmental quality of the sites using standard Environment Agency procedures. Samples and data have been retained but not analysed and represent an important, unrealised resource.

The data potentially available are particularly useful for detecting the biological impact of acidification and eutrophication. Each of these floral and faunal groups can be used to assess the biological condition of watercourses using the respective techniques of TDI, (Kelly 1998), MTR (Holmes *et al*. 1999) and CPET (Wilson 1996), as outlined in Furse (1998).

The sampling timetable

Sampling began on the 15th June 1998, one week after the completion of the training course. Macro-invertebrate, River Habitat Survey (RHS) and chemical samples were each taken on the single day that each survey square was visited. Replicate macro-invertebrate and chemical samples were taken on the same day. RHS audits, including additional chemical sampling, were undertaken on a later date at selected sites.

The sampling was undertaken between week one (starting on 15th June) and week 24 (starting on 16th November) with just a few squares sampled in weeks 25 and 26 (Figure 2.5). The pace of surveying was generally dictated by the rate achieved by the terrestrial surveys, since the agreed ITE/IFE strategy was that IFE would not undertake freshwater surveying in a square until ITE's terrestrial surveying had begun or had been completed. The peak of sampling in week 16 followed the release of permission to survey squares in Scotland where sampling had been postponed by ITE. Wet weather and high water levels slowed sampling in November and the last square was surveyed on 1st December, two weeks after the completion of the 1990 surveying on 14th November of that year. Surveying also began earlier in 1990 with the first samples taken on 30th May.

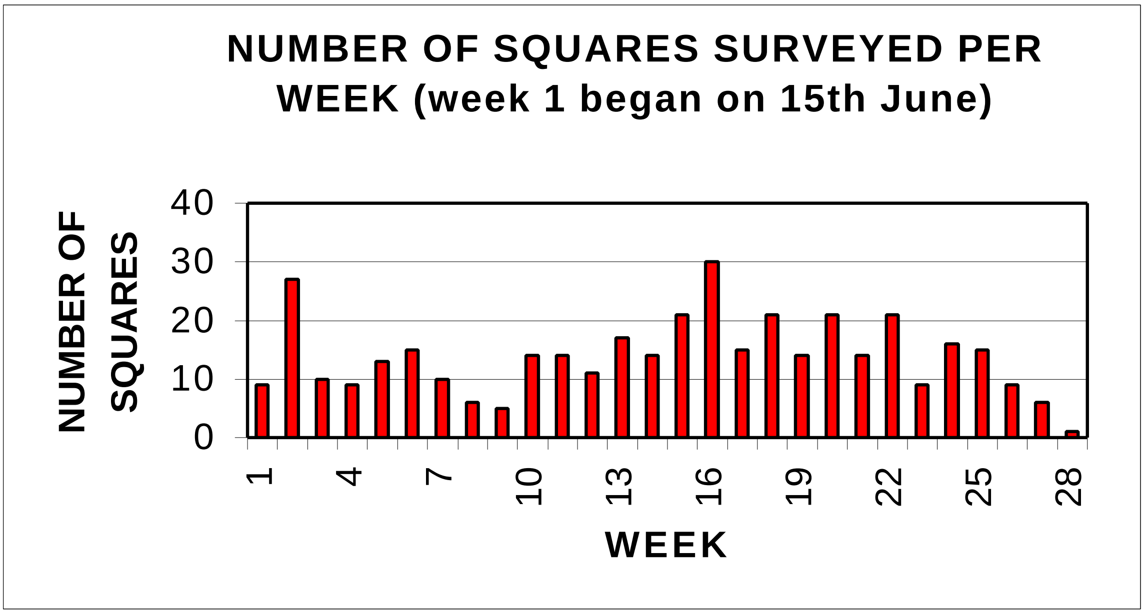

Figure 2.5 **The number of squares surveyed for freshwater habitats, per week, between the week beginning 15th June (week 1) and the week beginning 1st December (week 26)**

Of the 352 squares surveyed for macro-invertebrates in both 1990 and 1998, 48% were sampled within four weeks of each other in the two years (Figure 2.6). The average difference in calendar day number that the 1990 sample was taken and the calendar day number that the 1998 sample was collected was 37. However, because some squares were sampled earlier in 1998 than 1990 and others sampled later in 1998 than 1990 surveying in the latter year was, on average, 16 days later. This resulted from i) the later start and ii) the policy of not beginning freshwater surveys in any square until the terrestrial surveys had either started or, in most cases, was complete.

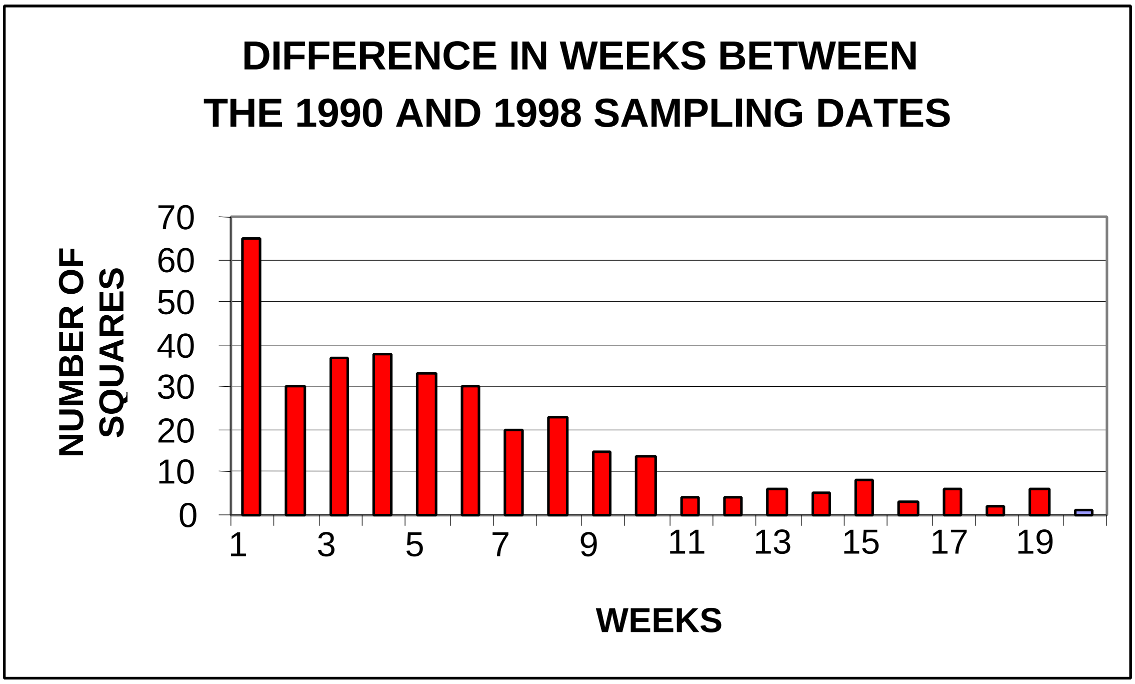

Figure 2.6 **The difference in weeks between the 1990 and 1998 sampling date for squares sampled for macro-invertebrates in both Countryside Surveys.**

Most sites are surveyed in the same calendar season and allow straightforward comparison of biological quality through use of RIVPACS (Wright *et al.* 1993). However, the latest version of RIVPACS, (RIVPACS III+) also allows statistical comparison between samples collected in different seasons (Clarke *et al.* 1999). Variation in species richness between seasons is small but the extensive IFE species level database will provide the background for understanding and compensating for these differences.

3 RESULTS

3.1 Macro-invertebrates

3.1.1 Number of sites

A total of 404 sites were sampled for aquatic macro-invertebrates. With one exception, these sites were approximately evenly distributed across the six environmental zones (EZ's), with 60 ± 5 sites in each (Table 3.1). The single exception was Environmental Zone 2, in which 97 sites were successfully sampled.

Table 3.1 Number of sites sampled per Environmental Zone, altitude classes and country units in CS2000

	EZ1	EZ2	EZ3	EZ4	EZ5	EZ6	England & Wales (EZ's 1-3)	Scotland (EZ's 4-6)	Lowlands (EZ's 1,2 & 4)	Uplands (EZ's 3, 5 & 6)	Great Britain (EZ's 1-6)
Number of sites sampled	64	97	56	60	65	62	217	187	221	183	404

Of the 404 samples, 217 (54%) were in England and Wales and 187 (46%) were in Scotland. The breakdown between the lowland environmental zones (221 sites – 55%) and those in the uplands (183 sites – 45%) was similarly evenly distributed.

In Countryside Survey 1990 (CS1990) a smaller set of 1km squares had been surveyed and 361 squares had been successfully sampled (Barr *et al*. 1993). In total, a matched set of 354 sites were sampled in both 1990 and 1998.

These 354 sites form the basis of the temporal, comparative analyses that are presented in this Section of the report. The breakdown of these matched sites is proportionally quite similar to the full set of CS2000 freshwater sites (Table 3.2), except that disproportionally fewer sites were sampled in England and Wales in general and Environmental Zone 1 in particular.

Table 3.2 Number of matched sites sampled per Environmental Zone, altitude classes and country units in both CS1990 and CS2000

	EZ1	EZ2	EZ3	EZ4	EZ5	EZ6	England & Wales (EZ's 1-3)	Scotland (EZ's 4-6)	Lowlands (EZ's 1,2 & 4)	Uplands (EZ's 3, 5 & 6)	Great Britain (EZ's 1-6)
Number of sites sampled	47	83	47	57	60	60	177	177	187	167	354

3.1.2 Number of taxa

The full range of taxa present in each zone is shown in Appendix 1. This taxon list is non-standardised, meaning that overlapping taxa occur in the list. Overlapping taxa are those in which one taxon name partially incorporates another (e.g. *Planorbis* sp. and *Planorbis carinatus* each occur in the list and *P. carinatus* is a component species of the genus *Planorbis*).

However, for comparative purposes no two overlapping taxa are listed for the same environmental zone, country unit, altitude class or for Great Britain as a whole. These geographic categories will be termed "regions" in the subsequent text. Where, and only where the inclusive taxon is present in one of these 11 geographic regions but not the included taxon, the record of the inclusive taxon is given in parentheses.

Thus the maximum recorded taxon richness of each geographic region can be legitimately compared (Table 3.3).

Table 3.3 The overall taxon richness of each environmental zone, altitude class and country unit in CS2000

	EZ1	EZ2	EZ3	EZ4	EZ5	EZ6	England & Wales (EZ's 1-3)	Scotland (EZ's 4-6)	Lowlands (EZ's 1,2 & 4)	Uplands (EZ's 3, 5 & 6)	Great Britain (EZ's 1-6)
Number of taxa	315	322	201	244	221	180	424	316	423	296	473

The number of taxa per zone, country unit and altitude zone can be increased by adding the taxa found at the 354 matched sites in their 1990 samples but not in samples collected in 1998. These are given in Appendix 2.

These taxa fall into two groups. The first of these are new taxa in major groups that were also identified to "species" level in 1998. The second group is the Oligochaeta and Chironomidae that were identified in detail in 1990 but not in 1998. The full number of distinct taxa found per region in 1990 and/or 1998 are thus shown in Table 3.4.

Table 3.4 **The overall taxon richness of each environmental zone, altitude class and country unit in CS2000. Records of the two bulk taxa, Oligochaeta and Chironomidae were first deleted from the 1998 totals for each region to eliminate over-lapping taxa.**

Data source	EZ1	EZ2	EZ3	EZ4	EZ5	EZ6	England & Wales	Scotland	Lowlands	Uplands	Great Britain
Number of distinct taxa in 1998	313	320	199	242	219	178	422	314	421	294	471
Number of non-Oligochaeta and non-Chironomidae found in 1990 but not found in 1998	11	26	6	15	13	4	32	26	33	21	45
Number of taxa of Oligochaeta in 1990	22	29	17	20	14	12	33	23	35	20	37
Number of taxa of Chironomidae in 1990	49	53	54	44	49	39	73	64	65	64	80
Total number of taxa per region (1990 + 1998)	395	428	276	321	295	233	560	427	554	399	633
Number of contributory samples	111	180	103	117	125	122	394	364	408	350	758

The greatest taxon diversity is exhibited in the three lowland Environmental Zones 1, 2 and 4. Equivalent altitude zones always have higher taxon richness in England and Wales than in Scotland.. Consequently, England and Wales have a greater overall taxon richness than Scotland and lowland zones have greater richness than upland. Intra-comparison of environmental zones, of country units and altitude classes are generally based on similar numbers of samples from each region in the comparison. The exception is Environmental Zone 2, which has considerably more contributory samples and may help explain the higher taxon richness in this zone than in Environmental Zone 1, the other lowland England and Wales zone.

Regional differences in the numbers of taxa can also be expressed by major taxonomic groups (Table 3.5). With the exception of Oligochaeta and Chironomidae, which are treated as two single taxa, the same data can be presented in the form of pie diagrams for each zone, showing the relative numbers of taxa in each of the major groups (Figure 3.1).

Table 3.5 **The number of distinct taxa per environmental zone, altitude class and country unit in CS2000. Values include numbers of Oligochaeta and Chironomidae per geographic region in 1990, the only year in which specimens were fully identified. Values in bold red represent the most taxon-rich environmental zone for the major taxonomic group. Green values indicate the second most taxon-rich.**

TAXON	ENVIRONMENTAL ZONE						REGION				
	1	2	3	4	5	6	ENGLAND & WALES	SCOTLAND	LOWLANDS	UPLANDS	GREAT BRITAIN
Coelenterata	0	0	0	0	0	1	0	1	0	1	1
Tricladida	4	7	4	3	3	3	8	5	7	4	8
Nematomorpha	0	1	0	0	1	1	1	1	1	1	1
Gastropoda	25	25	8	12	12	4	27	14	27	14	27
Bivalvia	10	11	7	6	5	2	12	6	12	7	13
Oligochaeta	1	1	1	1	1	1	1	1	1	1	1
[Oligochaeta 1990]	*22*	*29*	*17*	*20*	*14*	*12*	*33*	*23*	*35*	*20*	*37*
Hydracarina	1	1	1	1	1	1	1	1	1	1	1
Decapoda	0	0	1	0	0	0	1	0	0	1	1
Isopoda	2	2	0	3	2	1	2	3	3	2	3
Amphipoda	6	6	2	3	4	1	7	4	7	5	8
Ephemeroptera	18	17	18	22	17	19	24	27	26	24	29
Plecoptera	12	17	24	20	20	26	25	26	21	26	27
Odonata	15	8	3	4	5	3	15	7	15	6	17
Hemiptera	17	13	3	11	7	3	20	16	22	8	25
Coleoptera	69	63	20	40	41	28	89	62	92	52	105
Megaloptera	3	2	2	2	2	2	3	2	3	2	3
Neuroptera	1	0	0	0	0	0	1	0	1	0	1
Trichoptera	48	59	44	48	48	41	72	61	70	60	80
Lepidoptera	1	1	0	1	1	0	1	1	1	1	1
Diptera	71	79	57	62	47	41	103	72	102	73	110
[Chironomidae 1990]	*49*	*53*	*54*	*44*	*49*	*39*	*73*	*64*	*65*	*64*	*80*

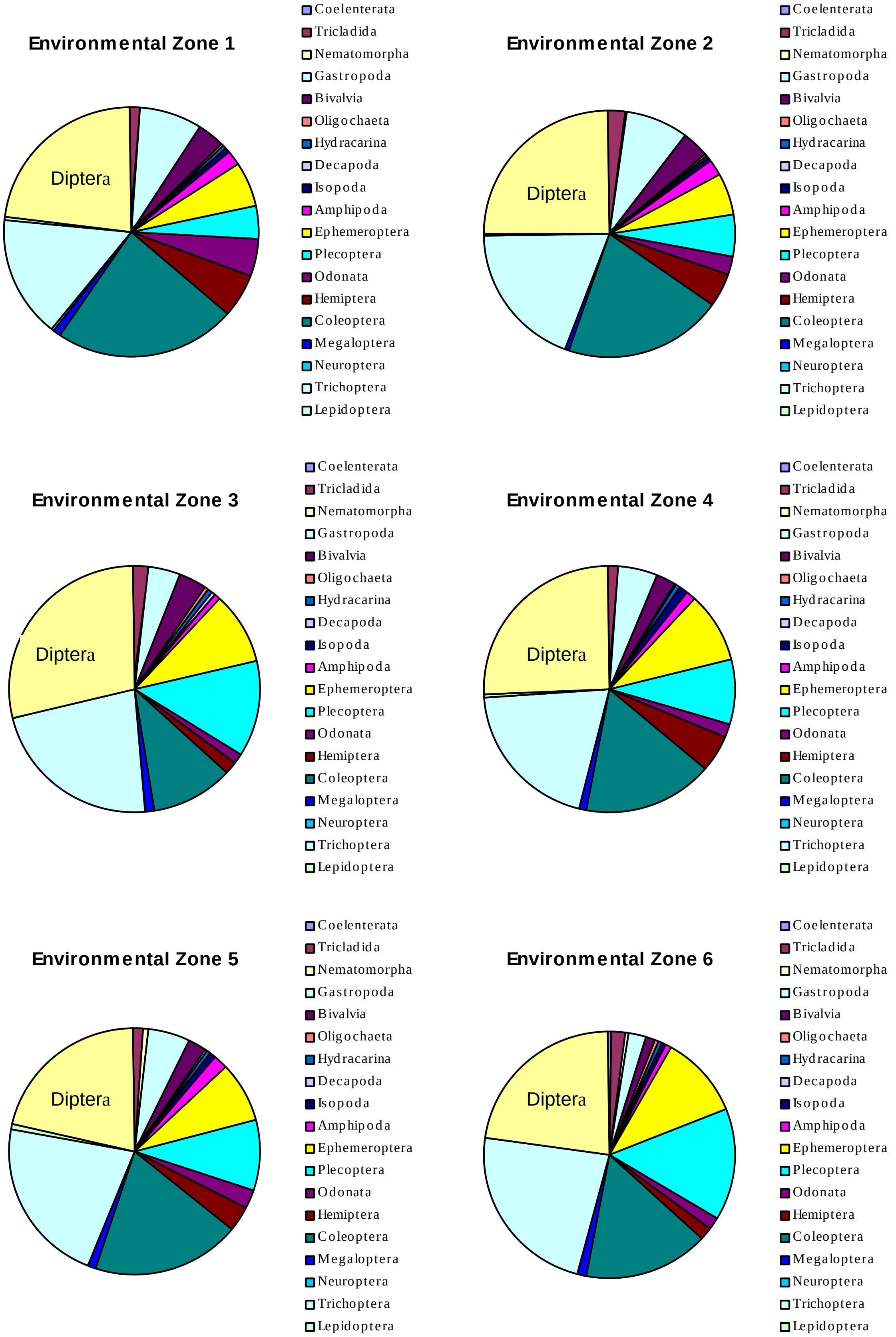

Figure 3.1 Distribution of major taxonomic groups by environmental zone, CS2000

The characteristics of the aquatic macro-invertebrate taxon lists from each zone are summarised below:

Environmental Zone 1:

The watercourses of this lowland zone, which is mainly in the east Midlands, East Anglia and South East England, tend to be slower flowing and more nutrient rich (see section 3.4) than any other zone, with greater weed growth and more silted substratum (boulders & cobbles 7% cover; silt 59%). Streams are often ditch-like or channelised.

The zone thus has the highest number of representatives of Gastropoda (jointly with EZ1), Odonata, Hemiptera and Coleoptera. Each of these groups contains high proportions of taxa that favour standing water or slow flow conditions. Conversely, there are fewer species of Plecoptera in this zone than in any other.

In this zone, the combined proportion of Ephemeroptera and Plecoptera, many of whose component species tend to be associated with fast-flowing streams, is a relatively low 9.6%. On the other hand, the 15.5% of the taxa (excluding Oligochaeta and Chironomidae) that are non-insects is relatively high compare to most other zones.

Environmental Zone 2:

This lowland zone is predominantly in the North, West Midlands and South West of England and the more coastal extremes of Wales. Watercourses tend to be at a slightly higher altitude than Environmental Zone 1 and therefore tend to have moderate flows, stony stream-beds (boulders & cobbles 23%; silt 37%) and nutrient levels (see section 3.4).

The zone has the highest numbers of Tricladida, Mollusca (Gastropoda plus Bivalvia), Oligochaeta, Amphipoda (jointly with EZ1), Trichoptera and Diptera (including Chironomidae). However, numbers of Plecoptera and Ephemeroptera remain low in comparison with the upland zones (3, 5 and 6) and the lowlands of Scotland (EZ4).

The faunal composition of sites in this zone is therefore similar to that of EZ1, with only 10.6% of the fauna being Ephemeroptera and Plecoptera but 16.8% of taxa being non-insects.

Environmental Zone 3

This zone is predominantly the Pennines, the central Welsh uplands and parts of Dartmoor and Exmoor. Streams are now predominantly fast flowing with coarser, large-particled stream beds (boulders & cobbles 48%: silt 9%) and lower nutrient levels (see section 3.4).

Overall taxon richness in this zone is much lower than the other two English and Welsh EZ's. In particular, the number of Mollusca species (15) is low compared to EZ1 (35) and EZ2 (36) and the range of Coleoptera (20 taxa) is less than any other zone in any country. No group attains its greatest taxon richness in this zone, except the Chironomidae identified in 1990. However, it does have the second greatest variety of Plecoptera.

The proportion of Ephemeroptera and Plecoptera in this group rises sharply to 21% but the proportion of non-insects falls to just 12.0%. The combined proportion of Trichoptera and Diptera (excluding Chironomidae), at 50.5%, is higher than any other zone.

Environmental Zone 4

This zone represents the Scottish lowlands. The streams tend to be intermediate in character between those of EZ2 and EZ5 (the Scottish foothills and islands) except that they are less nutrient-rich than EZ1 (see section 3.4) and with, on average, a coarser substratum (boulders & cobbles 23%; silt 24%).

The rivers in this zone are still taxon-rich in comparison with the other Scottish environmental zones and the upland English and Welsh EZ3. More species of Ephemeroptera were found in this zone than in any other and Plecoptera and Trichoptera were also well represented.

The combined number of Ephemeroptera and Plecoptera taxa represented 17.5% of the total faunal diversity, with non-insect taxa (12.1%) a higher proportion of the fauna than English and Welsh upland EZ3.

Environmental Zone 5

This zone represents the Scottish foothills and islands. The streams are slightly faster-flowing than EZ4 and have slightly lower nutrient concentrations (see section 3.4). Many have a coarse stony substratum (boulders & cobbles 44%; silt 19%) but others are peaty. Although not recorded, stream temperatures are likely to be lower than EZ4. Island streams are short and will tend to be species poor.

In total, excluding the contribution of 1990 samples, the samples collected from this environmental zone had 219 taxa, 23 fewer than the combined samples from EZ4 but 20 higher than the upland zone (EZ3) in England and Wales. No major taxonomic group had its most diverse fauna in this zone but Ephemeroptera, Plecoptera, Coleoptera and Trichoptera continued to be well represented, as would be expected in streams of good chemical quality and high dissolved oxygen levels.

In practice, the faunal composition is very similar to EZ4, with 16.7% of its total faunal richness derived from Ephemeroptera and Plecoptera and 13.1% from non-insect taxa.

Environmental Zone 6

This zone is the Scottish uplands, predominantly, but not exclusively in the northern half of the country. In general, streams in this zone will be faster-flowing, steeper and cooler than any other zone with coarser substrata (boulders & cobbles 55%; silt 11%) and lower nutrient levels (see section 3.4) than the other five.

These streams were less taxon-rich than those from any other zone. The total number of distinct taxa in this zone in 1998 was 180 which is 21 fewer than the next lowest zone, EZ3, the English and Welsh uplands. Although the number of taxa are impoverished, more Plecoptera were recorded in this zone than any other and the second greatest number of Ephemeroptera. Conversely there were only six taxa of molluscs in the base-poor waters compared with 36 distinct mollusc taxa in EZ2. Also present in relatively low diversity were Amphipoda (one species only) and Coleoptera.

As a result, the proportion of Ephemeroptera and Plecoptera was the highest of any zone, at exactly 25%, but the proportion of non-insect taxa was smaller than any other zone at just 8.3%.

3.1.3 Changes in species frequency between 1990 and 1995

Three hundred and fifty-four squares contained an appropriate stream channel for sampling in both the 1990 and 1998 surveys (see Section 3.1 and Table 3.2 for further information).In the following text, changes in the frequency of individual species are briefly presented, with particular reference to those environmental zones where the greatest changes in frequency have occurred. Where available, changes in frequency of occurrence of individual families are presented, based on the National Rivers Authority River Quality Survey of 1990 and General Quality Assessment of 1995. The latter comparisons are based on results from 3016 sites sampled in both years were compared (Davy-Bowker *et al*. 2000).

The changes in frequency of the large majority of identified taxa are also presented graphically in a series of 18 accompanying figures (Figures 3.2 to 3.19). Changes are recorded as the difference between the percentage of matched sites at which the taxon was recorded in 1998 and the proportion of the matched sites at which the taxon was recorded in 1990 (% frequency in1998 minus % frequency in 1990). In these figures, changes in the frequency of taxa are compared separately for the whole of Great Britain and for the separate country units of England and Wales and of Scotland.

COELENTERATA

Hydridae

Hydridae were rarely found in either year but showed a net loss of 0.85% of sites. All net losses occurred in England and Wales.

Hydridae are associated with slow flowing weedy water bodies.

TRICLADIDA

There were consistent gains in the frequency of abundance of all planariid taxa in both country units between 1990 and 1998.

Planariidae (Figure 3.2)

The biggest gains were exhibited by *Polycelis felina* and *P. nigra* group (= *P. nigra* + *P. tenuis*) particularly in the lowland environmental zones (EZs).

Dugesia tigrina, an invasive North American species was only gained in EZ2 where it was only present at 1% of sites. All gains in *Planaria torva* were also in EZ2.

In a similar, family level comparison there was a net gain in the frequency of Planariidae of 10.7%.between the 1990 River Quality Survey and the 1998 General Quality Assessment.

Dendrocoelidae (Figure 3.2)

The net GB gain of 3.39% in the frequency of *Dendrocoelum lacteum* was exclusively in the three lowland zones (EZs 1, 2 and 4). In the NRA studies a net loss of Dendrocoelidae was recorded between 1990 and 1995.

GASTROPODA

Viviparidae (Figure 3.2)

This family is characteristic of slow-flowing water bodies and occurred in only 1% of the study sites. Its sole representative was *Viviparus contectus*, which was only recorded in EZ1.

Valvatidae (Figure 3.2)

This family is also characteristic of slow flowing watercourses. In the current study *Valvata cristata* was only recorded in England and Wales and principally in EZ1, where it showed modest gains in frequency. *V. piscinalis* was more widespread, including EZ5 in Scotland. It recorded modest gains in both country units.

In contrast, in the NRA surveys there was a 2% loss of frequency of this family over the 5-year period (1990-1998) between the two surveys.

Hydrobiidae (Figure 3.2)

Large gains in the frequency of the sole representative of this family in this study, *Potamopyrgus antipodorum* Gray (formerly *P. jenkinsi*) were recorded in lowland EZs 1 and 4. Only in EZ6, upland Scotland, were there modest losses of this species. *P. antipodorum* occurs in all types of running waters. In both country units the net gain exceeded 5%.

Bithyniidae (Figure 3.2)

Neither of the two representative species of this family, *Bithynia tentaculata* and *B leachii* occurred in Scotland or upland England and Wales. Both showed small GB gains.

The combined abundance of Hydrobiidae and Bithyniidae increased by 10% between the NRA's 1990 River Quality Survey and their 1995 General Quality Assessment.

Physidae (Figure 3.2)

The commonest representative of this family, *Physa fontinalis*, occurred in 3% of 1998 samples, all in lowland England and Wales, and showed a net GB loss of 0.3%. It is a characteristic snail of slow, weedy watercourses. The second physid species, *Aplexa hypnorum* is characteristic of small, sometimes intermittent streams. This species made small gains in EZs 2 and 5.

In the NRA surveys the family made a net loss of 3.0% over the 5-year period.

Lymnaeidae (Figure 3.2)

This is the commonest family of gastropods in British rivers. Only in the base-poor streams of upland Scotland (EZ6) is it rarely represented. The commonest species is the ubiquitous *Lymnaea peregra* where substantial losses in EZ2 resulted in a net loss in England and Wales as a whole. However, gains in Scottish EZs 4 and 5 resulted in a net GB gain of 2.5%.

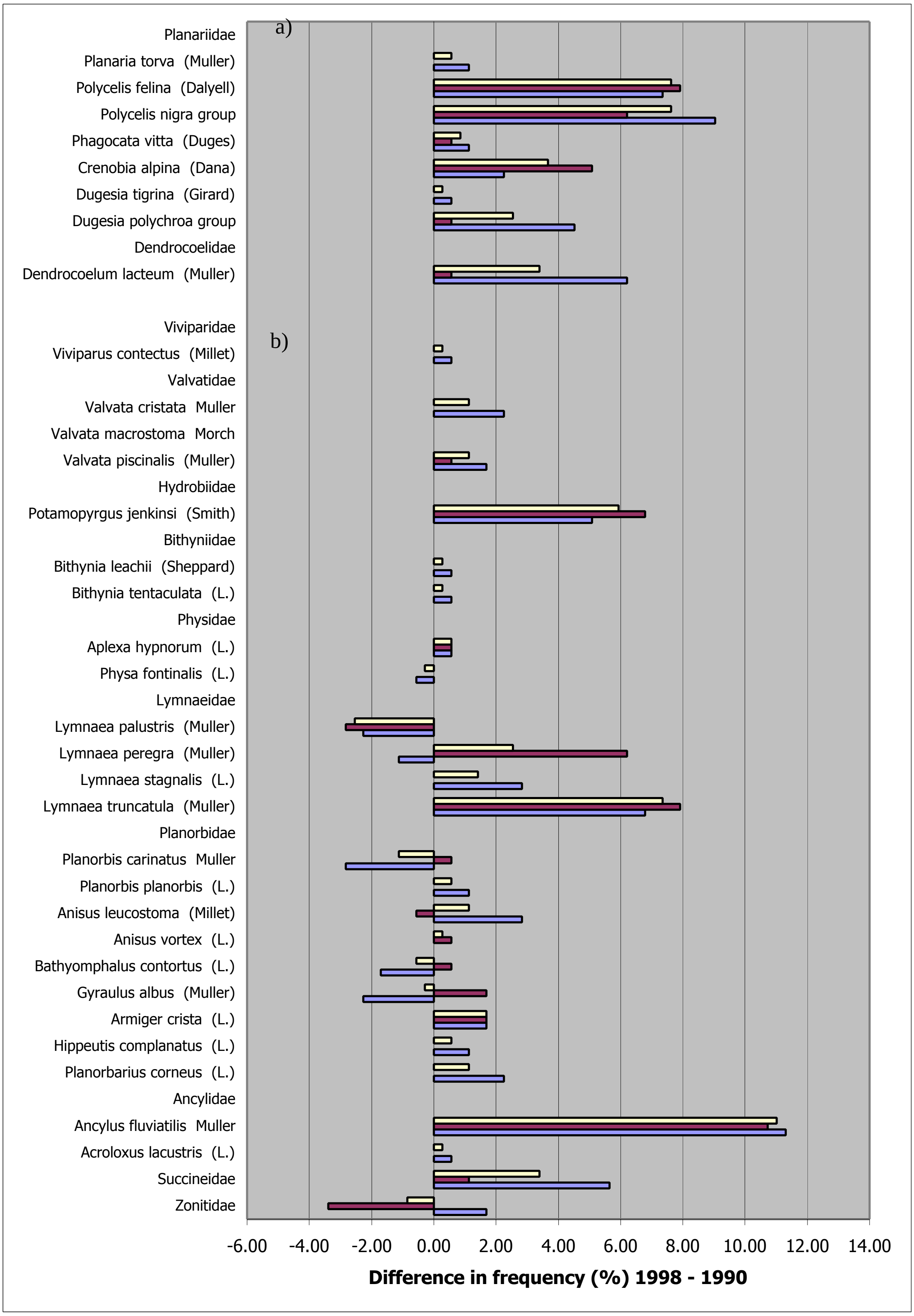

Figure 3.2. **Changes in the frequency of occurrence of species of a) Tricladida and b) Gastropoda between the 1990 and 1998 Countryside Surveys.**

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Lymnaeidae (continued)

In this family, the greatest gains were made by *L. truncatula*, which became more frequent in all EZs and showed net gains in excess of 6.5% in both country units. This semi-aquatic species is most common at the edges of ditches and small streams. *L. stagnalis*, whose habitats range from ponds to fairly swift rivers, showed net gains in EZs 1 and 2, the only ones in which it occurred.

Biggest losses, in excess of 2% in both country units were by *L. palustris*, a marsh and ditch species more commonly associated with slow-flowing or stagnant waters.

Between the 1990 and 1995 NRA surveys Lymnaeidae showed a net loss of 0.3%.

Planorbidae (Figure 3.2)

There were only small changes in the frequencies of the nine representative species of this family found in CS2000. Six made gains of no more than 1.7% for any one species and the three losses were each of less than 1.2%.

There were few records of most planorbid species in Scotland and none in EZ6. The biggest gains were by *Armiger crista* in EZs 2, 4 and 5, whilst losses of *Planorbis carinatus* of over 2% were exclusively due to the 10% loss in EZ1.

In the NRA surveys this family, most of whose taxa are characteristic of ponds, made a net loss of 3.1%.

Ancylidae & Acroloxidae (= BMWP "family" Ancylidae) (Figure 3.2)

The two representatives of these families have markedly different habitat preferences. *Ancylus fluviatilis* is very common, particularly in stony and swift-flowing streams. It increased in frequency in all EZs with gains in excess of 10% in both country units. *Acroloxus lacustris*, as its name suggests, is most common in slower flowing rivers in the south and east of England. Its modest gain in frequency was largely in EZ1.

In the NRA surveys the combined frequency of these families increased by 3.6% over the 5 years.

Succineidae (Figure 3.2)

This semi-aquatic family was predominantly found in the three lowland EZs and became more frequent in each.

Zonitidae (Figure 3.2)

This is another semi-aquatic family. It showed large losses of frequency in EZ4.

BIVALVIA

Unionidae (Figure 3.3)

These are the large swan mussels, most characteristically found in large, deep lowland rivers. In CS2000, where most study streams were headwaters, unionids in the *Anodonta* group (*Anodonta* spp. and *Pseudanodonta complanata*) were found in 3% of English and Welsh sites but were absent from EZ3 and EZs 4, 5 and 6 (Scotland). Net gains in England and Wales were 2.7% and in GB were 1.4%.

In the NRA surveys there were no changes in this family's frequency.

Sphaeriidae (Figure 3.3)

This family comprised two genera, *Sphaerium* (two species) and *Pisidium* (8 species). Each *Sphaerium* species and three *Pisidium* species were completely absent from Scotland and three other *Pisidium* spp. were absent from EZ6.

Sphaerium corneum gained in abundance by nearly 3% but showed modest losses in lowland Scotland. This widespread taxon is normally found in good quality water bodies but not in drying streams. In contrast *S. lacustre* is more commonly found in ditches and tolerates poorer water quality.

Most of the eight species of *Pisidium* showed modest increases in frequency in England and Wales. Four of the five species present in Scotland also increased there.

The main exception was *Pisidium hibernicum* that became very slightly less frequent. This species and two others, *P. henslowanum* and *P. casertanum* reversed the trend in other EZs by being less frequent in EZ1.

Biggest gainers were *P. personatum* and *P. subtruncatum*, especially in Scottish lowland zone, EZ4. *P. personatum* has been described as a "slum-dweller" (Boycott 1936) due to the poor stream and ditch conditions under which it often exists.

Sphaeriidae showed a net gain of 3.5% at NRA sites surveyed during both the 1990 RQS and the 1995 GQA.

Dreissenidae (Figure 3.3)

The invasive *Dreissena polymorpha* is regarded as a pest species because of its tendency to clog industrial and water supply inflows and outflows. It was not found during CS2000 but occurred at 2% of the EZ1 sites in 1998.

NEMATOMORPHA

These horsehair worms are rarely recorded in running water samples. The few records from EZ5 and EZ6 represented gains but similar slight losses occurred in EZ1.

POLYCHAETA

Nereis diversicolor was not recaptured at the one brackish EZ4 site at which it had been found in 1998.

OLIGOCHAETA

This widespread class was identified to species level in 1990, when 39 distinct taxa were recorded. No similar identification occurred in 1998. Therefore analysis of change can only be undertaken at class level.

Although oligochaetes occurred at most sites in both years, there was a net gain of 11% of sites in GB as a whole. This included a 19.1% gain in Scotland and a 25% gain in EZ6, the Scottish uplands.

HIRUDINEA

Piscicolidae (Figure 3.3)

Small gains in the frequency of the single representative species, *Piscicola geometra*, were made between 1990 and 1998. This taxon was never recorded in Scotland.

In the NRA surveys this family increased by 0.5% between 1990 and 1995

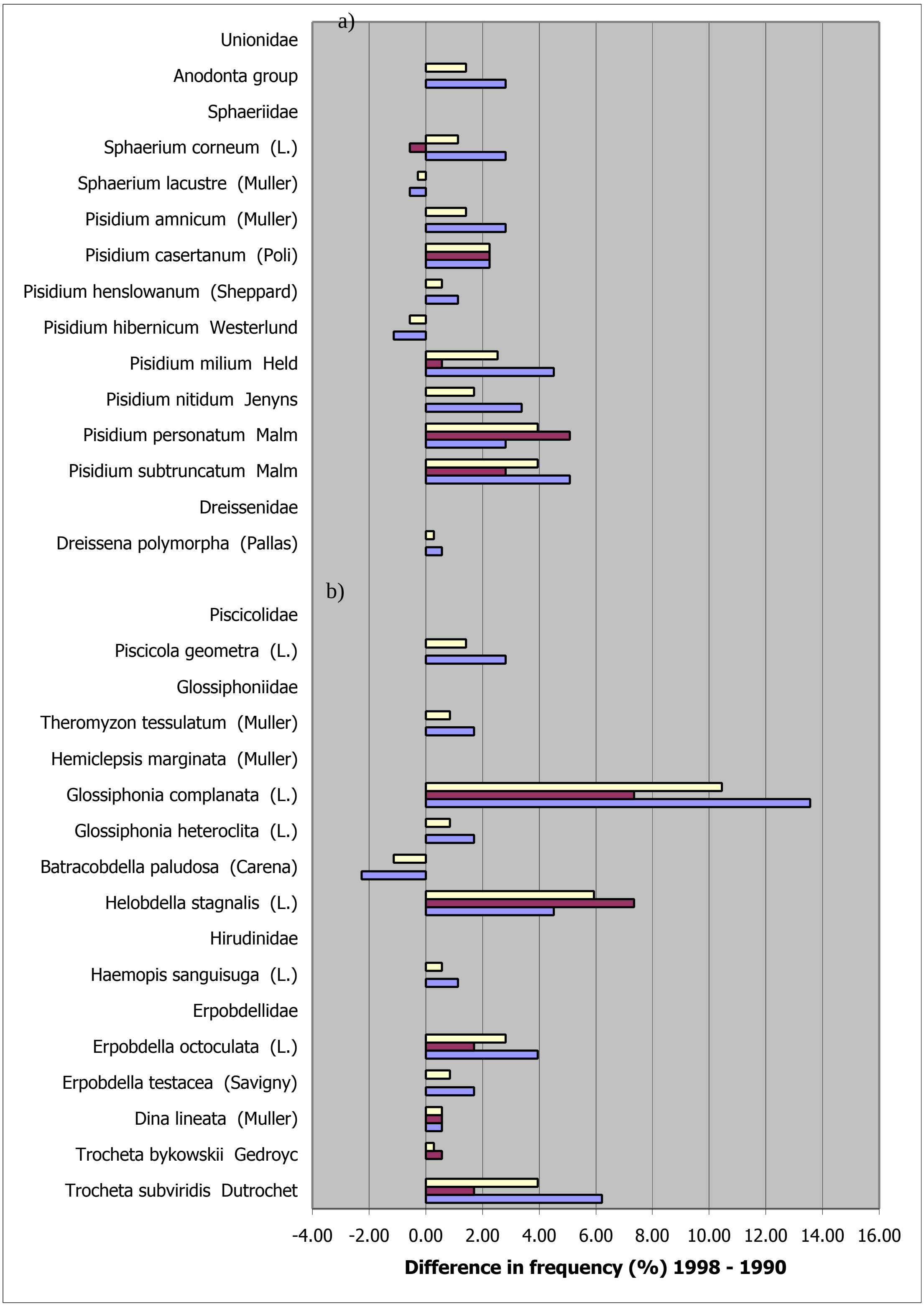

Figure 3.3. **Changes in the frequency of occurrence of species of a) Bivalvia and b) Hirudinea between the 1990 and 1998 Countryside Surveys.**

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

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Glossiphoniidae (Figure 3.3)

The commonest species, *Glossiphonia complanata* and *Helobdella stagnalis,* increased in frequency in both country units between the two surveys. Changes in the other species were small. Only the rare *Batracobdella paludosa*, present in EZs 1 and 2 in 1990 but nowhere in 1998, decreased in frequency between surveys.

In NRA surveys this family decreased in by 2.5% between 1990 and 1995.

Hirudinidae (Figure 3.3)

This family was represented by a single record of the horse leech, *Haemopsis sanguisuga,* in both EZ1 and EZ3 in 1998. It had not been found in the 1990 survey. This species is primarily lacustrine in distribution.

It was rarely found in the NRA surveys and decreased by 0.1% between years.

Erpobdellidae (Figure 3.3)

All recorded members of this widespread family increased in frequency between CS1990 and CS2000. This included small gains in Scotland where the component species are less common or absent.

In the NRA national surveys, Erpobdellidae increased in frequency by 1.1% from 73.6% in 1990 to 74.7% in 1995.

HYDRACARINA

Hydracarina, not illustrated, increased in frequency by 7.63%, comprising a 14.7% gain in Scotland and only 0.6% in England and Wales.

CRUSTACEA

Decapoda: Astacidae (Figure 3.4)

The native crayfish, *Austropotamobius pallipes* was found in one upland site (EZ3) in England and Wales in 1998 but not recorded in CS1990. In the NRA surveys it decreased in frequency from 1.9% to 1.7% over the 5 years.

Decapoda: Crangonidae (Figure 3.4)

The brackish waters species *Crangon vulgaris* was found once, in EZ2, in CS2000. This species was not found in 1990.

Isopoda: Sphaeromatidae (Figure 3.4)

One record of the brackish water *Sphaeroma rugicauda* was made in EZ2 in CS1990. This species was not found in CS2000.

Isopoda: Janiridae (Figure 3.4)

Jaera sp, a brackish water species, was found in one EZ3 site in 1998 but was not recorded in CS1990.

Isopoda: Asellidae (Figure 3.4)

The two species recorded in CS1990 and CS2000 were the common *Asellus aquaticus,* which increased in frequency in both country units and *A. meridianus* which increased in frequency in Scotland but showed bigger decreases in England and Wales.

In NRA surveys the family, which is associated with organically polluted water, decreased in frequency by 1.7% between 1990 and 1995.

Amphipoda: Niphargidae (Figure 3.4)

One record of the hyporheic species, *Niphargus aquilex,* was recorded in EZ2 in CS2000.

Amphipoda: Crangonyctidae (Figure 3.4)

The one representative species, the invasive *Crangonyx pseudogracilis*, showed a small overall increase between 1990 and 1998. It was absent from Scottish samples in both surveys.

Amphipoda: Gammaridae (Figure 3.4)

The commonest representative of this family is the widespread freshwater shrimp, *Gammarus pulex*. Between the 1990 and 1998 Countryside Surveys it increased in abundance by 4.5%. In Scotland the net gain was 7.2%, with the biggest increase (13.3%) in upland EZ6. The smaller net increase in England and Wales, of 2.1%, included a loss of 2.4% in EZ2.

The other species of *Gammarus* all increased slightly overall, except *G. duebeni*, which decreased in both EZ2 and EZ4. Records of *G. lacustris* were confined to Scotland and *G. tigrinus* to England and Wales.

In the BMWP score system, as used in the NRA's 1990 and 1995 surveys, the family Gammaridae is taken to also include both Niphargidae and Crangonyctidae. This taxonomic aggregate increased in frequency from 87.3% in 1990 to 90.5% in 1995.

Amphipoda: Corophiidae (Figure 3.4)

The brackish water *Corophium multisetosum* group occurred in one site in EZ1 in 1998 but was absent from CS1990.

EPHEMEROPTERA

Siphlonuridae (Figure 3.4)

Siphlonuridae was represented in Countryside Survey sites by two species. The first was *Siphlonurus lacustris,* which, as its name suggests, is associated with calcareous lakes and pools in slow-flowing rivers. In CS2000 it exhibited gains of 4.3% in upland sites in EZ3 (England and Wales) and 3.3% in EZ5 (Scotland) but was absent from lowland zones EZ1 and EZ2 in both 1990 and 1998.
The second species of Siphlonuridae to be recorded was *Ameletus inopinatus*, which was confined to upland zones EZ3, EZ4 and EZ6 and increased in frequency between surveys only in EZ4.

Siphlonuridae showed only a trivial gain of 0.1% between the 1990 and 1995 national NRA surveys. However, this figure excludes Scotland, where the family most frequently occurs.

Baetidae (Figure 3.4)

This is the most common and widespread family of mayfly in the United Kingdom. In the Countryside surveys of 1990 and 1995 nine species and one species group were recorded. These were divided into four genera: *Baetis*, *Centroptilum*, *Cloeon and Procloeon*.

Baetis rhodani was the commonest species of *Baetis* recorded in both surveys and this widespread species increased in frequency by a massive 19.5% over the 8 years between surveys. Gains in excess of 10% were recorded in every environmental zone except EZ6 where there was only a 5% increase in frequency.

The next most common species in this genus was *B. vernus* whose overall net increase of 3.4% masked decreases in three zones, EZ2, EZ3 and EZ4.

Similar net gains were achieved by *Baetis muticus*, following individual gains in all environmental zones except EZ1.

Baetis niger showed no net change as a result of balancing losses in EZs 1-4 and gains in EZ5 and EZ6.

The only *Baetis* species to decline in frequency between 1990 and 1998 was *Baetis scambus* group that comprises *B. scambus* and *B. fuscatus*. Both are associated with macrophytes (Elliott *et al.* 1988).

Whereas the genus *Baetis* is primarily associated with moderate to fast flowing rivers, often with few macrophytes, the remaining genera, *Centroptilum*, *Cloeon* and *Procloeon*, were each represented by two taxa more frequently found in slow-flowing weedy reaches.

Centroptilum pennulatum declined in frequency in all environmental zones between 1990 and 1995 whilst *C. luteolum* was unchanged or declined in frequency in all zones except EZ5.

Cloeon dipterum declined in three zones, was unchanged in two and only gained in EZ4. This resulted in a net decline between surveys. The other species, *C. simile*, showed no net change thanks to balancing losses in EZ1 and gains in EZ4.

The final species, *Procloeon bifidum*, showed small gains in EZ1 and EZ3 and was unchanged in the other four zones.

In the two national NRA surveys the frequency of occurrence of Baetidae increased from 89.1% in 1990 to 92.2% in 1995. It was the third commonest family recorded in the 1995 survey.

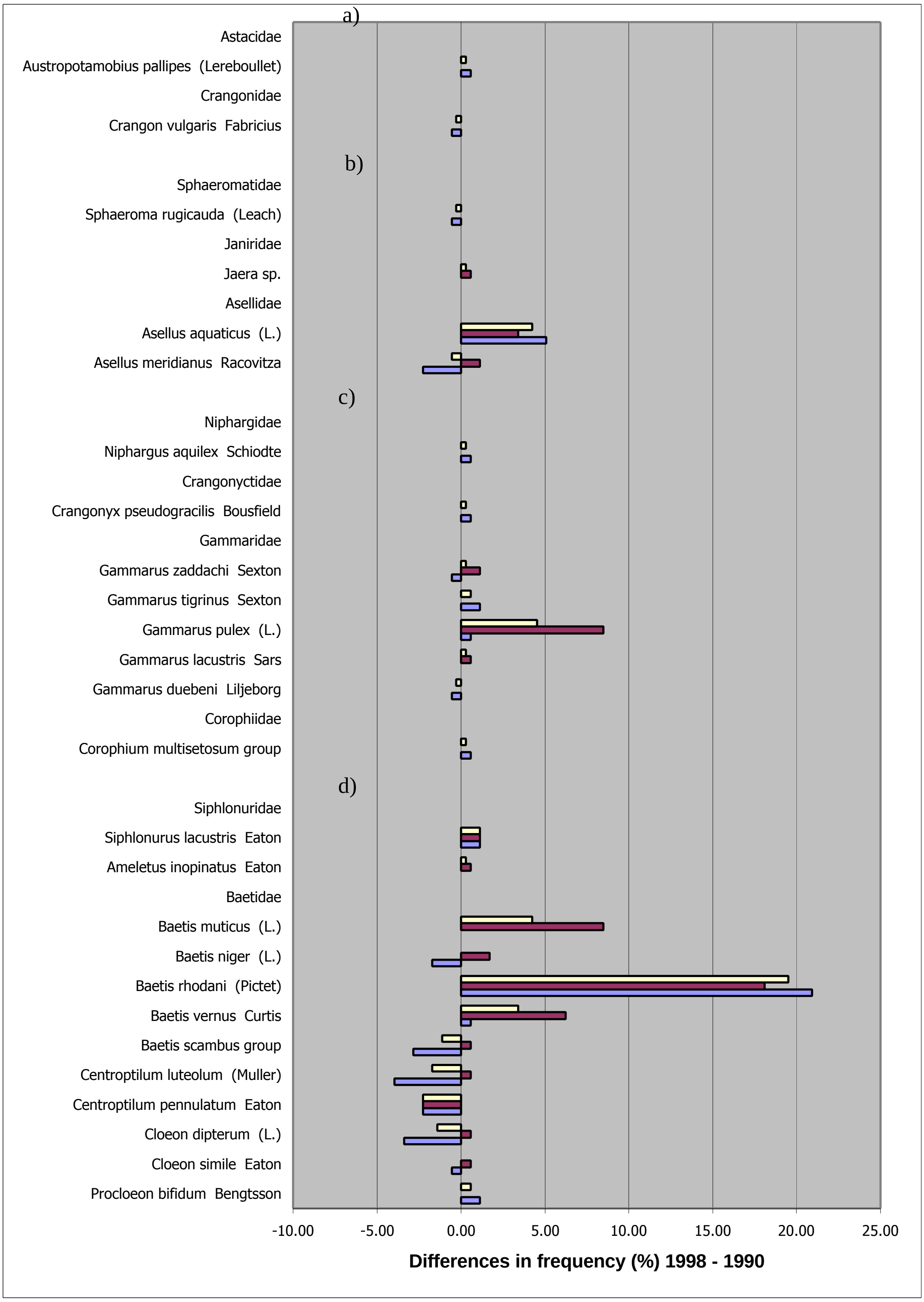

Figure 3.4. **Changes in the frequency of occurrence of species of a) Decapoda, b) Isopoda, c) Amphipoda and d) selected families of Ephemeroptera between the 1990 and 1998 Countryside Surveys.**

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Heptageniidae (Figure 3.5)

This family of mayfly is associated with fast-flowing streams with stony substrata, of the type commonly found in upland regions.

The three commonest taxa, *Rhithrogena* sp. (almost certainly all *R. semicolorata* – although this cannot be confirmed), *Heptagenia lateralis* and *Ecdyonurus* spp. (a mixture of three species that cannot readily be distinguished taxonomically in their early instars), all increased in frequency between 1990 and 1998.

Rhithrogena sp. was the most widespread of these taxa and increased in frequency in all environmental zones except EZ1, where it remained unchanged. Gains in all other zones were close to or in excess of 10%.

Heptagenia lateralis was more characteristically associated with upland zones and increased in frequency by 30.0% in EZ6.

H. sulphurea was more widely dispersed, especially in less extreme uplands and gained in each of Environmental Zones 1-4. However, the rare *H. fuscogrisea* was not recorded in CS1990 and was only found at one EZ4 site in 1998.

Ecdyonurus spp., by virtue of the range of component species, occurred in all zones and showed an increase in frequency in each of them. Greatest gains were in the three Scottish environmental zones where gains in excess of 10% occurred in each of them.

In NRA surveys this family increased in frequency by 2.7% between 1990 and 1995.

Leptophlebiidae (Figure 3.5)

In the Countryside Survey samples, Leptophlebiidae was represented by two species in each of two genera.

Both *Leptophlebia marginata* and *L. vespertina* are associated with standing waters and with pools and margins of streams and rivers. In each case they tend to be associated with macrophytes and each species is more common in upland than lowland watercourses.

In Countryside Surveys, *L. marginata* increased in frequency by a net 2.3% between 1990 and 1998, with gains in each of EZ3 to EZ6. In contrast, *L. vespertina* showed a net loss of 0.3%, mainly due to declines in EZ3 and EZ6.

Between the two NRA surveys, Leptophlebiidae increased in frequency by 1.9%.

Ephemeridae (Figure 3.5)

Only two of the three British species of *Ephemera* was recorded in the 1990 and 1998 surveys. One of these, *Ephemera vulgata*, was recorded in a single square in EZ1 in both 1990 and 1998. This species is not shown in the preceding diagram.

The commonest species of *Ephemera* is *Ephemera danica*, the fisherman's mayfly. It characteristically occurs in the pools and margins of running waters where it is associated with sand and gravel substrata. Between 1990 and 1998, this species showed large gains in EZ1 (+8.5%) and EZ2 (4.8%) but similar losses in EZ3 (-6.4%). In EZ6, a single record was noted for the first time in 1998.

Between the two NRA national surveys, of 1990 and 1995, Ephemeridae increased in frequency by 2.3%.

Ephemerellidae (Figure 3.5)

There are two British species of this family, including the rare *Ephemerella notata* that was not found in any Countryside Survey site in either 1990 or 1998.

In contrast, the other British species *Ephemerella ignita* (now called *Seratella ignita*) is common and widespread. It was present in all environmental zones in 1998 and increased in four of them, giving a net increase of 3.1%. The exceptions were EZ3 (uplands of England and Wales), where it declined by a large 10.6%, and EZ4 (the Scottish lowlands), where it declined by a more modest 3.5%. Ten per cent gains were recorded in both of the other two Scottish zones.

In the NRA surveys Ephemerellidae increased in frequency by 6.6% between 1990 and 1995.

Caenidae (Figure 3.5)

Four taxa were recorded from two genera, *Brachycercus* and *Caenis*. Each showed very modest net changes of no more than 1.5% in any case.

The only marked change by environmental zone was the 8.3% gains of *Caenis rivulorum*, a characteristic taxon of faster flowing streams with coarse substrata, in EZ6 and 8.5% gain of *C. luctuosa* group, a characteristic taxon of slower flowing streams with fine substrata in EZ1.

There was an equally modest gain of Caenidae of 0.5% in the NRA surveys.

PLECOPTERA

Taeniopterygidae (Figure 3.5)

Two species from this family were recorded in Countryside Survey samples. The commoner of the two, *Taeniopteryx nebulosa*, is associated with emergent vegetation in mainly upland rivers Hynes (1977). It was only recorded in Scotland in CS1990 and CS2000 and its net gain of 4.5% in this country was principally due to increases in EZ5 and EZ6.

In 1998, the less common *Brachyptera risi* occurred in small numbers in EZ3, EZ4 and EZ6. Most of these records were gains from 1990, leading to a small net gain of 0.9%.

In the NRA surveys, which were confined to England and Wales, this family increased by 3.3% between 1990 and 1995.

Nemouridae (Figure 3.5)

Nine taxa from this family were recorded in CS1990 and/or CS2000. All increased in frequency except one, and gains in Scotland were often, but not always, greater than in England and Wales.

The greatest gains were made by *Nemoura cambrica* group, which included *N. cambrica* and *N. erratica*. Both taxa are associated with small stony streams in wooded areas (Hynes 1977). Gains were made in all zones but particular gains in excess of 10% occurred in EZs 2-4.

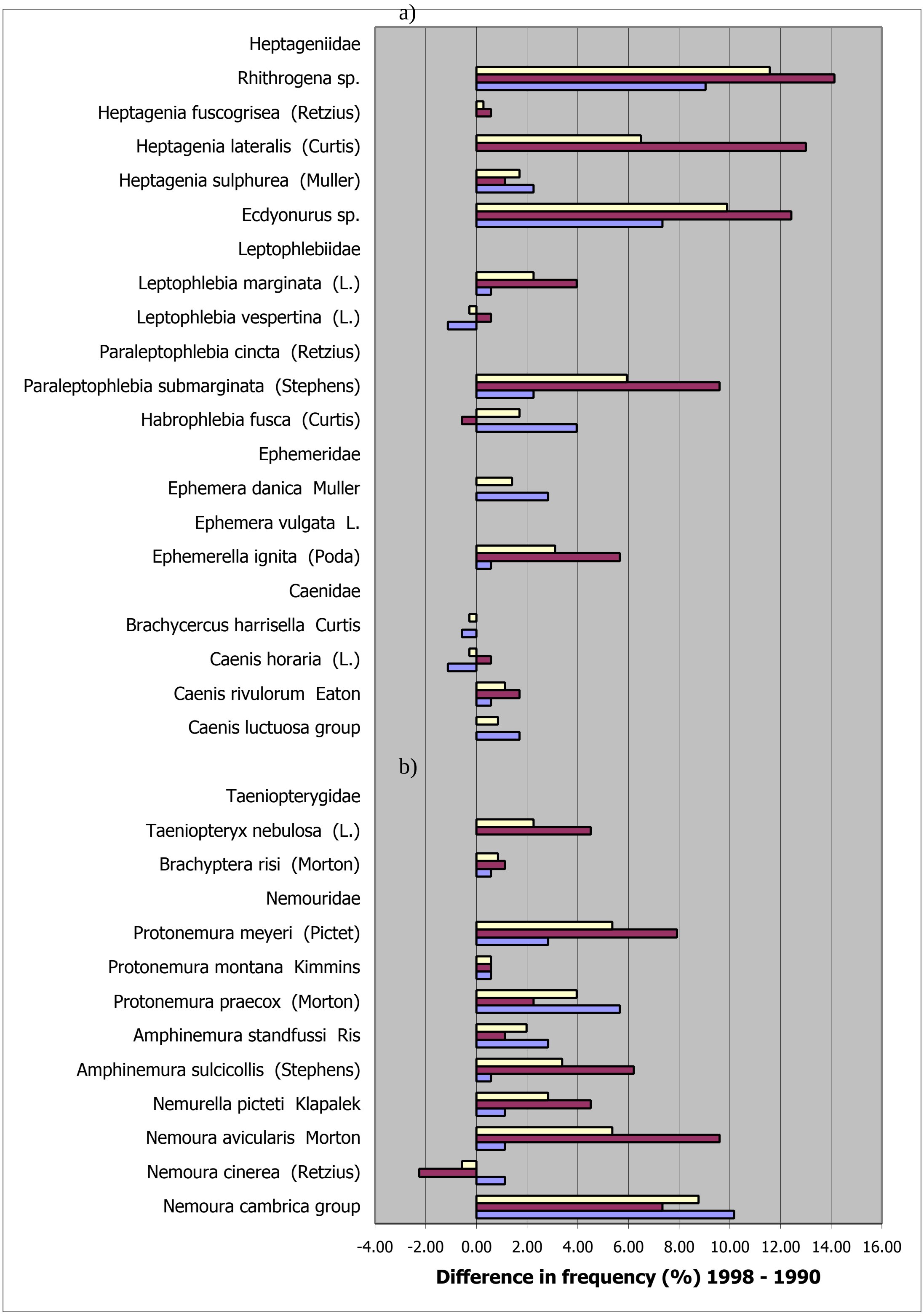

Figure 3.5. **Changes in the frequency of occurrence of species of a) selected families of Ephemeroptera and b) selected families of Plecoptera between the 1990 and 1998 Countryside Surveys.**

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Nemouridae (continued)

Two taxa, *Protonemura meyeri* and *Nemoura avicularis*, made particularly large gains, of around 8% in Scotland, whilst the gains by *Nemurella picteti* were predominantly in the Scottish lowland zone, EZ4, where it showed a 12.3% increase in frequency..

The only taxon to decrease in frequency was *Nemoura cinerea*, entirely due to an 8.3% decline in EZ6. The presence of this species is associated with still or slow flowing water (Hynes 1977).

Nemouridae increased in frequency by 3.9% between the two NRA surveys.

Leuctridae (Figure 3.6)

Leuctridae are the commonest and most widespread family of stoneflies in Britain. In Countryside Surveys it was represented by six distinct species.

The commonest of these was *Leuctra fusca*, which occurs in all types of stony-bottomed rivers (Hynes 1977). It also made one of the greatest gains. Significantly, all the net gains originated in Scotland where this species increased in frequency by 30.0% in EZ5 and 25.0% in EZ6. Set against this was a small loss in EZ4. The net overall gain in Scotland balanced out at 18.1%.

Even greater overall gains were made by *Leuctra hippopus*, which increased in all environmental zones but most notably EZ3 (+25.5%), EZ4 (+19.3%) and EZ 6 (+20.0%). The overall net gain in Britain was 13.0%. This broke down to an 8.6% gain in England and Wales and 18.0% in Scotland. It is also found characteristically in stony streams.

Most of the other species made clear net gains, especially in Scotland, but the exception was *Leuctra geniculata*. The small loss of this species in Scotland was not fully offset by an even smaller gain in England and Wales. It is also associated with stony watercourses but these tend to be larger rivers than the other *Leuctra* species (Hynes 1977).

Leuctridae increased by a substantial 10.4% in England and Wales between the NRA surveys of 1990 and 1995.

Capniidae (Figure 3.6)

This family tends to occur in small stony streams and stony lake shores and is less common than Leuctridae. Two species occurred during Countryside Survey sampling, *Capnia bifrons* and *C. atra*, but both showed trivial between-survey differences in frequency.

The increase of 0.7% between the two NRA surveys was equally small.

Perlodidae (Figure 3.6)

All three component species made substantial gains in both country units but particularly in Scotland.

Perlodes microcephala lives in stony rivers and streams up to about 400m in altitude (Hynes 1977). This species made gains of 10% or more in all three upland zones (EZ4, EZ5 and EZ6) but showed a small net loss in lowland England and Wales (EZ1 and EZ2).

Diura bicaudata is a less common species and tends to occur in stony streams above 300m. Thus its gains also occurred in the three upland zones, with the biggest increases being recorded in EZ6 (+13.3%).

Isoperla grammatica is the commonest and most widespread of the three perlodids and made gains in frequency in all zones except the easterly lowlands of England and Wales (EZ1). Biggest gains were in EZ3 (+25.5%), EZ5 (+16.7%) and EZ6 (+20.0%). Net Scottish gains were 13.6% and gains in England and Wales were a net 10.2%.

Perlodidae made a gain of 2.5% between the 1990 and 1995 NRA surveys of England and Wales. No comparable figures were readily available for Scotland.

Perlidae (Figure 3.6)

Perlidae made a net loss of 0.6% in England and Wales, with the biggest declines in both component species occurring in EZ3, the upland zone.

In Scotland the picture was very different with *Dinocras cephalotes* making a net gain of 5.6% and *Perla bipunctata* gaining a net 3.4%. In both cases the increases in frequencies were greatest in the most extreme upland zone, EZ6.

In the national surveys of England and Wales a small net increase in frequency of just 0.1% was recorded.

Chloroperlidae (Figure 3.6)

The two component species, *Chloroperla* (now *Siphonoperla*) *torrentium* and *C. tripunctata*, each increased in net frequency. Both species are typical of stony streams.

Once again the biggest gains were in Scotland, with a particularly striking gain of 18.3% increase in frequency of *C. torrentium* in EZ6.

In the two NRA surveys Chloroperlidae increased in frequency by 3.2%.

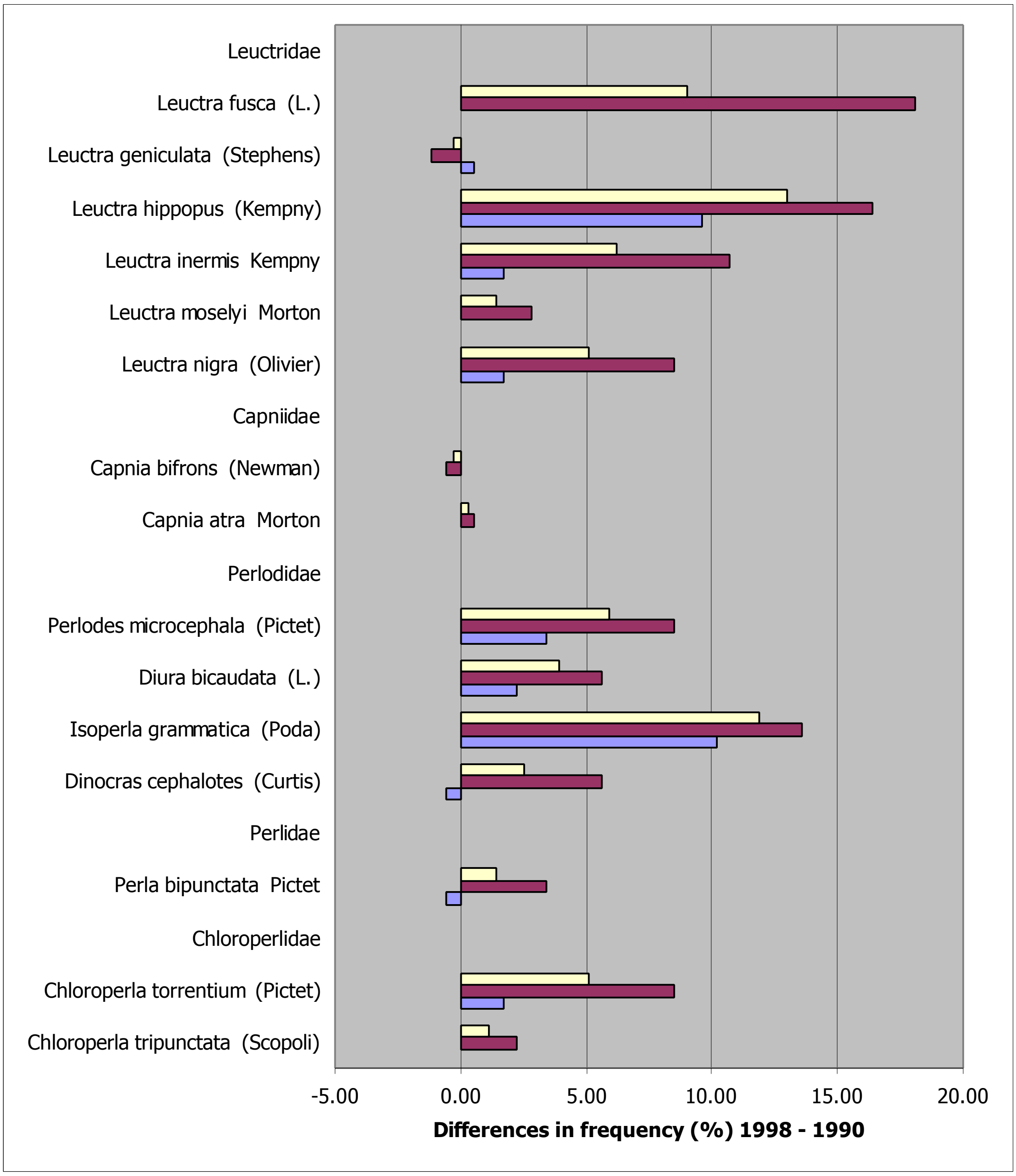

Figure 3.6. Changes in the frequency of occurrence of species of selected families of Plecoptera between the 1990 and 1998 Countryside Surveys.

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

ODONATA

Zygoptera: Platycnemididae (Figure 3.7)

Platycnemis pennipes is associated with slow-flowing rivers with luxuriant vegetation (Brooks 1997). In CS2000 it only occurred in EZ1 (Easterly lowlands) where its increase in frequency from 1990 to 1998 was just 2.1%. In the NRA surveys of 1990 and 1995 it increased in frequency by 1.0%

Zygoptera: Coenagrionidae (Figure 3.7)

Five species were recorded, four of which gained in frequency. The most common of these was *Pyrrhosoma nymphula*, which increased in frequency in all environmental zones and made gains in each of the three Scottish zones. Its most characteristic habitats are ponds, canals, ditches and acid bogs (Brooks 1997) but it also occurs in streams, as CS2000 confirms.

Ischnura elegans is the second commonest taxon recorded in CS2000 but, unlike *P. nymphula*, it was confined to the three lowland zones EZ1, EZ2 and EZ4. It is most frequent in standing water bodies and exhibits some tolerance of pollution and brackish water (Brooks 1997).

Enallagma cyathigerum and *Erythromma najas* were both present in single sites in EZ1 in 1998 but absent completely from the 1998 survey.

The only taxon to decrease in abundance was *Coenagrion puella* group and this was only from the single EZ1 site at which it was recorded in 1990.

In the NRA surveys a gain of 1.0% was recorded but this increase was only from 1.6% frequency in 1990 to 2.6% in 1995.

Zygoptera: Calopterygidae (Figure 3.7)

The two representative species of this family, *Calopteryx splendens* and *C. virgo*, were each confined to England and Wales in CS2000. Of these, only *C. virgo* occurred in EZ3.

The small gains made by each species were in the lowland zones EZ1 and EZ2.

In the NRA's national surveys of 1990 and 1995 there was a 4.0% gain in frequency of this family.

<u>Anisoptera</u>: Cordulegastridae (Figure 3.7)

This family is represented in Great Britain by the single species, *Cordulegaster boltonii*. This dragonfly species is typically found in small, often acidic moorland and heathland streams with slow to moderate flow (Brooks 1997).

In CS2000 it was captured in all environmental zones but was least frequent in EZ6.

Increases in frequency occurred in all zones but were greatest in Scotland, particularly in EZ4 (+7.0%) and EZ5 (+13.3%). Net gains of 7.9% in Scotland and 3.4% in England and Wales led to a combined GB gain of 5.7%.

In the NRA surveys this family decreased in frequency by a modest 0.3% in England and Wales.

<u>Anisoptera</u>: Aeshnidae (Figure 3.7)

Two taxa were recorded in Countryside Surveys, *Aeshna grandis* and *A. mixta* group. The latter group comprises *Aeshna mixta* and *Aeshna cyanea*. All three species are most common in standing water but all also occur in slow-flowing streams and rivers.
In CS2000 both taxa occurred once in EZ5, whilst *A. mixta* group also occurred in one EZ1 site. All records were gains on CS1990 when this family was not recorded.

Nationally, in England and Wales, the family increased from 0.8% frequency in 1990 to 1.1% in 1995.

<u>Anisoptera</u>: Libellulidae (Figure 3.7)

Four representative species of this family of dragonfly occurred in CS2000. In no case was any of them found at more than one site in a zone. The small gains shown by three of the species were records from single sites where they were not found in 1990.

The only taxon not to have increased in frequency was *Sympetrum striolatum*, which was only found in EZ1 in each survey.

Between the NRA surveys of 1990 and 1995 this family increased in frequency by 1.0% from its low baseline 1990 frequency of 0.3%.

HEMIPTERA

Hydrometridae (Figure 3.7)

Of the two British species of *Hydrometra*, only the commoner *H. stagnorum* was captured during CS2000, and then only once in EZ1. In the two NRA surveys the frequency of Hydrometridae increased by 2.3% from 2.8% in 1990 to 5.1% in 1995.

Veliidae (Figure 3.7)

All taxa in this family are surface dwelling and common on standing water and at the edges of streams.

There are two British species of *Velia*, *Velia caprai* and *V. saulii*. About half the specimens collected from CS2000 were capable of identification and *V. caprai* is known to have occurred at 68 sites spread across each of the six zones. *V. saulii*, on the other hand, was known with certainty from just one site in EZ5.

As a result of taxonomic difficulties with nymphs, changes in frequency were considered at generic level. Increases in frequency were recorded in all zones except EZ2 but were greatest in EZ1 (+17.0%), EZ5 (+16.7%) and EZ6 (+11,7%). Gains in Scotland of 10.2% compared with gains of 4.5% in England and Wales.

Microvelia reticulata occurred in small numbers only and showed trivial gains in EZ1 and losses in EZ2.

Veliidae was not included in the NRA surveys of 1990 and 1995.

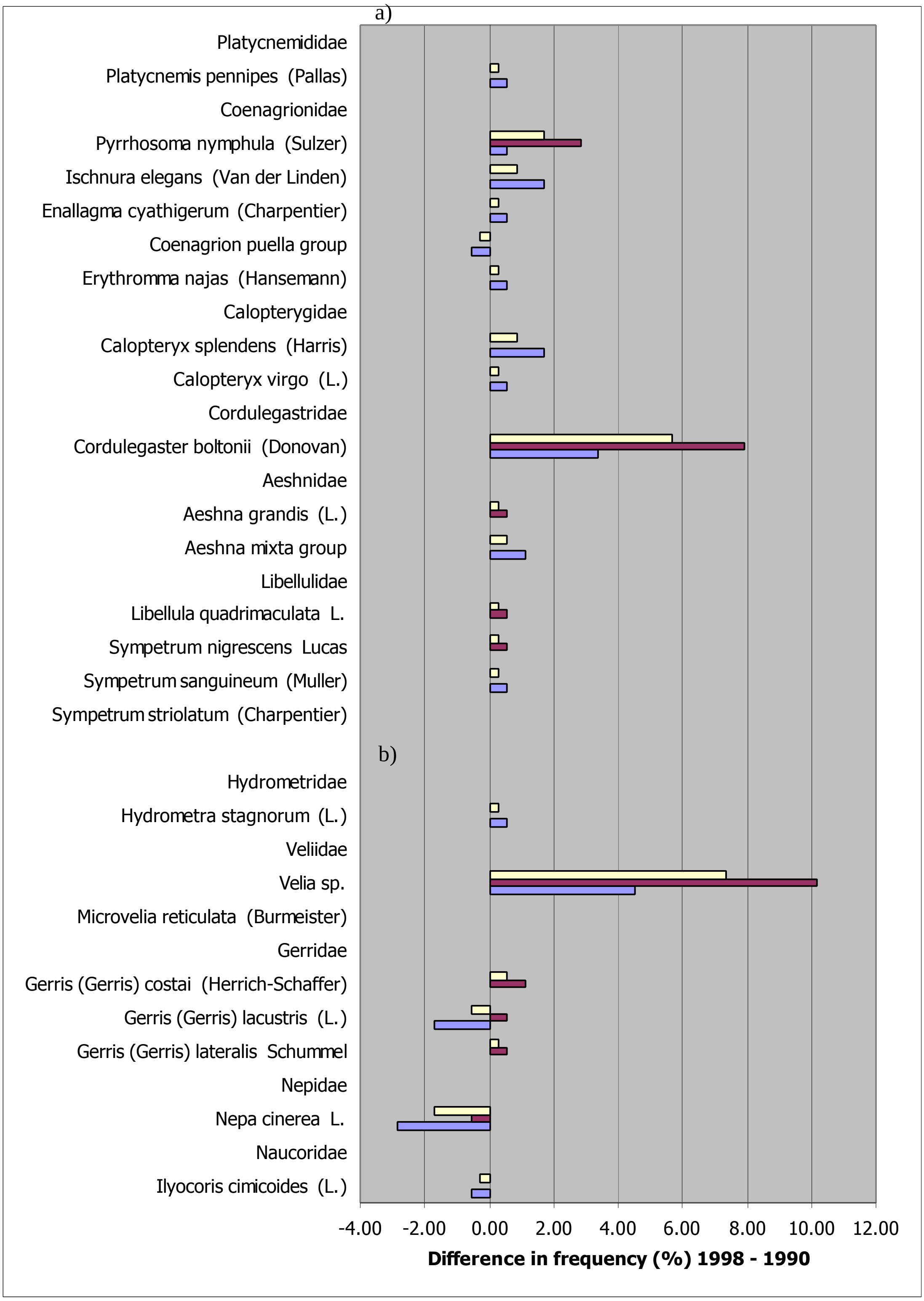

Figure 3.7 **Changes in the frequency of occurrence of species of a) Odonata and b) selected families of Hemiptera between the 1990 and 1998 Countryside Surveys.**

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Gerridae (Figure 3.7)

Like Veliidae, this family lives on the surface of standing water bodies and at stream margins. In CS2000 three species of *Gerris* were recorded in low numbers and each of them was slightly more abundant in Scotland in 1998 than in 1990.

G. lacustris showed a small net loss between Countryside Surveys because of a 3.6% loss in EZ2.

In the two NRA surveys the frequency of Gerridae decreased by 1.1% between 1990 and 1995.

Nepidae (Figure 3.7)

The single recorded species was *Nepa cinerea.* The few records during CS2000 included sites in EZ1, EZ2 and EZ4. This species is associated with weedy watercourses and standing waters. It decreased in frequency in NRA surveys from 1.6% in 1990 to 1.0% in 1995.

Naucoridae (Figure 3.7)

The single British species, *Ilyocoris cimicoides* lost its only 1990 EZ2 record in CS2000. In both NRA surveys it had a frequency of 1.1%.

Notonectidae (Figure 3.8)

Three species were recorded. None of these was common in Countryside Surveys because they are more typically associated with standing water.

Of the three, only *Notonecta maculata* increased in frequency and all the gains in this southern species were in EZ1. All losses in *N. glauca* were in EZ4 and all losses of *N. obliqua* were in EZ5.

In the NRA surveys there was a gain of 0.9%.

Corixidae (Figure 3.8)

Corixidae are the most diverse group of waterbugs in Great Britain and 15 distinct taxa were recorded in CS2000. The family is characteristic of standing waters and, usually, slower-flowing waters and is the first group to be considered that showed large losses between 1990 and 1998.

The most widespread losses were recorded for *Hesperocorixa sahlbergi*, which declined in four environmental zones (EZs 1-3 and 5), and *Sigara nigrolineata*, which declined in five zones (EZs 1-3, EZ5 and EZ6).

Other taxa are confined to a more limited geographic range and some of the losses in particular zones are much greater than the net British values. Good examples are *Sigara (Sigara)* sp., *S. falleni* and *S. lateralis*, that are characteristic of the lowlands of England and Wales. In the easterly lowlands these three taxa made respective losses of 17.0%, 12.8% and 8.5%. [*S. (Sigara) sp*. comprises *S. dorsalis and S. striata*].
Elsewhere, the 7.0% loss of *Sigara venusta* in EZ4 is masked by small gains in three other zones.

About half of the taxa did actually gain in frequency overall, but these were always the rarer taxa that were found in a very small number of sites in CS2000. No taxa made overall net gains greater than 0.6% and the greatest single gain by an individual species in a single zone was the 3.3% gain in *Sigara venusta* in EZ5.

Between the NRA surveys of 1990 and 1995 Corixidae showed one of the largest declines (3.1%) of any family.

COLEOPTERA

Haliplidae (Figure 3.8)

In Countryside Survey samples there were marked declines in the frequency of occurrence of many of the10 recorded species.

Most of these species were commonest in the lowland environmental zones of England and Wales and in the easterly lowlands (EZ1) in particular. In this zone three species, *Haliplus fluviatilis*, *H. lineatocollis* and *H. wehnkei*, declined in frequency by more than 10%.

H. lineatocollis also declined by 7.2%.in EZ2 and 4.3% in EZ3. Three other species showed greater than 4% loss in EZ1. These were *H. laminatus*, *H. ruficollis* and *Brychius elevatus*.

This family inhabits a wide range of standing and running water habitats (Friday 1988) but is less frequent in fast flowing, upland watercourses. Hence few of the recorded species occurred in Scotland, and then only in lowland zone EZ4.

In NRA surveys this family also recorded the greatest single loss (7.6%) of any of the recorded families.

Dytiscidae and Noteridae (=BMWP family Dytiscidae) (Figures 3.9 and 3.10)

Dytiscidae are a widespread and diverse family occupying a broad range of habitats.

In the context of the BMWP score system, and hence this report, this family incorporates the current, separate family of Noteridae. It is represented here solely by *Noterus clavicornis*.

This species showed a small net gain of 0.9%, based solely on a 6.4% gain in EZ1. It is species is primarily associated with still waters.

Most of the other dytiscids (*sensu strictu*) showed very small changes in frequency and were characterised by a small number of increased records, often in Scotland, of taxa that were scarce or absent in 1990.

Two exceptions to this generalisation were *Hyphydrus ovatus*, in England and Wales, and *Hydroporus pubescens*, in Scotland, which both showed a small decline.

The one species to show comparatively big gains was *Hydroporus tessalatus*, which increased by 4.3% in EZ1 and 7.2% in EZ2.

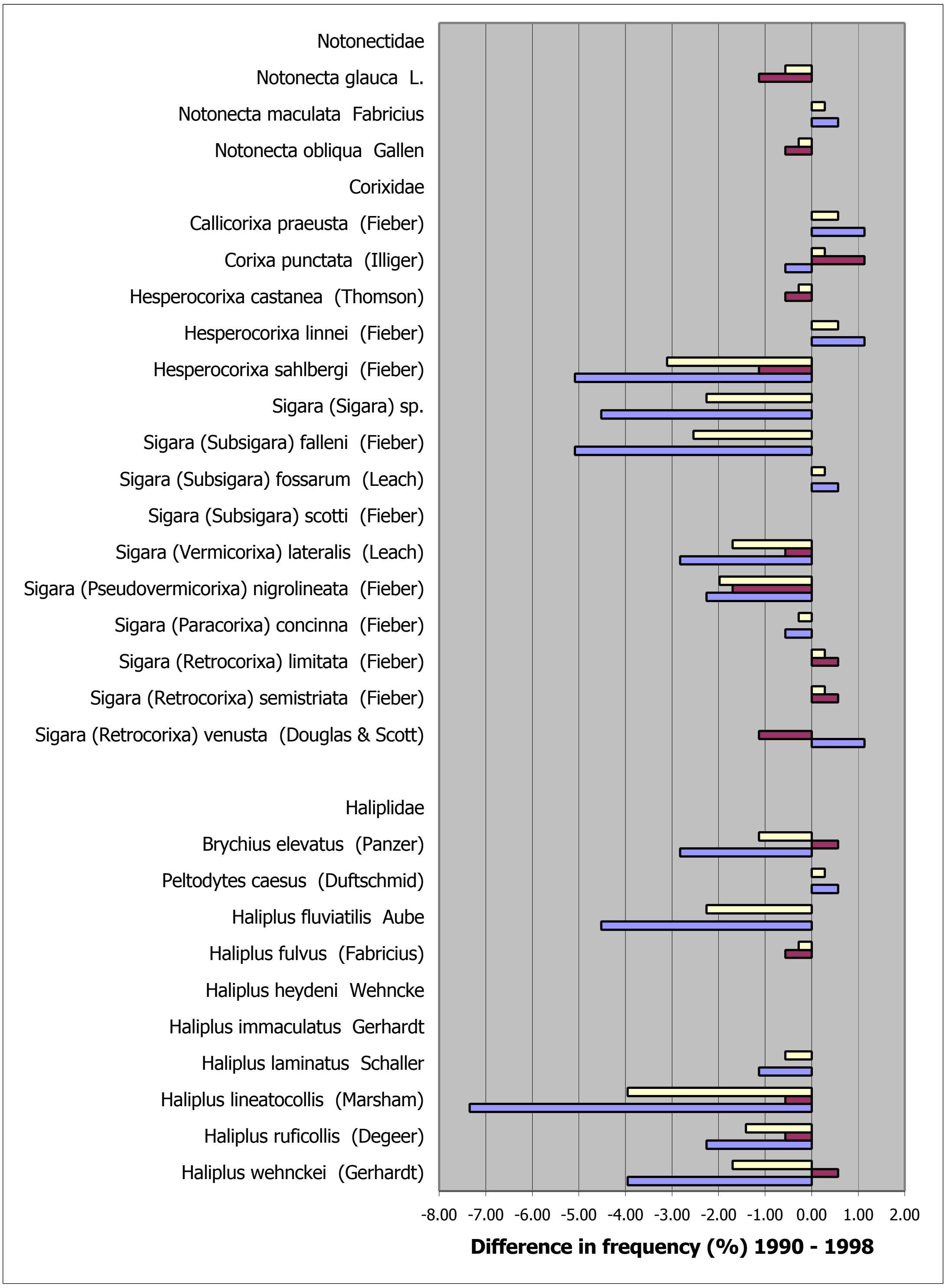

Figure 3.8. **Changes in the frequency of occurrence of species of a) selected Hemiptera and b) Haliplidae between the 1990 and 1998 Countryside Surveys.**

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

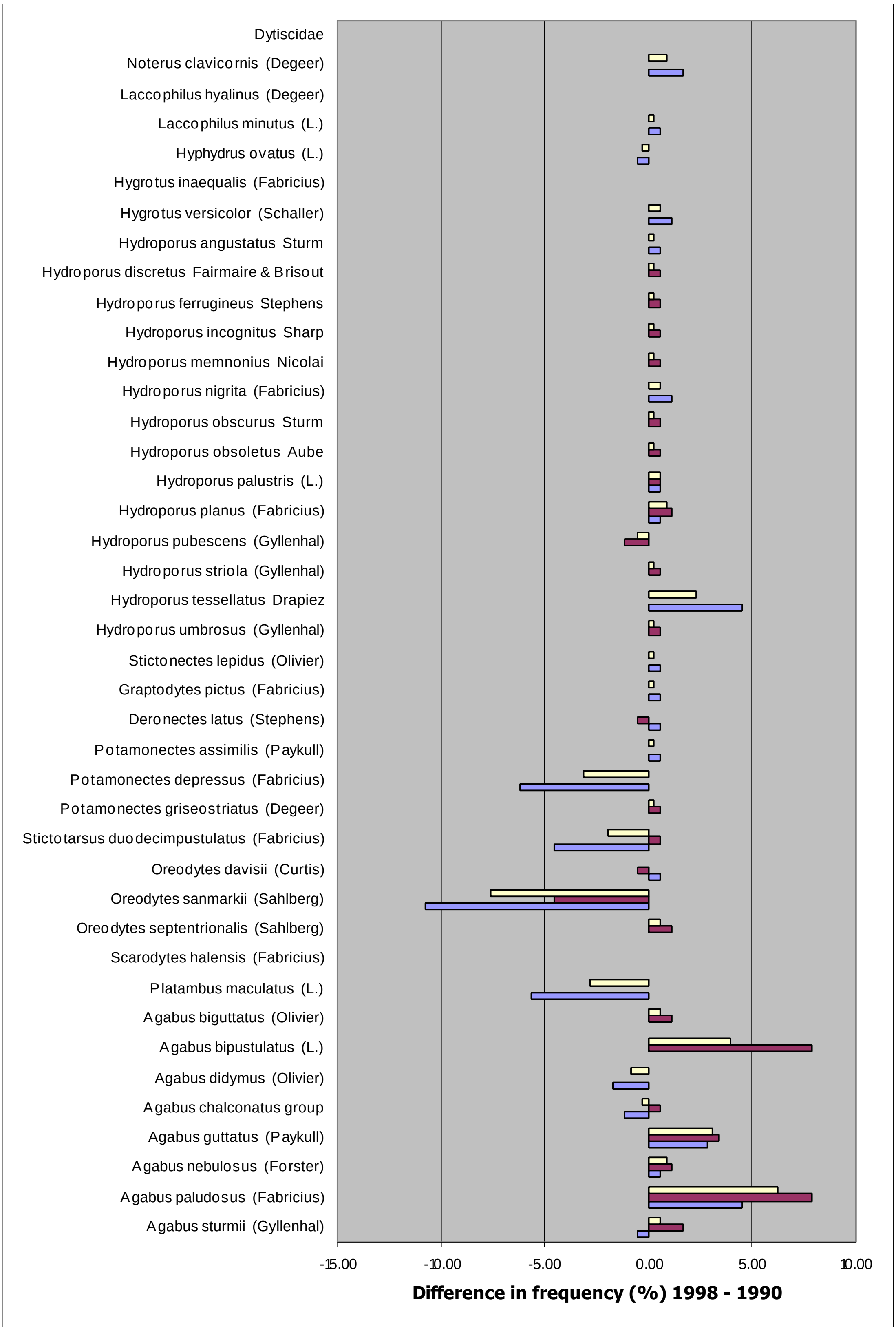

Figure 3.9. Changes in the frequency of occurrence of species of Dytiscidae between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Dytiscidae (continued)

The dytiscids that showed the greatest decrease in frequency (Figures 3.9 and 3.10) were *Potamonectes depressus*, *Stictotarsus duodecimpustulatus, Oreodytes sanmarkii* and *Platambus maculatus*.

Each is a common and widespread species, occurring throughout Great Britain in both rivers and standing waters. In three cases the net losses were confined to England and Wales and only *Oreodytes sanmarkii*, which is a predominantly northern species, showed a net decline in Scotland

Losses in excess of 10% in individual environmental zones were recorded by *Potamonectes depressus* (EZ1), *O. sanmarkii* (EZs 2, 3 and 4) and *Platambus maculatus* (EZ2).

In contrast, most species of *Agabus* showed net gains, and three in particular showed quite large increases, particularly in Scotland. These three species were *Agabus bipustulatus*, whose only net gains were in Scotland, *A. guttatus* and *A. paludosus*. The distribution of each of these species includes the whole of Great Britain. Of these three, *A. guttatus* and *A. paludosus* are primarily riverine.

Gains in excess of 10% in individual environmental zones were recorded by *A. bipustulatus* (EZs 4 and 5), *A. guttatus* (EZ4) and *A. paludosus* (EZ4).

However, most of the Dytiscidae were infrequently captured during Countryside Surveys. Most exhibited small changes that were mainly declines in frequency, between 1990 and 1998.

The major exception to this was another common and widespread species, *Ilybius fuliginosus*. This taxon has broad habitat preferences and its gains were mainly in England and Wales (+5.1%), especially EZ2 (+9.6%) but there was also a gain of 5.3% in the Scottish lowlands (EZ4).

Dytiscus semisulcatus, gained exclusively in EZ5, and is normally associated with stagnant, shallow water (Friday, 1988).

In the NRA surveys Dytiscidae decreased in frequency by 1.6% between 1990 and 1995.

Gyrinidae (Figure 3.10)

Larval gyrinids live under water but the adults live on the surface and are commonly known as whirligig beetles.

Four distinct taxa were recorded and most made modest net gains.

Notable change features were the 2.3% increase in *Gyrinus natator* group (*G. natator* (probably extinct) and *G. substriatus*) in Scotland and the small loss of the same taxon in England.

In the NRA surveys Gyrinidae increased in frequency by 4.8% over the 5-year period.

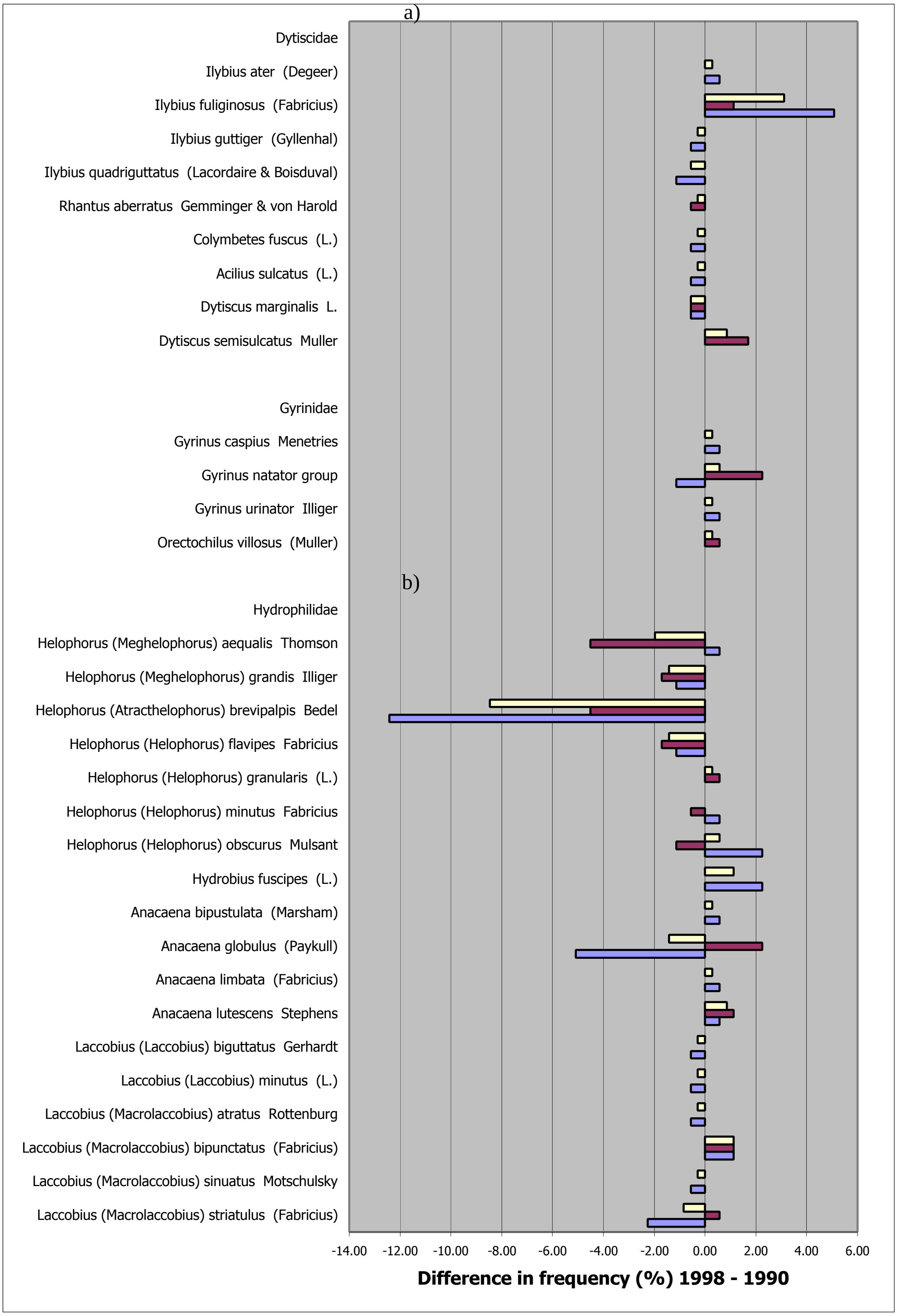

Figure 3.10. Changes in the frequency of occurrence of species of a) Dytiscidae and b) Hydrophilidae between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Hydrophilidae (Figure 3.10)

The family Hydrophilidae, in the sense used in the BMWP Score system is now a composite group. Component families are given in bold italics below, when used as section headers.

Helophoridae **(Figure 3.10)**

Seven species of *Helophorus* were recorded from three distinct sub-genera. These semi-aquatic species are associated with marginal and emergent vegetation.

The general picture, for Great Britain as a whole, was of decline in frequency of these species. Most species occurred rarely and changes were trivial. However, there were two exceptions, of which the strongest was the net loss of 8.5% of *Helophorus brevipalpis*. This is the member of its genus most frequently associated with rivers. Losses were observed in both country units but were greatest in the lowland zones EZ1, EZ2 and EZ4, where each loss exceeded 12%

Also declining in Scotland was *H. aequalis* where the greatest reduction (-8.3%) occurred in EZ5.

Hydrophilidae **(Figures 3.10 and 3.11)**

Very few hydrophilids made significant net gains, although there were some large increases in individual environmental zones. These included a 4.8% gain in *Hydrobius fuscipes* in EZ2 and a 13.3% gain in *Anacaena globulus* in EZ6.

The gain in *A. globulus* in the highlands of Scotland is odd in two respects. Firstly, the taxon is often associated with stressed habitats of various types and evidence suggests that highland streams have shown strong improvements in biological condition in the inter-survey period. Secondly, this taxon declined in all other environmental zones except EZ4 where it was unchanged.

The other taxon with a big change in a single zone was *Laccobius striatulus* that was 6.4% less common in EZ1 in 1998.

In CS2000, Hydrophilidae were represented by *Helochares lividus* and by three species of *Enochrus*. All four species are characteristic of ponds and/or bogs and were found occasionally at Countryside Survey sites in 1998 but never in 1990. In consequence each shows small gains over the intervening period.

Hydraenidae (Figure 3.11)

Ten species of Hydraenidae from three genera were found in one or other of the 1990 and 1998 surveys.

The genus *Ochthebius* was represented by three species that are more commonly found in pools. In contrast most of the *Hydraena* species, except *H. riparia*, principally inhabit lentic water, e.g. *Limnebius truncatellus*.

Most of these 10 species occurred in small numbers only and either showed no change or trivial gains and losses between years.

The two exceptions to this generality were the more widespread *H. gracilis* and *L. truncatellus*, which each showed large gains in Scotland.

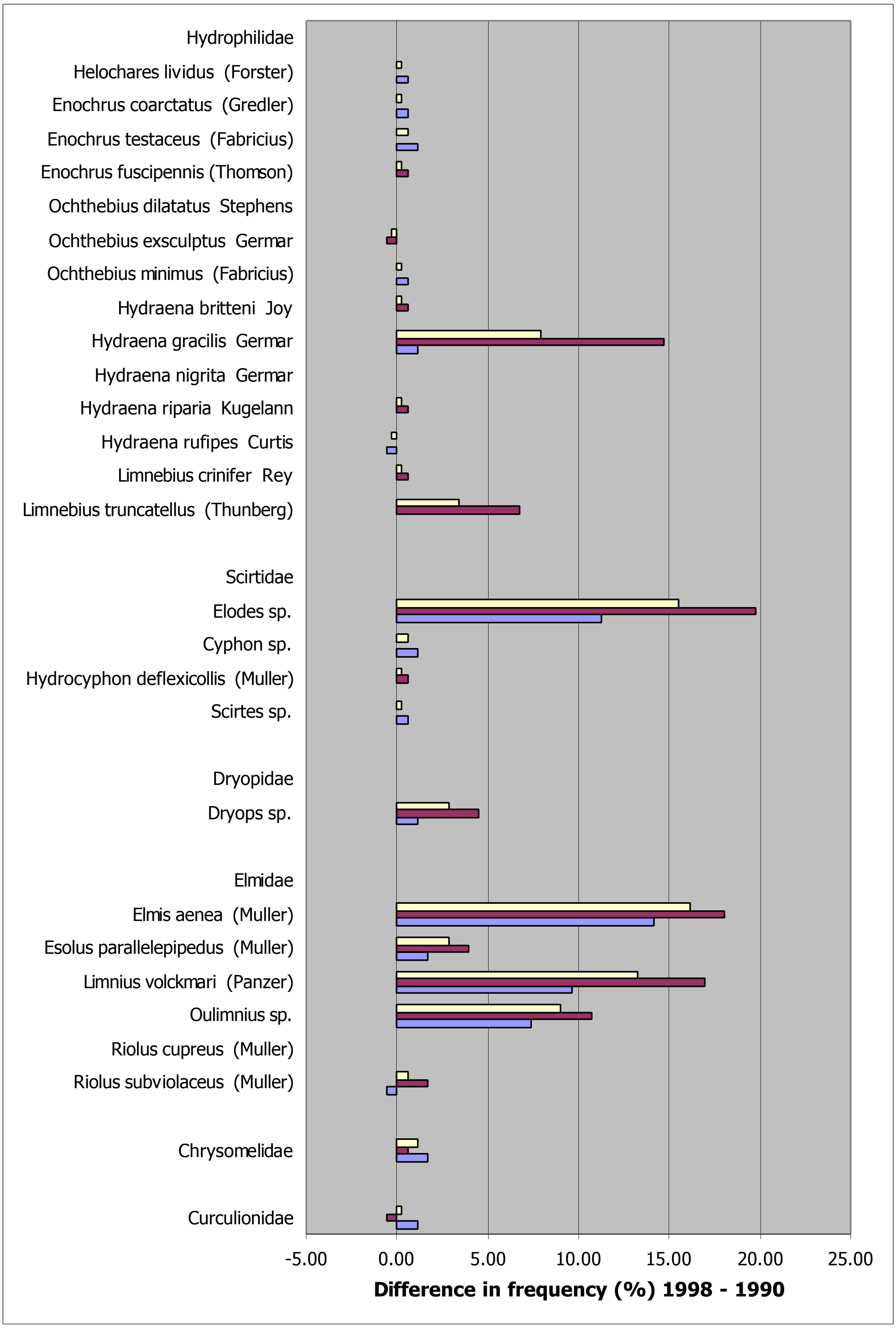

Figure 3.11 Changes in the frequency of occurrence of species of selected families of Coleoptera between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Hydraenidae* (Continued*)

H. gracilis is a running water species (Friday 1988) that showed increases of 21.7% in EZ6 and 20.0% in EZ5. Most gains by *L. trucatellus* were in Scotland and upland England and Wales. In each of environmental zones EZ3-EZ6 this species increased in frequency by between 5.0 and 8.8%.

The composite "BMWP family", Hydrophilidae, increased in frequency by 9.6 % between the NRA surveys of 1990 and 1995.

Scirtidae (Figure 3.11)

This family was formerly known as Helodidae and had four taxa represented in Countryside Surveys.

Three of these were rarely found in either 1990 or 1998 and showed minimal changes. However, the fourth, *Helodes* sp., which is a typical headwater genus, exhibited one of the biggest recorded changes. Its net GB gain of 15.5% included a 28.1% gain in EZ4 and gains exceeding 12% in EZs 2, 3, 5 and 6. The net gain in Scotland was 19.8% and in England and Wales, 11.3%.

Between the 1990 and 1995 NRA surveys Scirtidae increased by 4.0%.

Dryopidae (Figure 3.11)

The single recorded genus, *Dryops*, showed small increases in frequency in all Countryside Survey environmental zones except EZ3, leading to a net GB gain of 2.8%, including a net Scottish gain of 4.5%.

The England and Wales gain of 1.1% between 1990 and 1995 compared with a 0.4% decline between the NRA surveys of 1990 and 1995.

Elmidae (Figure 3.11)

The Elmidae are called "riffle beetles" and they are characteristic of stony streams. The family includes some of the commonest and most widespread British water beetles and many of these showed substantial increases in frequency between 1990 and 1998.

The commonest elmid species, *Elmis aenea*, recorded the fourth largest net GB gain of 16.1%. Gains occurred in all environmental zones with the biggest in EZ6 (+28.3%). Scottish gains of another common species, *Limnius volckmari* (+17.0%) were almost as great as *E. aenea* (+18.1). Gains in *L. volkmari* in individual zones included 22.8% in EZ4 and 21.7% in EZ6. The third taxon with large gains was *Oulimnius* spp. (predominantly *O. tuberculatus*) which exhibited gains in excess of 10% in EZs 1,4 and 6.

Elmidae frequency increased by 6.7% between the two NRA surveys.

Chrysomelidae and Curculionidae (Figure 3.11)

These families were not included in NRA surveys. Only small changes in frequency of their few semi-aquatic species were recorded between CS1990 and CS2000.

NEUROPTERA

Sisyridae (Figure 3.12)

Sisyridae are the sponge-flies. The only genus, *Sisyra*, which includes six British species, was recorded for the first time in Countryside Surveys at a single EZ1 site in CS2000.

The family is not included in the NRA surveys.

Osmylidae (Figure 3.12)

This family contains a single species *Osmylus fulvicephalus*, whose larvae live in moss along the edges of streams (Elliott 1996) In CS2000, this species was not captured at the single EZ2 site at which it occurred in 1990.

This family is not included in the NRA surveys.

MEGALOPTERA

Sialidae (Figure 3.12)

Sialidae are the alder-flies. The single genus, *Sialis*, comprises three species, of which *S. lutaria* is the most common. The least common taxon, *S. nigripes*, was first recorded in Britain only in the late 1970s.

Sialis fuliginosa is limited to moderately fast streams and the upper reaches of rivers (Elliott 1996) and increased in net GB abundance by 4.2%, with moderate gains in each of the six environmental zones.

In contrast, *Sialis lutaria* is commonly associated with silty watercourses (Elliott 1996). In both CS1990 and CS2000 it was often found in EZ1, the easterly lowlands. It was here that the greatest decline in frequency (-14.9%) between the two surveys was recorded, suggesting a loss of siltation that might result from a general increase in flow.

Sialis nigripes only record in a Countryside Survey sample was when it was taken from a single EZ1 site in CS2000.

This family is not included in the NRA surveys.

TRICHOPTERA

Rhyacophilidae and Glossosomatidae (= BMWP Rhyacophilidae) (Figure 3.12)

Rhyacophilidae, as used in the BMWP score system incorporates the current family Glossosomatidae. In the NRA surveys the aggregate family increased by 2.2% between 1990 and 1995.

Rhyacophilidae (Figure 3.12)

Rhyacophila species are free-ranging predators. Each of the four British species was recorded in CS2000 and each was more common in 1998 than 1990.

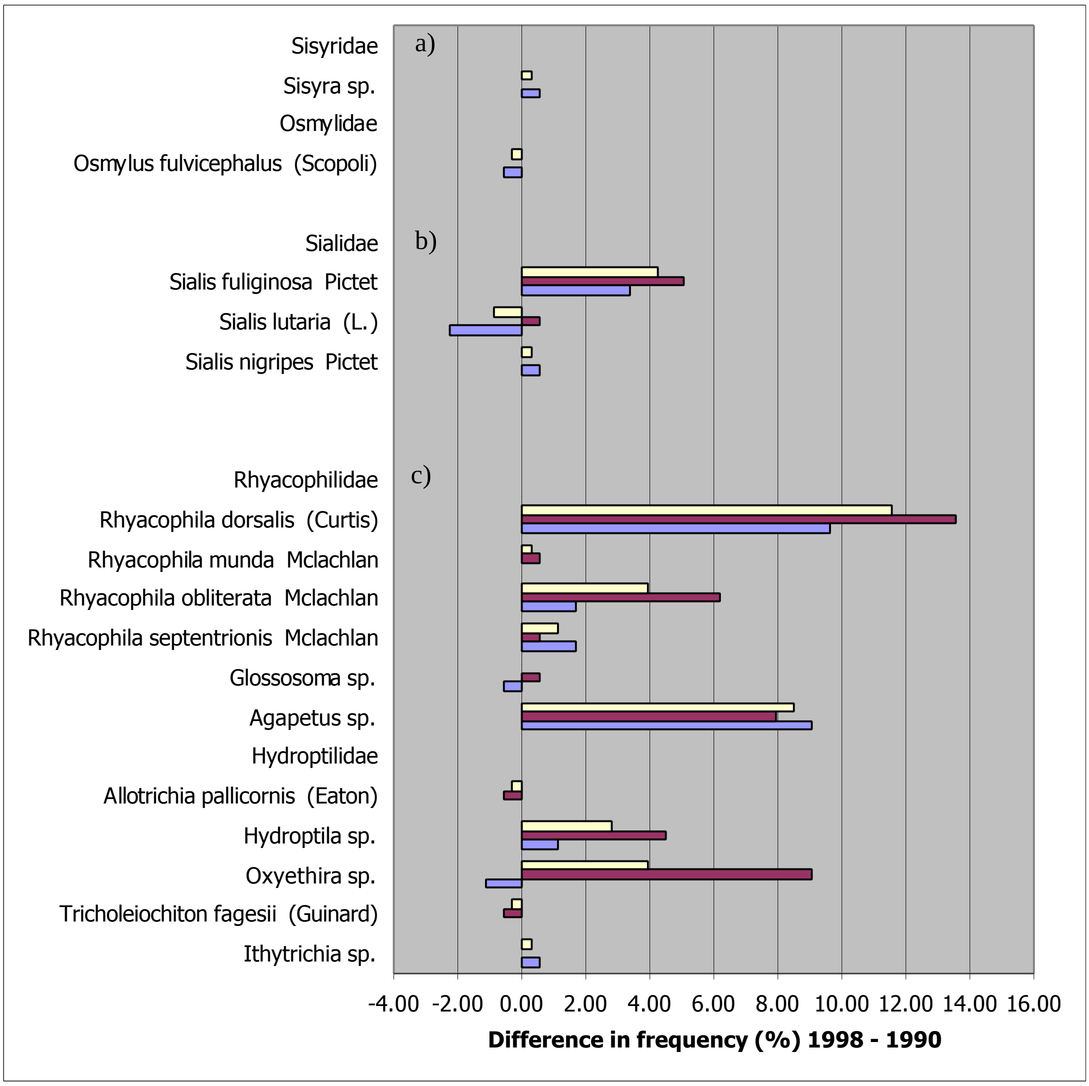

Figure 3.12. Changes in the frequency of occurrence of species of a) Neuroptera, b) Megaloptera and c) selected families of Trichoptera between the 1990 and 1998 Countryside Surveys.

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Rhyacophilidae (continued)

The greatest gains were made by the commonest species, *Rhyacophila dorsalis,* which increased in frequency by more than 13% in each of the upland zones, including a 28.3% increase in EZ6 and a 21.3% gain in EZ4.

Similarly, *R obliterata* increased markedly in the upland zones, especially EZ6, but made small losses in the lowlands. In contrast, *R. septentrionis* net gains depended entirely on the lowlands. *R. munda* was the least frequently recorded taxon and only increased in frequency in EZ6.

Glossosomatidae (Figure 3.12)

Larvae of this micro-caddis could only be routinely identified to genus. One of the two genera present, *Glossosoma*, showed small balanced losses in England and Wales and gains in Scotland. However, the other genus, *Agapetus* increased in frequency in all environmental zones and most notably in EZ4 (+21.1%) and EZ3 (+14/9%).

Hydroptilidae (Figure 3.12)

These micro-caddis are also difficult to identify to species and three of the taxa present were only recorded at generic level.

Few substantial net changes in frequency were recorded for any of the five recorded taxa and this generality tended to hold for individual environmental zones as well. However, EZ6 provided a notable exception to this pattern with 18.3% and 15.0% increases in *Oxyethira* sp. and *Hydroptila* sp. respectively.

Between the NRA surveys of 1990 and 1995 this family showed the largest increase (+17.8%) of any family.

Philopotamidae (Figure 3.13)

Philopotamidae are caseless caddis that tend to occur in small, headwater streams.

Of the three taxa recorded in Countryside Surveys, *Chimarra marginata* is the only one whose range regularly extends into larger rivers (Edington and Hildrew 1981). This species was rarely recorded in Countryside Survey samples and showed only small changes in frequency between surveys.

On the other hand, the two headwater taxa, *Philopotamus montanus* and *Wormaldia* sp. showed strong and similar gains in both country units. In the case of *P. montanus* the large majority of gains were in upland zones but *Wormaldia* sp. showed similar increases in both the uplands and lowlands. Neither taxon was recorded in EZ1.

In the two NRA national surveys, of 1990 and 1995, Philopotamidae decreased by 0.3%, although it must be noted that, unlike CS2000, these NRA surveys only included a small proportion of headwater sites.

Psychomyiidae (Figure 3.13)

Psychomyiidae are also caseless caddis and, like Philopotamidae, many of the component species are associated with headwaters.
Lype sp. was the most frequent of the six taxa captured during countryside surveys and was principally taken in lowland England and Wales (EZs 1 and 2). Its Scottish distribution was also confined to the lowlands. Its moderate net GB increase was dominated by a 19.2% gain in frequency in EZ1.

Psychomyia pusilla is the representative of this family that most frequently extends into larger rivers and it was infrequently taken during either CS1990 or CS2000.

Tinodes is a typical headwater genus and all three recorded species showed small gains in frequency, from a low base, between 1990 and 1995.

Between the two NRA surveys Psychomyiidae showed a very large gain of 15.6%, despite the small proportion of headwater sites in these surveys.

Polycentropodidae (Figure 3.13)

This family contains 13 British species of net-spinnng, caseless caddis, the status of one of which is uncertain. Eight of these were recorded in Countryside Surveys. With the exception of *Cyrnus flavidus*, which was rarely recorded, those species that were found are characteristic of fast-flowing streams and show well marked longitudinal replacement sequences (Edington and Hildrew 1981).

Many of the eight recorded species were rarely taken and showed just small losses or gains. However, the three commonest taxa, *Plectrocnemia conspersa*, *Plectrocnema geniculata Polycentropus flavomaculatus,* showed large net gains, particularly in Scotland. The largest gains for these three species, of 23.3%, 11.7% 18.3% respectively were each in EZ6. In fact, both *Polycentropus flavomaculatus* and *P. kingi* recorded net losses in England and Wales, with P. flavomaculatus declining most in EZ3 (-8.5%) and EZ2 (-4.8%).

In the NRA's two national surveys of England and Wales, of 1990 and 1995, this family showed a small net gain of only 0.4%.

Hydropsychidae (Figure 3.13)

Hydropsychidae are also a diverse family of net-spinnng, caseless caddis. The British list includes 12 species, three of which may now be extinct. Of the nine extant taxa, all but the large river species, *Hydropsyche contubernalis,* were recorded. Like Polycentropodidae, this family shows clear longitudinal species sequences (Edington and Hildrew 1981).

Of the eight species captured, the only one to show a net decline between 1990 and 1998 was the Red Data Book 1 species, *H. saxonica*, which showed no gains in any environmental zone.

Otherwise, most gains in the remaining species were positively related to the baseline frequency of the taxa in 1990. Thus, biggest gains were made by *H. siltalai*, particularly in the more upland Scottish zones (EZ5 and EZ6). Conversely, the other species showed similar or greater gains in England and Wales than in Scotland, with the headwater species *Diplectrona felix* making a 10.6% gain in EZ3.

When the NRA surveys of 1990 and 1995 were compared, Hydropsychidae were shown to have made a 9% gain.

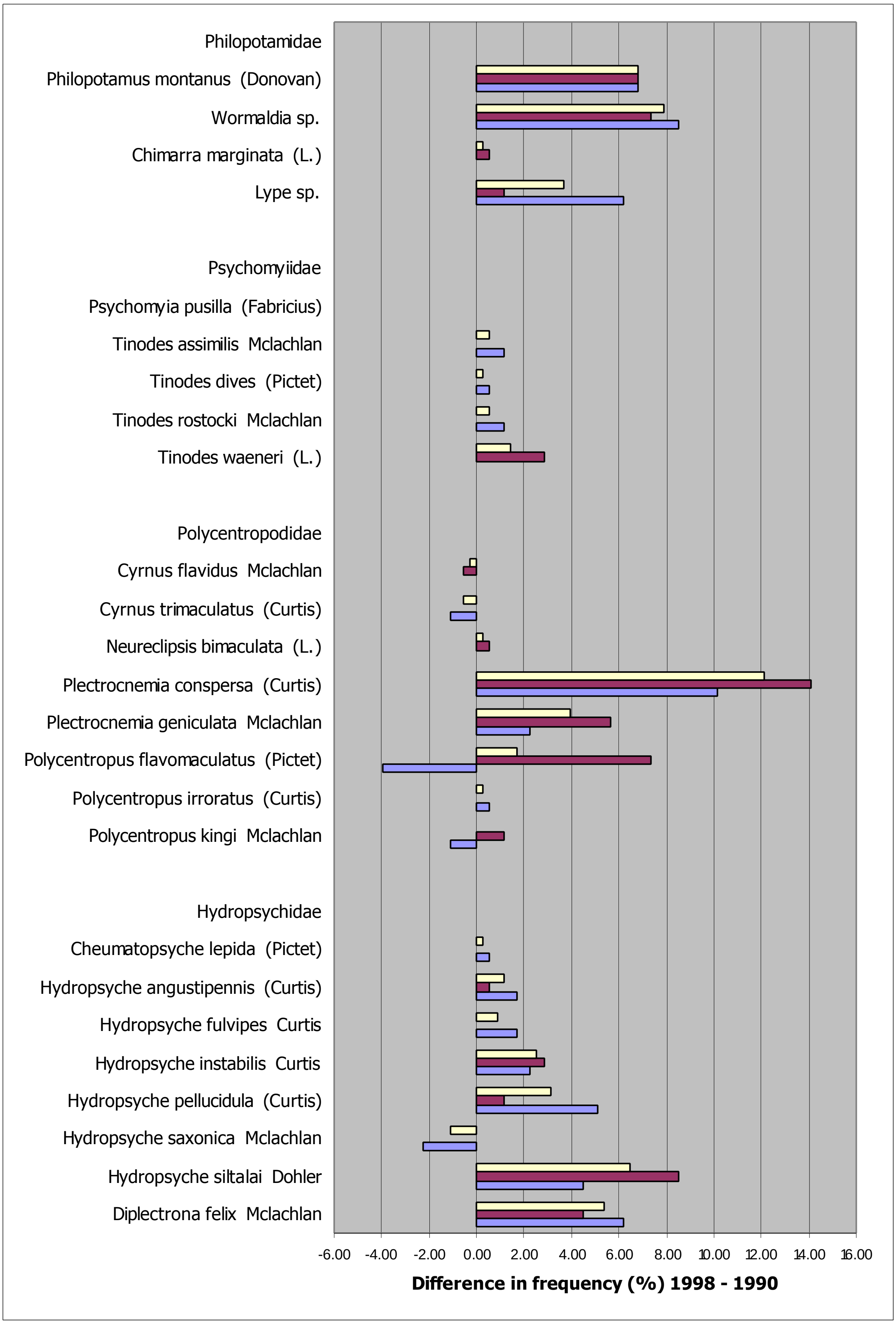

Figure 3.13. Changes in the frequency of occurrence of species of selected families of Trichoptera between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Phryganeidae (Figure 3.14)

Phryganeids are large cased caddis characteristic of standing water-bodies, canals and larger, slow-flowing, rivers (Wallace *et al*. 1990). Consequently there were few records of this family in either CS1990 or CS2000, although the two genera that were found each increased in frequency over the eight-year period.

Between the two NRA surveys of this family increased in frequency by 1.8%.

Brachycentridae (Figure 3.14)

In Britain this family is represented by a single species, *Brachycentrus subnubilus*. It is widespread in larger streams and rivers but rarely found in smaller headwaters. Thus this taxon was not often found in Countryside Surveys and was equally infrequent in 1990 and 1998.

In the NRA surveys it decreased by just 0.2% between 1990 and 1995.

Lepidostomatidae (Figure 3.14)

The three British species were all found in Countryside Survey samples but the rarest of these nationally was found at two sites only in EZ1 in both 1990 and 1995. The most commonly recorded taxon, *Crunoecia irrorata* is characteristic of small streams in woods and made moderate gains in each of EZ2 and EZs 4-6. *Lepidostoma hirtum* extends widely into larger watercourses and its main gains (+4.2%) were in upland EZ3. In NRA surveys this family showed a gain of 4.2% over the five-year period.

Goeridae (Figure 3.14)

All three GB species are widespread in stony rivers and were found in CS1990 and CS2000. Only two of these showed marked changes in frequency. *Goera pilosa* increased mainly in EZ1 (+12.8%) whilst *Silo pallipes* increased most in EZ2 (+16.9%) and EZ3 (8.5%). It also made modest gains in all three Scottish zones. Between NRA surveys this family made a gain of 7.2%.

Limnephilidae (Figure 3.14)

Limnephilidae is by far the most diverse and widespread of the British caddis families. The family comprises 59 UK species, of which 58 occur in Great Britain. Their widespread habitats include all forms and sizes of running and standing water bodies and one species is even terrestrial.

In Countryside Surveys, 22 taxa were recorded. These included 21 distinct species and one species group comprising two component species. Changes in the frequency of these taxa are given in the following pages. They compare with a substantial net increase of this family of 15.4% between the national NRA surveys of 1990 and 1995.

In CS2000, five taxa of Limnephilidae occurred at more than 10% of the matched 1990 and 1998 sites. These were *Drusus annulatus*, *Micropterna sequax*, *Potamophylax cingulatus* group (comprising *P. cingulatus* and *P. latipennis*) and *Chaetopteryx villosa*. Each is widespread and common in streams. The first three of these taxa made gains in excess of 7% in each country unit and net gains in excess of 8% in GB as a whole. In general the gains were equally distributed between the two country units and, in two cases, between upland (EZ3, EZ5 and EZ6) and lowland (EZ1, EZ2 and EZ4) zones. However, there was a distinct tendency for *Micropterna sequax* to make greater gains in lowland zones, particularly EZ2 (+15.7%) and EZ4 (+14.0%).

The fourth frequent taxon, *Chaetopteryx villosa*, a headwater species, showed smaller gains, of around 3% in both Scotland and in England and Wales, with a net national gain of 3.1%. However, these figures masked a notable loss of 6.4% in the upland English and Welsh environmental zone EZ3.

The remaining taxa occurred at 7% or fewer sites in CS2000 and seven of these showed gains in the range 1–5%.

Rarely did any of these less frequent taxa make notably larger gains in one country unit than another or make gains in excess of 5% in any given environmental zone. Exceptions to the first of these two generalities were *Halesus radiatus, Micropterna lateralis, Limnephilus centralis* and *L. extricatus* which made most of their gains in Scotland and *Limnephilus lunatus* which increased in frequency most in England and Wales.

Gains in excess of 5% in individual environmental zones were as follows: *Halesus digitatus* (EZ2 +6.0%; EZ4 +5.3%), *Micropterna lateralis* (EZ4 +5.3%), *Anabolia nervosa* (EZ1 +6.4%), *Limnephilus extricatus* (EZ4 +10.5%), *Limnephilus lunatus* (EZ2 +8.4%; EZ4 +8.7%). The biggest single loss by any limnephilid in any environmental zone was –4.3% by *Limnephilus rhombicus* in the easterly lowlands (EZ1).

The remainder of the taxa, not referred to above, tended to be infrequent in samples and showed small changes in frequency. In all there were eleven of the 22 recorded taxa whose net change (gain or loss) was less than 1%.

Only three of the 22 taxa made net overall GB losses and each of these represented a loss of just a single site.

Beraeidae (Figure 3.15)

Three of the four British beraeids were found in Countryside Survey samples. Two of these, *Beraea pullata and B. maurus*, occur in springs and small streams, whilst *Beraeodes minutus* extends into larger watercourses.

Each of the taxa increased in overall frequency between 1990 and 1998 and the *Beraea* species each showed similar gains in each country unit. However, the small gains by *Beraeodes minutus* were confined to Scottish zone EZ5. Between the NRA surveys Beraeidae increased by 1.8%.

Odontoceridae (Figure 3.15)

The single British species in this family, *Odontocerum albicorne*, was found at approximately 12% of sites in both country units. It is a sand-grain cased caddis that is commonly found in stony streams. In England and Wales it increased in frequency by 5.7%, whilst the gain in Scotland was 8.5%. Increases in frequency occurred in all zones but were greatest in the uplands, particularly EZ5 (+11.7%).

This family/species occurred at 5.4% of matched sites in the NRA's 1990 survey and 8.4% of sites in their 1995 survey.

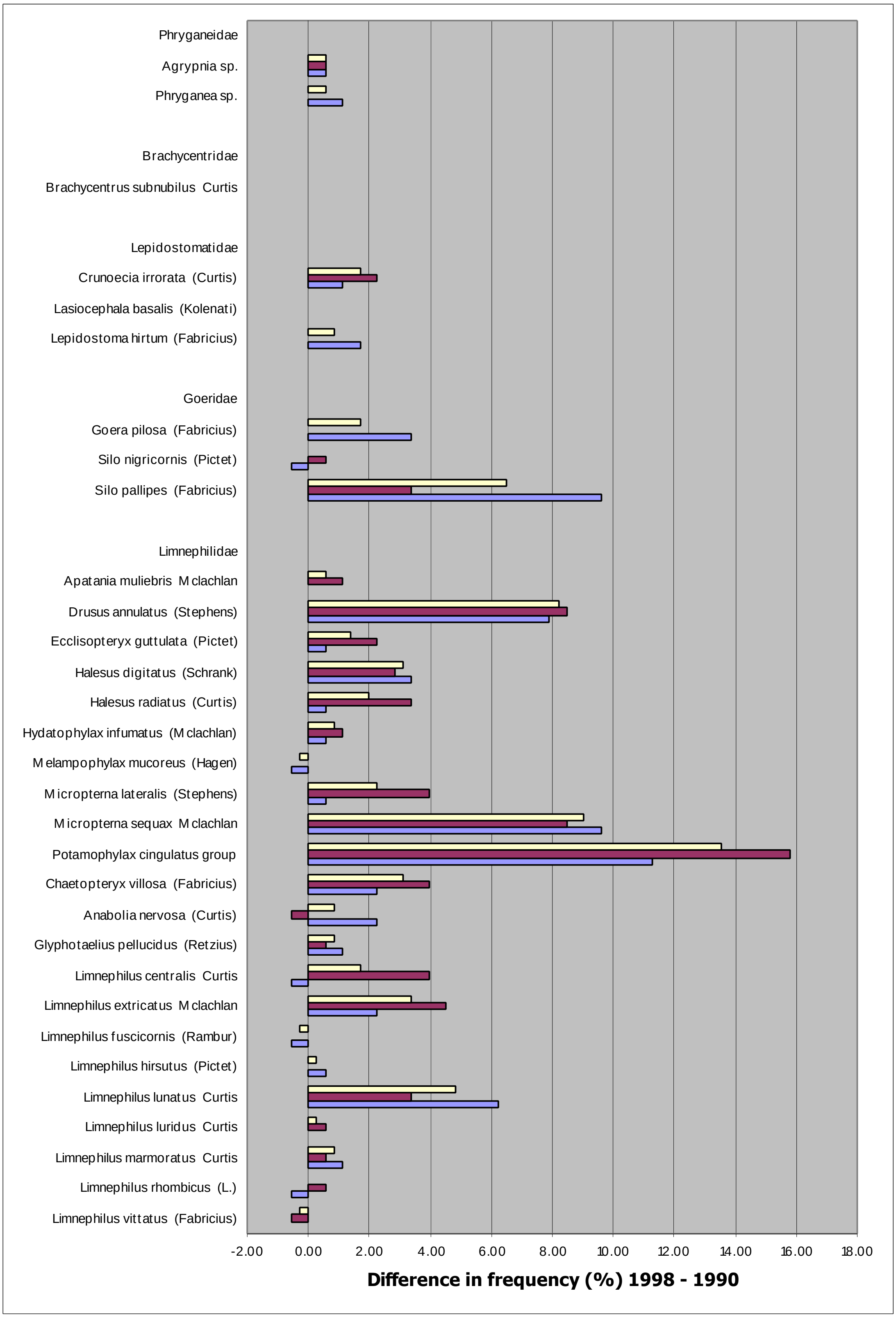

Figure 3.14. Changes in the frequency of occurrence of species of selected families of Trichoptera between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Odontoceridae (Figure 3.15)

The single British species in this family, *Odontocerum albicorne*, was found at approximately 12% of sites in both country units. It is a sand-grain cased caddis that is commonly found in stony streams. In England and Wales it increased in frequency by 5.7%, whilst the gain in Scotland was 8.5%. Increases in frequency occurred in all zones but were greatest in the uplands, particularly EZ5 (+11.7%).

This family/species occurred at 5.4% of sites in the NRA's 1990 survey and 8.4% of sites in their 1995 survey.

Sericostomatidae (Figure 3.15)

There are two British species in this family, of which the common and widespread *Sericostoma personatum* was recorded in Countryside Surveys. The characteristic habitat of this species is the stony substratum of streams, rivers and lakes.

This species showed a net gain in frequency of 6.5% between CS1990 and CS2000. This increase was distributed approximately evenly between country units. Gains occurred in all zones except EZ1 where there was no change, but biggest increases, of about 12.5%, were in EZ3 and EZ4.

Between the 1990 and 1995 NRA surveys Sericostomatidae increased in frequency by 6.6%.

Molannidae (Figure 3.15)

The single recorded species was *Molanna angustata*. This is primarily a standing-water species that also occurs in slow-flowing watercourses. In CS2000 it showed a gain of one site in EZ2 in comparison with CS1990. It also occurred in small numbers in EZ1 but showed no change in frequency.

In the two national NRA surveys it made a five year gain in frequency of 1.2%.

Leptoceridae (Figure 3.15)

Leptoceridae is a diverse family of cased caddis. It contains 31 British species, of which just nine were recorded in Countryside Survey samples.

Few of the nine species showed major gains or losses between surveys and only *Athripsodes bilineatus* (+1.7%) and *Mystacides azurea* (+1.1%) showed net GB gains of more than 1%.

The greatest changes per country unit were the 2.2% gain of *A. bilineatus* in Scotland and the 1.7% loss of *A. aterrimus* in England and Wales.

In contrast, in the NRA surveys of England and Wales, which are predominantly of larger rivers than sampled in CS2000, Leptoceridae showed a large gain in frequency of 15.0%.

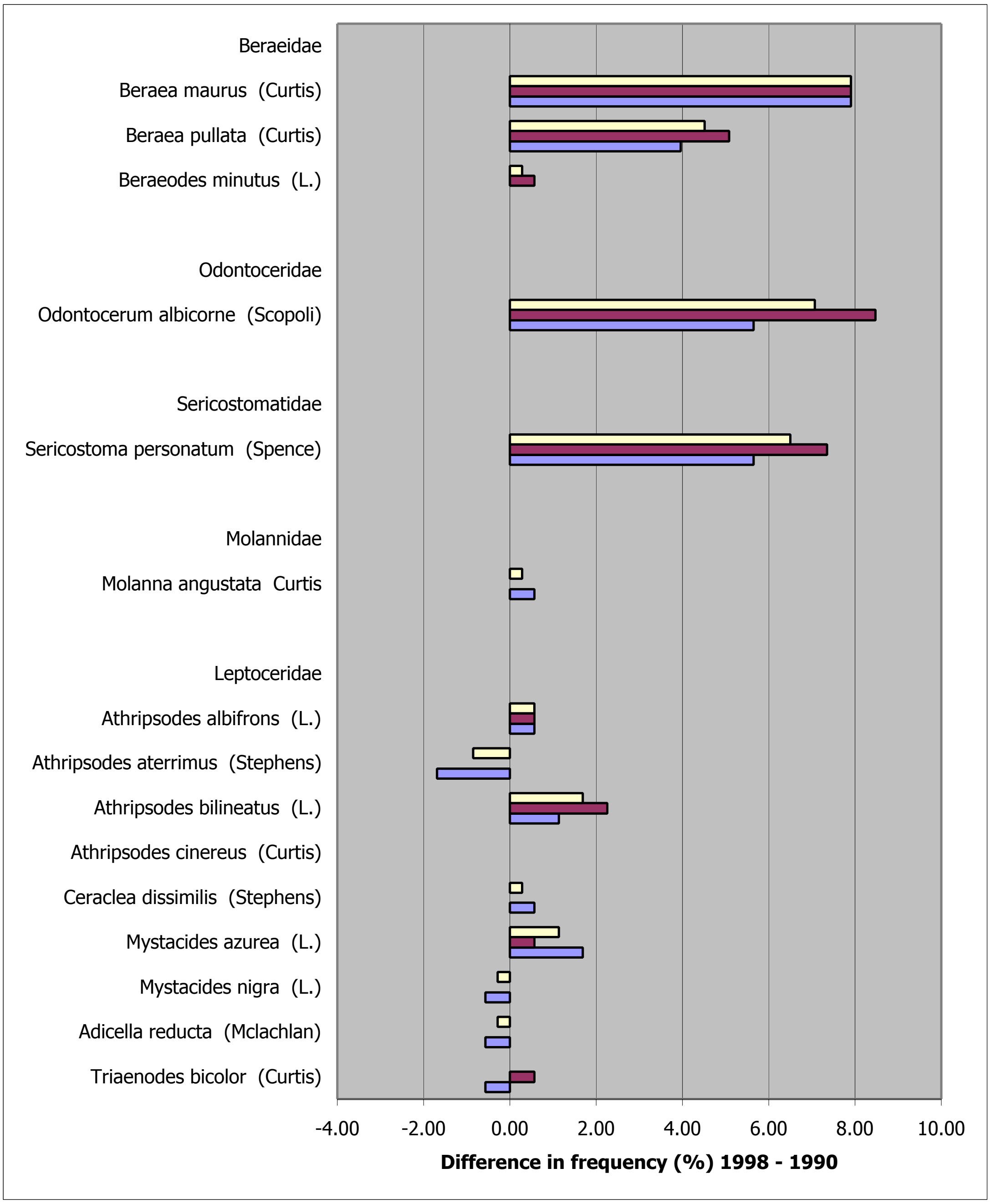

Figure 3.15. Changes in the frequency of occurrence of species of selected families of Trichoptera between the 1990 and 1998 Countryside Surveys

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

DIPTERA

Tipulidae (Figure 3.16)

Tipulidae are a very diverse group commonly known as crane flies. The taxon known as Tipulidae in the BMWP score system is now divided into four component families, Tipulidae, Limoniidae, Pediciidae and Cylindrotomidae, given in italics when used as section headers below.. The composite family Tipulidae gained in frequency by 4.2% between the NRA surveys.

Tipulidae (*sensu strictu*) (Figure 3.16)

Only two taxa were commonly recorded, *Tipula montium* group *(T. montium*, *T couckei* and *T. lateralis*) and *T. maxima* group (*T. maxima* and *T. fulvipennis*). Both showed marked increases in frequency, particularly in Scotland for *T. maxima* group. All other species were much less frequently recorded and showed net changes in the range + 0.85% to -0.3%.

Cylindrotomidae (Figure 3.16)

Of the family's two British species, *Phalacoptera replicata* was found at single sites in environmental zones EZ4 and EZ5 in CS2000. It was not recorded in CS1990.

Limoniidae (Figure 3.16)

Twenty limoniid taxa were recorded in CS2000. This compares with the British listing, which stands at approximately 163 freshwater species, according to the definition of fresh water. However the 20 recorded taxa were mainly genera or sub-genera and potentially encompassed a much wider range of individual species.

Of the 20 taxa, 16 showed changes in net GB frequency of less than 2%. In only five cases were these changes losses.

The biggest gains were by *Limnophila (Eloeophila)* sp. Its 13.8% increase in frequency included a 17.5% gain in Scotland. Two sub-genera of the genus *Pilaria* showed gains of about 5%. Of these, gains by *P. (Neolimnomyia)* sp. were mainly in Scotland (especially in EZ4) and most gains by *P. (Pilaria)* sp. were in England and Wales (mainly in lowland zones EZ1). A third taxon, *Limnophila (Brachylimnophila)* increased by 2.3% in both country units with most of the increases (+3.7%) in the lowlands.

***Pediciidae* (Figure 3.16)**

Dicranota sp. (eight UK species) made one of the biggest gains, between Countryside Surveys, of any taxon (+20.%) with a net gain in Scotland of 27.1% (EZ 4, +33.3%, EZ%, +23.3% and EZ6, +25.0%).

Pedicia (Pedicia) group, a complex of sub-genera and species that *includes P. (Pedicia) rivosa, P. (Crunobia) sp*., P. *(Amalopsis) occulata* and *P. (Ludicia)* sp., also showed a marked net GB gain of 7.9%, equally distributed between country units but primarily in the three upland environmental zones (+10.8%).

The least commonly recorded sub-genus of *Pedicia, P. (Tricyphona)* sp., showed small increases in frequency in England and Wales that were greater than the losses that it incurred in Scotland.

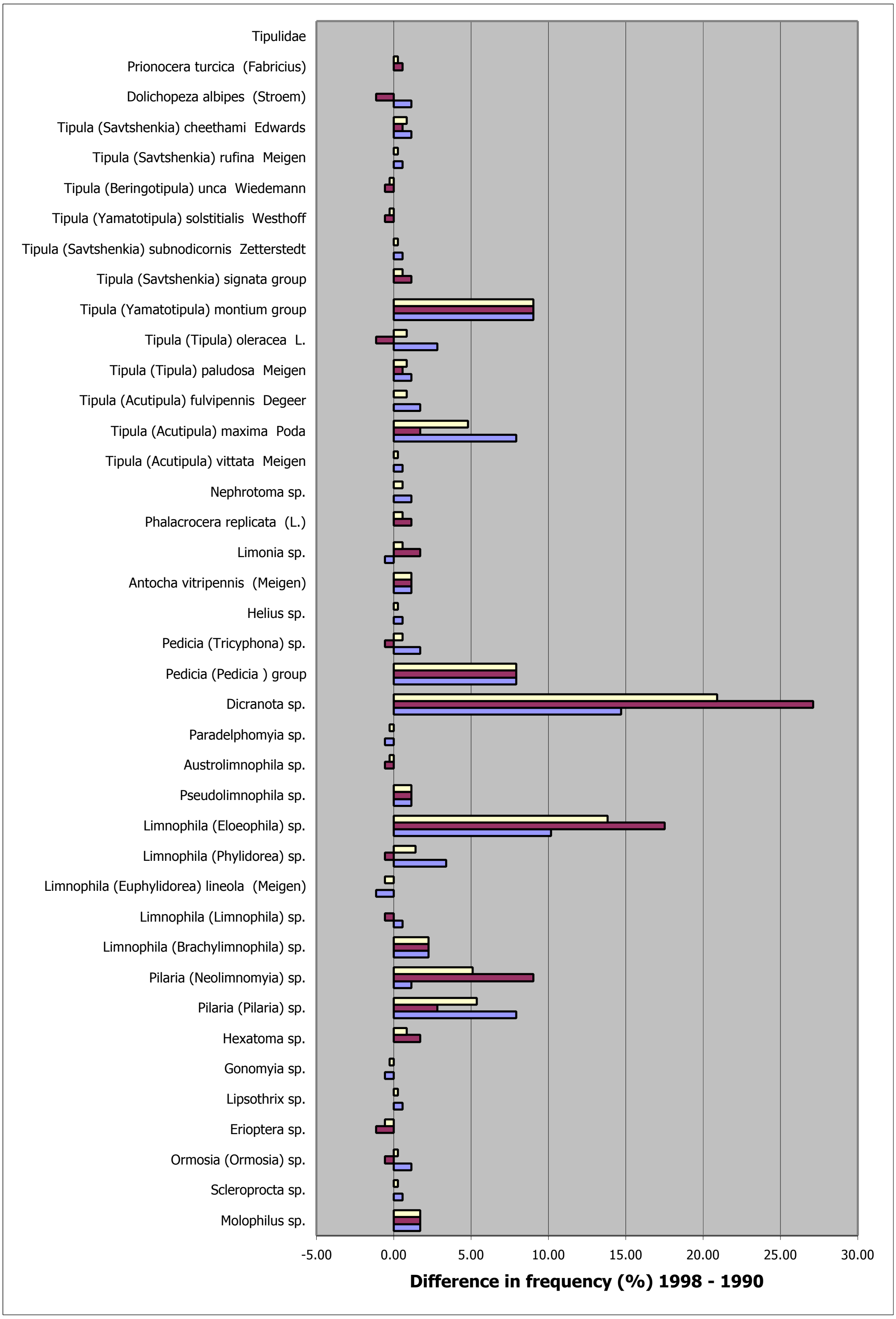

Figure 3.16. Changes in the frequency of occurrence of species and genera of Tipulidae between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Psychodidae (Figure 3.17)

In Countryside Surveys 14 distinct taxa in this family were recorded in three genera.

All taxa, with the exception of *Pericoma canescens*, showed a net GB increase between CS1990 and CS2000 and these increases tended to be evenly distributed between the two country units. The exceptions were *P. neglecta*, *P. pseudoexquiseta and P. pulchra* that were gained in Scotland but lost in England and Wales. The biggest gains were by *P. trivialis* group, a common and widespread complex of an unknown number of species. Greatest gains and frequencies of occurrence of almost all taxa were in the lowland zones, EZ1, EZ2 and EZ4.

Ptychopteridae (Figure 3.17)

Specimens could only be identified to the genus *Ptychoptera*. Gains in frequency in England and Wales in 1998 were almost completely offset by losses in Scotland.

Dixidae (Figure 3.17)

Nine taxa of Dixidae were recorded, including eight species and one species complex. The family is known as the meniscus midges and are found suspended from the surface of still or slow-moving water.

Only *Dixa maculata* complex (*D. maculata*, *D. nubilipennis* and *D. submaculata*) occurred in more than 8% of GB samples and all the other species were found at ≤3% of sites. This “*maculata*” complex was gained at 7.0% of sites in the Scottish lowlands (EZ4) lost in 8.5% of sites in EZ3 (English and Welsh uplands).

Of the eight taxa, five showed small net gains (<3%) and three small net losses of >2%. As a result of their preference for slow-flow conditions, greatest gains, and frequencies, of occurrence of almost all taxa were in lowland zones, EZ1, EZ2 and EZ4.

Chaoboridae (Figure 3.18)

Chaoboridae, the phantom midges, normally live in standing water. The two recorded species decreased in frequency in 1998 from the already low levels recorded in CS1990

Culicidae (Figure 3.18)

Culicidae are mosquitoes and they normally live in standing waters. In 1998 they decreased in frequency from the already low base levels recorded in CS1990

Thaumaleidae (Figure 3.18)

Thaumaleidae are characteristic of small headwater streams. There are three British species in the single genus, *Thaumalea*, and species level identification of larvae was not possible.

The genus was rarely found in Countryside Surveys and small gains in lowland England and Wales (EZ2) were offset by equivalent losses in upland Scotland (EZ5 and EZ6).

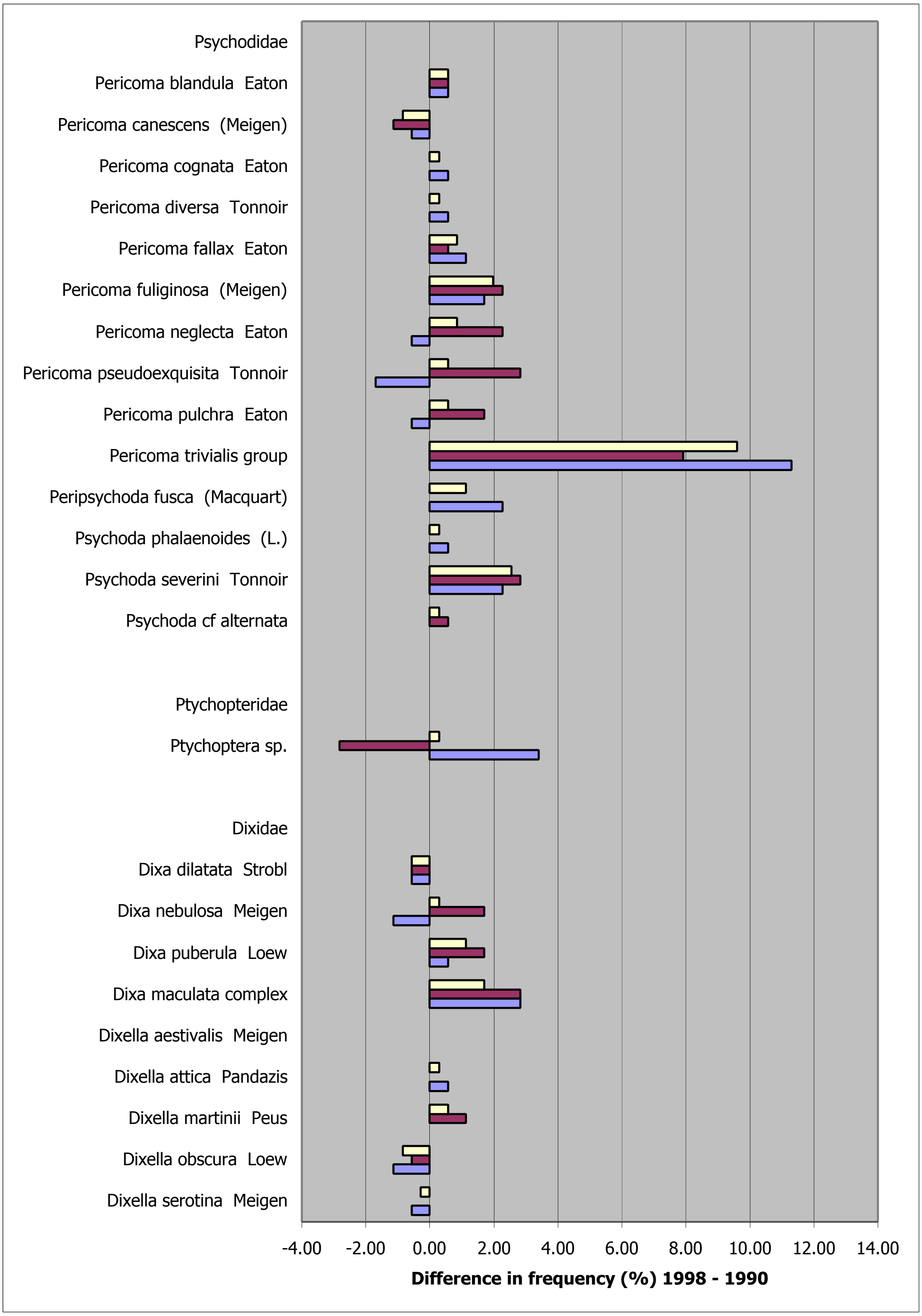

Figure 3.17 Changes in the frequency of occurrence of species of selected families of Diptera between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Ceratopogonidae (Figure 3.18)

Ceratopogonidae is a widespread and diverse family of non-biting midges. There are in excess of 180 British species but most cannot be reliably identified as larvae. Identification has therefore been at family level only. At this level there has been a net increase of 13.5% in England and Wales and 15.3% in Scotland. Gains in excess of 20% were recorded in upland Scottish zones EZ5 and EZ6 and in excess of 20% in lowland EZs 2 and 4.

Simuliidae (Figure 3.18)

This family is known as the blackflies. Collectively the constituent taxa occur in all types of running waters, although the family are filterers and is therefore less frequent and abundant in slower flowing watercourses.

Between CS1990 and CS2000 there was a general increase in frequency of the five most commonly occurring taxon groups. This compares with a family-level gain of 5.3% between the NRA surveys of 1990 and 1995.

Of the 13 recorded taxa of Simuliidae, six were species groups and another was a genus. This is because early instars of this family are consistently difficult to identify as, in many cases, are later instars too.

Thus the five commonest taxa (frequency of occurrence of >10%) were *Simulium (Nevermannia) cryophilum* group (present in 21% of CS2000 samples), *S. (N.) vernum* group (12%), *S. (Eusimulium) aureum* group (15%), *S. (S.) argyreatum* group (14%) and *S. (S.) ornatum* group (40%).

S. (S.) ornatum group showed large gains in all environmental zones, ranging from 8.3% in EZ6 to 36.8% in EZ4, with an overall net GB gain of 20.9%. This, along with *Dicranota* sp., was the joint largest gain of any single taxon.

The second largest net GB gain was made by *S. (E.) vernum* group (+10.7%), closely followed by *S. (N.) cryophilum* group (+10.5%). In both cases the greatest gains were in Scotland, although large increases in frequency also occurred in upland EZ3 in England and Wales.

Of the five commonest simuliids, the smallest gains were made by *S. (E.) aureum* group. Net gains of almost 5% were made in both the lowland and upland groups of zones. However, this taxon also declined slightly (-2.1%) in EZ3.

The fifth of the common simuliid taxa, *S. (S.) argyreatum* group, made a net GB gain of 8.2%, with highly polarised differences between the upland zones (net gain of 15.6%) and lowland zones (net gain of 1.6%).

The only two taxa to show net losses were *S. (Hellichella) latipes* and *S. (N.) costatum*. Each of these is associated with extreme headwater sites that are susceptible to very low flows or occasional drying out.

The remaining simuliid taxa showed various small net gains throughout GB, although *S. (N.) angustitarse* group recorded a small loss in Scotland (-1.7%) that derived from losses in both EZ4 and EZ6 and no gains in EZ5.

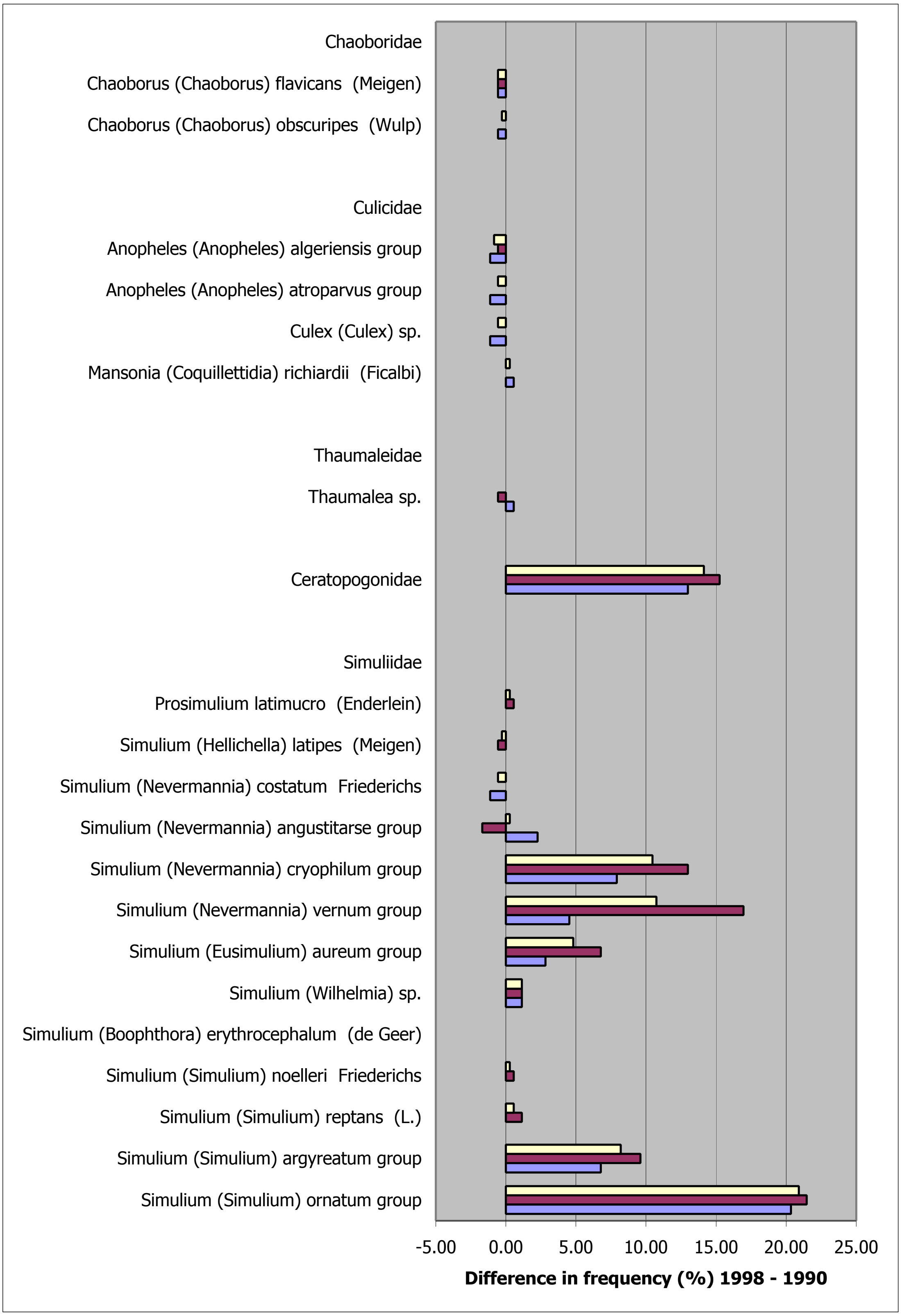

Figure 3.18. Changes in the frequency of occurrence of species and genera of selected families of Diptera between the 1990 and 1998 Countryside Surveys. Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Chironomidae (Figure 3.19)

These are the almost ubiquitous non-biting midges and they were present at all sites in the 1990 and 1995 NRA surveys. In Countryside Surveys they occurred in 94% of sites and showed a net GB gain of 4.0% between 1990 and 1998. However, this was composed of contrasting 5.1% losses in England and Wales and 13.0% gains. in Scotland

Stratiomyidae (Figure 3.19)

Three genera were recorded, of which only *Oxycera* sp. was present in more than five sites. Between CS1990 and CS2000, this genus showed changes in frequency in three zones; EZ1 (+6.4%), EZ2 (+3.6%) and EZ6 (-1.7%). *Odontomyia* sp. showed no net changes but *Stratiomyis* sp. showed minimum increases in EZ1 and EZ2.

Rhagionidae (Figure 3.19)

This family group includes the current family Athericidae. *Atherix ibis* and *A. marginata* belong to Athericidae and *Chrysophilus* sp. is the only true rhagionid. None of the three was common and the small losses and gains involved one or two site differences, principally in England and Wales.

Tabanidae (Figure 3.19)

Tabanid larvae could not be identified to species. The two recognised taxa occurred rarely and only *Tabanus* sp. showed any change in frequency. The net loss of this genus was due to losses in England and Wales being greater than gains in Scotland.

Empididae (Figure 3.19)

Empididae are not easily identified as larvae and, hence, identification was to four groups of genera. Each group made net GB gains but, because of the potentially diverse range of species in each of the four taxa, some paradoxical results were obtained. Thus *Wiedemannia* group made a gain of 20.0% in highland Scotland (EZ6). However a 12.8% loss in upland England and Wales (EZ3) was balanced by a similar gain in lowland Scotland (EZ4). Collectively the taxon was lost at 1.7% of English and Welsh sites but gained at 11.9% of sites in Scotland. A less extreme contrast was the 2.8% gain of *Hemerodromia* sp. in England and Wales (notably EZ1) compared with the 0.6% Scottish loss.

Syrphidae (Figure 3.19)

Family was the standard level of identification and the net GB gain, of 2.3%, was entirely due to gains in the three Scottish environmental zones.

Sciomyzidae (Figure 3.19)

This taxon was also identified to family and its net gain of 4.2% reflected gains in five of the environmental zones (EZ3 no change).

Ephydridae (Figure 3.19)

Gains were made in all environmental zones and the net GB gain of 3.7% was equally spread between country units.

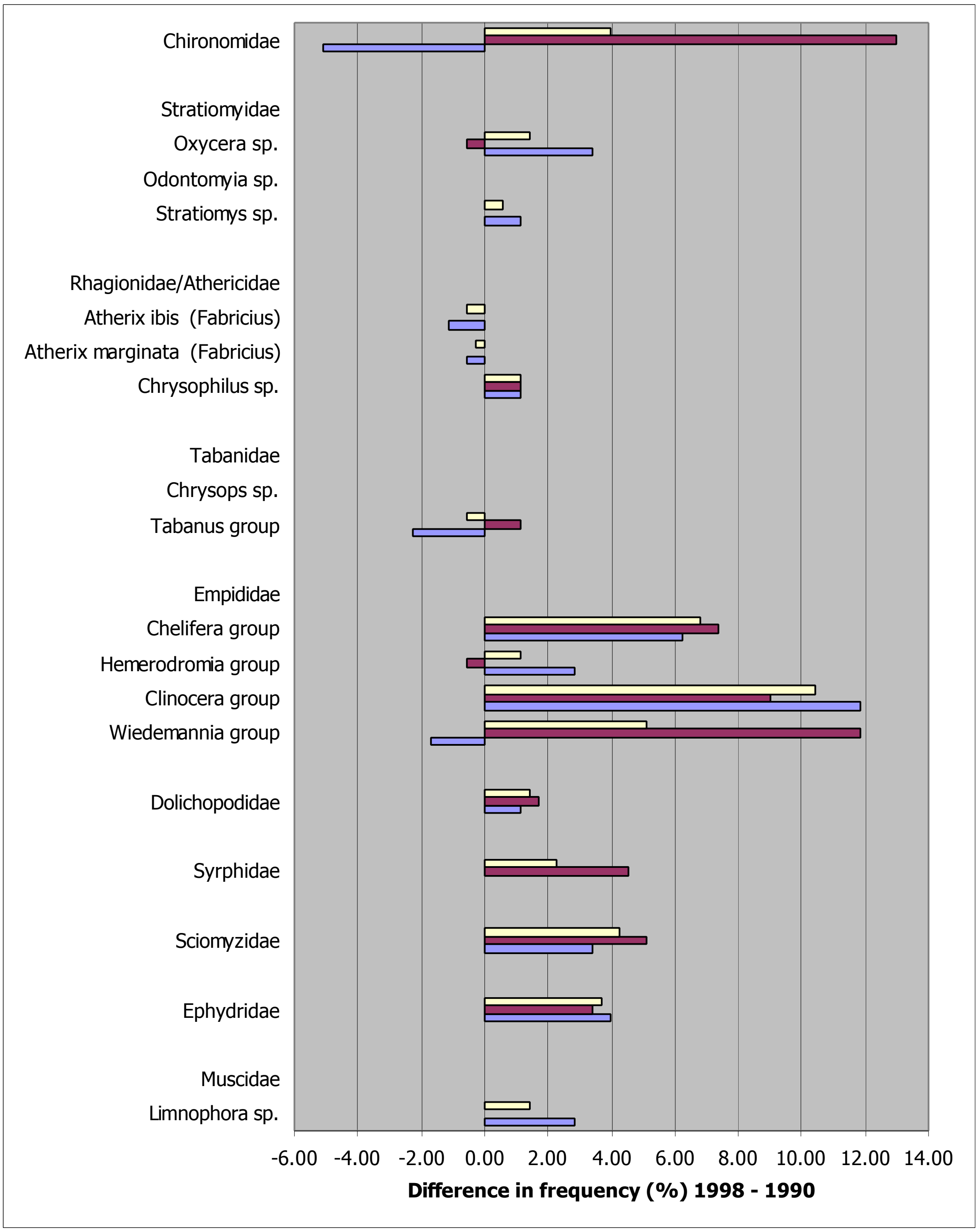

Figure 3.19. Changes in the frequency of occurrence of selected dipteran taxa between the 1990 and 1998 Countryside Surveys.

Histogram shades indicate: Great Britain (straw-coloured bars) and for the separate country units of England and Wales (blue bars) and of Scotland (burgundy bars).

Muscidae (Figure 3.19)

Limnophora sp., the sole taxon, gained in EZs 1, 2 and 6. A net gain of 1.4% was wholly derived from the 2.8% net gain in England and Wales. There was no net change in Scotland.

3.1.4 Conservation status of individual species

General

There is no standard published list offreshwater macro-invertebrate`` taxa with national conservation status and data within this section are based on listings compiled by the authors from a wide variety of sources, particularly Ball (1986), Shirt (1987), Bratton (1990), Wallace (1991) and Foster (in press).

In the 1990 Countryside Survey a variety of taxa were recorded in running water samples that were known, at the time of data analysis, to have national conservation status (unpublished data). Comparison with the captures of taxa with some form of national conservation status, showed that in five Red Data Book and 37 nationally scarce taxa were recorded in either or both of CS90 and CS2000 (Table 3.6). Of these, two of the Red Data Book records are doubtful and should not be regarded as confirmed.

All three reliable Red Data Book species occurred in both 1990 and 1998, whilst 30 nationally scarce taxa were recorded from the 441 samples (including replicates) from the 404 sites sampled in 1998 and 16 definite and one probable nationally scarce taxa were recorded from the 361 sites sampled in CS90.

Table 3.6 **The occurrence of taxa with national conservation status in CS2000 (1998) and/or CS90 (1990) sites. Dark circles indicate certain records. The open circle indicates a probable record. Question marks indicate doubtful/unconfirmed records.**

Species Name	National Status	Species Code	1998	1990
Gastropoda				
Valvata macrostoma Morch	Red Data Book 2	16130102	●	●
Ephemeroptera				
Heptagenia fuscogrisea Retzius	Nationally Scarce	40130201	●	
Plecoptera				
Taeniopteryx nebulosa L.	Red Data Book 5	41110101	●	●
Coleoptera				
Peltodytes caesus (Duftschmid)	Nationally Scarce B	45110201	●	
Haliplus heydeni Wehncke	Nationally Scarce B	45110307	●	●
Haliplus laminatus Schaller	Nationally Scarce B	45110309		●
Hydroporus ferrugineus Stephens	Nationally Scarce B	45140807	●	
Hydroporus obsoletus Aube	Nationally Scarce B	45140823	●	
Stictonectes lepidus (Olivier)	Nationally Scarce B	45140901	●	
Deronectes latus (Stephens)	Nationally Scarce B	45141201	●	●
Potamonectes griseostriatus Degeer	Nationally Scarce B	45141304	●	
Oreodytes davisii (Curtis)	Nationally Scarce B	45141501	●	●
Scarodytes halensis (Fabricius)	Nationally Scarce B	45141601	●	●
Agabus biguttatus (Olivier)	Nationally Scarce B	45142003	●	
Agabus ○halconatus (Panzer)	Nationally Scarce B	45142006		●
Ilybius guttiger (Gyllenhal)	Nationally Scarce B	45142105		●
Rhantus aberratus Gemminger & von Harold	Red Data Book 0	45142201		?
Rhantus grapii (Gyllenhal)	Nationally Scarce B	45142205	●	
Gyrinus urinator Illiger	Nationally Scarce B	45150212	●	
Anacaena bipustulata Marsham	Nationally Scarce B	45311301	●	
Laccobius (Macrolaccobius) atratus (Rottenburg)	Nationally Scarce B	45311421		●
Laccobius (Macrolaccobius) sinuatus Motschulsky	Nationally Scarce B	45311426	●	●
Helochares lividus (Forster)	Nationally Scarce B	45311601	●	
Chaetarthria seminulum (Herbst)	Nationally Scarce B	45312101	●	
Ochthebius exsculptus Germar	Nationally Scarce B	45410106		●
Hydraena nigrita Germar	Nationally Scarce B	45410204	●	
Hydraena rufipes Curtis	Nationally Scarce B	45410209		●
Limnebius crinifer Rey	Red Data Book I	45410302	?	
Riolus cupreus Muller	Nationally Scarce B	45630701	●	●

Species Name	National Status	Species Code	1998	1990
Riolus subviolaceus Muller	Nationally Scarce B	45630702	●	●
Megaloptera				
Sialis nigripes Pictet	Nationally Scarce B	46110103	●	
Trichoptera				
Rhyacophila septentrionis Mclachlan	Nationally Scarce	48110104	●	●
Tricholeiochiton fagesii (Guinard)	Nationally Scarce	48130501		●
Tinodes dives (Pictet)	Nationally Scarce	48220402	●	
Tinodes rostocki Mclachlan	Nationally Scarce	48220406	●	
Tinodes unicolor (Pictet)	Nationally Scarce	48220407	●	
Hydropsyche fulvipes Curtis	Nationally Scarce	48250205	●	●
Hydropsyche saxonica Mclachlan	Red Data Book 1	48250208	●	●
Diptera				
Tipula (Savtshenkia) cheethami Edwards	Nationally Scarce	50110332	●	
Phalacrocera replicata L.	Nationally Scarce	50120201		●
Oxycera pardalina Meigen	Nationally Scarce	50610307	●	
Odontomyia tigrina Fabricius	Nationally Scarce	50610505	●	

Brief information on the habitat preferences and Countryside Survey records of each species are given in the following section. Localities of records are confidential.

Species specific information

Valvata macrostoma Mörch – RD2 (vulnerable): The habitat of this species is described by Kerney (1999) as "drainage ditches in lowland marshland levels and river floodplains". Here he lists it as living in stagnant or slowly flowing waters in well-vegetated places". It is calcicolic. It is predominantly found in an area north of Peterborough, with other records near Oxford, the Pevensey and Somerset levels and eastern Dorset.

In both CS90 and CS2000 it was recorded from a single site in Environmental Zone 2 (western lowlands).

Heptagenia fuscogrisea Retzius – Nationally scarce: The nomenclature of this taxon has been recently revised to *Kageronia fuscogrisea*. According to Bratton (1990) the nymphs of this taxon occurs on stony substratum and on the vegetation of calcareous lakes and rivers. Records include the Rivers Thames and Nene catchments, the Rivers Hull and Derwent in Yorkshire and a small stream in Wigtownshire (now Dumfries and Galloway) in southern Scotland.

In CS2000 it was found in a single site in EZ4 (Scottish lowlands).

Taeniopteryx nebulosa L. – RDB5 (endemic): The sole status of this species is endemic and no other conservation categories apply. Thus, Bratton (1990) lists it as widespread in England, Wales and Scotland but possibly absent from East Anglia and South East England. He describes it as a riverine species with associations with the river margins rather than the central channel.

In CS90 this taxon was recorded at five sites in EZ6 (highland Scotland), whilst in CS2000 it occurred nine times in this zone, three times in EZ5 (Scottish foothills) and once in EZ4. In neither year was it recorded from England and Wales.

Peltodytes caesus (Duftschmid) – Nationally Scarce B: According to a recent review of the conservation status of British aquatic beetles Foster (in press) the revised IUCN status of this species is LRnsB (Lower Risk Nationally Scarce category B). According to Friday (1988) this taxon occurs mainly in England with occasional records from the West of England and Wales, preferring habitats such as fenland drains and quarry ponds.

It was not recorded in CS90 but in CS2000 was taken from a single site in EZ1 (eastern lowlands).

Haliplus heydeni Wehnke – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Friday (1988) records that this species principally occurs in Wales and western and eastern England, with occasional records in northern England. Its habitat preferences are given as small grassy ponds and ditches.

This species was found in both CS90 and CS2000. The CS90 distribution comprised a single site in EZ2. In 1998 the single record was in EZ1.

Haliplus laminatus Schaller – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This species occurs mainly in eastern England with occasional records in northern England. Its range of habitats extends from canals and rivers to silt ponds (Friday 1988).It was only found in CS90 where the two records were both from EZ1.

Hydroporus ferrugeneus Stephens – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Friday (1988) lists Scotland and northern England as the main range of this species but with occasional records throughout the rest of England and Wales. She gives the habitat preferences as springs and pools.

In CS2000, the only one of the two Countryside Surveys in which it was recorded, the single record was from EZ4.

Hydroporus obsoletus Aubé – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. *H. obsoletus* occurs occasionally in Scotland, northern and western England and Ireland and is characteristic of springs and small streams (Friday 1988).

It was only found in CS2000 when it occurred in one site in EZ4.

Stictonectes lepidus (Olivier) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This species occurs in all regions of the UK (Friday 1988) though records are less frequent in Scotland and eastern England.

In Countryside Surveys its records were confined to 1998 when it was captured at single sites in both EZ2 and EZ4

Deronectes latus (Stephens) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Friday (1988) records its distribution as covering all regions of Great Britain but that it is only rarely found in each. Its habitat preference is given as clear rivers and streams.

It occurred in both Countryside Surveys. In 1990 it was taken at one site in EZ5, whilst in 1998 its single record was from EZ2.

Potamonectes griseostriatus Degeer – Nationally Scarce B: Foster (in press) does not include it in his UK checklist and its UK conservation status is therefore uncertain. This is reflected in its current taxonomic position. Nilsson (1996) lists *Stictotarsus griseostriatus* (DeGeer) and *S. multineatu* (Falkenström). According to Foster (personal communication) *Potamonectes griseostriatus* should be described as *S. multineatus* for the present. However, the status remains uncertain and Foster believes that there may be two members of the *griseostriatus* complex in Britain and that the genus of these two species may rightly be *Potamodytes*.

The taxon listed as *P. griseostriatus* by Friday (1988), whose key was used for Countryside Survey identifications, was given to be most common in Scotland with less frequent records in northern and Western England, Wales and Ireland. The taxon's preferred habitat was described as hill lochs with peat over gravel.

In CS2000 the taxon was identified from one sample in EZ5. It was not recorded in CS90.

Oreodytes davisii (Curtis) - Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. According to Friday (1988) this is a northern species most commonly present in Scotland and the North of England. Less frequent occurrences can also be expected in Ireland and western England and Wales. The preferred habitat is rocky streams.

The taxon occurred in both Countryside Surveys. In 1990 it was captured at one site in EZ5 and two in EZ6. There were also two EZ6 records in 1998 but the only other record was from EZ3 (upland England and Wales).

Scarodytes halensis (Fabricius) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Friday (1988) states that infrequent records occur only in northern and eastern England and that the species is characteristically found in slow-flowing streams and silt ponds.

In CS2000 a single site in EZ1 was found to support this species and the same had held true for CS90.

Agabus biguttatus (Olivier) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This species occurs in all regions of the UK but that its greatest frequency is in Scotland, Wales and western and northern England. Its habitat preference is streams and wells (Friday 1988).

In 1990 *A. biguttatus* was not captured but in CS2000 it was recorded at two sites in EZ4.

Agabus chalconatus (Panzer) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Specimens of *Agabus chalconatus* were identified to species in CS90 but to *A. chalconatus* group (containing *A. chalconatus* and *A. melanocornis* Zimmerman) in CS2000. It is believed that the 1998 records were of *A chalconatus* but this could not be confirmed definitively. The other species in the group, *A. melanocornis*, is now called *A. melanarius* Aubé and is also RLnsB. In 1990 the taxon was found at single sites in both EZ1 and EZ2. The only CS2000 record of *A. chalconatus* group was from EZ1.

According to Friday (1988), *A. chalconatus* is most frequent in northern and western England, Wales and Ireland with a few records in northern England but none in Scotland. Its preferred habitat is acid water. She lists both *A. melanarius* and *A. melanocornis* and cites the latter as occurring in acid waters in all regions of the UK.

Ilybius guttiger (Gyllenhal) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This is a species of stagnant water, fens and bogs. Its distribution includes each of the five regions of UK considered by Friday (1988) but its greatest frequency is given as in northern and eastern England.

In Countryside Surveys it only occurred in one sample collected from EZ2 in 1990.

Rhantus aberratus Gemminger & von Harold – Red Data Book 0 Extinct: Foster (in press) ascribes the status EX (Extinct in the wild in GB) to this taxon, which is now called *R. bistriatus*. Friday (1988) also lists this speces as possibly extinct in Britain but gives its preferred habitat as fens. Its single 1990 record from EZ5 must therefore be considered to be very doubtful.

Rhantus grapii (Gyllenhal) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Friday (1988) lists eastern England as the area where *R. grapii* is most likely to be captured. Other, less frequent, records exist for Ireland, Wales and northern and western England. The taxon is most commonly associated with ponds and fen drains.

It was only taken in CS2000 and the single record was from EZ1.

Gyrinus urinator Illiger – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This species is characteristic of some lowland watercourses in western England and Wales, although its known range (Friday 1988) also includes Ireland, and northern and eastern England.

It only occurred in the Countryside Survey of 1998 where it was found in one site in EZ1.

Anacaena bipustulata Marsham – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. The habitat range of this taxon incorporates streams, rivers and pits and it is most commonly found in eastern and western England and Wales (Friday 1988). Some additional records exist for northern England.

Countryside Survey records were confined to a single sample collected in EZ1 in 1998.

Laccobius (Macrolaccobius) atratus (Rottenburg) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This taxon occurs in acid water flushes in all regions of UK but most particularly in western England and Wales Friday (1988).
It was found only in CS90 and the single record was in EZ3.

Laccobius (Macrolaccobius) sinuatus Motschulsky – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This species is occasionally present in slow-flowing drains and new ponds in England (Friday 1988).

It was captured in both Countryside Surveys. In both 1990 and 1998 it was present at a single site in EZ3, whilst the CS2000 records were supplemented by an additional record in EZ1.

Helochares lividus (Forster) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This is primarily a pond species with records throughout England and particularly in the east of the country (Friday 1988).

In Countryside Surveys it was only captured in 1998, where the only record was from a site in EZ2.

Chaetarthria seminulum (Herbst) – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Although never common, this species range includes all regions of UK (Friday 1988). Its specialist habitat requirements are moss and mud in fens and bogs.

Its single Countryside Survey record was from an EZ1 site in 1998.

Ochthebius exsculptus Germar – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. *O. exsculptus* is found throughout the UK but the greatest frequency of records is in Scotland, Wales and western England (Friday 1988). It tends to occur in shallow flowing water.

It was found in CS90 only, where the single record was from EZ6.
Hydraena nigrita Germar – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. The species is found infrequently throughout UK. Its preferred habitat is gravel and stones in, often shaded, rivers (Friday 1988).

Countryside Survey records were limited to two sites in EZ2 and one site in EZ4. All captures were made in 1998.

Hydraena rufipes Curtis – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. Like H. nigrita this species has been recorded occasionally in all major regions of UK (Friday 1988). Its normal habitats are rivers and mossy streams.

In Countryside Surveys the two observations of this species were both from EZ1 in 1990.

Limnebius crinifer Rey – Red Data Book 1 (Endangered): Foster (in press) ascribes the status EN (B12bc) (= Endangered category B (severely fragmented, continuing decline in area of occupancy and area, extent and/or quality of habitat)) to this taxon. Its stated occurrence in UK is limited to a single acid pool site in Kent (Carr 1984).

The record in Countryside Surveys was from EZ5 (the Scottish foothills) and must, therefore, be considered doubtful. Regrettably, the specimen was misplaced prior to checking. Given the known environmental ranges of *Limnebius* species (Friday 1988), the more likely identification of this specimen was *L. truncatellus* Thunberg.

Riolus cupreus Muller – Nationally Scarce B: Foster (in press) ascribes the status LRnsB to this taxon. This taxon is stated to occur occasionally throughout GB (Friday 1988). Its favoured habitats are base-rich rivers and lakes.

In both Countryside Surveys this taxon was found at a single site in EZ5.

Riolus subviolaceus Muller – Nationally Scarce B: Foster (in press) ascribes the status LR1c (no national conservation status) to this taxon. This taxon is known to occur occasionally throughout GB (Friday 1988). Its favoured habitat is base-rich rivers.

It was one of the most commonly recorded species, in Countryside Surveys, of the taxa that once had national conservation status and it is no surprise that its status has been downgraded by Foster (in press). In 1990 there were single records from EZ1 and EZ5 but in 1998 there were two records from each of EZ1, EZ5 and EZ6.

Sialis nigripes Pictet – Nationally Scarce B: This species was discovered in GB for the first time in the mid-1970's. Although more and more records are now being established it is still the rarest of the three British species in this genus. Elliott (1996) lists its location types as large rivers (in England and Scotland), calcareous rivers (in Ireland), fast-flowing small streams (in Ireland and Holland) and lakes (in Ireland).

In Countryside Surveys it was only found in 1998 where one record was obtained from EZ1.

Rhyacophila septentrionis McLachlan – Nationally Scarce: This taxon is found in calcium carbonate rich, stony streams. Its records extend from Gloucestershire, to North Wales, Yorkshire and calcareous areas of Scotland (Wallace 1991).

In CS90 one collection of this taxon was made in EZ5, whereas it was much more commonly found in CS2000 with two records in each lowland zone (EZ's 1, 2 and 4) and single records in EZ3 and EZ5.

Tricholeiochiton fagesii (Guinard) – Nationally Scarce: UK records of this micro-caddis have been confined to lochs, ponds, pools, fishing lakes and bogs (Wallace 1991).

Locations included Perthshire, Merseyside, Shropshire, Hampshire, Gwynedd and South Glamorgan.

This taxon was only recorded once in Countryside Surveys, from a site in EZ4 in 1990.

Tinodes dives (Pictet) – Nationally Scarce: It is typically found in calcareous headwaters and recorded locations include Perthshire, Lothian, Yorkshire, Derbyshire, Staffordshire, Cumbria, Herefordshire, Breconshire and north Clywd (Wallace 1991).

A single collection of this species was made from an EZ3 site in 1998.

Tinodes rostocki McLachlan – Nationally Scarce: Its preferred habitat is streams flowing through woodlands (Edington and Hildrew 1981). Credible records include Surrey, the New Forest, south east Devon, Staffordshire and south Wales.

This taxon was taken in CS2000. Both records were from EZ3.

Tinodes uniclor (Pictet) – Nationally Scarce: This species has been found in highly calcareous small streams in both England and Wales (Wallace 1991).

In Countryside Surveys the only record was from EZ1 in 1998.

Hydropsyche fulvipes (Curtis) – Nationally Scarce: This taxon prefers base-rich spring streams and there are infrequent records across south west and central England, Yorkshire, Clwyd, Glamorgan and the Loch Tay limestone region (Wallace 1991).

In Countryside Surveys this species was captured in both 1990 and 1998. In 1990 there was just one record from EZ3. The number of EZ3 records increased to three in 1998 and there was also one record from EZ1.

Hydropsyche saxonica McLachlan – Red Data Book 1 (Endangered): The current status of this species may need reconsideration. Wallace (1991) cited records for it from Oxfordshire and the Midlands but stated that if further populations were to be found in the Midlands, then a lower threat category might be appropriate. In CS90 this taxon occurred six times. Four of the records were from EZ2 but there were also single records for EZ3 and EZ5. Furthermore, Blackburn and Forrest (1995) list yet more records from Worcestershire, Leicestershire, Dorset, Herefordshire, north west England and south west Scotland. With the number of 10km squares inhabited by this species now exceeding 30 the status category RDB3 (Rare) or Nationally Scarce might be more appropriate.

According to Wallace (1991) the taxon is characteristic of fast-flowing streams but from information given by Blackburn and Forrest (1995) these appear to be principally headwaters.

By the time of Countryside Survey 2000 the number of records had decreased to three, one each in EZ1 and EZ2 and a third in EZ5.

Tipula (Savtschenkia) cheethami Edwards – Nationally Scarce: This species is confined to aquatic mosses in streams, waterfalls or in other hygropetricous situations (i.e. on moist or submerged rocks) (Brindle 1960). Details of its distribution have not yet been traced.

In Countryside Surveys the taxon was captured three times in 1998 only. Two of the records were from EZ2 and the third was from EZ4.

Phalacrocera replicata L. – Nationally Scarce: The larvae of this species occur in acid pools on moors or in woodlands (Brindle 1967) but details of its distribution have not yet been traced.

In Countryside Surveys, *P. replicata* occurred at one site in EZ4 and one in EZ5. Both records were from 1990.

Oxycera pardalina Meigen – Nationally Scarce: The genus *Oxycera* is generally found in hygropetricous habitats or in semi-aquatic mosses and/or muddy or marshy places. In particular, *O. pardalina* is described as a hygropetricous-rheophile by Brindle (1964a). Details of its distribution have not yet been traced.

The taxon was found only in CS2000 where it was limited to just one site in EZ2.

Odontomyia tigrina Fabricius – Nationally Scarce: The larvae of the genus *Odontomyia* occur in mud or silt covered by static water or occur freely in ponds and marshes (Brindle 1964b). However, no precise information has been traced on the special habitat requirements of *O. tigrina* or its distribution pattern in the UK.

In Countryside Surveys the species was recorded in both years. In 1990 it was found once in EZ2. In CS2000 (1998) it occurred at one site in EZ2 and another in EZ1.

Distribution of conservation status taxa by environmental zone and country unit

The information presented above can be summarised by both environmental zone and country unit (Table 3.7).

Table 3.7 The distribution of taxa with conservation status by environmental zone and country unit (Excludes *Agabus chalconatus*, *Rhantus aberratus* and *Limnebius crinifer*). Values in parentheses are proportions of the total number of conservation status taxa in the geographic area, to the nearest whole number.

VARIABLE	ENVIRONMENTAL ZONE						
	EZ1	EZ2	EZ3	EZ4	EZ5	EZ6	TOTAL
Number of taxa present	18	14	8	10	8	3	61
Number of taxon records	26	22	13	12	12	7	92
	COUNTRY UNIT						
	ENGLAND & WALES			SCOTLAND			TOTAL
Number of taxa present	29			17			39
Number of taxon records	61			31			92

Evaluation of biological condition of sites

RIVPACS

The software package RIVPACS was introduced in the methods section. RIVPACS uses known environmental data from a site in order to predict the probability of capture of species and families of aquatic macro-invertebrates at a site in the absence of significant (chemical and physical) environmental stress. The probabilities can be converted into site specific target values for the number of BMWP (Biological Monitoring Working Party) families (number of scoring taxa or NTaxa) that are expected in the absence of stress and the Average Score Per Taxon (ASPT) of those families.

Mathematical comparison of the observed and expected (predicted) index values provides the Ecological Quality Indices for both NTaxa and ASPT (Armitage *et al.* 1983).

From an experimental knowledge of the errors associated with the collection, processing and evaluation of biological and environmental data from sites RIVPACS III+ can be used to evaluate the probability that a site has genuinely improved or declined in quality (Furse *et al*. 1995).

Number of taxa

Number of scoring taxa (NTaxa) is one of the primary indices that comprise the BMWP system. The taxa concerned are families of aquatic macro-invertebrates plus all aquatic Oligochaeta as a single group (Armitage *et al.* 1983). NTaxa is a simple measure of biodiversity, in the sense of taxon richness, and will vary at a given site in response to current and historic stresses.

The number of scoring taxa to be expected at unstressed sites varies naturally with the environmental characteristics of sites. RIVPACS uses unstressed reference sites of known environmental characteristics and macro-invertebrate assemblages to predict the expected fauna, if unstressed, of newly sampled sites. Predictions are site specific and reflect the natural variation in the optimal fauna (and biotic indices) of sites. Sites of very good biological condition may have slightly greater species richness than predicted by RIVPACS that forecasts the average level of richness at unstressed sites and not the maximum level achievable.

NTaxa values are effort dependent if standardised sampling procedures are not operated.

The expected values of NTaxa per site per Environmental Zone in Table 3.8 show that lowland sites (EZ1, EZ2 and EZ4) naturally have a higher intrinsic species richness than upland sites (EZ3, EZ5 and EZ6). Furthermore, English and Welsh sites have higher intrinsic taxon richness than those in Scotland because the nutrient levels, macrophyte growth, stream temperatures and habitat variability are generally more conducive.

Table 3.8 The mean numbers of observed and expected (i.e. RIVPACS predicted) BMWP scoring taxa (+ Coefficient of Variation (CV)) per site per Environmental Zone and per Country Unit (n sites = 404).

ENVIRONMENTAL ZONE	OBSERVED VALUES		EXPECTED VALUES	
	MEAN	CV (%)	MEAN	CV (%)
EZ1	16.4	35.9	21.4	20.6
EZ2	17.0	39.1	19.5	22.5
EZ3	15.8	37.0	18.7	15.4
ENGLAND & WALES	16.5	37.7	19.8	21.0
EZ4	17.7	28.0	18.4	18.5
EZ5	15.9	29.8	16.5	15.2
EZ6	16.6	31.9	15.4	11.0
SCOTLAND	16.7	30.1	16.7	17.3
OVERALL	16.6	34.3	18.4	21.5

In contrast, the observed values show lesser differences between Environmental Zones/Country Units. This is because lowland sites in particular, and English and Welsh sites in general, exhibit a wider range of stress levels, which results in greater variability in observed species richness. In comparison, sites in Scotland have less variability in recorded number of taxa because of generally lower levels of environmental stress. This results in the number of taxa at most sites lying within the 95% confidence intervals for the number of taxa predicted to occur by RIVPACS. In EZ6, in particular, the average number of taxa per site slightly exceeds the mean expected species richness derived from the RIVPACS reference sites. The average condition of sites in Scotland as a whole exactly meet expectations in terms of species richness, but the variability in biological condition of sites means that the associated coefficients of variation are greater than for the predicted values. To a lesser extent, the tendency for the prediction system to predict modal, rather than extreme values, also contributes to this differential.

Figure 3.20 shows the frequency distribution of numbers of taxa per sample for each of the six Environmental Zones. The mean values and coefficients of variation given in Table 3.8 are based on these distributions.

ASPT

Average Score Per Taxon (ASPT) is one of the primary indices which comprise the BMWP system. It represents the average stress tolerance (particularly to organic pollution) of the BMWP scoring taxa in a sample. Stress-intolerant taxa are assigned high scores, in the range 1-10, because their presence is indicative of the absence of significant environmental stress. Conversely, stress-tolerant taxa are assigned low scores. A site ASPT is determined by summing the scores of the individual scoring taxa present and dividing the total by the number of contributory taxa.

Like NTaxa, the intrinsic values of ASPT vary considerably between unstressed sites of different natural environmental characteristics (e.g. altitude, slope, distance from source, alkalinity, width, depth, substratum type etc.). ASPT is an average value and, hence, less prone to variation with sampling effort. However, there is a slight tendency for ASPT to increase with increased number of scoring taxa. This is because high scoring taxa tend to occur at lower abundance levels than low scoring taxa and are more likely to be missed due to reduced sampling effort or efficiency.

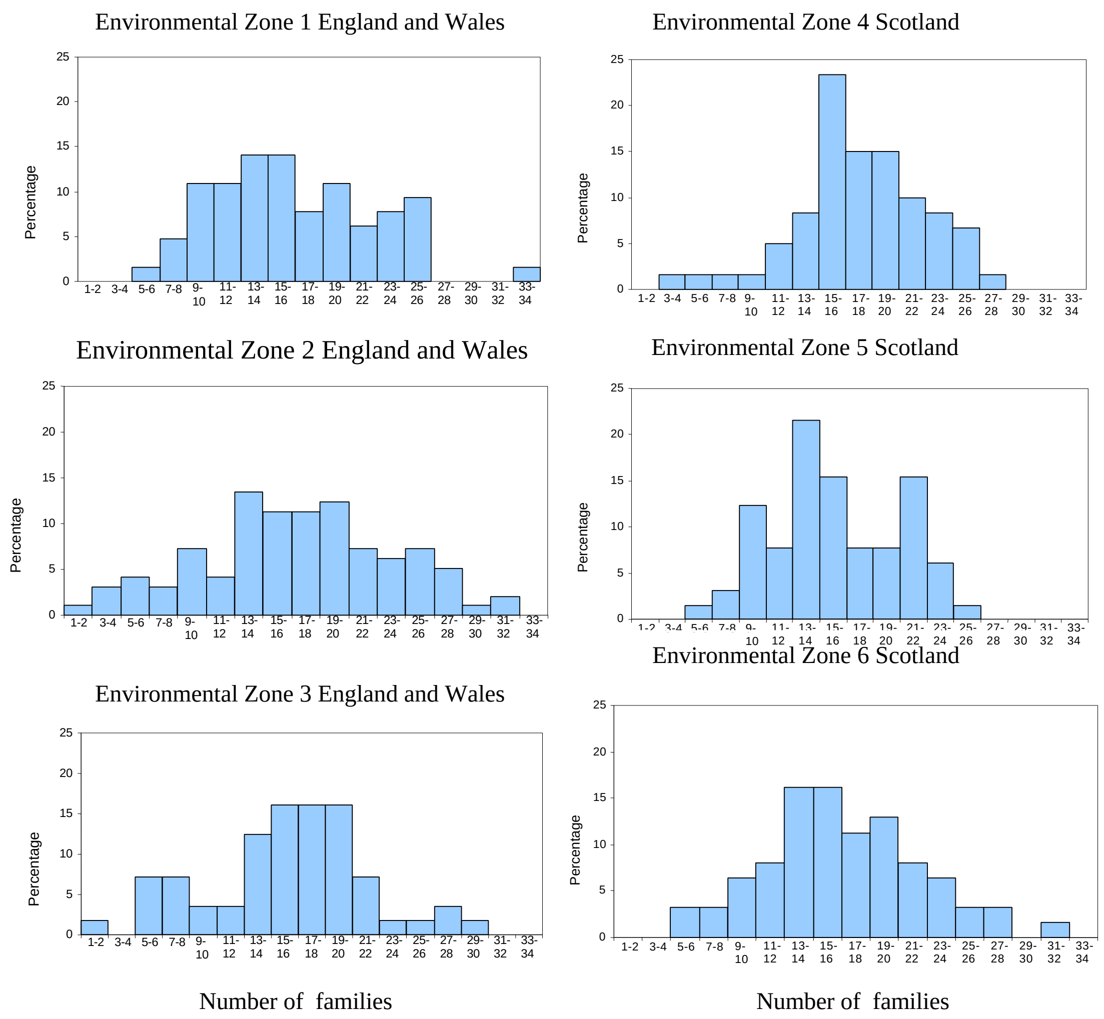

Figure 3.20 The distribution of number of scoring taxa (NTaxa) per sample in each of the six environmental zones of Great Britain

The expected values of ASPT per site per Environmental Zone in Table 3.9 are intrinsically lower in lowland sites (EZ1, EZ2 and, to a lesser extent, EZ4) than upland (EZ3, EZ5 and EZ6). Furthermore, English and Welsh lowland sites have much lower intrinsic ASPT values than those sites at similar altitudes in Scotland.

Table 3.9 The mean observed and expected (i.e. RIVPACS predicted) ASPT values (+ Coefficient of Variation (CV)) per site per Environmental Zone and per Country Unit (n sites = 404).

ENVIRONMENTAL ZONE	OBSERVED VALUES		PREDICTED VALUES	
	MEAN	CV(%)	MEAN	CV
EZ1	4.48	18.3	4.98	8.7
EZ2	5.01	21.5	5.52	11.2
EZ3	5.91	11.8	6.17	5.8
ENGLAND & WALES	5.08	20.9	5.53	12.2
EZ4	5.26	18.1	5.80	8.1
EZ5	5.59	16.8	5.95	6.3
EZ6	6.22	9.6	6.05	4.6
SCOTLAND	5.69	16.4	5.94	6.6
OVERALL	5.37	19.5	5.72	10.4

The tendency for upland sites to have higher natural ASPT values is because they have a higher ratio of insects (generally high to medium scoring) to non-insects (generally medium to low scoring) than lowland sites. High-scoring stoneflies (Plecoptera) are particularly associated with cold, fast-flowing, nutrient-poor, upland sites with predominantly boulder and cobble substrata.

Observed values (Table 3.9, Figure 3.21) show that, like NTaxa, the lowland sites fall more short of the expected values (approximately 0.50 units) than upland sites and show higher levels of variability. This provides further evidence of the variability of biological condition in the lowland sites. Once again, the average biological condition of sites in EZ6 just exceeds the average level expected at significantly unstressed sites in this zone.

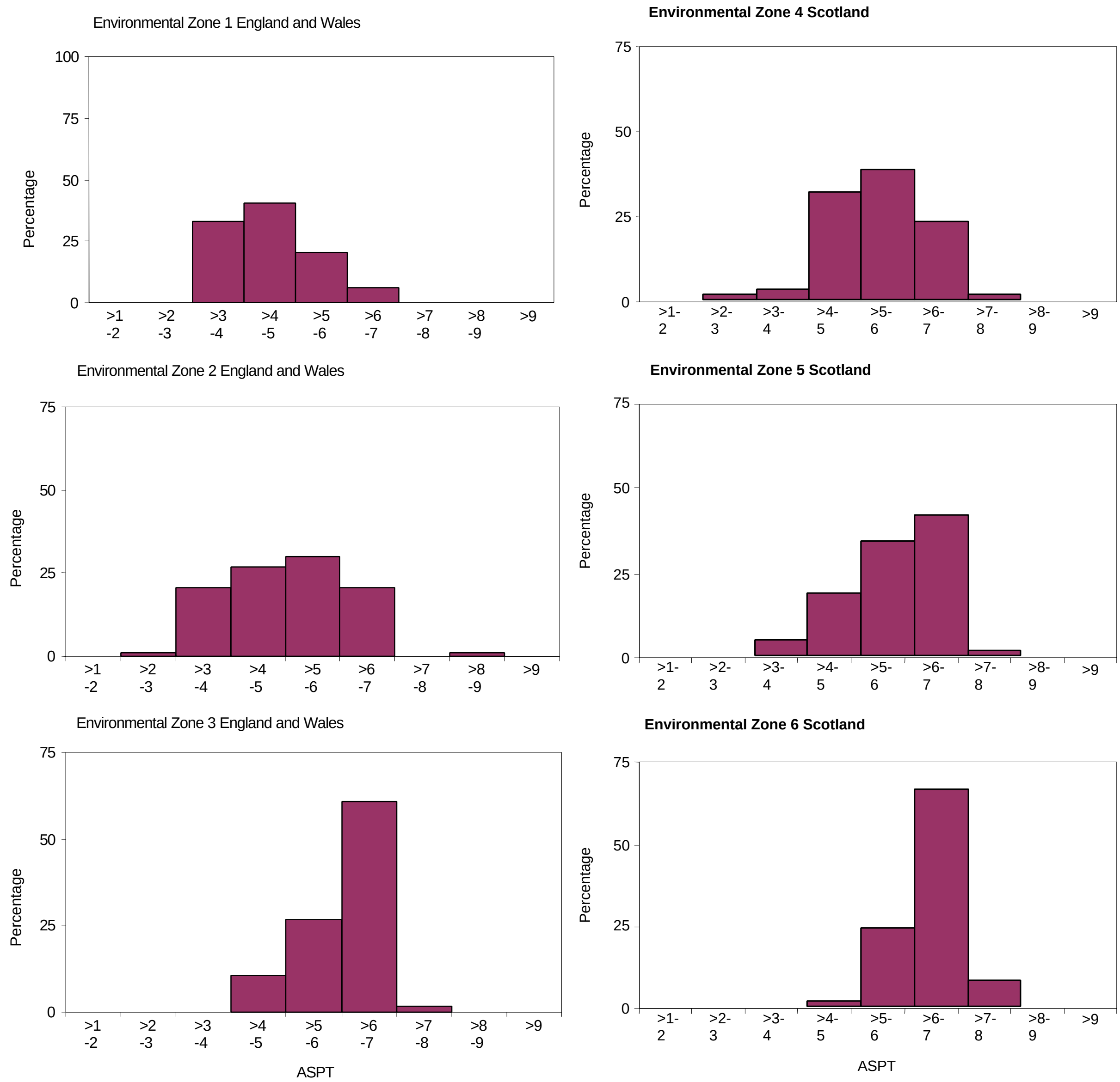

Figure 3.21 The distribution of ASPT values per sample in each of the six environmental zones of Great Britain

Comparison of biotic index values of sites for 1990 and 1998

A set of matched sites was identified that had been sampled in both CS1990 and CS2000. These enabled comparisons to be made between the observed values of biotic indices obtained on the two occasions. Histograms of the number of families per sample in each environmental zone (EZ) (3.22) re-inforce the findings of the species level analyses that there has been a consistent increase in the number of families per site in each environmental zone between 1990 and 1998. This is clearly indicated by the migration of the modal values to the right of each distribution plot between the two survey years (Figure 3.22).

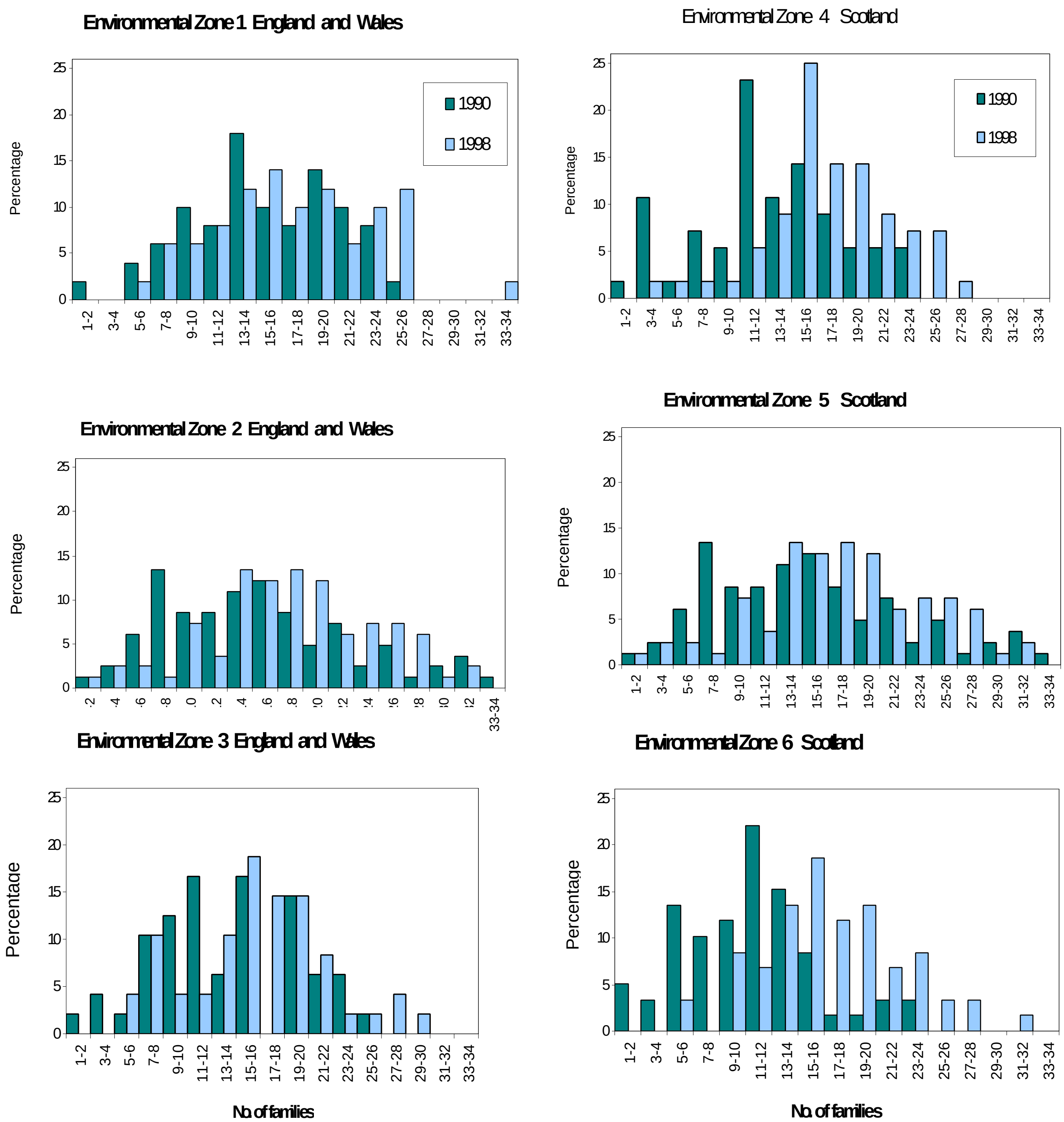

Figure 3.22 Comparison of numbers of families per site per EZ in 1990 and 1995

The increase in the average number of families per site per zone was matched by a parallel increase in the mean ASPT values per site per zone. Again this is best illustrated by a shift in the modal value of ASPT in each towards the right-hand end of the distribution plot in each environmental zone in 1998 (Figure 3.23). This shift provides evidence that not only did the quantity of families (taxon richness) increase between survey years but so too did the average "quality" of taxa present, as represented by their perceived intolerance to organic pollution.

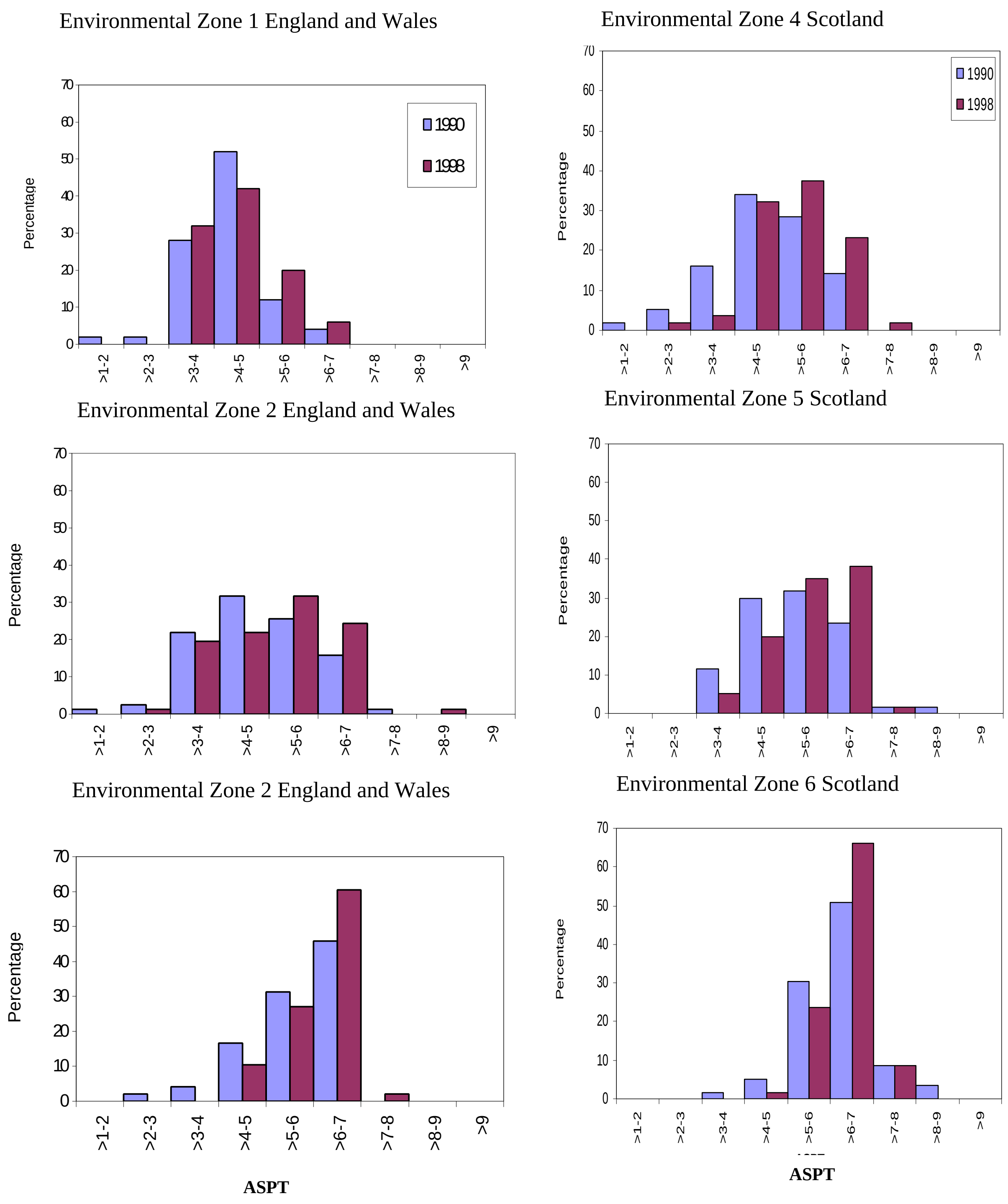

Figure 3.23 Comparisons of ASPT values per site per EZ in 1990 and 1995

EQI's/Grades

For individual sites, the ratio between an observed (E) and expected (E) BMWP index value is termed the observed to expected (O/E) ratio (Wright *et al.* 1993) or Ecological Quality Index (EQI) (Sweeting *et al* 1992). EQI's of close to unity indicate sites that meet their expected biological condition but values below unity reflect increasing impacts of environmental stress.

For the purposes of national surveys the Environment Agency has divided EQI values into six quality bands for both ASPT and NTaxa (Murray-Bligh *et al.* 1997). Bands range from "a" (best quality) to "f" (worst quality). The minimum band values for each set of EQI's are as follows:

Band	**EQI (ASPT)**	**(NTaxa)**
a	**1.00**	**0.85**
b	**0.90**	**0.70**
c	**0.77**	**0.55**
d	**0.65**	**0.45**
e	**0.50**	**0.30**
f	**0.00**	**0.00**

An overall site band is derived from the lower of the two separate bands for the EQI's for ASPT and NTaxa.

The biological condition of sites in the upland regions is shown to be consistently better in upland Environmental Zones (EZ3, EZ5 and EZ6) than in lowland Zones (EZ1, EZ2 and EZ4) (Table 3.10). This is particularly so when grades "a" and "b" (the highest grades) as a whole are compared with grades "d-f" (the lowest grades) as a whole. These data confirm that lowland streams are more vulnerable to the detrimental impacts of environmental stress than upland streams.

Similarly, the overall grades of Scottish sites, where upland sites are proportionally more common, are consistently better than equivalent English and Welsh sites, even in the lowland categories. However, lowland Scottish streams (EZ4) have a higher proportion of high quality sites than their English and Welsh equivalents (EZ1 and EZ2).

The highest proportion of grade "a" sites are derived from use of the EQI for NTaxa, but the same overall patterns are exhibited by all indices. The overall grades assigned to sites are more dependant on the ASPT grade than that for NTaxa because the former are more frequently the same or lower than the latter.

The following banding of sites is based on the 350 matched sites from 1990 and 1995 upon which subsequent analyses of change in biological condition are based.

Table 3.10 The distribution of CS2000 running water sites by grade of biological condition in each Environmental Zone and Country Unit (E&W = England and Wales) (n samples = 350).

a) NTaxa

BIOLOGICAL GRADE	PROPORTION OF SITES								
	EZ1	**EZ2**	**EZ3**	**E&W**	**EZ4**	**EZ5**	**EZ6**	**Scot**	**Overall**
a	43.5	53.1	48.9	49.4	61.4	66.7	72.9	67.0	58.3
b	10.9	16.0	23.4	16.7	19.3	11.7	13.6	14.8	15.7
c	23.9	12.3	10.6	14.9	15.8	8.3	8.5	10.8	12.9
d	6.5	8.6	6.4	7.5	0.0	8.3	0.0	2.8	5.1
e	13.0	7.4	6.4	8.6	1.8	5.0	3.4	3.4	6.0
f	2.2	2.5	4.3	2.9	1.8	0.0	1.7	1.1	2.0

b) ASPT

BIOLOGICAL GRADE	PROPORTION OF SITES								
	EZ1	**EZ2**	**EZ3**	**E&W**	**EZ4**	**EZ5**	**EZ6**	**Scot**	**Overall**
a	19.6	32.1	34.0	29.3	26.3	40.0	67.8	44.9	37.1
b	32.6	28.4	40.4	32.8	31.6	13.3	23.7	21.0	26.9
c	32.6	21.0	19.1	23.6	31.6	30.0	6.8	22.7	23.1
d	13.0	14.8	4.3	11.5	12.3	15.0	0.0	9.1	10.3
e	2.2	3.7	2.1	2.9	3.5	1.7	0.0	1.7	2.3
f	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.6	0.3

c) Overall

BIOLOGICAL GRADE	**PROPORTION OF SITES**								
	EZ1	**EZ2**	**EZ3**	**E&W**	**EZ4**	**EZ5**	**EZ6**	**Scot**	**Overall**
a	15.2	25.9	25.5	23.0	22.	36.7	61.0	40.3	31.7
b	30.4	29.6	31.9	30.5	26.	11.7	22.0	19.9	25.1
c	30.4	17.3	25.4	23.0	35.	26.7	11.9	24.4	23.7
d	8.7	14.8	6.4	10.9	12.	18.3	0.0	10.2	10.6
e	13.0	9.9	6.4	9.8	1.8	6.7	3.4	4.0	6.9
f	2.2	2.5	4.3	2.9	1.8	0.0	1.7	1.1	2.0

Change in Grades

RIVPACS III+ can be used to calculate the probability that a site has changed its grade of biological condition. It achieves this by first taking account of the known sources of variation associated with the collection, sorting, identification and data-logging of biological data and the collection of environmental data. Monte Carlo procedures are then used to assess the probability of changes in grade of the site, either as a decline or improvement in condition with time.

A >50% probability of change in grade means that a site is more likely to have changed grade than not. A 95% probability of change means that the site has almost certainly changed its grade of biological condition when methodological variation has been discounted.

Table 3.11 provides the results of comparison of change analyses carried out on 350 matched sites that were successfully sampled in 1990 (CS90) and 1998 (CS2000).

Table 3.11 The probability of sites having undergone a change in biological grade between 1990 (CS90) and 1998 (CS2000). Proportions of sites in each category for each Environmental Zone and Country Unit are expressed at four probability levels including "Same Grade" which is a probability of change in grade of no more than 50%. Note that the proportion of sites with a probability of change are cumulative. Thus, for example, the sites included in the category >50% also include all of the sites in the categories >75% and >95%. The same Hence the three central columns of the table sum to 100%.

Environ-mental Zone	Index (EQI) type	Probability of being downgraded Cumulative %			Same grade	Probability of being upgraded Cumulative %		
	OVERALL	>95	>75	>50	0	>50	>75	>95
EZ1		2.2	4.4	15.3	43.5	41.3	23.9	10.9
EZ2		4.9	11.1	19.7	32.1	48.2	42.0	22.2
EZ3		0.0	8.5	19.1	38.3	42.5	25.5	14.9
England & Wales		2.9	8.7	18..5	36.8	44.8	32.7	17.2
EZ4		3.5	10.5	19.3	21.1	59.6	47.3	29.8
EZ5		0.0	1.7	6.7	31.7	61.7	46.7	31.7
EZ6		0.0	3.4	6.8	25.4	67.8	49.2	37.3
Scotland		1.1	5.1	10.8	26.1	63.1	47.8	33.0
Overall		2.0	6.9	14.6	31.4	53.9	40.2	25.1
	ASPT	>95	>75	>50	0	>50	>75	>95
EZ1		0.0	0.0	21.7	45.7	32.7	15.3	10.9
EZ2		2.5	7.4	21.0	40.7	38.3	28.4	17.3
EZ3		2.1	8.5	19.1	48.9	32.0	17.1	12.8
England & Wales		1.7	5.7	20.6	44.3	35.1	21.9	14.4

EZ4		1.8	10.6	19.4	31.6	49.1	38.6	21.1
EZ5		0.0	6.7	13.4	48.3	38.3	25.0	10.0
EZ6		3.4	8.5	17.0	50.9	32.3	20.4	8.5
Scotland		1.7	8.5	16.5	43.8	39.8	27.9	13.1
Overall		1.7	5.4	11.4	44.0	12.6	11.1	13.7
	NTaxa	>95	>75	>50	0	>50	>75	>95
EZ1		2.2	6.6	19.6	34.8	45.7	19.6	8.7
EZ2		4.9	12.3	20.9	39.5	39.5	35.8	27.2
EZ3		0.0	10.6	17.0	36.2	46.8	31.9	21.3
England & Wales		2.9	10.4	19.6	37.4	43.1	30.5	20.7
EZ4		3.5	10.5	19.3	21.1	59.6	47.3	29.8
EZ5		0.0	1.7	6.7	31.7	61.7	46.7	31.7
EZ6		0.0	3.3	6.6	25.0	68.3	50.0	38.3
Scotland		0.6	2.3	6.3	33.5	60.2	44.9	35.2
Overall		1.7	6.3	12.9	35.4	51.7	37.7	28.0

The analysis of changes in grade showed a substantial net improvement in the apparent biological condition of sites. Using the overall grade of sites for all 350 sites, 53.9% have a probability in improvement in grade of >50% (including 25.1 % of sites with a 95% chance of an improvement of grade). The comparative figures for decline show only 14.6% of sites with a >50% chance of declining and only 2.0% with a >95% probability. The net gain in proportion of sites changing grade at the >50% level is 39.3% (53.9% - 14.6%).

The net improvement in grade is more marked in Scotland (52.3%) than in England (26.3%).

The greatest improvements in grade in Scotland are in the more upland zones where the net improvements at the >50% level are in EZ5 (55.0%) and EZ6 (61.0%). The least improvement occurred in the lowland Zone EZ4 (40.3%).

Lower net improvements were recorded in each of the three English and Welsh Environmental Zones. The highest net improvements at the >50% probability level were in lowland EZ2 (28.5%) and EZ1 (26.0%). In England and Wales, unlike Scotland, the least net improvement in grade at the >50% probability level was in upland Zone EZ3 (23.4%).

3.2 River Habitat Survey

3.2.1 General

River Habitat Survey (RHS) was introduced in section 2.2.4. It is an assessment procedure for evaluating the physical structure of streams and rivers, based on a standard 500m survey section (Environment Agency 1997; Raven *et al*. 1998). The data collected during RHS is used to generate two indices for assessing the condition of the river and its immediate bankside zone. These are the Habitat Quality Assessment (HQA) and the Habitat Modification Score (HMS) and they are considered in the two following sections.

3.2.2 Habitat Quality Assessment

Habitat Quality Assessment (HQA) is one of two key indices derived from River Habitat Surveys. It is a broad measure of the diversity and "naturalness of the physical (habitat) structure of the river channel and corridor (Raven *et al*. 1998). Its site value is determined by the presence and extent of features of known wildlife interest recorded by the standard survey procedure. A limitation of the system is the subjective nature of the scoring system, based, as it is, on a consensus of informed professional judgement. However, the well-defined field protocols and its links to other conservation procedures (e.g. SERCON (Boon *et al*. 1997)) make it a valuable tool for an initial assessment of the habitat quality of river sections.

Highest (best) mean HQA values were recorded in the upland Zones (EZ3, EZ5 and EZ6) (Table 3.12) where the variation (CV%) in index values was also less. Scotland had a higher mean value than England. The lowest (worst) mean HQA index value was in EZ1, where variation was also greatest. The distribution of individual HQA values per site per environmental zone (EZ) is shown in Figure 3.24

Table 3.12 The mean observed Habitat Quality Assessment (HQA) index values (+ Coefficient of Variation (CV)) per site per Environmental Zone and per Country Unit (n sites = 421).

ENVIRONMENTAL ZONE	OBSERVED VALUES OF HQA	
	MEAN	CV (%)
EZ1	31.4	48.5
EZ2	39.5	35.4
EZ3	45.5	27.0
ENGLAND AND WALES	38.3	39.0
EZ4	40.6	32.5
EZ5	41.4	32.0
EZ6	41.3	23.3
SCOTLAND	41.1	29.4
OVERALL	39.5	34.9

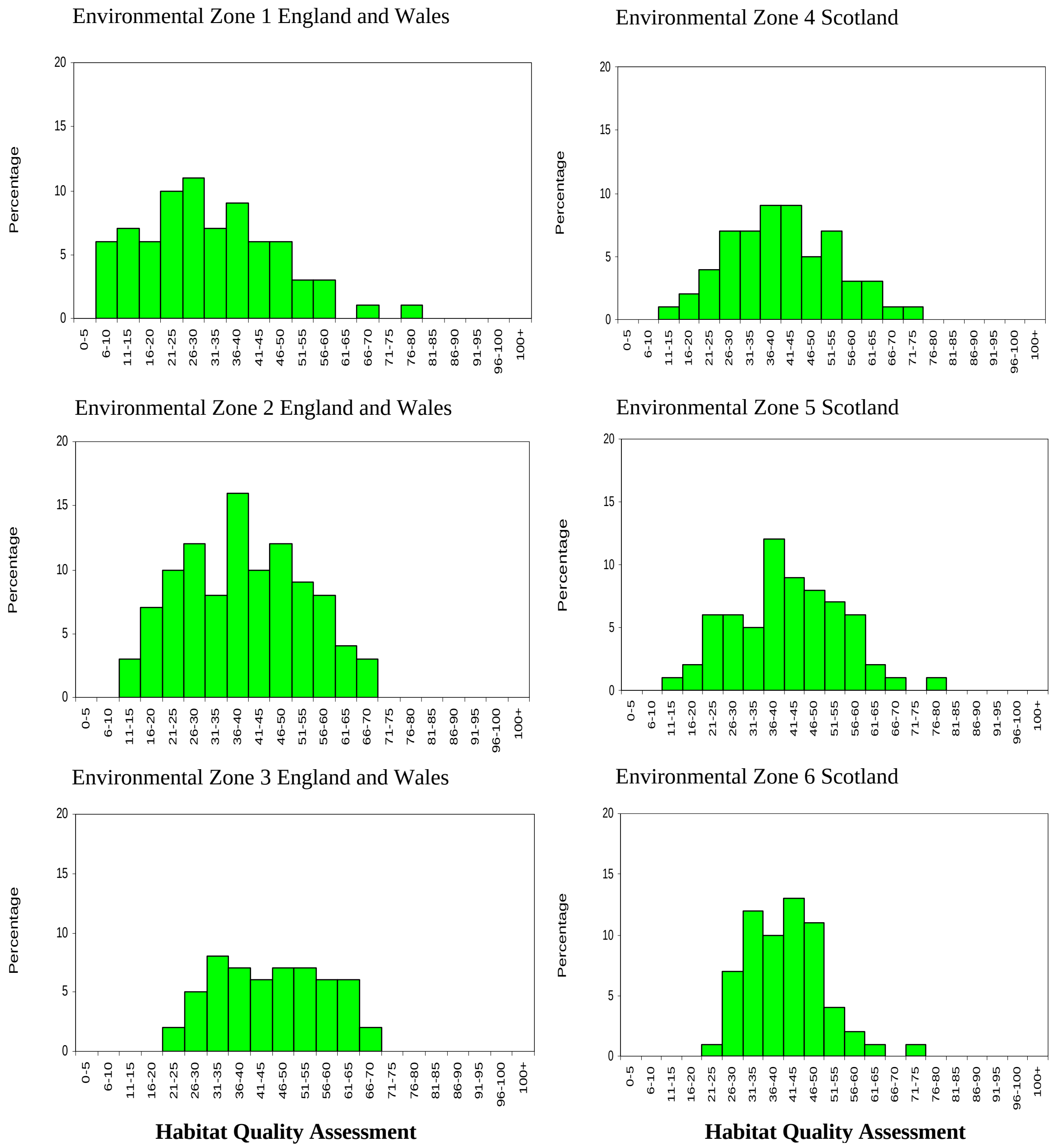

Figure 3.24 The distribution of HQA values by site by EZ

3.2.3 Habitat Modification Score

Habitat Modification Score (HMS) is a measure of the extent that the natural characteristcs of the survery section have been modified by man. An HMS value of zero indicates no significant modification and represents natural (good) conditions. HMS values increase with increasing levels of modification. Like the HQA, the HMS is described as ab objective application of a set of subjective rules that provide a consistent form of comparison between sites (Raven *et al*. 1998).

Factors that contribute to high HMS values include resectioned, reinforced, poached, bermed and embanked banks and culverted, resectioned, dammed, weired and forded channels.

The values of HMS for individual sites are very variable, even within a given Environmental Zone. Sites can vary between entirely natural and completely modified. This inherent potential for variation leads to high co-efficients of variation for each EZ and Country Unit.

The lowest levels of stream modification are in the upland Environmental Zones (EZ3, EZ5 and EZ6) with the majority of sites little modified if at all (Table 3.13). This holds particularly true for EZ6. As a consequence of the greater number of "lowland" sites in England and Wales, where the extent of channel modification is greatest, the mean HMS value for England and Wales is twice that of Scotland. The distribution of individual HQA values per site per environmental zone (EZ) is shown in Figure 3.25.

Table 3.13 The mean observed Habitat Modification Score (HMS) index values (+ Coefficient of Variation (CV)) per site per Environmental Zone and per Country Unit (n sites = 421)

ENVIRONMENTAL ZONE	OBSERVED VALUES OF HMS	
	MEAN	CV (%)
EZ1	23.9	72.3
EZ2	16.6	114.9
EZ3	7.4	165.5
ENGLAND AND WALES	16.8	107.8
EZ4	15.6	102.7
EZ5	7.3	202.4
EZ6	2.1	278.3
SCOTLAND	8.2	171.7
OVERALL	13.0	130.8

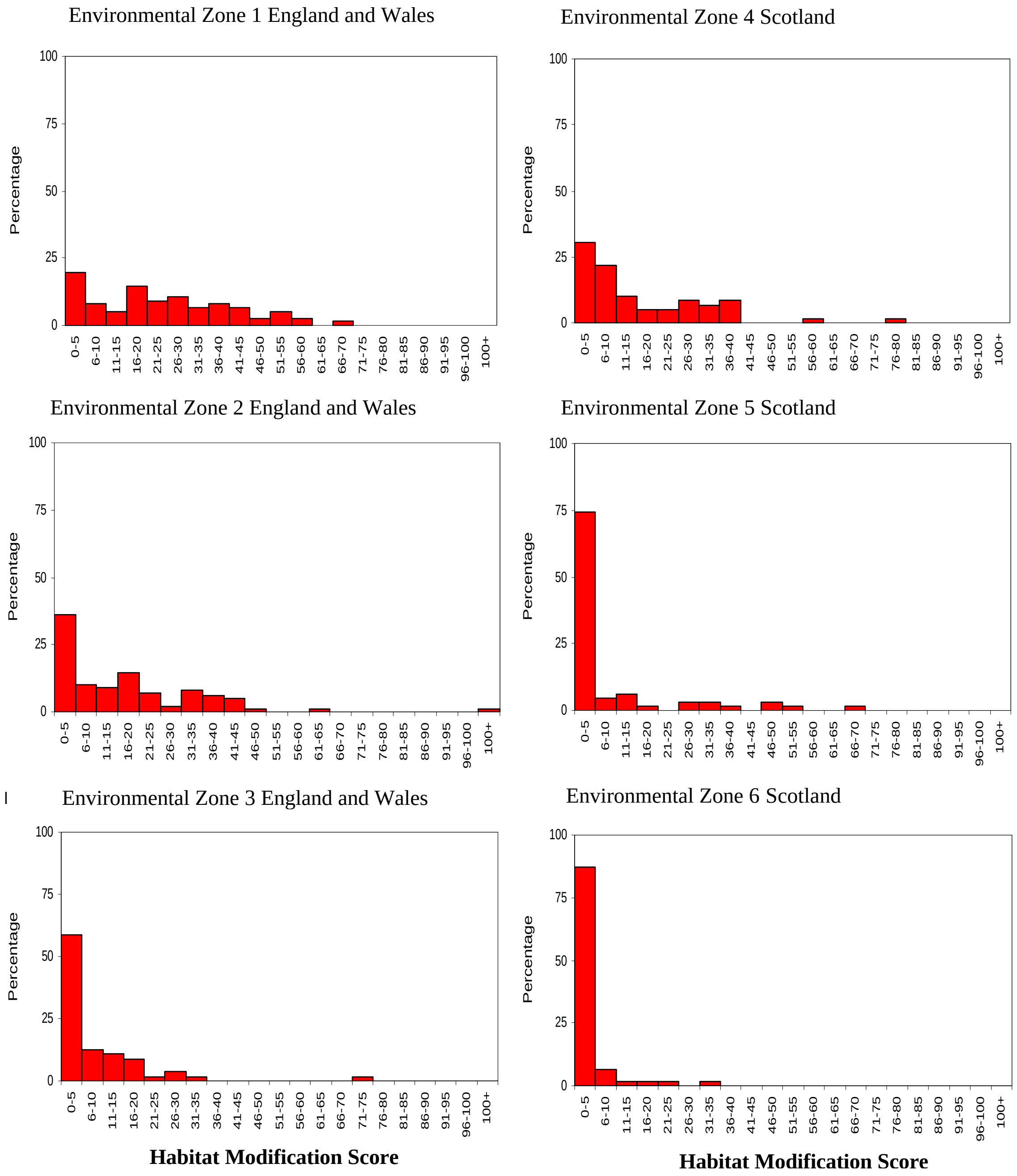

Figure 3.25 The distribution of HMS values by site by EZ

3.3 Riparian Land Cover

3.3.1 Distribution of bankside Broad Habitat by Environmental Zone

A 20m riparian strip was created, within GIS, for each stream subject to a River Habitat Survey (RHS). This electronic zone was created by combining 10m strips alongside each bank with the river channel itself. It extended for the whole of the length of stream subject to RHS and lying within the boundaries of the survey square. Within the combined zone, the total area of land in each Broad Habitat, as determined by the terrestrial land cover mapping, was calculated. For comparative purposes, the areas for each stream were converted to percentage cover. The mean values (and standard deviations) for each Environmental Zone (Table 3.14) illustrate the differences in character of these six zones.

Table 3.14 The mean percentage cover of broad habitats (with standard deviations) of a 20m bankside buffer zone on each side of streams subject to River Habitat Surveys.

BROAD HABITAT	EZ1 (n=65)		EZ2 (n=93)		EZ3 (n=48)		EZ4 (n=53)		EZ5 (n=62)		EZ6 (n=51)	
	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD	MEAN	SD
Broadleaved, mixed and yew woodland	18.14	26.29	27.57	31.31	25.59	34.17	20.07	28.81	8.06	20.89	6.80	17.58
Coniferous woodland	0.20	1.24	0.94	5.57	2.67	10.35	1.00	3.24	10.31	27.71	12.19	28.42
Boundary & linear features	3.35	9.12	2.43	6.37	1.14	2.86	3.78	8.98	1.26	5.32	0.25	0.74
Arable & horticulture	39.47	40.10	7.85	20.55	0.49	3.41	8.02	18.19	2.65	11.57	0.00	0.00
Improved grassland	25.44	32.83	44.41	33.59	17.47	28.65	19.86	31.25	8.11	20.57	2.27	14.02
Neutral grassland	4.51	11.45	5.04	13.46	1.65	5.74	21.44	30.60	2.46	7.98	1.92	7.16
Calcareous grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.41	0.00	0.00
Acid grassland	0.18	1.20	0.72	3.84	13.70	25.46	3.54	12.53	9.50	20.89	14.00	27.15
Bracken	0.00	0.00	1.16	8.00	3.78	9.52	0.21	1.32	1.71	9.62	2.14	7.58
Dwarf shrub heath	0.00	0.00	0.05	0.52	8.08	23.09	2.38	13.89	7.77	19.27	16.14	30.31
Fen, marsh & swamp	2.84	14.12	3.70	12.89	7.62	18.71	8.40	19.91	13.93	27.92	9.42	20.28
Bog	0.30	2.42	0.03	0.27	9.47	24.68	3.79	15.00	25.33	33.04	28.30	39.03
Standing open water & canals	0.72	4.21	0.19	0.80	0.33	2.23	0.43	1.76	1.44	10.91	0.06	0.29
Rivers & streams	2.00	7.88	1.30	6.21	0.50	3.45	0.28	1.62	1.24	7.26	0.86	5.37
Montane habitats	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Inland rock	0.00	0.00	0.00	0.00	1.20	8.28	2.02	13.32	0.45	2.84	0.19	1.39
Built up areas & gardens	2.84	8.46	4.28	13.59	2.00	6.26	3.65	14.83	0.78	2.99	0.00	0.00
Supralittoral rock	0.00	0.00	0.03	0.28	0.00	0.00	0.00	0.02	1.58	6.95	0.18	1.31
Supralittoral sediment	0.00	0.00	0.00	0.00	0.00	0.00	0.17	1.27	0.22	1.42	0.00	0.00
Littoral sediment	0.00	0.00	0.28	2.72	0.00	0.00	0.14	0.76	0.00	0.00	0.00	0.00
Inshore rock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.43	0.00	0.00

Mosaic (2 types)	0.00	0.00	0.00	0.00	1.94	11.05	0.09	0.60	2.47	13.28	4.71	16.65
Mosaic (3 types)	0.00	0.00	0.00	0.00	0.00	0.00	0.34	2.46	0.00	0.00	0.00	0.00
Mosaic (4 types)	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1.84	0.00	0.00	0.12	0.86
Unknown (Code 136)	0.00	0.00	0.00	0.00	0.34	2.35	0.00	0.00	0.00	0.00	0.00	0.00
Unknown (Code 252)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.32	0.00	0.00
Unknown (Code 60810)	0.00	0.00	0.00	0.00	0.59	3.31	0.00	0.00	0.00	0.00	0.00	0.00
Unknown (Code 60812)	0.00	0.00	0.00	0.00	1.40	9.66	0.00	0.00	0.00	0.00	0.00	0.00
Unknown (Code 61210)	0.00	0.00	0.00	0.00	0.03	0.23	0.00	0.00	0.00	0.00	0.00	0.00
Unknown (Code 66163)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.92
Unknown (Code 67163)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.98
Unrecorded	0.00	N/A	0.01	N/A	0.01	N/A	0.14	N/A	0.57	N/A	0.17	N/A

3.3.2 Characteristics of each environmental zone

Environmental Zone 1: EZ1 has, at almost 40% cover, the highest proportion of arable and horticultural land bordering its streams, as is to be expected in a zone predominantly comprising the eastern and south eastern lowlands of England. However, the zone includes over 25% cover of improved grassland and approximately 4% cover of neutral grassland. The 18%+ cover of riparian woodlands is almost exclusively in the Broad Habitat "Broadleaved, mixed and yew". The proportion of bankside boundaries and linear features (3.4%) is higher than any zone except EZ4.

Environmental Zone 2: EZ2, with 44.4% cover, has the highest proportion of bankside improved grassland of any of the zones. Together with the 5% neutral grassland, almost 50% of the streamside riparian strip was agricultural grassland. At 27%+ cover, this zone (the western lowlands of England and Wales, also had the highest proportion of riparian broadleaved, mixed and yew woodland, although the area of coniferous woodland was still less than 1%. The third Broad Habitat to achieve its maximum percentage cover in this zone, albeit with a high co-efficient of variation, was "Built up areas and gardens" which covered an average of 4.3% of the land bordering the survey streams. In contrast, the area of arable and horticultural land in this zone had fallen to less than 8%.

Environmental Zone 3: EZ3 comprises the upland areas of England and Wales and the proportion of agricultural land in the riparian strip was much smaller than either EZ1 or EZ2. The proportion of improved grassland was only 17.5%, supported by a further 1.7% of neutral grassland. In addition, arable and horticultural land had become very uncommon and occupied just 0.5% of total cover. The total proportion of woodland, at over 28%, was similar to EX2 but this included an increased proportion of coniferous woodland (2.7%). The big increases in cover were achieved by typical upland and moorland vegetation including acid grassland (13.7%), bog (9.5%), dwarf shrub heath (8.1%) and fen, marsh and swamp (7.6%). Furthermore, the proportion of bankside bracken (3.8%) was higher than any other zone.

Environmental Zone 4: The Scottish lowlands, EZ4, have the highest proportion of bankside neutral grassland (21.5%), which is just greater than the average proportion of improved grassland (19.9%) in the riparian strip. The proportion of woodland remains high, at approximately 21%, but only 1% of this is coniferous. The proportion of arable and horticultural land was similar to EZ2 but differed from it in having higher proportions of acid grassland (3.5%), fen marsh and swamp (8.4%) and bog (3.8%) than its English and Welsh equivalent. At 3.8%, it had a higher proportion of bankside boundaries and linear features than any other zone.

Environmental Zone 5: The riparian zones of EZ5, the intermediate Scottish uplands and islands, included the highest proportion of fen, marsh and swamp (13.9%) of any of the six zones. However, the highest proportion of bankside land (25%+) was covered by bog, whilst two other characteristic upland and moorland Broad Habitats were also common (acid grassland – 9.5%, dwarf shrub heath – 7.8%). In total, over 18% of the bankside was recorded as woodland but now, unlike the four previous zones, just over half of this was broad-leaved, mixed and yew woods. The proportion of riparian arable and horticultural land in this environmental zone was only 2.7%, whilst there was a moderate 8%+ cover of improved grassland and only 2.5% cover of neutral grassland. Although not common, this zone, with its many islands, also supported a higher proportion of supralittoral rock (1.6%) and sediment (0.2%) than any other.

Environmental Zone 6: EZ6 (the Scottish Uplands) had characteristic upland and moorland land cover, dominated by the highest proportion of bog (28.3%) of any of the zones. Similarly, the zone also supported the highest proportions of riparian acid grassland (14%) and dwarf shrub heath (16%+), whilst fen, marsh and swamp covered a further 9.4% of the bankside area. The total area of riparian woodland, of approximately (20%) was nearly two thirds coniferous and only approximately one third broadleaved, mixed and yew woodland. Intensive agriculture was rare in this environmental zone and only 2.3% of the riparian strip, on average, was improved grassland and there was no arable or horticultural land in the riparian strips of the surveyed rivers.

3.3.3 Correlation between Broad Habitat cover and indices of habitat quality and biological condition.

The proportions of the 10 most frequently recorded riparian Broad Habitats were correlated with indices of river corridor habitat quality (Habitat Quality Assessment – HQA, Habitat Modification Score – HMS) and biological condition of the watercourses (Ecological Quality Indices for number of scoring taxa (EQI NTaxa) and Average Score

Per Taxon (EQI ASPT). Correlations were calculated for all sites and for each of the six individual environmental zones (Table 3.15).

The table shows three significance levels and highlights significant and "desirable" correlation coefficients in bold type and significant and "undesirable" correlations in italics. In most cases (HQA, EQI NTaxa and EQI ASPT) it is the positive correlations that are desirable. However, HMS index values increase with increasing modification of the river corridor and hence, in this case only, it is the negative correlations that are considered desirable.

The percentage cover of broadleaved, mixed and yew woodlands is commonly and desirably correlated with the two RHS indices but this is an expected result since tree cover is generally considered to be a desirable feature of the corridor in the RHS methodology. In addition, the cover of this Broad Habitat is often positively correlated with EQI indices and significantly so in two cases (NTaxa - EZ1 and ASPT – EZ2). Similarly, the relationships between coniferous cover and habitat quality and biological condition tend to be desirable but less strongly so than for broadleaved woodlands. In this analysis, coniferous woods were most highly correlated ($p>0.001$) with EQI ASPT for the full set of sites ($n=339$), although this biotic index has little explanatory power ($r=0.126$).

In contrast, almost all correlations of habitat and stream biological condition with arable and horticultural cover are undesirable, including the overall relationships ($p<0.001$) with EQI NTaxa and EQI ASPT. Of the 24 correlations involving cover of this Broad Habitat in individual environmental zones, only two are "desirable" in the sense used here.

The situation with improved grassland is less clear. Of the seven significant correlations involving this Broad Habitat only two are desirable. These are with EQI NTaxa in EZ3 and EQI ASPT in EZ1. Despite this, the overall correlation between EQI ASPT is sufficiently large to be significant overall ($P<0.01$, 337df). Correlations with neutral grassland are rarely significant and it is only in EZ5 (Intermediate uplands and islands of Scotland) where all relationships are undesirable and where those with HMS ($p<0.001$) and EQI ASPT ($p<0.05$) are significant.

Table 3.15 Correlation coefficients between the riparian cover of ten broad habitats and two indices of river corridor habitat quality and two indices of biological condition of the water courses. (Red cells – p<0.001; green cells – p<0.01; yellow cells – p<0.05).

Zone / Index (Number of sites RHS/EQI)	Broadleaved, mixed and yew woodland	Coniferous woodland	Arable & horticulture	Improved grassland	Neutral grassland	Acid grassland	Dwarf shrub heath	Fen, marsh & swamp	Bog	Built up areas & gardens
ALL (369/339)										
HMS	**-0.108**	**-0.129**	***0.322***	***0.223***	0.079	***-0.200***	**-0.159**	**-0.124**	-0.276	0.436
HQA	**0.483**	**0.120**	***-0.413***	-0.094	-0.090	0.057	0.019	-0.052	0.052	-0.063
NTAXA	-0.013	0.014	***-0.181***	0.052	0.064	0.088	-0.061	0.024	0.034	-0.024
ASPT	0.097	**0.126**	***-0.183***	*-0.155*	-0.065	0.088	0.040	-0.006	**0.155**	*-0.162*
EZ1 (64/52)										
HMS	**-0.325**	-0.051	0.221	-0.038	-0.119	-0.217	N/A	-0.207	0.126	0.123
HQA	**0.531**	-0.056	***-0.515***	0.179	0.240	**0.287**	N/A	0.057	-0.163	0.056
NTAXA	**0.289**	0.116	*-0.306*	0.197	0.038	0.155	N/A	-0.019	-0.181	-0.043
ASPT	0.045	0.017	-0.190	**0.305**	0.061	**0.375**	N/A	0.058	-0.169	*-0.289*
EZ2 (93/88)										
HMS	***-0.344***	-0.083	0.080	0.118	-0.071	-0.118	0.150	-0.114	-0.103	***0.616***
HQA	**0.594**	-0.017	*-0.229*	*-0.239*	-0.121	0.068	-0.157	0.076	-0.144	-0.200
NTAXA	0.029	-0.133	-0.201	0.171	-0.014	0.144	-0.119	-0.039	-0.150	0.042
ASPT	**0.293**	0.008	-0.114	-0.135	0.019	0.077	-0.102	-0.029	-0.097	-0.163
EZ3 (48/47)										
HMS	0.027	-0.108	*0.303*	*0.455*	0.210	-0.270	0.089	-0.171	-0.215	*0.324*
HQA	**0.645**	-0.062	-0.063	0.008	-0.058	-0.049	-0.181	*-0.435*	-0.193	0.242
NTAXA	0.108	-0.223	-0.080	**0.392**	-0.065	0.062	-0.261	-0.077	*-0.310*	0.169
ASPT	0.275	-0.127	-0.269	0.038	-0.170	**0.321**	*-0.370*	-0.126	-0.194	0.027
EZ4 (52/47)										
HMS	-0.154	-0.055	0.192	-0.051	0.039	-0.015	-0.119	-0.070	-0.190	***0.551***
HQA	**0.496**	-0.102	-0.364	-0.003	-0.247	0.027	0.097	-0.026	-0.022	-0.098
NTAXA	-0.124	0.155	0.171	-0.183	0.128	0.066	0.207	0.101	-0.052	-0.167
ASPT	0.049	0.074	-0.018	-0.239	0.006	0.020	0.229	0.241	0.043	-0.170
EZ5 (62/55)										
HMS	-0.010	-0.108	***0.424***	***0.410***	***0.450***	-0.110	-0.169	-0.027	**-0.316**	0.050
HQA	**0.497**	0.170	*-0.294*	-0.157	-0.091	-0.030	-0.009	-0.131	-0.069	**0.312**
NTAXA	-0.026	0.170	0.091	0.095	-0.153	0.074	*-0.369*	0.035	0.027	**0.279**
ASPT	0.174	0.239	-0.007	-0.223	*-0.328*	-0.129	-0.128	-0.167	0.180	0.085
EZ6 (51/51)										
HMS	0.272	0.141	N/A	-0.050	0.151	-0.126	-0.141	*0.289*	-0.219	N/A
HQA	0.187	**0.295**	N/A	-0.240	-0.233	-0.065	-0.091	-0.246	0.191	N/A
NTAXA	-0.158	-0.164	N/A	0.131	0.150	0.068	-0.028	-0.033	0.043	N/A
ASPT	-0.119	0.011	N/A	-0.027	0.211	-0.204	0.083	-0.142	0.118	N/A

Correlations between acid grassland and the two RHS indices are frequently weak but are, more often than not, desirable. On two occasions, in English and Welsh EZ's (EZ1 and EZ3) the correlation between acid grasslands and EQI ASPT is desirable and statistically significant. Opposed to this are the undesirable, but non-significant correlations with EQI ASPT in upland Scottish Zones (EZ5 and EZ6).

No consistent messages emerge concerning three, primarily upland Broad Habitats; "Dwarf Shrub Heath", "Fen, swamp and marsh" and "Bog". Whilst each was significantly correlated with low habitat modification overall the correlations with indices of biological condition were often undesirable and significantly so in the case of EQI ASPT in EZ3 and EQI NTaxa in EZ5. Percentage cover of bog was also significantly, negatively correlated with EQI NTaxa in EZ3 but its overall correlation with EQI ASPT was both positive and significant ($p>0.01$).

"Built Up Areas & Gardens" tended to be positively (undesirably) correlated with the Habitat Modification Score and, in four instances (overall and EZ's 2, 3 and 4) this relationship was significant. There was also an undesirable (negative) correlation between this land class and EQI ASPT in EZ1. In contrast, EQI NTaxa and HQA were both positively and desirably correlated with the Broad Habitat in EZ5. There was no "Built Up Areas & Gardens" in the riparian strip of any EZ6 stream.

3.4 Water Chemistry

A water sample was collected from each biological sampling site in order to provide **indicative** information on the chemical character of the site. In the case of total alkalinity, the information also facilitated RIVPACS predictions of the expected macro-invertebrate fauna of the site if it were unstressed by pollution and/or by habitat degradation.

The summary statistics for pH, total alkalinity, conductivity and soluble reactive phosphorus of all sampled sites in each zone indicate the differences in the general characteristics of each of them (Table 3.16).

The data demonstrate the higher average nutrient concentration of sites in the lowland zones of both country units. By far the highest concentrations of soluble reactive phosphorus, total alkalinity values and conductivity were recorded in Environmental Zone 1, which has the highest percentage of the "Arable and horticulture" Broad Habitat in its immediate riparian strip (see section 3.3.1) above. The zone also had the highest mean, maximum and minimum pH values but, as with all four determinands, the values of individual sites are extremely variable.

In the other lowland zones, EZ2 (England and Wales) and EZ4 (Scotland), pastural farming predominated and improved and neutral grassland was the commonest land cover in the riparian strip (Table 3.X). Here the average chemical conditions were intermediate between EZ1 and the three upland zones and more similar to each other than any of the other four zones. Of the two zones, EZ2 had the higher average nutrient status, as particularly represented by the levels of soluble reactive phosphorus.

The three upland zones have the lowest nutrient status and the most acidic waters. The most oligotrophic waters tended to be in the most extreme upland zone (EZ6 – Scottish Highlands), as indicated by the median values of all four determinands, although the lowest single pH value was recorded from an EZ3 stream. The lowest average soluble reactive phosphorus value was recorded for EZ6 where the geology is predominantly base-poor and where there was no arable or horticultural land cover in the riparian strip.

Table 3.16 The mean, standard deviation of the mean (SDev), maximum, minimum, median and modal (when possible to determine) values of pH, total alkalinity, conductivity and soluble reactive phosphorus in each of six environmental zones. The number of sites per zone are EZ1, 68 ; EZ2, 98 ; EZ3, 55 ; EZ4 58 ; EZ5, 64 and EZ6, 62.

Variable	Zone	Mean	Sdev	Maximum	Minimum	Median	Mode
pH	**1**	7.92	0.38	8.42	6.15	8.00	8.00
	2	7.72	0.57	8.34	5.19	7.83	8.15
	3	6.87	1.18	8.22	3.67	7.32	8.00
	4	7.62	0.61	8.31	4.61	7.79	7.92
	5	7.05	0.76	8.31	4.40	7.23	6.95
	6	6.86	0.73	8.15	4.08	6.96	6.43
Alkalinity	**1**	4.87	2.75	16.42	0.10	4.77	3.94
	2	2.56	2.08	9.55	0.03	2.02	2.14
	3	0.63	0.77	3.25	0.00	0.38	0.00
	4	1.73	1.26	4.63	0.01	1.35	0.91
	5	0.70	0.97	6.14	0.00	0.41	0.42
	6	0.35	0.42	2.09	0.00	0.21	0.05
Conductivity	**1**	1087	1078	6390	104	828	740
	2	609	862	7130	2	436	445
	3	146	144	802	33	100	445
	4	326	205	841	50	283	341
	5	197	183	1062	24	128	N/A
	6	67	48	253	18	50	54
Phosphate	**1**	510.0	1170.1	8620.0	0.0	83.7	0.0
	2	139.8	360.8	2160.0	0.0	26.9	0.0
	3	14.7	43.0	305.0	0.0	2.0	0.0
	4	51.9	158.3	1110.0	0.0	8.6	0.0
	5	14.2	34.2	271.0	0.0	8.6	0.0
	6	7.1	18.1	136.0	0.0	1.8	0.0

3.5 Relationship Between the Biological Condition of Sites and the Habitat Quality of their River Corridors

RIVPACS and River Habitat Survey (RHS) are the two standard procedures, along with chemical sampling, used to monitor the quality of Britain's streams and rivers. Yet little effort has been made to date to link the data on the quality of the river corridor with that of the in-stream macro-invertebrate assemblages.

The CS2000 data-set has provided the best opportunity to date to make this comparison. Initial analyses have been made on index values but greater opportunities exist for relating more of the detailed information derived from each type of monitoring.

Correlation analyses show highly significant correlations between biological and river corridor index values in many Environmental Zones (Table 3.17), suggesting the possibility of causal links between poor habitat quality and poor biological condition of rivers.

Table 3.17 Correlations between the individual values of BMWP indices of biological condition (ASPT and NTaxa) and RHS indices of river corridor condition (HQA and HMS). Significance levels are colour-coded as follows

P< 0.05 **P<0.001**

BIOLOGICAL INDEX	ENVIRONMENTAL ZONE	n	RIVER HABITAT INDEX				
			HQA			HMS	
			R	R^2		R	R^2
ASPT	EZ1	77	**0.4349**	0.1891		**0.5725**	0.3277
ASPT	EZ2	103	**0.5992**	0.3590		**0.4861**	0.2363
ASPT	EZ3	57	0.1990	0.0396		0.1960	0.0384
ASPT	EZ4	60	**0.4174**	0.1742		**0.4527**	0.2049
ASPT	EZ5	66	**0.4440**	0.1971		0.2093	0.0438
ASPT	EZ6	62	**0.2828**	0.0800		**0.2793**	0.0780
NTaxa	EZ1	77	0.2010	0.0404		**0.2613**	0.0683
NTaxa	EZ2	103	**0.3870**	0.1498		**0.3507**	0.1230
NTaxa	EZ3	57	0.2057	0.0423		0.1718	0.0295
NTaxa	EZ4	60	0.1072	0.0115		0.1903	0.0362
NTaxa	EZ5	66	0.1942	0.0377		0.0000	0.0000
NTaxa	EZ6	62	0.1005	0.0101		**0.0265**	0.0007

The correlations are greatest in lowland Zones (EZ1, EZ2 and EZ4) where both the biological and RHS indices demonstrate a wider range of quality conditions. Correlations are poorest in upland Zones (EZ3, EZ5 and EZ6) where the biological conditions and habitat quality are both almost always high. The results stress the importance of best management practices for maintaining the naturalness of river corridors in order to ensure the integrity of aquatic macro-invertebrate assemblages.

Surprisingly, correlations between ASPT (normally an indicator of organic pollution) and the RHS indices are higher than those between NTaxa and RHS indices. This suggests that sites where habitat quality is poorest and habitat modification is greatest tend to also be prone to the highest levels of organic enrichment.

The disentanglement of the physical effects of habitat modification and the chemical effects of organic enrichment presents one particularly important avenue for more detailed study of the comparative influences of different forms of environmental stress on aquatic macro-invertebrate assemblages.

4 DISCUSSION

4.1 Changes in Taxon Distribution and Frequency

Previous studies have shown that headwater streams, i.e. those within 2.5km of their source make a major contribution to biodiversity in river basins (Furse *et al.* 1993). Whilst the fauna of these streams is less diverse than that of downstream, large river reaches (Vannote *et al.* 1980), many of the taxa present in these small streams are characteristic of the headwater zone (Furse *et al.* 1991) and hence additions to river basin diversity. Their importance is emphasised by the estimated 70% of total British river length represented by these near-source reaches (Furse 2000).

The large majority of the Countryside Survey stream sampling sites (approximately 70%) meet the definition of headwaters and are, therefore, of great potential value, if unpolluted or otherwise heavily modified, in promoting diversity in the wider countryside. Unfortunately, by virtue of their size and predominantly rural location headwater streams are susceptible to a wide variety of impacts, including, point and non-point source agricultural pollution, channel dredging, straightening, relocation, culverting, loss of riparian zones, forestry practices and acidification (Furse, 2000). Many of these impacts may be further exacerbated by low flows resulting from field drainage management, abstraction and climatic change (Giles *et al.* 1991; English Nature 1997; Furse 1998; Vuori *et al.* 1998).

Against this background, the increase, by the time of CS2000, in the distribution of the majority of taxa recorded in the 1990 survey appears to be a welcome trend. This appraisal, however, is based on the principle that the taxa increasing in frequency are those indicative of the improved biological conditions of rivers. Whist there are no existing metrics of direct equivalence to the botanical Condition Measures used to interpret the CS2000 vegetation plot data (Haines-Young *et al.* 2000), the BMWP Score system (Armitage *et al.* 1983) incorporates a system of scoring of individual aquatic macro-invertebrate families based on their tolerance to organic pollution. Thus, in combination with the RIVPACS prediction system (Wright *et al.* 1993), an evaluation can be made of the integrated ecological status of streams and the impacts of increased nutrient loads on the type and range of taxa present can be detected.

In addition to the BMWP Score system, a new metric designed to link qualitative and semi-quantitative changes in the aquatic macro-invertebrate assemblage structure of river sites to prevailing river conditions has recently been published (Extence *et al.* 1999). This index, called LIFE (Lotic-invertebrate Index for Flow Evaluation), is currently under evaluation (Clarke personal communication) in the context of its use in applying the European Union's "Water Framework Directive" (Council of the European Communities 2000).

4.1.1 Changes in species distribution and frequency

Analyses have shown widespread and often large increases in the frequency of occurrences of individual macro-invertebrate species and families.

Of the 473 distinct species recorded in either CS90 or CS2000, 329 showed an increase in frequency of occurrence, 38 showed no change and only 106 showed a reduction in frequency (Table 4.1). This provided a quotient of the number of taxa increasing in frequency to the number of taxa decreasing in frequency of 3.1.

Table 4.1 The number of distinct taxa (usually species) of invertebrates that increased in frequency of occurrence at the 354 Countryside Survey sites included in both the 1990 and 1998 surveys and flowing in at least one of these years. Also given are the mean number of distinct taxa per site in each of the 11 geographic regions identified in this report.

Geographic region	Change in number of taxa per region			Gain/ Loss Ratio	Mean no. taxa/site	
	Increased frequency 1998-1990	No change	Decreased frequency 1998-1990		1990	1998
Environmental Zone 1	167	222	84	1.99	20.15	25.24
Environmental Zone 2	205	173	95	2.16	18.65	25.99
Environmental Zone 3	126	280	67	1.88	16.96	22.06
Environmental Zone 4	178	229	66	2.70	16.93	26.60
Environmental Zone 5	170	253	50	3.40	13.23	21.38
Environmental Zone 6	151	297	25	6.04	13.05	24.03
Lowland zones	275	94	104	2.64	18.51	25.99
Upland zones	218	189	66	3.30	14.20	22.53
England + Wales	263	100	110	2.39	18.61	24.73
Scotland	245	166	62	3.95	14.35	23.96
Great Britain	329	38	106	3.10	16.48	24.34

The pattern of relatively greater increases than decreases in frequency of occurrence of individual taxa in Britain as a whole was also repeated in all major geographic regions recognised in this report. However, the gains to losses ratios were more strongly skewed towards gains in the uplands compared with the lowlands and in Scotland compared with England and Wales (Table 4.1). Similarly, the greatest gains in the average numbers of taxa per site was most marked in Environmental Zones 5 and 6 and therefore in the uplands rather than the lowlands and in Scotland rather than England and Wales.

Accompanying the increase in the frequency of individual taxa was a concomitant increase in the average number of taxa (normally species) per site (Figure 4.1). These changes were often very substantial, particularly in Scotland, and led to an approximate equalisation of the mean number of taxa per site in the two country units.

Previously, in 1990, sites in the England and Wales country unit supported almost 30% more taxa per site than Scotland. By the time of the 1998 survey this proportion had been reduced to a mere 3%.

Assuming comparable sampling efficiency in the two surveys (see section 4.3), the most likely explanation for this sort of increase in taxon richness is improvements in the biological condition of sites resulting from the amelioration of chemical or physical stresses, including improved habitat structure and flow regime.

An alternative possibility is that numbers of taxa can increase slightly as a result of a modest increase in nutrient status of the watercourse. In this case, the increase in taxon richness is normally accompanied by the gain of species at the site that are relatively tolerant of organic pollution.

Where mild organic pollution occurs, the change in nutrient status is generally reflected in a reduction in the site ASPT value, where ASPT is a measure of the mean tolerance of taxa present at the site to organic pollution. However, in this survey, the mean ASPT values increased in all environmental zones, suggesting that increase in nutrient status was not the primary cause of increase in taxon richness in either country unit.

The gain in site taxon richness, a key component of biodiversity, is thus to be welcomed. Its achievement is in line with key objectives of national government and conservation agencies. These include (see section 1.3):

> *to conserve as far as reasonably possible the wide variety of wildlife species and habitats in the UK, and to ensure that commercially exploited species are managed in a sustainable way. (DETR: UK Sustainable Development Strategy)*

surface waters will sustain a diverse variety of habitats and wildlife. (Environment Agency: An Environmental Vision)

to improve understanding of the way the natural heritage works by documenting changes and trends in it, and explaining these and their causes widely (Scottish Natural Heritage: A Natural Perspective).

The results section of this report also includes details of changes in the frequency of individual taxa. A collective evaluation of these changes is summarised in Table 4.2, where gains and losses in individual taxa are summarised by the magnitude, frequency and direction of change for the component taxa of each major taxonomic group.

Table 4.2 A breakdown by major taxonomic group of the number of distinct taxa (usually species) that have increased in frequency of occurrence at the 354 Countryside Survey sites included in both the 1990 and 1998 surveys and flowing in at least one of these years. Analysis broken down by eight, non-cumulative categories of magnitude of change.

Major group	No. of taxa increasing						No. of taxa decreasing		TOTAL
	>20	>15	>10	>5	>0	0	<-5	<-10	
Coelenterata	0	0	0	0	0	0	1	0	1
Planariidae	0	0	0	2	6	0	0	0	8
Nematomorpha	0	0	0	0	1	0	0	0	1
Gastropoda	0	0	1	2	16	1	6	0	26
Bivalvia	0	0	0	0	10	0	2	0	12
Polychaeta	0	0	0	0	0	0	1	0	1
Oligochaeta	0	0	1	0	0	0	0	0	1
Hirudinea	0	0	1	1	9	1	1	0	13
Hydracarina	0	0	0	1	0	0	0	0	1
Decapoda	0	0	0	0	1	0	1	0	2
Isopoda	0	0	0	0	2	0	2	0	4
Amphipoda	0	0	0	0	7	0	1	0	8
Ephemeroptera	0	1	1	3	13	4	7	0	29
Plecoptera	0	0	2	8	13	0	3	0	26
Odonata	0	0	0	1	12	1	1	0	15

Hemiptera	0	0	0	1	10	3	12	0	26
Hymenoptera	0	0	0	0	0	0	0	0	0
Coleoptera	0	2	1	3	58	11	31	2	108
Megaloptera	0	0	0	0	2	0	1	0	3
Neuroptera	0	0	0	0	1	0	1	0	2
Trichoptera	0	0	3	11	48	9	11	0	82
Lepidoptera	0	0	0	0	0	0	0	1	1
Diptera	2	0	5	8	59	7	21	0	105

The lowest increase to decrease ratios (Table 4.2), excluding groups with fewer than five representative taxa, were Hemiptera (0.92 – i.e. more decreases than increases) and Coleoptera (1.94). Both these orders contain a high proportion of species commonly associated with slow-flowing watercourses (Savage 1989; Friday 1998).

The tendency for taxa associated with slow (low) flow to increase in frequency at a lower rate than taxa preferring fast (high) flow was examined using a component of the LIFE Index (Extence *et al.* 1999). In this index, each species of aquatic macro-invertebrate is assigned a category, in the range I to VI, according to the flow type (current velocity) with which it is primarily associated. These categories are as follows:

- I Rapid flow
- II Moderate to fast flow
- III Slow or sluggish flow
- IV Flowing (usually slow) and standing waters
- V Standing waters
- VI Drying or drought impacted sites

Although the full data needed to calculate this index for each site are not currently available, the differences in character between the fauna of Countryside Survey sites in 1990 and 1998 have been examined by comparing the changes in frequency of occurrence of individual taxa over the 8-year period with the LIFE Index scores of each of these taxa. This has shown that the greatest increases in frequency have been associated with taxa primarily associated with rapid flows [typically >100cm s^{-1} (Extence et al. 1999)] and moderate to fast flows [typically 20-100 cm s^{-1}] (Table 4.3). Conversely, the smallest increases are exhibited by taxa associated with standing water (Group V). Group VI appears to disrupt the general pattern but this group of specialised taxa is only represented by four species and average gains are heavily influenced by the 7.3% increase in the frequency of one taxon, *Lymnaea truncatula*.

Table 4.3 The relationship between the LIFE Index flow group of individual taxa and their changes in frequency in Countryside Survey (CS) samples between 1990 and 1998

	LIFE Index flow group					
	I	II	III	IV	V	VI
Mean change in taxon frequency (+%) (1990 - 98)	3.90	3.24	0.55	0.67	0.07	1.62
Number of taxa per group in CS samples	37	104	28	129	66	4
Proportion of taxa increasing in frequency	86.5	76.0	60.7	64.3	53.0	75.0
Proportion of taxa decreasing in frequency	8.1	12.5	32.1	28.7	37.9	25.0
Proportion of taxa with no change in frequency	5.4	11.5	7.1	7.0	9.1	0.0

This pattern of greater increases in frequency of taxa preferring fast flow and relatively fewer taxa decreasing in frequency in fast flow categories was examined further by correlation analyses of results for each of five major geographic regions, including the two country units of England and Wales and of Scotland, the lowlands (EZ's 1, 2 and 4) and uplands (EZ's 3, 5 and 6) and Great Britain as a whole (Table 4.4).

Table 4.4 Correlation co-efficients (r) between the changes in frequency of individual aquatic macro-invertebrate taxa (n = 367) at Countryside Survey sites (n = 354) between 1990 and 1998 and each taxon's LIFE Index flow group. All r values highly significant (p<0.001).

LOWLANDS	UPLANDS	ENGLAND + WALES	SCOTLAND	GREAT BRITAIN
-0.2751	**-0.4107**	**-0.2276**	**-0.4518**	**-0.3788**

The relationship between changes of taxon frequencies and their LIFE Index flow groups was highly significant in all regions but the correlations between these two sets of variables was greatest in the upland zones and in Scotland.

These results indicate that differing flow conditions, with lower flows in 1990 than 1998, may have contributed to the observed differences in macro-invertebrate assemblages and that this impact may have been greatest in the upland regions of Great Britain. However, other factors complicate this simplistic interpretation.

Firstly, many of the taxa associated with fast flow are also those with high BMWP scores because of their intolerance to organic pollution. The converse applies to many taxa with preference for low flow conditions. Therefore, the impact of reduced organic pollutants and increased flow will be superficially similar. Secondly, it is known that there were extremely high spring flows in Scotland in 1990, in the period prior to CS90 sampling, and this may have led to the wash-out of most of the fauna of Scottish Highland streams, including the characteristic fast-flow taxa that might have been anticipated to occur in them. The issue of high spring Scottish flows is returned to in a later section of this discussion (see section 4.3).

Thus, whilst it appears possible that flow-related factors are influential in determining temporal changes in aquatic communities over the period 1990 to 1998, more detailed analyses are necessary in order to disaggregate the many factors that are operating in the small watercourses studied. The potential effect of annual and regional climatic variability on temporal and spatial variation in Countryside Survey results also suggests that consideration is given to replacing the 6-8 year cycle of Countryside surveys with a smaller, annual rolling programme of sampling, complemented by a ten-yearly major survey of the kind operated in 1998.

4.1.2 The occurrence of species with national conservation status

In the 1990 Countryside Survey, a variety of taxa were recorded in running water samples that were known to have national conservation status (unpublished data). Many of these records were made in small, near-source stream sites.

Concurrently with the 1990 survey, the National Rivers Authority started to fund a series of projects, later continued by the Environment Agency, collectively termed “The Faunal Richness of Headwater Streams” (Furse *et al.* 1991).

The headwater streams studies confirmed the important contribution of small streams to total catchment biodiversity, including many taxa with national conservation status (Furse *et al*. 1991). An estimated 20% of macro-invertebrate diversity could be attributed to small streams (Furse *et al*. 1993) and over 100 taxa were shown to be statistically associated with headwaters, including 16 Red Data Book or Nationally Scarce (formerly Nationally Notable) taxa. Other taxa with high conservation status occur in, but are not exclusively associated with, headwaters. Thus, taxa with national conservation status can also potentially occur in larger Countryside Survey sites, other than headwaters.

In practice, the number of taxa with conservation status increased in CS2000, compared with CS90. In part, this may have been due to the higher number of samples in 1998 (441, including replicates) in comparison with 1990 (361). However, the increase in national conservation taxa from 19 confirmed taxa in 1990 to 33 in 1998 (i.e. 74%

increase) is greater than pro-rata with the increased number of samples (i.e. 22%). A more probable explanation is that the rare taxa are benefiting from the same improvements in the biological conditions of the stream as the majority of the commoner taxa.

Amongst the taxa gained between 1990 and 1998, one was a mayfly (a species characteristic of larger watercourses), 13 were beetles, one was an alderfly, three were caddis flies and three were true flies. The taxa lost over the 8-year period comprised five beetles, one caddis fly and one true fly.

One Red Data Book, the caseless caddis fly *Hydropsyche saxonica*, unexpectedly declined in absolute frequency of occurrence by 1.1%. Although this value is small, it derived from a small baseline frequency in 1990 and resulted from losses of the taxa from several sites were it had been previously found and no new gains. Given the apparent flow category preference of I (Extence *et al*. 1999), its decline, at a time when other rheophilic animals were increasing in frequency, gives some cause for concern.

It should be noted that the conservation status of the British fauna and flora is undergoing a comprehensive and as yet uncompleted review, in order to bring the UK categories in line with the revised IUCN categories introduced in 1994 (see http://www.iucn.org/themes/ssc/redlists/categor.htm).

4.1.3 Changes in family distribution and frequency

The relationship between the number of species of aquatic macro-invertebrates in a sample and the number of families they represent is highly significantly correlated (Wright *et al.* 1998). Thus, given the increase in number of taxa (mostly species) at Countryside Survey sites, it is no surprise that the frequency of distribution of most families increased in line with simultaneous increases in the frequency of individual species (Table 4.5).

Thus the proportions of taxa increasing (88%), decreasing (8%) and showing no change in frequency (4%) in the UK are similar to, but even more skewed than, the respective proportions for these three categories at species level, which were 70%, 22% and 8%.

Table 4.5 A comparison of the changes in frequency of occurrence of 81 BMWP families per country unit between CS90 and CS2000 and their changes, in England and Wales (E + W) between the NRA's 1990 River Quality Survey (RQS) and 1995 General Quality Assessment (GQA).

BMWP family	% change CS90 to CS200			% change GQA-RQS
	GB	Scotland	E + W	E+W
Dendrocoelidae	3.39	0.56	6.21	-0.4
Planariidae (incl. Dugesiidae)	18.08	17.51	18.64	10.7
Neritidae	0.00	0.00	0.00	0.9
Viviparidae	0.28	0.00	0.56	0.0
Valvatidae	1.98	0.56	3.39	-2.0
Hydrobiidae (incl. Bithyniidae)	6.78	6.78	6.78	10.0
Physidae	0.85	0.56	1.13	-3.0
Lymnaeidae	7.06	11.30	2.82	-0.3
Planorbidae	1.41	2.82	0.00	-3.1
Ancylidae (incl. Acroloxidae)	11.02	10.73	11.30	3.6
Unionidae	1.41	0.00	2.82	0.0
Sphaeriidae	12.99	11.30	14.69	3.5
Oligochaeta	14.12	18.64	9.60	0.0
Piscicolidae	1.41	0.00	2.82	0.5
Glossiphoniidae	11.86	9.60	14.12	-2.5
Hirudinidae	0.56	0.00	1.13	-0.1
Erpobdellidae	5.08	3.95	6.21	1.1
Astacidae	0.28	0.00	0.56	-0.2
Asellidae	3.39	3.95	2.82	-1.7
Corophiidae	0.28	0.00	0.56	1.1
Gammaridae (incl. Crangonyctidae & Niphargidae)	7.06	10.73	3.39	3.2
Siphlonuridae	1.41	1.69	1.13	0.1
Baetidae	14.97	19.77	10.17	3.1
Heptageniidae	13.84	17.51	10.17	2.7
Leptophlebiidae	10.45	15.25	5.65	1.9
Potomanthidae	0.00	0.00	0.00	0.1
Ephemeridae	0.00	-0.56	0.56	2.3
Ephemerellidae	3.11	5.65	0.56	6.6
Caenidae	1.13	2.26	0.00	0.5
Taeniopterygidae	3.39	6.21	0.56	3.3
Nemouridae	15.82	16.95	14.69	3.9
Leuctridae	11.02	15.25	6.78	10.4
Capniidae	0.00	-1.13	1.13	0.5
Perlodidae	12.99	16.38	9.60	2.5
Perlidae	3.11	7.91	-1.69	0.1
Chloroperlidae	6.50	9.04	3.95	3.2
Platycnemididae	-0.85	0.00	-1.69	1.0
Coenagriidae	1.98	2.26	1.69	1.9
Lestidae	0.00	0.00	0.00	0.0
Calopterygidae	1.13	0.00	2.26	4.0
Gomphidae	0.00	0.00	0.00	0.0
Cordulegasteridae	5.65	7.91	3.39	-0.3
Aeshnidae	1.41	1.69	1.13	0.3

Table 4.5 (continued)

BMWP family	% change CS90 to CS200			% change GQA-RQS
	GB	Scotland	E + W	E+W
Corduliidae	0.00	0.00	0.00	0.0
Libellulidae	1.98	1.13	2.82	1.0
Hydrometridae	0.85	0.56	1.13	2.3
Gerridae	0.85	2.82	-1.13	-1.1
Nepidae	-1.69	-0.56	-2.82	-0.6
Naucoridae	-0.28	0.00	-0.56	0.0
Aphelocheiridae	0.00	0.00	0.00	0.9
Notonectidae	0.00	-0.56	0.56	0.9
Pleidae	0.00	0.00	0.00	0.7
Corixidae	-5.93	-0.56	-11.30	-3.1
Haliplidae	-5.65	2.26	-13.56	-7.4
Hygrobiidae	0.00	0.00	0.00	-0.3
Gyrinidae	0.85	2.82	-1.13	4.8
Dytiscidae (incl. Noteridae)	-2.26	7.34	-11.86	-1.6
Hydrophilidae (incl. Hydraenidae)	3.39	14.69	-7.91	9.7
Scirtidae	16.67	20.34	12.99	4.0
Dryopidae	3.11	5.08	1.13	-0.4
Elmidae	18.08	22.03	14.12	6.7
Sialidae	2.26	5.08	-0.56	-0.8
Hydroptilidae	5.37	9.04	1.69	17.8
Rhyacophilidae (incl. Glossosomatidae)	12.15	12.99	11.30	2.2
Philopotamidae	11.30	11.30	11.30	-0.4
Polycentropodidae	10.73	17.51	3.95	0.4
Hydropsychidae	11.58	14.69	8.47	9.0
Psychomyiidae (incl. Ecnomidae)	4.80	5.08	4.52	15.6
Phryganeidae	0.56	0.56	0.56	1.8
Brachycentridae	0.00	0.00	0.00	-0.2
Lepidostomatidae	2.54	2.82	2.26	4.2
Limnephilidae	25.14	26.55	23.73	15.4
Goeridae	8.76	5.65	11.86	7.2
Beraeidae	10.45	11.86	9.04	1.8
Sericostomatidae	6.21	6.78	5.65	6.6
Odontoceridae	7.06	8.47	5.65	3.0
Molannidae	0.28	0.00	0.56	1.2
Leptoceridae	1.41	3.39	-0.56	15.0
Tipulidae	14.69	18.64	10.73	4.2
Simuliidae	24.01	31.07	16.95	5.3
Chironomidae	5.65	14.69	-3.39	0.0

Changes in the frequency of individual BMWP Score system families (Armitage *et al.* 1983) can be compared with changes in the frequency of the same families between the two National Rivers Authority's national surveys of 1990 (RQS) and 1995 (1990). The NRA surveys were confined to England and Wales and included approximately 6000 riverine sites in each survey. Of these, 3018 were common to both surveys and were used in this analysis (Table 4.5).

The values given for frequency changes between the two NRA surveys (Table 4.5) are taken from Table 7.7 of Davy-Bowker *et al.* (2000) and have been corrected for the variable sample biases associated with the individual NRA laboratories that processed the samples. In making comparisons with the Countryside Survey data, two important differences in the data need to be recognised.

Firstly, the Countryside Survey sites were sampled only once in each year, mainly in either summer or autumn, whereas the NRA survey results are based on combined species lists from two samples per site, comprising one each in spring and autumn.

Secondly, Countryside Survey sites were mainly in headwaters, within 2.5km of source, and never in streams of greater than third order, whereas the majority of the NRA sites were collected on streams of more than 5km from source (Furse 1997).

Within these caveats, the respective gains and losses of families in England and Wales for the respective inter-survey periods showed a positive and significantly correlated relationship ($n = 81$, $r = 0.4218$, $p<0.001$). The annual mean rate of change of frequency for the full set of 81 families recorded in one or more of the two Countryside Surveys and/or the two NRA surveys is +0.44% per annum for the Countryside Surveys and +0.30% for the NRA surveys. Currently, no comparable analyses are available for Scotland.

The significance of these comparisons is that the trends observed in the limited range of 354 countryside survey sites are corroborated by the similar trends observed in the much wider set of samples collected nationally by the National Rivers Authority (now incorporated in the Environment Agency).

4.2 Changes in the Biological Condition of Streams.

Analyses of the structure of the macro-invertebrate assemblages at Countryside Survey sites indicated substantial improvements in the biological condition (ecological status) of these sites between 1990 and 1998. Furthermore, the statistical significance of these changes has been validated using new testing procedures incorporated in the RIVPACS software package (Clarke *et al.* 1999). Using these, it was shown that 25.1% of 350 matched Countryside Survey sites, within the scope of RIVPACS, significantly improved in quality over the 8-year period ($p<0.05$), whilst only 2.0% significantly deteriorated ($p<0.05$). Furthermore, the same tests revealed that 53.9% of sites had more than a 50% probability of having improved in quality, whilst just 14.6% had more than a 50% chance of having deteriorated over the same time period.

Whilst the improvement in biological condition of sites occurred in all environmental zones and both country units, there were inter-regional differences in the rate of change.

Thus, the most marked improvements were in Scotland, and particularly in the two more upland environmental zones, EZ5 (Intermediate uplands and islands) and EZ6 (True uplands).

The principal factor leading to these changes in overall grade appeared to have been the increase in the taxon richness of sites in 1998 (Table 4.5). Of the two BMWP indices recorded, NTaxa is the most vulnerable to variable sampling effort, but this variation is accounted for by a knowledge of the characteristics and magnitude of this variability (Furse *et al.* 1995; Clarke *et al.* 1999). Lower rates of net change in ASPT, than NTaxa, were recorded in all six zones but, again, all zones exhibited a clear net improvement in the distribution of grades of biological condition when all sources of variation in the data were accounted for in the most recent version of RIVPACS (Clarke *et al*. 1999).

The apparent improvement in the biological condition of the 174 English and Welsh streams within the full 350-stream set, can be put into context by comparison with the changes which occurred at up to 3018 matched English and Welsh sites between the 1990 River Quality Survey (RQS) and 1995 General Quality Assessment (GQA).

The 1990 and 1995 national surveys used the same RIVPACS-based standard field and laboratory procedures and methods of analysis used in Countryside Survey 2000. The only difference in the sets of data compared (Table 4.6) is that the national survey comparisons are based on three seasons' sampling and Countryside Survey samples on just one season. However, RIVPACS accounts for this by using broader, experimentally derived, levels of variation for single samples than three seasons' samples (Clarke *et al*. 1999). The comparisons therefore remain statistically valid.

Net improvements in England and Wales between CS90 and CS2000 were mirrored by general improvements in the biological condition of matched sites from broader national surveys in 1990 and 1995 (Table 4.6). Although fewer sites from the 1990/95 national surveys had >50% probability of change, the net rates of improvement (proportion improving in quality – proportion declining) in overall grade were of similar magnitude (Table 4.6).

Table 4.6 **A comparison between the probability of change in grade of biological condition of a set of 174 matched English and Welsh sites from CS90 (1990) and CS2000 (1998) and a second set of over 6000 matched English and Welsh sites from the 1990 RQS and the 1995 GQA. No comparable data available for Scotland.**

Context	Index (EQI) type	Probability of being downgraded (p<0.5)	Probability of no change (p<0.5)	Probability of being upgraded (p<0.5)	Net overall rate of improvement	Annual rate of improve-ment
CS2000 (1998) c.f. CS1990 England and Wales only	Overall	18.5	36.8	44.8	26.3	3.3
GQA 1995 c.f. RQS 1990 England and Wales only	Overall	9.9	59.0	31.3	21.4	4.3
GQA 1995 c.f. RQS 1990 England and Wales only. Steams within<5k of source only	Overall	11.1	59.4	29.5	18.4	2.3
CS2000 (1998) c.f. CS1990 England and Wales only	ASPT	20.6	44.3	35.1	14.5	1.8
GQA 1995 c.f. RQS 1990 England and Wales only	ASPT	8.8	62.0	29.2	20.4	4.1
CS2000 (1998) c.f. CS1990 England and Wales only	NTaxa	19.6	37.4	43.1	23.5	2.9
GQA 1995 c.f. RQS 1990 England and Wales only	NTaxa	9.9	67.2	22.9	13.0	2.6

For the two Countryside Surveys the net rate of improvement was 26.3%. For all matched sites in the 1990 and 1995 national surveys the equivalent net improvement was 21.4%. When only small streams from the national surveys were considered, making a closer match with the mainly small Countryside Survey sites, the net improvement between 1990 and 1995 in England and Wales fell to 18.4%.

Data from Countryside Surveys and the national surveys are even more closely comparable if annual rates of change are considered. The overall, net annual rate of improvement for Countryside Survey sites was 3.3% which compares to an equivalent annual rate of 4.3% for NRA sites. However, if only those NRA sites within 5km of their source are included in analyses, providing a better match with the Countryside Survey sites, then the NRA net rate of improvement is 2.3% per annum (Table 4.6).

The principal difference between changes in the two pairs of surveys is that, whereas rates of change in the NTaxa index are very similar (2.9% and 2.6% - Table 4.6) the rate of improvement signified by the ASPT index is much greater for the NRA sites (4.9%) than for the Countryside Survey sites (1.8%). The ASPT index was designed to indicate changes in the impact of organic pollution. The implication of the relative rates of change in the two surveys is that, whilst reducing organic loads is a contributory factor in both cases, the relative importance of this form of amelioration of stress is more important in the larger NRA sites than in the smaller Countryside Survey sites. A corollary of this is that improvement in overall habitat quality may be playing a relatively greater role in the Countryside Survey sites.

Comparable analyses are not available for Scotland. The England and Wales comparisons in this and preceding sections were made possible by separate funding provided by the Environment Agency through R&D Project E1-036 *"Analysis of 1995 Survey Data. Phase 2 Post-Survey Appraisal"*.

The main conclusion to be drawn from this suite of comparisons is that the rate of improvement of Countryside Survey sites is analogous to the rates of change recorded in wider national surveys, adding greater credence to the reliability of the Countryside Survey results. However, the relative contribution of different mechanisms to the process of amelioration may vary with stream type and character.

The net improvement in the biological conditions of Countryside Survey streams is to be welcomed and is in line with the findings of broader national surveys (Davy-Bowker *et al.* 2000). Its achievement is in line with key objectives of national government and conservation agencies. These include (see section 1.3):

> *to sustain and improve water quality and the aquatic environment (DETR: UK Sustainable Development Strategy)*
>
> *Improving river quality (Ccount 8.30) (DEFRA: Quality of Life Counts, relating to their Sustainable Development Strategy)*
>
> *Our rivers, lakes and coastal waters will be far cleaner (Environment Agency: An Environmental Vision)*
>
> *The causes of water pollution, eutrophication, and acidification will have been fully controlled (Environment Agency: An Environmental Vision)*

Habitats will improve in their extent and quality to sustainable levels for the benefit of all species (Environment Agency: An Environmental Vision)

Degraded habitats, especially rivers, estuaries and wetlands, will have been restored (Environment Agency: An Environmental Vision)

To achieve a strategic and catchment-based approach to fresh waters which safeguards features of interest, restores ecological functions (Scottish Natural Heritage: A Natural Perspective)

The improvement in the biological condition of rivers is also in line with the pivotal requirement of the new "Water Framework Directive" (Council of the European Communities 2000) that requires (Article 4 Section 1 Paragraph (a) Sub-paragraph (i)) that:

Member States shall protect, enhance and restore all bodies of surface water with the aim of achieving good surface water status

4.3 Causes of Change in the Biological Condition of Streams

Differential sampling efficiency

The reasons for the overall and widespread improvements in the biological condition and taxon richness of sites are not yet clear and may differ for different environmental zones with different land cover and potential environmental stresses.

One possibility that cannot be discounted is differential sampling efficiency between the ITE surveyors employed in 1990 and the IFE surveyors employed in 1998. However, great care was taken to employ equivalent teams of people experienced in conducting field surveys but with no previous experience of aquatic macro-invertebrate samples. Both sets of surveyors were given training courses of equivalent duration and content, led by the same module leader.

Further credibility is given to the belief that differential sampling efficiency was not operating by the consistency of rates of observed change noted in the two Countryside Surveys and the pair of NRA national surveys in 1990 and 1995. In the NRA surveys all field staff were trained to the same high levels and, against this consistent level of efficiency, they recorded similar net annual rates of change (improvement) to the Countryside Survey samplers over approximately the same span of time.

Finally, RIVPACS III+ is designed to account for the sampling variability associated with the standardised sampling procedures used by the field surveyors.

Even so, the possibility that the 1998 surveyors performed their single freshwater surveying tasks with greater efficiency than the 1990 surveyors, with their greater multiplicity of tasks cannot be entirely discounted. This possibility could have been better assessed if trained IFE personnel had taken sub-sets of samples for quality control in each year. This was not possible within the limited budget for Module 2.

If relative sampling efficiency is discounted as a major source of the improvement in the biological conditions of streams in 1990 and 1998, then a number of alternative options may responsible, operating either singly or in combination.

Improved water quality

One obvious possibility is that there has been a genuine improvement in the chemical quality of streams. Chemical stresses may result from a number of potential sources, including industry, domestic sources such as sewage treatment works, highway run-off and a multiplicity of agricultural activities. In the context of the small headwater streams that predominated the Countryside Survey data-set, their rural setting, low catchment population density and general lack of industrial development mean that agricultural activities are the most likely source of chemical pollution.

Data collected by the Environment Agency in England and Wales, and available via their web site show that substantial reductions in stress have been occurring. For example, the Environment Agency has reported a 31% improvement in the chemical grades of rivers in England and Wales over the last decade (www.environment-agency.gov.uk/s-enviro/viewpoints/3compliance/2fwater-qual/3-2-1.html [9th November, 2000]). They have also recorded a substantial reduction in the number of major water pollution incidents. For example, the number of category 1 pollution incidents decreased from 571 in 1990 to 128 in 1998 (www.environment-agency.gov.uk/s-environ/stresses/6illegal-prac/1pollution/6-1a.txt [1st August, 2000]).

The Agency has concluded that these changes in water quality and pollution incidents are linked to tighter regulation and to their pollution prevention activities (Environment Agency 1997). Prophylactic pollution prevention activities activities include advisory visits to farms, by the Agency’s pollution control officers, to discuss farm management and waste disposal strategies.

Further help with these issues has also been available from advisory bodies such as the Farming and Rural Conservation Agency (FRCA) and the Farming and Wildlife Advisory Group (FWAG). Amongst the services FWAG has offered in the last decade is the development of water management plans designed to reduce and control pollution in river catchments. Other practical advice and information on statutory obligations are available to farmers and land managers through detailed codes of practice (Ministry of Agriculture, Fisheries and Food 1991; Forestry Commission undated).

Development of buffer zones

Amongst the advice given by the Environment Agency (Environment Agency 1996), FWAG and FRCA is that “buffer zones” should be developed alongside watercourses to help promote the good biological condition of the watercourse. These zones are narrow, vegetated strips between the farmed land and the watercourse, that are managed separately from the rest of the field.

Whilst the extent of the benefits of buffer zones remains a subject of debate, attributed advantages include reduction of in-stream sedimentation and diffuse pollution. Well-developed buffer strips also enhance the visual quality and amenity of the landscape and may provide diverse habitats for aquatic and terrestrial wildlife and act as corridors for their movement.

The current study, one of the few where sampling of aquatic macro-invertebrates and River Habitat Surveys have been carried out simultaneously along the same stretches of watercourses, has shown that there are, often strong, significant relationships between habitat quality and the in-stream biological condition. This provides supportive but not conclusive evidence for the benefits of this form of watercourse management.

However, other CS2000 studies on bankside vegetation (Haines-Young *et al.* 2000; CEH in preparation) have shown that the gains within the aquatic environment must, be balanced evidence of a decline in the botanical quality of streamside vegetation. There has, during the 1990s been an increase in tall growing, common grasses and herbs and an increase in woody species at the expense of lower growing stress tolerating plants that are also under pressure elsewhere in the landscape.

The trend observed for the vegetation along streamsides probably results from less intensive or different forms of land management. Although this form of management is apparently beneficial for the biological condition of the streams and rivers, and possibly for small mammals, birds and other elements of the terrestrial fauna, it does not appear to be so for streamside, or riparian vegetation. Thus, further management strategies may need to be developed to sustain botanical quality and to maintain the biological condition of the water bodies.

Intrinsic to good habitat quality, as determined in this study using River Habitat Survey, is the adjacent land cover, as categorised here using the Broad Habitat designations. To date, only superficial analyses of the relationship between riparian land cover and river habitat and in-stream biological condition have been attempted (see section 3.3.3). These provide confirmatory evidence of the expected positive links between the extent of different riparian Broad Habitat cover and each of the quality of the river habitat and stream biota and the degree of habitat modification of the river channel. The data available from all elements of CS90 and CS2000 allow for much more detailed analysis of the direction, rate and environmental impact on streams and their biota of both riparian and whole catchment land cover structure and patterns of change.

Climatic and flow related factors

The preceding discussion of potential causes of improvement of the biological condition of streams has largely focused on England and Wales. Many of the possible reasons are also applicable to Scotland but they appear unlikely to wholly explain the much greater rate and extent of improvement in biological condition of Scottish streams, particularly those in the more upland regions.

Confidence in the assignment of 82% of Scottish CS2000 sites to biological grades “a” or “b” is supported by the Scottish Environment Protection Agency’s allocation of about 91% of river length, in 1996, to the top two classes in the Scottish River Classification Scheme (Scottish Office 1999).

One possible explanation for poorer biological condition of Highland rivers in 1990 is climate. In their report on the 1990 Water Quality Survey, the Scottish Office (1992) noted that “exceptionally wet weather, in spring 1990, may have contributed to the particularly low faunal diversity at many Highland sites”.

Further significant evidence for the importance of differential flow regions came from the use of components of the LIFE index (Extence 1999) to examine the nature of change in macro-invertebrate communities in Countryside Survey sites. Furthermore, the significant apparent influence of changes in flow regime came from Scotland.

The implication of the results was that the increase in species richness in Scottish sites derived from a switch away from taxa preferring low flow or standing water towards those associated with much faster flow. This evidence that flows were lower and less rapid in 1990 and 1998 appears to contradict the suggestion that high spring flows were responsible for the low aquatic macro-invertebrate diversity in Scotland (Scottish Office 1992). In fact this need not be the case for high spring taxon washout, when considerable loss of rheophilic taxa might occur, could be followed by low summer flows that could be exploited by the more lentic species.

Whatever the explanation, and much more detailed analyses of climatic and other factors is needed, changes in flow regime appear to be strongly implicated in the observed changes in macro-invertebrate species richness and assemblage structure.

An imperative, indicated by the importance of changing climatic conditions, is that serious consideration needs to be given to supporting the periodic, full Countryside Surveys by annual surveys of an adequate sub-set of sites. It is mainly in this way that significant temporal patterns of change can be distinguished from the potential impacts of differential climatic conditions during the full surveys.

4.4 Future Research

The results of the limited interpretation of the results of CS2000 afforded by the current study have provided firm evidence of their information content that has yet to be fully exploited. Included in the untapped potential are the other surveys of diatoms, chironomid pupal exuviae and macrophytes, much of which are relevant to the requirements of the Water Framework Directive and its requirement of a holistic evaluation of the biological and environmental components of watercourses and their riparian corridors (Council of European Communities 2000).

Particular area of possible research are proposed in the next section. In addition to an investigation of:

- the targeted use of different sources of biotic and river habitat information in a diagnostic fashion

the other two prime areas of potential research are:

- the relationship between broader catchment land cover, the quality of the riparian habitat and the in-stream biological assemblages, and

- the investigation and interpretation of the causes of change in upland watercourses with particular reference to land cover change and climatic variability

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Macro-invertebrates

Species information

There was a substantial increase in the number of recorded species per site between 1990 and 1998. An average of 24.3 taxa (mainly species) per sample was recorded in 1998, compared with an average of 16.5 taxa per equivalent sites in 1990.

Mean gains in taxa per sample occurred in all environmental zones but were greater in the uplands than the lowlands and greater in Scotland than England and Wales.

Despite the relatively larger gains in species richness in Scotland, the mean number of taxa recorded per site remained slightly higher in England and Wales than in Scotland.

The increase in mean taxa per site was accompanied by an increase in the frequency of distribution of most taxa. Of the 473 recorded taxa, 70% increased in frequency of occurrence, 22% decreased and 8% showed no change.

There was a tendency for the greatest gains in frequency to be made by taxa associated with fast-flow conditions. Conversely, taxa making least increase or greatest decrease in frequency tended to be those associated with slow-flow conditions or standing water.

The changes in frequency of individual taxa were significantly correlated by their known flow preferences, as categorised in the Lotic invertebrate Index for Flow Evaluation (LIFE).

The relationship between changes in taxon frequency and their flow-preference category was most marked in upland regions and Scotland in general, indicating that differences in flow conditions in 1990 and 1998 may have been influential in explaining the observed temporal differences.

The Countryside Survey sampling sites, which were mainly on headwaters, supported a wide variety of taxa with national conservation status. In CS2000, three Red Data Book and 30 Nationally Scarce taxa were confirmed records. Two other Red Data Book taxa possibly occurred, although their identity is considered doubtful.

In total 40 confirmed Red Data Book or Nationally Scare taxa occurred in either CS90 or CS2000, or both. This is 8.5% of the 473 distinct taxa recorded in the two surveys.

Family information

Increases in the average number of taxa recorded per site also occurred at family level and showed similar geographical patterns to the gains at species level.

5.1.2 Biological condition of streams

The number of relevant families present in a sample (NTaxa) is one of the two indices of biological condition of sites derived from the BMWP Score system for the purposes of this study. The other is the Average Score Per Taxon (ASPT). ASPT is a measure of the average organic pollution tolerance of the taxa present in a sample.

A general increase in the number of scoring taxa per site and of ASPT values led to an apparent increase in the biological condition of Countryside Survey sites in 1998 compared to their condition in 1990. These increases occurred in all Environmental Zones but were most marked in Scotland.

The ratio of the observed BMWP index values of sites and the values predicted by RIVPACS is termed its Ecological Quality Index or EQI. The values of EQI's are commonly sub-divided into grades of biological condition. The statistical significance of changes in grades of condition of sites can be tested by RIVPACS.

Analyses showed that 25.1% of sites in GB showed a significant increase in their grade ($p<0.05$) between 1990 and 1998, whilst only 2.0% showed a significant decline. The respective figures for Scotland were 33.0% (significant improvement) and 1.1% (significant decline). In England and Wales the corresponding values were 17.2% and 2.9%).

The general improvement in biological condition of Countryside Survey streams and rivers between 1990 and 1998 is matched but an equivalent annual rate of improvement between the National Rivers Authority's 1990 River Quality Assessment and their 1995 General Quality Assessment.

5.1.3 River Habitat Survey

Habitat condition of river corridors

Values of the Habitat Quality Assessment (HQA) index, as derived from River Habitat Survey (RHS) were, on average, higher in Scotland than in England and Wales.

The lowest mean value per environmental zone was from EZ1 (Easterly lowlands of England and Wales). However, the highest recorded mean value was in EZ1 (Uplands of England and Wales).

Modification of river corridors

Low values of Habitat Modification Scores (HMS) signify little channel management and are considered desirable.

Habitat Modification Scores were lower in the uplands than the lowlands and in Scotland rather than England and Wales.

The lowest value was in EZ6 (True uplands of Scotland) where a mean of only 2.1 indicated minimal management practices. Conversely, the highest mean value, of 23.9, was in the EZ1 (Easterly lowlands of England and Wales), where practices such as channel straightening and dredging are commonplace.

5.1.4 Water Chemistry

Watercourses in the easterly lowlands of England and Wales (EZ1) had the highest mean values of pH, total alkalinity, conductivity and soluble reactive phosphorus, as determined by single indicative water samples. Lowest values of each of these four determinands were recorded from streams in the true uplands of Scotland (EZ6).

5.1.5 Comparative analyses

Relationship between biotic indices and river corridor indices

In many environmental zones biotic index values derived from the BMWP Score system were significantly correlated with the HQA and HMS values derived from River Habitat Survey.

This confirms expectations that the biological condition of streams tends to be highest in stretches that are of good habitat quality and subject to little channel management.

Relationship between the extent of Broad Habitats alongside watercourses and river corridor index values and values for indices of biological condition of the watercourse

Strong significant relationships ($p<0.001$) occurred between riparian Broad Habitat type and indices of river corridor condition.

Some significant relationships between Broad Habitat type and the biological condition were also recorded, although these were fewer and weaker than with the RHS indices.

In particular corridor and in-stream biological condition were negatively correlated with the frequency of the “Arable and Horticulture” Broad Habitat. Positive correlations were strongest with “Broadleaved, mixed and yew woodland” and, to a lesser extent, with “Coniferous woods”.

The extent of habitat modification was significantly and positively correlated ($p<0.001$) with the extent of “Arable and horticulture”, “Improved grassland” and “Built up areas & gardens”. Significant negative correlations ($p<0.001$) between extent of individual Broad Habitats and Habitat Modification Score occurred with “Acid grassland” and “Bog. At the $p<0.05$ level, additional negative correlations were with “Broadleaved, mixed and yew woodland”, “Coniferous woods”, “Dwarf shrub heath and “Fenland, marsh and swamp”.

5.1.6 Causes of improvement in the biological condition of watercourses

The possibility that they resulted from the differential performance of the field surveyors was discounted. The previous experience of the 1990 and 1998 field teams and the pre-survey training that each group received were well matched.
Other possible explanations included:

- differences in flow conditions
- improved water chemistry
- reduction in pollution incidents
- increase in the development of vegetated riparian strips (buffer zones), managed separately from the rest of the adjacent field

5.1.7 Management of buffer zones

Whilst the presence of buffer zones was shown to be correlated with good in-stream biological condition, results from other modules of CS2000 suggest that this form of vegetated riparian strip is also associated with some undesirable botanical changes.

Management procedures which consolidate the improvement in in-stream conditions whilst reversing unwelcome changes in botanical assemblages need to be sought.

5.1.8 Further research

Three research programmes are proposed, in order to examine the results of CS2000 in more detail. These are outlined in the following section (5.2).

5.2 Recommendations for Further Research

5.2.1 Introduction

The results of Countryside Survey 2000 have indicated that there were substantial improvements in the biological condition of small streams over the previous decade. These changes co-incided with the awareness and promotion of the advantages of developing separately managed, vegetated riparian buffer zones. It is suggested that these zones confer a number of benefits to the biological condition of the stream and the habitat structure of the river corridor. Preliminary analyses of CS2000 data demonstrated strong positive correlations between the habitat quality of river corridors and the biological condition of streams.

Over the same decade, botanical data collected during the Countryside Surveys of 1990 and 1998 indicate a general increase in eutrophication reflected in a shift towards tall herbs and woody plants and away from plants with lower fertility and competitor scores. These changes were particularly apparent in streamside plots where there was a strong shift towards woody plants that was associated with a reduction in species richness.

Some of the greatest improvements in the biological condition of streams were recorded in the upland environmental zones EZ5 and EZ6 in Scotland. The reasons for these improvements are not entirely clear but may be related to either or both of climatic conditions and changes in upland land management.

On the basis of these observations, three follow-up studies are proposed as outlined below.

5.2.2 Proposal 1:

Proposal 1 addresses the following question:

How is the improvement in the quality of freshwater habitats related to management, use and structure of the river corridor and adjacent catchment land cover?

Objectives:

- To determine the relationship between the land cover and landscape pattern (and changes in those characteristics) and the structure and modification of river corridors and the biological condition of the watercourse
- To determine the impact of spatial scale on these relationships
- To determine the risks of loss of habitat quality and biological condition associated with particular catchment land cover characteristics

- To identify the characteristics of the river corridor habitats that are most directly related to the biological condition of watercourses
- To determine the spatial relationships between river habitat structure and biological condition of rivers. How long do vegetated riparian strips need to be to benefit the biological condition of streams and how persistent are improvements when habitat condition becomes degraded
- To examine the relationship between the structure and condition of the river corridor habitats and the botanical composition of the river banks
- To propose appropriate management regimes to minimise the loss of desirable botanical diversity whilst maintaining the benefits of vegetated riparian zones for the biological condition of rivers

Work programme

Year 1 (desk studies)

- Quantification of the land cover characteristics (composition and pattern) of CS2000 stream site catchments, and temporal change in those characteristics, using both survey data and satellite imagery
- Analysis of the relationships between landscape characteristics, at various spatial scales, and the habitat condition and extent of modification of river corridors
- Disaggregation of the component information contained in River Habitat Surveys into discrete variables or variable combinations and identification of those variables most directly related to the composition and biological condition of macro-invertebrate assemblages and changes in these assemblages
- Extension of these analyses, where relevant, to include the results of national river quality surveys and river habitat surveys
- Elucidation of those macro-invertebrate taxa which benefit most from the presence of vegetated buffer strips
- Analysis of the botanical composition of streamside plots and the relationship between individual species, species types and measures of vegetation condition and the habitat quality and extent of modification of river corridors
- Production of an interim report on the results of the desk study.

Year 2 (field and laboratory studies)

- River Habitat Survey, macro-invertebrate sampling and botanical surveying of extended lengths of small headwater streams to examine the spatial relationships between changes in each sampled component and changes in each of the other component. Studies to include upland and lowland streams, streams with continuous, discontinuous and no well developed vegetated riparian zones
- Laboratory processing of macro-invertebrate samples
- Data-logging of all field data

Year 3 (laboratory and desk studies)

- Completion of laboratory processing of macro-invertebrate samples
- Statistical analysis and interpretation of field data
- Recommendations for the best management practices for riparian zones for the promotion of appropriate botanical diversity and maintenance and enhancement of in-stream botanical condition.
- Recommendations for trial headwater restoration schemes based on the findings of this study and agreed desirable ecological objectives
- Production of an R&D Technical report and R&D Project Record.

Benefits to sponsors

- An understanding of the factors and risks linking land cover and landscape patterns and changes to the quality of the river corridor and the botanical condition of the banksides and biological condition of the watercourse
- Recommendations for the best management practice for river corridors in order to promote desirable ecological objectives

5.2.3 Proposal 2

Proposal 2 addresses the following question:

How can the multiple sources of ecological information collected during CS2000 be best used to indicate the nutrient status of small watercourses?

Objectives

- To obtain multi-source ecological information of value in determining the general ecological status of CS2000 headwaters and their riparian corridors
- To use CS2000 data to integrate and cross-calibrate metrics derived from assessment procedures and taxonomic groups of value in determining the eutrophication of streams and their banksides (e.g. Mean Trophic Ranking – MTR - macrophyte data; Trophic Diatom Index - TDI – diatom data; and streamside botanical plots – fertility scores and competitor scores) with the information content of samples of other common taxonomic groups (e.g. RIVPACS and Chironomid Pupal Exuviae Technique – CPET- macro-invertebrate samples; and River Habitat Survey – RHS – habitat quality and modification index).
- To develop a suite of metrics specifically directed towards evaluating the eutrophication status of headwater streams.
- To test the proposed metrics by experimental sampling of a range of streams of known nutrient status
- To develop the recommendations as a standard procedure for evaluating the nutrient status of headwaters.

Available data

Countryside Survey 2000:	RIVPACS macro-invertebrate samples – fully processed Chironomid Pupal Exuviae samples – in store and available for processing Mean Trophic Ranking in-stream macrophyte samples – available for analysis Trophic Diatom Index – in store and available for processing Streamside “S” & “W” plots – available for analysis Bankside “S” & “W” plots – analysed River Habitat Surveys – analysed Indicative chemical samples analysed from nitrate and phosphate concentrations
Environment Agency (NRA)	1990, 1995 and 2000 national invertebrate survey data and complementary chemical data

CEH Dorset & EA (NRA)	National Invertebrate Database (2000 sites) Mean Trophic Ranking Database (5,000 sites) River Habitat Survey Database (15,000 sites)

Examples of questions to be addressed

- Which taxonomic group(s) is/are best suited to indicate the nutrient status of headwaters – or should all sources of information be integrated into a common metric?
- Can knowledge of the eutrophication index value of one taxonomic group be used to develop new indicator metrics based on other taxonomic groups, such as invertebrates that may be more easy to sample or may provide extensive historical data? For example, so far we have made inadequate use of the in-stream S and W plot data.
- How can the results of these surveys be used to help develop macro-invertebrate metrics that indicate the impact of eutrophication rather than other forms of organic enrichment?
- Do the signals emanating from MTR (Mean Trophic Ranking) echo the signals emanating from the Indicators of Botanical Diversity (IBD's) of fertility and competitive species derived from the adjacent streamside plots?
- Can the streamside botanical data (particularly from the instream sub-quadrat) provide a history of change at the CS2000 sites and which of the four survey years (1978, 1984, 1990 and 1998) are amenable to this analysis?

Work programme

Year 1 (desk studies)

- Data logging of CS2000 MTR data
- Processing and data-logging of CS2000 diatom samples
- Processing of CS2000 CPET data
- Data logging of CS2000 instream "S" and "W" plot botanical data
- Analysis and inter-calibration of data and assessment metrics
- Development of test metrics using macro-invertebrate data to indicate eutrophication

- Development of an integrated suite of eutrophication metrics for operational testing
- Production of an interim report on metric development

Year 2 (field and laboratory studies)

- Collection of field data of the taxonomic groups identified as relevant to the assessment of the impacts of eutrophication on headwater streams. Sampling to be undertaken in contrasting stream types subject to different intensities of nutrient enrichment in catchments of differing land cover characteristics
- Processing and data-logging of field data
- Acquisition of appropriate test data from other sources
- Production of an interim report on the field survey

Year 3 (desk studies)

- Metric testing using field and other acquired data
- Metric refinement and re-testing
- Development of a supplementary, rapid assessment protocol based on the developed metrics
- Production of standard protocol manual for the biological detection of eutrophication in small streams
- Production of an R&D Technical Report and R&D Project Record

Benefit to sponsors

- A practical protocol providing practical operational protocols for the biological detection of eutrophication in headwaters
- Application to the implementation of the Water Framework Directive

5.2.4 Proposal 3:

Proposal 3 addresses the following question:

How are changes in the biological condition of upland streams related to changes in land management and climate?

Objectives

- To relate changes in the biological condition of upland headwaters to changes in upland management strategies, including the impacts of differential grazing pressures by both agricultural livestock and native deer populations, heather burning, forestry practices, the development of riparian zones and tourism.
- To consider the inter-related or over-arching impacts of annual and medium-term climatic variation.
- To identify those macro-invertebrate taxa whose distribution, frequency of occurrence and abundance have shown the strongest recent beneficial and detrimental changes in relation to changing land management practices and other environmental influences, with special reference to taxa of special national or international conservation value.
- To document the findings of the study and recommend best practices for upland land management in order to minimise the impact on small upland streams

General approach

Changes in upland land management practices have been the subject of detailed recent review, for example by MLURI and detailed land cover maps are available or are becoming available for the last decade. Over the same period the Scottish River Purification Boards and the National Rivers Authority and their successor bodies the Scottish Environment Protection Agency (SEPA) and the Environment Agency have been carrying out extensive surveys of the macro-invertebrate fauna of upland watercourses. Countryside Surveys of 1990 and 1998 represent additional, specific surveys that incorporate both land cover and stream quality elements.

The current proposal would collate, review and interpret all existing data on the fauna of upland streams and upland land management and other potential sources of environmental impact. Apparently beneficial and detrimental influences would be identified and conclusions drawn would be tested by a series of experimental field surveys in matched upland streams subjected to different forms and intensity of land management.

Brief outline work programme

Year 1

- Review of existing data and development of testable hypotheses
- Development of a project database and webpage
- Production of an interim report on the review process.

Year 2

- Experimental field studies
- Laboratory analyses of field studies

Year 3

- Production of a report on the analysis, conclusions, recommendations of the experimental study.
- Production of a project record

Benefit to sponsors

- A comprehensive review of trends of change in the macro-invertebrate assemblages of upland streams and an evaluation of the probable drivers and processes of change.
- Recommendations for the best management practices of upland catchments to promote and enhance the biological condition and biodiversity of upland streams.

REFERENCES

Armitage, P.D., Moss, D., Wright, J.F. and Furse, M.T. (1983) The performance of a new biological water quality score system based on macroinvertebrates over a wide range of unpolluted running-water sites, *Water Research*, **17**, 333-347.

Ball, S.G. (1986*) Terrestrial and Freshwater Invertebrates with Red Data Book, Notable or Habitat Indicator Status*. Invertebrate Site Register Report No. 66. Peterborough: Nature Conservancy Council.

Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M., Furse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M., Howard, D.C., and Ness, M.J. (1993). *Countryside Survey 1990 Main Report*, London: Department of the Environment.

Blackburn, J.H. and Forrest, M.B. (1995) New records of *Hydropsyche saxonica* McLachlan (Trichopt., Hydropsychidae) from small streams in Great Britain, *Entomologist's Monthly Magazine*, **131**, 71-76.

Boon, P.J., Holmes, N.T.H., Maitland, P.S., Rowell, T.A. and Davies, J. (1997) A system for evaluating rivers for conservation (SERCON): development, structure and function. In: *Freshwater Quality: Defining the Indefinable?*, 299-326, edited by P.J. Boon and D.L. Howell, Edinburgh: The Stationery Office.

Boycott, A.E. (1936) Habitats of freshwater Mollusca in Britain, *Journal of Animal Ecology*, **5**, 116-186.

Bratton, J.H. (1990) *A Review of the Scarcer Ephemeroptera and Plecoptera of Great Britain*. Research and Survey in Nature Conservation, No. 29. Peterborough: Nature Conservancy Council.

Brindle, A. (1960) The larvae and pupae of the British Tipulinae (Diptera: Tipulidae), *Transactions of the Society for British Entomology*, **14**, 63-216.

Brindle, A (1964a) Taxonomic notes on the larvae of British Diptera. No. 17 – The Clitellarinae (Stratiomyidae), *The Entomologist*, **97**, 134-139 + plate.

Brindle, A (1964b) Taxonomic notes on the larvae of British Diptera. No. 16 – The Stratiomyinae (Stratiomyidae), *The Entomologist*, **97**, 91-96.

Brindle, A. (1967) The larvae and pupae of the British Cylindrotominae and Limoniinae (Diptera, Tipulidae), *Transactions of the Society for British Entomology*, **17**, 151-216.

Brooks, S. (1997*) Field guide to the dragonflies and damselflies of Great Britain and Ireland.* British Wildlife Publishing: Hook.

Carr, R. (1984) *Limnebius crinifer* Rey new to Britain, with a revised key to the British *Limnebius* species (Coleoptera: Hydraenidae), *Entomologist's Gazette*, **35**, 181-184.

Clarke, R T, Cox, R, Furse, M T, Wright, J F and Moss, D (1999) RIVPACS III+. River InVertebrate Prediction and Classification System with error assessments. User Manual. Release 1.3 (March 1999), 64pp + appendices. Wareham and Bristol: Institute of Freshwater Ecology and Environment Agency.

Cooper, A., Murray, R.and McCann, T.P. (1997) *The Northern Ireland Countryside Survey: summary report and application to rural decision making*, Belfast: Environment and Heritage Service, Department of the Environment for Northern Ireland.

Council of the European Communities (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, *Official Journal of the European Communities* **L327** (43), 1-72.

Davy-Bowker, J., Furse, M.T., Clarke, R.T. and Gravelle, M.J. (2000) *Analysis of 1995 survey data. Phase 2. Post-survey appraisal. Unit I: Taxon distribution studies*. Bristol: Environment Agency, 578pp.

Edington, J.M. and Hildrew, A.G. (1981) Caseless caddis of the British Isles. Scientific Publication of the Freshwater Biological Association No. 43, Ambleside: Freshwater Biological Association, 92pp

Elliott, J.M. (1996) British freshwater Megaloptera and Neuroptera: A key with ecological notes Scientific Publication of the Freshwater Biological Association No. 54, Ambleside: Freshwater Biological Association, 72pp

Elliott, J.M. Humpesch, U.H. and Macan, T.T (1988) Larvae of the British Ephemeroptera. Scientific Publication of the Freshwater Biological Association No. 49, Ambleside: Freshwater Biological Association, 145pp.

English Nature (1997) *Wildlife and Freshwater. An Agenda for Sustainable Development.* Peterborough: English Nature.

Environment Agency (1996) *Understanding buffer strips*. An information booklet, Bristol: Environmenmt Agency.

Environment Agency (1997) *The quality of rivers and canals in England and Wales 1995*, Bristol: Environment Agency.

Environment Agency (1997) *River Habitat Survey. 1997 field survey guidance manual, incorporating SERCON.* Unpublished Environment Agency Manual.

Environment Agency (2001) *An environmental vision: The Environment Agency's contribution to sustainable development*, Bristol: Environment Agency.

Extence, C.A., Balbi, D.M. and Chadd, R.P. (1999) River flow indexing using British benthic macroinvertebrates: A framework for setting hydroecological objectives, *Regulated Rivers: Research & Management*, **15**, 543-574.
Forestry Commission (undated) Forests and Water Guidelines, Forestry Commission internal publication.

Foster, G.N. (in press) A review of the scarce and threatened Coleoptera of Great Britain Part 3 Aquatic Coleoptera. Peterborough: JNCC.

Friday, L.E. (1988) A key to the adults of British Water Beetles, *Field Studies*, **7**, 1-51.

Furse, M.T. (1997) *Operational mechanisms for the protection and enhancement of headwaters – scoping study*. Environment Agency R&D Technical Report E25, Bristol: Environment Agency.

Furse, M.T. (1998) *The Faunal Richness of Headwater Streams*. Unpublished Ph.D. thesis. University of Reading.

Furse, M.T. (2000) The application of RIVPACS procedures in headwater streams – an extensive and important resource. In: *Assessing the Biological Quality of Fresh Waters. RIVPACS and Other Techniques*, edited by J.F. Wright, D.W.Sutcliffe and M.T.Furse, 79-91, Ambleside: Freshwater Biological Association.

Furse, M T, Clarke, R T, Winder, J M, Symes, K L, Blackburn, J H, Grieve, N J and Gunn, R J M (1995) *Biological Assessment Methods: Controlling the Quality of Biological Data. Package 1: The Variability of Data used for Assessing the Biological Condition of Rivers.* R&D Note 412, Bristol: National Rivers Authority.

Furse M.T., Dawson F.H., Henville P., Irons G.P., Gunn R.J.M. and Winder, J.M. (1998) Countryside Survey 2000 Field Handbook Module 2: Survey of Freshwater Habitats. Unpublished handbook, 147pp.

Furse, M.T., Winder, J.M., Symes, K.L. and Clarke, R.T. (1991) *The faunal richness of headwater streams. A review of existing information*. A preliminary report (R&D Document 08Y) to the National Rivers Authority by the Institute of Freshwater Ecology, R&D Project 242. [NRA publication reference P-96]

Furse, M.T., Winder, J.M., Symes, K.L., Clarke, R.T., Gunn, R.J.M., Blackburn, J.H. and Fuller, R.M. (1993) *The Faunal Richness of Headwater Streams. Stage 2 - Catchment Studies*, National Rivers Authority R&D Note 221, Bristol: National Rivers Authority.

Giles, N., Phillips, V.E. and Barnard, S. (1991) *The Current Crisis: Ecological Effects of Low Flows*. Lincoln: Royal Society for Nature Conservation.

Government Statistical Service (1999) Quality of Life Counts – Indicators for a strategy for sustainable development: a baseline assessment, London: Department of the Environment, Transport and the Regions.

Haines-Young, R.H., Barr, C.J., Black, H.I.J., Briggs, D.J., Bunce, R.G.H., Clarke, R.T., Cooper, A., Dawson, F.H., Firbank, L.G., Fuller, R.M., Furse, M.T., Gillespie, M.K., Hill, R., Hornung, M., Howard, D.C., McCann, T., Morecroft, M.D., Petit, S., Sier, A.R.J., Smart, S.M., Smith, G.M., Stott A.P., Stuart, R.C. and Watkins, J.W. (2000) *Accounting for nature: assessing habitats in the UK countryside*, London: Department of the Environment, Transport and the Regions.

Holmes, N.T.H., Newman, J.R., Chadd, S., Rouen, K.J., Sharp, L. and Dawson, F.H. (1999) *Mean Trophic Rank: A users' manual*. R&D Technical Report No E38. Bristol: Environment Agency

Hynes, H.B.N. (1977) Adults and nymphs of British stoneflies (Plecoptera) with notes on their ecology and distribution. Scientific Publication of the Freshwater Biological Association No. 17, Ambleside: Freshwater Biological Association, 92pp

Kelly, M.G. (1998) Use of the Trophic Diatom Index to monitor eutrophication in rivers. *Water Research*, **32**, 236-242.

Kerney, M. (1999) *Atlas of the Land and Freshwater Molluscs of Britain and Ireland*. Great Horkesley: Harley Books, 264pp.

Ministry of Agriculture, Fisheries and Food (1991) *Code of Good Practice for the Protection of Water*, London: MAFF Publications.

Murray, R., McCann, T. and Cooper, A. (1992) *A Land Classification and Landscape Ecological Study of Northern Ireland*. A report to the Environment Service, Department of the Environment for Northern Ireland. Coleraine: University of Ulster.

Murray-Bligh, J.A.D., Furse, M.T., Jones, F.H., Gunn, R.J.M, Dines, R.A. and Wright, J.F. (1997) *Procedure for collecting and analysing macroinvertebrate samples for RIVPACS*. Joint publication by the Institute of Freshwater Ecology and the Environment Agency, 162pp.

Nilsson, A. (1996) Coleoptera Dytiscidae, diving water beetles. In: *Aquatic insects of North Europe. A taxonomic handbook. Volume 1: Ephemeroptera – Plecoptera – Heteroptera – Neuroptera – Megaloptera – Coleoptera – Trichoptera – Lepidoptera.*, edited A. Nilsson, 145-172, Stenstrup: Apollo Books, 274pp.

Raven, P.J., Holmes, N.T.H., Dawson, F.H., Fox, P.J.A.,Everard, M., Fozzard, I.R. and Rouen, K.J. (1998) *River Habitat Quality – the physical character of rivers and streams in the UK and Isle of Man*. River Habitat Survey Report Number 2, Bristol: Environment Agency, Stirling: Scottish Environment Protection Agency. Belfast: Environment and Heritage Service, 84pp.

Savage, A.A. (1989) Adults of the British aquatic Hemiptera Heteroptera. A key with ecological notes. Scientific Publication of the Freshwater Biological Association No. 50, Ambleside: Freshwater Biological Association, 173pp

Scottish Office (1992) *Water Quality Survey of Scotland*, Edinburgh: The Scottish Office Environment Department.
Scottish Office (1999) *Improving Scotland's water environment*, Edinburgh: The Scottish Office Environment Department.

Shirt, D. (ed.) (1987). *British Red Data Books: 2. Insects*, Peterborough: Nature Conservancy Council.

Strahler, A.N. (1957) Quantitative analysis of watershed geomorphology, *Transactions of the American Geophysical Union*, **38**, 913-920.

Sweeting, R.A., Lowson, D., Hale, P. and Wright, J.F. (1992) 1990 biological assessment of rivers in the UK. In: *Proceedings of the International Conference on River Water Quality - Ecological Assessment and Control* (Brussels 1991), edited P.J. Newman, M.A. Pivaux and R.A. Sweeting, 319-326, Luxembourg: Commission of the European Communities publication EUR 14606 EN-FR.

UK Biodiversity Steering Group (1995*) Biodiversity: The UK Steering Group Report. Volumes 1 and 2*, London: HMSO.

UK Government (1994a) *Sustainable Development: The UK Strategy.* Cm2426, TSO. ISBN 0-10-124262-X

UK Government (1994b) *Biodiversity. The UK Action Plan*, London: HMSO.

Vannote, R.L., Minshall, G.W., Cummins, K.W., Sedell, J.R. and Cushing, C.E. (1980) The river continuum concept, *Canadian Journal of Fisheries and Aquatic Sciences*, **37**, 130-137.Vuori, K-M.,

Wallace, I.D. (1991) *A Review of the Trichoptera of Great Britain.* Research and Survey in Nature Conservation, No. 32. Peterborough: Nature Conservancy Council.

Wallace, I.D., Wallace, B. and Philipson, G. N. (1990) A key to the case-bearing caddis larvae of Britain and Ireland. Scientific Publication of the Freshwater Biological Association No. 51, Ambleside: Freshwater Biological Association, 237pp.

Williams P.J., Briggs, J., Barr, C.J., Cummins, C.P., Gillespie, M.K., Rich, T.C.G., Baker, A., Beaseley, J., Corfield, A., Dobson, D., Collin, A.S., Fox, G., Howard, D.C., Luursema, K., Rich, M., M., Samson, D., Scott, W.A., White, R. and Whitfield, M. (1998) *Lowland Pond Survey 1996: Final Report*, London: Department of the Environment, Transport and the Regions.

Wilson, R.S. (1996) A practical key to the genera of pupal exuviae of the British Chironomidae (Diptera: Insecta) with an account of the CPET method of water quality monitoring. 98pp., Wedmore: Wilson, self-published.

Wright, J.F., Furse, M.T. and Armitage, P.D. (1993) RIVPACS - a technique for evaluating the biological quality of rivers in the UK. *European Water Pollution Control*, 3, 15-25.

Wright J.F., Moss D. & Furse M.T. (1998) Macroinvertebrate richness at running-water sites in Great Britain: A comparison of species and family level data. *Verh. int. Vereinn. theor. angew. Limnol.*, **26**, 1174-1178

APPENDIX 1

The occurrence of distinct taxa of macro-invertebrates in each of six environmental zones, two country units and two altitude classes. Taxa given in parentheses are inclusive of other taxa identified more precisely in other regions

TAXON	ENVIRONMENTAL ZONE						REGION			
	1	2	3	4	5	6	ENGLAND & WALES	SCOTLAND	LOWLANDS	UPLANDS
Coelenterata										
Hydridae						+		+		+
Tricladida										
Planaria torva (Muller)		+					+		+	
Polycelis felina (Dalyell)	+	+	+	+	+	+	+	+	+	+
Polycelis nigra group	+	+	+	+	+		+	+	+	+
Phagocata vitta (Duges)			+			+	+	+		+
Crenobia alpina (Dana)		+	+		+	+	+	+	+	+
Dugesia polychroa group	(+)									
Dugesia polychroa (Schmidt)		+					+		+	
Dugesia tigrina (Girard)		+					+		+	
Dendrocoelum lacteum (Muller)	+	+		+			+	+	+	
Nematomorpha										
Nematomorpha		+			+	+	+	+	+	+
Gastropoda										
Viviparus contectus (Millet)	+						+		+	
Valvata cristata Muller	+	+					+		+	
Valvata macrostoma Morch		+					+		+	
Valvata piscinalis (Muller)	+	+			+		+	+	+	+
Potamopyrgus jenkinsi (Smith)	+	+	+	+	+		+	+	+	+
Bithynia leachii (Sheppard)	+	+					+		+	
Bithynia tentaculata (L.)	+	+					+		+	
Aplexa hypnorum (L.)	+	+			+		+	+	+	+

Taxon	Environmental zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Physa fontinalis (L.)	+	+					+		+	
Physa acuta group	+						+		+	
Lymnaea palustris (Muller)	+	+		+	+		+	+	+	+
Lymnaea peregra (Muller)	+	+	+	+	+	+	+	+	+	+
Lymnaea stagnalis (L.)	+	+					+		+	
Lymnaea truncatula (Muller)	+	+	+	+	+	+	+	+	+	+
Gastropoda (continued)										
Planorbis sp.			(+)							(+)
Planorbis carinatus Muller	+	+		+			+	+	+	
Planorbis planorbis (L.)		+					+		+	
Anisus leucostoma (Millet)	+	+					+		+	
Anisus vortex (L.)	+	+		+	+		+	+	+	+
Bathyomphalus contortus (L.)	+	+	+	+			+	+	+	+
Gyraulus albus (Muller)	+	+		+	+		+	+	+	+
Armiger crista (L.)	+	+		+	+		+	+	+	+
Hippeutis complanatus (L.)	+	+					+		+	
Planorbarius corneus (L.)	+	+					+		+	
Ancylus fluviatilis Muller	+	+	+	+	+	+	+	+	+	+
Acroloxus lacustris (L.)	+	+					+		+	
Succineidae	+	+	+	+	+		+	+	+	+
Zonitidae	+	+	+	+	+	+	+	+	+	+
Bivalvia										
Anodonta group	+	+					+		+	
Sphaerium sp.				(+)	(+)			(+)		
Sphaerium corneum (L.)	+	+	+				+		+	+
Sphaerium lacustre (Muller)		+					+		+	
Pisidium amnicum (Muller)	+	+	+				+		+	+
Pisidium casertanum (Poli)	+	+	+	+	+	+	+	+	+	+
Pisidium henslowanum (Sheppard)	+	+					+		+	
Pisidium hibernicum Westerlund		+					+		+	
Pisidium milium Held	+	+	+	+	+		+	+	+	+
Pisidium nitidum Jenyns	+	+	+	+	+		+	+	+	+
Pisidium personatum Malm	+	+	+	+	+	+	+	+	+	+
Pisidium subtruncatum Malm	+	+	+	+			+	+	+	+
Dreissena polymorpha (Pallas)	+						+		+	

Taxon	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
	Environmental Zone						Region			
Oligochaeta										
Oligochaeta	+	+	+	+	+	+	+	+	+	+
Hirudinea										
Piscicola geometra (L.)	+	+	+				+		+	+
Theromyzon tessulatum (Muller)	+	+					+		+	
Hemiclepsis marginata (Muller)	+						+		+	
Glossiphonia complanata (L.)	+	+	+	+	+	+	+	+	+	+
Glossiphonia heteroclita (L.)	+	+					+		+	
Helobdella stagnalis (L.)	+	+	+	+	+	+	+	+	+	+
Haemopis sanguisuga (L.)	+		+				+		+	+
Hirudinea (continued)										
Erpobdella octoculata (L.)	+	+	+	+	+		+	+	+	+
Erpobdella testacea (Savigny)	+	+					+		+	
Dina lineata (Muller)	+	+		+			+	+	+	
Trocheta bykowskii Gedroyc					+			+		+
Trocheta subviridis Dutrochet	+	+	+	+			+	+	+	+
Hydracarina										
Hydracarina	+	+	+	+	+	+	+	+	+	+
Decapoda										
Austropotamobius pallipes (Lereboullet)			+				+			+
Isopoda										
Asellus aquaticus (L.)	+	+		+	+	+	+	+	+	+
Asellus meridianus Racovitza	+	+		+	+		+	+	+	+
Jaera sp.				+				+	+	
Amphipoda										
Corophium multisetosum group	+						+		+	
Crangonyx pseudogracilis Bousfield	+	+					+		+	
Gammarus duebeni Liljeborg	+	+		+	+		+	+	+	+
Gammarus lacustris Sars					+			+		+
Gammarus pulex (L.)	+	+	+	+	+	+	+	+	++	+

Gammarus tigrinus Sexton	+	+					+		+	
Gammarus zaddachi Sexton	+	+		+	+		+	+	+	+
Niphargus aquilex Schiodte		+	+				+		+	+
Ephemeroptera										
Siphlonurus lacustris Eaton			+	+	+	+	+	+	+	+
Ameletus inopinatus Eaton			+		+	+	+	+		+
Baetis muticus (L.)	+	+	+	+	+	+	+	+	+	+
Baetis niger (L.)					+	+		+		+
Baetis rhodani (Pictet)	+	+	+	+	+	+	+	+	+	+
Baetis vernus Curtis	+	+	+	+	+	+	+	+	+	+
Baetis scambus group	+	+	+	+	+	+	+	+	+	+
Centroptilum luteolum (Muller)	+	+		+	+	+	+	+	+	+
Centroptilum pennulatum Eaton			+	+			+	+	+	+
Cloeon dipterum (L.)	+	+		+			+	+	+	
Cloeon simile Eaton				+				+	+	
Procloeon bifidum Bengtsson	+		+				+		+	+
Rhithrogena sp.	+	+	+	+	+	+	+	+	+	+

Taxon	**Environmental Zone**						**Region**			
	1	**2**	**3**	**4**	**5**	**6**	**E&W**	**Scotland**	**Upland**	**Lowland**
Ephemeroptera (continued)										
Heptagenia fuscogrisea (Retzius)				+				+	+	
Heptagenia lateralis (Curtis)			+	+	+	+	+	+	+	+
Heptagenia sulphurea (Muller)	+	+	+	+			+	+	+	+
Ecdyonurus sp.	+	+	+	+	+	+	+	+	+	+
Leptophlebia marginata (L.)			+	+	+	+	+	+	+	+
Leptophlebia vespertina (L.)				+	+	+		+	+	+
Paraleptophlebia sp.	+	+		+		+	+	+	+	+
Paraleptophlebia cincta (Retzius)						+		+		+
Paraleptophlebia submarginata (Stephens)	+	+	+	+	+	+	+	+	+	+
Habrophlebia fusca (Curtis)	+	+	+	+			+	+	+	+
Ephemera danica Muller	+	+	+			+	+	+	+	+
Ephemera vulgata L.	+						+		+	
Ephemerella ignita (Poda)	+	+	+	+	+	+	+	+	+	+
Caenis horaria (L.)	+	+		+			+	+	+	
Caenis rivulorum Eaton		+	+	+	+	+	+	+	+	+
Caenis luctuosa group	+	+			+		+	+	+	+

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Plecoptera										
Taeniopteryx nebulosa (L.)				+	+	+		+	+	+
Brachyptera risi (Morton)			+	+		+	+	+	+	+
Protonemura meyeri (Pictet)		+	+	+	+	+	+	+	+	+
Protonemura montana Kimmins			+			+	+	+		+
Protonemura praecox (Morton)		+	+	+	+	+	+	+	+	+
Amphinemura standfussi Ris		+	+	+		+	+	+	+	+
Amphinemura sulcicollis (Stephens)	+	+	+	+	+	+	+	+	+	+
Nemurella picteti Klapalek	+	+	+	+	+	+	+	+	+	+
Nemoura avicularis Morton	+	+	+	+	+	+	+	+	+	+
Nemoura cinerea (Retzius)			+		+	+	+	+		+
Nemoura cambrica group	+	+	+	+	+	+	+	+	+	+
Nemoura erratica Claassen						+		+		+
Leuctra fusca (L.)	+	+	+	+	+	+	+	+	+	+
Leuctra geniculata (Stephens)	+	+	+	+		+	+	+	+	+
Leuctra hippopus (Kempny)	+	+	+	+	+	+	+	+	+	+
Leuctra inermis Kempny		+	+	+	+	+	+	+	+	+
Leuctra moselyi Morton			+	+	+	+	+	+	+	+
Leuctra nigra (Olivier)	+	+	+	+	+	+	+	+	+	+
Capnia sp.			(+)				(+)			
Capnia atra Morton						+		+		+
Capnia bifrons (Newman)	+						+		+	
Perlodes microcephala (Pictet)	+	+	+	+	+	+	+	+	+	+
Diura bicaudata (L.)			+		+	+	+	+		+
Plecoptera (continued)										
Isoperla grammatica (Poda)	+	+	+	+	+	+	+	+	+	+
Dinocras cephalotes (Curtis)		+	+	+	+	+	+	+	+	+
Perla bipunctata Pictet			+		+	+	+	+		+
Chloroperla torrentium (Pictet)		+	+	+	+	+	+	+	+	+
Chloroperla tripunctata (Scopoli)	+	+	+	+	+	+	+	+	+	+
Odonata										
Platycnemis pennipes (Pallas)	+						+		+	
Pyrrhosoma nymphula (Sulzer)	+	+	+	+	+	+	+	+	+	+
Ischnura elegans (Van der Linden)	+	+		+			+	+	+	
Enallagma cyathigerum (Charpentier)	+						+		+	

Coenagrion puella group	+	+					+		+	
Erythromma najas (Hansemann)	+						+		+	
Lestes sponsa (Hansemann)	+						+		+	
Calopteryx splendens (Harris)	+	+					+		+	
Calopteryx virgo (L.)	+	+	+				+		+	+
Cordulegaster boltonii (Donovan)	+	+	+	+	+	+	+	+	+	+
Aeshnidae				(+)						
Aeshna sp.		(+)				(+)		(+)		
Aeshna cyanea (Muller)	+						+		+	
Aeshna grandis (L.)					+			+		+
Aeshna mixta group	+						+		+	
Libellula quadrimaculata L.					+			+		+
Sympetrum nigrescens Lucas	+				+		+	+	+	+
Sympetrum sanguineum (Muller)	+	+					+		+	
Sympetrum striolatum (Charpentier)	+						+		+	
Hemiptera										
Hydrometra sp.				(+)				(+)		
Hydrometra stagnorum (L.)	+	+					+		+	
Velia (Plesiovelia) caprai Tamanini	+	+	+	+	+	+	+	+	+	+
Velia (Plesiovelia) saulii Tamanini					+			+		+
Microvelia reticulata (Burmeister)	+						+		+	
Gerris (Gerris) costai (Herrich-Schaffer)					+	+		+		+
Gerris (Gerris) lacustris (L.)	+			+		+	+	+	+	+
Gerris (Gerris) lateralis Schummel					+			+		+
Nepa cinerea L.	+	+			+		+	+	+	+
Ilyocoris cimicoides (L.)	+						+		+	
Notonecta sp.		(+)			(+)					
Notonecta glauca L.	+			+			+	+	+	
Notonecta maculata Fabricius	+						+		+	

Taxon	**Environmental Zone**						**Region**			
	1	**2**	**3**	**4**	**5**	**6**	**E&W**	**Scotland**	**Upland**	**Lowland**
Hemiptera (continued)										
Notonecta viridis Delcourt	+						+		+	
Callicorixa praeusta (Fieber)		+	+				+		+	+
Corixa punctata (Illiger)	+	+		+			+	+	+	
Hesperocorixa linnei (Fieber)	+	+					+		+	
Hesperocorixa sahlbergi (Fieber)	+			+			+	+	+	

Taxon	Environmental Zone 1	2	3	4	5	6	Region E&W	Scotland	Upland	Lowland
Sigara (Sigara) sp.	+	+		+			+	+	+	
Sigara (Subsigara) falleni (Fieber)	+	+					+		+	
Sigara (Subsigara) fossarum (Leach)	+	+					+		+	
Sigara (Subsigara) scotti (Fieber)				+				+	+	
Sigara (Pseudovermicorixa) nigrolineata (Fieber)	+	+		+			+	+	+	
Sigara (Retrocorixa) limitata (Fieber)				+				+	+	
Sigara (Retrocorixa) semistriata (Fieber)		+		+			+	+	+	
Sigara (Retrocorixa) venusta (Douglas & Scott)		+	+		+		+	+	+	+
Sigara (Halicorixa) stagnalis (Leach)	+						+		+	
Hymenoptera										
Agriotypus armatus (Walker)			+				+			+
Coleoptera										
Brychius elevatus (Panzer)	+		+	+			+	+	+	+
Peltodytes caesus (Duftschmid)	+						+		+	
Haliplus fluviatilis Aube	+						+		+	
Haliplus fulvus (Fabricius)				+				+	+	
Haliplus heydeni Wehncke	+						+		+	
Haliplus immaculatus Gerhardt		+					+		+	
Haliplus lineatocollis (Marsham)	+	+		+	+	+	+	+	+	+
Haliplus ruficollis (Degeer)		+					+		+	
Haliplus wehnckei (Gerhardt)	+	+		+			+	+	+	
Noterus clavicornis (Degeer)	+	+					+		+	
Laccophilus hyalinus (Degeer)	+						+		+	
Laccophilus minutus (L.)	+						+		+	
Hygrotus inaequalis (Fabricius)	+	+			+		+	+	+	+
Hygrotus versicolor (Schaller)	+	+					+		+	
Hydroporus angustatus Sturm		+					+		+	
Hydroporus discretus Fairmaire & Brisout	+	+		+	+		+	+	+	+
Hydroporus ferrugineus Stephens				+				+	+	
Hydroporus incognitus Sharp	+				+	+	+	+	+	+
Hydroporus memnonius Nicolai	+	+			+		+	+	+	+
Hydroporus nigrita (Fabricius)	+	+	+		+	+	+	+	+	+
Hydroporus obscurus Sturm					+			+		+
Hydroporus obsoletus Aube				+				+	+	

Coleoptera (continued)										
Hydroporus palustris (L.)	+	+		+	+		+	+	+	+
Hydroporus planus (Fabricius)	+	+	+	+			+	+	+	+
Hydroporus pubescens (Gyllenhal)	+	+		+	+		+	+	+	+
Hydroporus striola (Gyllenhal)					+			+		+
Hydroporus tessellatus Drapiez	+	+					+		+	
Hydroporus umbrosus (Gyllenhal)				+				+	+	
Stictonectes lepidus (Olivier)		+		+			+	+	+	
Graptodytes pictus (Fabricius)	+						+		+	
Deronectes latus (Stephens)		+					+		+	
Potamonectes assimilis (Paykull)		+					+		+	
Potamonectes depressus (Fabricius)	+	+			+	+	+	+	+	+
Potamonectes griseostriatus (Degeer)					+			+		+
Stictotarsus duodecimpustulatus (Fabricius)	+	+		+		+	+	+	+	+
Oreodytes davisii (Curtis)			+			+	+	+		+
Oreodytes sanmarkii (Sahlberg)	+	+	+	+	+	+	+	+	+	+
Oreodytes septentrionalis (Sahlberg)						+		+		+
Scarodytes halensis (Fabricius)	+						+		+	
Platambus maculatus (L.)	+	+	+	+	+	+	+	+	+	+
Agabus biguttatus (Olivier)				+				+	+	
Agabus bipustulatus (L.)	+	+		+	+	+	+	+	+	+
Agabus chalconatus (Panzer)						+		+		+
Agabus didymus (Olivier)	+	+					+		+	
Agabus chalconatus group	+						+		+	
Agabus guttatus (Paykull)	+	+	+	+	+	+	+	+	+	+
Agabus nebulosus (Forster)		+		+	+		+	+	+	+
Agabus paludosus (Fabricius)	+	+	+	+	+	+	+	+	+	+
Agabus sturmii (Gyllenhal)		+		+		+	+	+	+	+
Ilybius ater (Degeer)		+					+		+	
Ilybius fuliginosus (Fabricius)	+	+		+	+	+	+	+	+	+
Ilybius quadriguttatus (Lacordaire & Boisduval)	+						+		+	
Rhantus sp.		**(+)**								
Rhantus grapii (Gyllenhal)	+						+		+	
Colymbetes fuscus (L.)	+						+		+	
Dytiscus sp.	**(+)**						**(+)**		**(+)**	
Dytiscus semisulcatus Muller					+			+		+
Gyrinus caspius Menetries	+						+		+	
Gyrinus substriatus Stephens	+	+		+	+	+	+	+	+	+
Gyrinus urinator Illiger	+						+		+	
Orectochilus villosus (Muller)	+	+			+		+	+	+	+

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Helophorus (Meghelophorus) aequalis Thomson		+					+		+	
Helophorus (Meghelophorus) grandis Illiger	+	+					+		+	
Coleoptera (continued)										
Helophorus (Atracthelophorus) brevipalpis Bedel	+	+	+	+	+	+	+	+	+	+
Helophorus (Helophorus) sp.	+	+					+		+	
Helophorus (Helophorus) flavipes Fabricius	+	+			+		+	+	+	+
Helophorus (Helophorus) granularis (L.)				+				+	+	
Helophorus (Helophorus) minutus Fabricius	+	+					+		+	
Helophorus (Helophorus) obscurus Mulsant	+	+					+		+	
Paracymus sp.			+				+			+
Hydrobius fuscipes (L.)	+	+					+		+	
Anacaena bipustulata (Marsham)	+						+		+	
Anacaena globulus (Paykull)	+	+	+	+	+	+	+	+	+	+
Anacaena limbata (Fabricius)	+	+					+		+	
Anacaena lutescens Stephens		+		+		+	+	+	+	+
Laccobius sp.		(+)						(+)		(+)
Laccobius (Laccobius) minutus (L.)	+						+		+	
Laccobius (Macrolaccobius) bipunctatus (Fabricius)	+			+	+		+	+	+	+
Laccobius (Macrolaccobius) sinuatus Motschulsky	+			+			+	+	+	
Laccobius (Macrolaccobius) striatulus (Fabricius)				+				+	+	
Helochares sp.	(+)									
Helochares lividus (Forster)		+					+		+	
Enochrus coarctatus (Gredler)		+					+		+	
Enochrus testaceus (Fabricius)	+	+					+		+	
Enochrus fuscipennis (Thomson)					+			+		+
Chaetarthria seminulum (Herbst)	+						+		+	
Ochthebius dilatatus Stephens		+					+		+	
Ochthebius minimus (Fabricius)	+	+					+		+	
Hydraena britteni Joy					+			+		+
Hydraena gracilis Germar	+	+	+	+	+	+	+	+	+	+
Hydraena nigrita Germar		+		+			+	+	+	
Hydraena riparia Kugelann	+	+		+			+	+	+	
Limnebius crinifer Rey					+			+		+
Limnebius truncatellus (Thunberg)	+		+	+	+	+	+	+	+	+
Elodes sp.	+	+	+	+	+	+	+	+	+	+
Cyphon sp.	+	+					+		+	

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Hydrocyphon deflexicollis (Muller)			+		+		+	+		+
Scirtes sp.		+					+		+	
Dryops sp.	+	+		+	+	+	+	+	+	+
Elmis aenea (Muller)	+	+	+	+	+	+	+	+	+	+
Esolus parallelepipedus (Muller)	+	+	+	+	+	+	+	+	+	+
Limnius volckmari (Panzer)	+	+	+	+	+	+	+	+	+	+
Oulimnius tuberculatus (Muller)	+	+	+	+	+	+	+	+	+	+
Riolus cupreus (Muller)					+			+		+
Coleoptera (continued)										
Riolus subviolaceus (Muller)	+				+	+	+	+	+	+
Chrysomelidae					(+)			(+)		(+)
Donacia sp.	+						+		+	
Phaedon sp.		+					+		+	
Curculionidae	+	+					+		+	
Megaloptera										
Sialis fuliginosa Pictet	+	+	+	+	+	+	+	+	+	+
Sialis lutaria (L.)	+	+	+	+	+	+	+	+	+	+
Sialis nigripes Pictet	+						+		+	
Neuroptera										
Sisyra sp.	+						+		+	
Trichoptera										
Rhyacophila dorsalis (Curtis)	+	+	+	+	+	+	+	+	+	+
Rhyacophila munda Mclachlan			+			+	+	+		+
Rhyacophila obliterata Mclachlan		+	+	+	+	+	+	+	+	+
Rhyacophila septentrionis Mclachlan	+	+	+	+	+		+	+	+	+
Glossosoma sp.	+	+	+	+	+	+	+	+	+	+
Agapetus sp.	(+)	(+)	(+)		(+)	(+)	(+)			(+)
Agapetus fuscipes Curtis				+				+	+	
Hydroptila sp.	+	+	+	+	+	+	+	+	+	+
Oxyethira sp.	+	+	+	+	+	+	+	+	+	+
Ithytrichia sp.	+	+					+		+	
Philopotamus montanus (Donovan)	+	+	+	+	+	+	+	+	+	+
Wormaldia sp.	+	+	+	+	+	+	+	+	+	+

Taxon	Environmental Zone 1	2	3	4	5	6	Region E&W	Scotland	Upland	Lowland
Chimarra marginata (L.)					+			+		+
Lype sp.	(+)		(+)	(+)				(+)		(+)
Lype reducta (Hagen)		+					+		+	
Psychomyia pusilla (Fabricius)		+	+	+		+	+	+	+	+
Tinodes assimilis Mclachlan		+					+		+	
Tinodes dives (Pictet)			+				+			+
Tinodes rostocki Mclachlan			+				+			+
Tinodes unicolor (Pictet)	+						+		+	
Tinodes waeneri (L.)	+	+	+	+	+	+	+	+	+	+
Cyrnus trimaculatus (Curtis)	+						+		+	
Neureclipsis bimaculata (L.)					+			+		+
Plectrocnemia conspersa (Curtis)	+	+	+	+	+	+	+	+	+	+
Plectrocnemia geniculata Mclachlan		+	+	+	+	+	+	+	+	+
Polycentropus flavomaculatus (Pictet)	+	+		+	+	+	+	+	+	+
Trichoptera (continued)										
Polycentropus irroratus (Curtis)		+			+	+	+	+	+	+
Polycentropus kingi Mclachlan					+	+		+		+
Cheumatopsyche lepida (Pictet)		+					+		+	
Hydropsyche angustipennis (Curtis)	+	+		+			+	+	+	
Hydropsyche fulvipes Curtis	+		+				+		+	+
Hydropsyche instabilis Curtis	+	+	+	+	+	+	+	+	+	+
Hydropsyche pellucidula (Curtis)	+	+	+	+	+	+	+	+	+	+
Hydropsyche saxonica Mclachlan	+	+			+		+	+	+	+
Hydropsyche siltalai Dohler	+	+	+	+	+	+	+	+	+	+
Diplectrona felix Mclachlan		+	+	+	+	+	+	+	+	+
Agrypnia sp.	+			+			+	+	+	
Phryganea sp.		(+)								
Phryganea grandis group	+						+		+	
Brachycentrus subnubilus Curtis		+					+		+	
Crunoecia irrorata (Curtis)		+	+	+	+	+	+	+	+	+
Lasiocephala basalis (Kolenati)	+						+		+	
Lepidostoma hirtum (Fabricius)		+	+		+	+	+	+	+	+
Apatania muliebris Mclachlan				+	+	+		+	+	+
Drusus annulatus (Stephens)	+	+	+	+	+	+	+	+	+	+
Ecclisopteryx guttulata (Pictet)	+	+		+	+	+	+	+	+	+
Halesus digitatus (Schrank)		+	+	+	+	+	+	+	+	+

Halesus radiatus (Curtis)	+	+	+	+	+	+	+	+	+	+
Hydatophylax infumatus (Mclachlan)			+	+		+	+	+	+	+
Micropterna lateralis (Stephens)	+	+	+	+	+	+	+	+	+	+
Micropterna sequax Mclachlan	+	+	+	+	+	+	+	+	+	+
Potamophylax cingulatus (Stephens)	+	+	+	+	+	+	+	+	+	+
Potamophylax latipennis (Curtis)	+	+	+	+	+		+	+	+	+
Chaetopteryx villosa (Fabricius)	+	+	+	+	+	+	+	+	+	+
Stenophylax sp.		(+)								
Stenophylax permistus Mclachlan	+						+		+	
Stenophylax vibex (Curtis)			+				+			+
Anabolia nervosa (Curtis)	+	+			+		+	+	+	+
Glyphotaelius pellucidus (Retzius)		+		+			+	+	+	
Limnephilus centralis Curtis	+			+	+	+	+	+	+	+
Limnephilus extricatus Mclachlan	+	+		+	+		+	+	+	+
Limnephilus hirsutus (Pictet)		+					+		+	
Limnephilus lunatus Curtis	+	+	+	+	+		+	+	+	+
Limnephilus luridus Curtis						+		+		+
Limnephilus marmoratus Curtis		+		+			+	+	+	
Limnephilus rhombicus (L.)		+		+			+	+	+	
Goera pilosa (Fabricius)	+		+				+		+	+

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Trichoptera (continued)										
Silo nigricornis (Pictet)						+		+		+
Silo pallipes (Fabricius)	+	+	+	+	+	+	+	+	+	+
Beraea maurus (Curtis)	+	+	+	+	+	+	+	+	+	+
Beraea pullata (Curtis)	+	+	+	+	+	+	+	+	+	+
Beraeodes minutus (L.)		+		+	+		+	+	+	+
Sericostoma personatum (Spence)	+	+	+	+	+	+	+	+	+	+
Odontocerum albicorne (Scopoli)	+	+	+	+	+	+	+	+	+	+
Molanna angustata Curtis	+	+					+		+	
Athripsodes albifrons (L.)		+		+			+	+	+	
Athripsodes aterrimus (Stephens)					+			+		+
Athripsodes bilineatus (L.)	+	+		+	+	+	+	+	+	+
Athripsodes cinereus (Curtis)	+		+		+		+	+	+	+
Ceraclea dissimilis (Stephens)		+	+				+		+	+
Mystacides azurea (L.)	+	+	+		+		+	+	+	+
Mystacides nigra (L.)	+	+					+		+	

Taxon	Environmental Zone 1	2	3	4	5	6	Region E&W	Scotland	Upland	Lowland
Adicella reducta (Mclachlan)		+					+		+	
Triaenodes bicolor (Curtis)				+				+	+	
Lepidoptera										
Pyralidae				(+)	(+)			(+)		(+)
Cataclysta lemnata (L.)	+	+					+		+	
Diptera										
Prionocera turcica (Fabricius)					+			+		+
Dolichopeza albipes (Stroem)		+	+				+		+	+
Tipula (Savtshenkia) sp.					(+)					(+)
Tipula (Savtshenkia) cheethami Edwards		+		+			+	+	+	
Tipula (Savtshenkia) rufina Meigen		+					+		+	
Tipula (Savtshenkia) subnodicornis Zetterstedt			+				+			+
Tipula (Savtshenkia) signata group				+		+		+	+	+
Tipula (Yamatotipula) montium group	+	+	+	+	+	+	+	+	+	+
Tipula (Tipula) oleracea L.	+	+					+		+	
Tipula (Tipula) paludosa Meigen		+		+			+	+	+	
Tipula (Acutipula) fulvipennis Degeer	+	+	+	+			+	+	+	+
Tipula (Acutipula) maxima Poda	+	+	+	+	+	+	+	+	+	+
Tipula (Acutipula) vittata Meigen	+	+					+		+	
Nephrotoma sp.	+	+					+		+	
Phalacrocera replicata (L.)				+	+			+	+	+
Limonia sp.	(+)	(+)	(+)	(+)	(+)		(+)		(+)	
Limonia (Dicranomyia) sp.						+		+		+
Antocha vitripennis (Meigen)	+	+		+	+		+	+	+	+
Diptera (continued)										
Helius sp.	+	+					+		+	
Pedicia (Pedicia) sp.	+	+	+	+	+	+	+	+	+	+
Pedicia (Pedicia) rivosa (L.)		+	+				+		+	+
Pedicia (Tricyphona) sp.	+	+	+	+		+	+	+	+	+
Dicranota sp.	+	+	+	+	+	+	+	+	++	+
Austrolimnophila sp.		+	+				+		+	+
Pseudolimnophila sp.	+	+		+	+		+	+	+	+
Limnophila (Eloeophila) sp.	+	+	+	+	+	+	+	+	+	+
Limnophila (Phylidorea) sp.	+	+	+	+		+	+	+	+	+

Limnophila (Limnophila) sp.		+	+	+			+	+	+	+
Limnophila (Brachylimnophila) sp.	+	+		+		+	+	+	+	+
Pilaria (Neolimnomyia) sp.	+	+	+	+	+	+	+	+	+	+
Pilaria (Pilaria) sp.	+	+	+		+	+	+	+	+	+
Hexatoma sp.			+		+	+	+	+		+
Gonomyia sp.			+				+			+
Lipsothrix sp.	+	+		+			+	+	+	
Erioptera sp.		+					+		+	
Ormosia (Ormosia) sp.	+	+		+			+	+	+	
Ormosia (Rhypholophus) sp.	+				+		+	+	+	+
Scleroprocta sp.			+				+			+
Molophilus sp.	+	+	+	+	+		+	+	+	+
Molophilus obscurus (Meigen)		+					+		+	
Oxydiscus sp.			+				+			+
Pericoma blandula Eaton	+	+		+		+	+	+	+	+
Pericoma cognata Eaton		+					+		+	
Pericoma diversa Tonnoir	+						+		+	
Pericoma fallax Eaton	+	+		+			+	+	+	
Pericoma fuliginosa (Meigen)	+	+	+	+	+		+	+	+	+
Pericoma neglecta Eaton	+	+	+	+	+	+	+	+	+	+
Pericoma pseudoexquisita Tonnoir				+	+	+		+	+	+
Pericoma pulchra Eaton	+	+	+	+			+	+	+	+
Pericoma trivialis group	+	+	+	+	+	+	+	+	+	+
Peripsychoda fusca (Macquart)	+	+	+				+		+	+
Psychoda cinerea Banks	+						+		+	
Psychoda phalaenoides (L.)			+				+			+
Psychoda severini Tonnoir	+	+	+	+	+		+	+	+	+
Psychoda cf alternata	+			+			+	+	+	
Ptychoptera sp.	+	+	+	+	+		+	+	+	+
Dixa dilatata Strobl		+	+	+	+	+	+	+	+	+
Dixa nebulosa Meigen	+	+	+	+		+	+	+	+	+
Dixa puberula Loew		+	+	+	+	+	+	+	+	+

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Diptera (continued)										
Dixa submaculata Edwards	+						+		+	
Dixa maculata complex	+	+	+	+		+	+	+	+	+

Dixella sp.						(+)	(+)			(+)
Dixella aestivalis Meigen				+				+	+	
Dixella attica Pandazis	+						+		+	
Dixella martinii Peus				+	+			+	+	+
Chaoborus (Chaoborus) flavicans (Meigen)	+						+		+	
Chaoborus (Chaoborus) obscuripes (Wulp)	+						+		+	
Anopheles (Anopheles) algeriensis group	+	+		+			+	+	+	
Anopheles (Anopheles) atroparvus group	+						+		+	
Mansonia (Coquillettidia) richiardii (Ficalbi)	+						+		+	
Culiseta (Culiseta) sp.	+						+		+	
Culex (Culex) sp.	+						+		+	
Thaumalea sp.		+	+	+			+	+	+	+
Ceratopogonidae	+	+	+	+	+	+	+	+	+	+
Forcipomyia sp.	+	+					+		+	
Atrichopogon sp.		+			+	+	+	+	+	+
Prosimulium sp.					(+)					
Prosimulium latimucro (Enderlein)			+			+	+	+		+
Simulium (Nevermannia) angustitarse (Lundstrom)		+					+		+	
Simulium (Nevermannia) cryophilum Rubtsov						+		+		+
Simulium (Nevermannia) angustitarse group	+	+	+	+	+	+	+	+	+	+
Simulium (Nevermannia) cryophilum group	+	+	+	+	+	+	+	+	+	+
Simulium (Nevermannia) vernum group	+	+	+	+	+	+	+	+	+	+
Simulium (Eusimulium) aureum group	+	+	+	+	+	+	+	+	+	+
Simulium (Wilhelmia) sp.	(+)	(+)					(+)		(+)	
Simulium (Wilhelmia) equinum (L.)					+			+		+
Simulium (Boophthora) erythrocephalum (de Geer)	+						+		+	
Simulium (Simulium) argyreatum Meigen		+	+				+		+	+
Simulium (Simulium) noelleri Friederichs				+	+			+	+	+
Simulium (Simulium) ornatum Meigen		+		+			+	+	+	
Simulium (Simulium) reptans (L.)			+	+			+	+	+	+
Simulium (Simulium) argyreatum group	+	+	+	+	+	+	+	+	+	+
Simulium (Simulium) ornatum group	+	+	+	+	+	+	+	+	+	+
Chironomidae	+	+	+	+	+	+	+	+	+	+
Stratiomyidae			(+)							(+)
Oxycera fallenii Staeger		+					+		+	
Oxycera formosa Meigen		+					+		+	
Oxycera pardalina Meigen		+					+		+	
Oxycera pulchella Meigen	+			+			+	+	+	
Odontomyia viridula (Fabricius)	+	+					+		+	

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Diptera (continued)										
Stratiomys sp.	(+)						+		+	
Stratiomys furcata (Fabricius)		+					+		+	
Rhagionidae (including Athericidae)				(+)				(+)		
Atherix ibis (Fabricius)	+	+					+		+	
Chrysophilus sp.		+	+		+		+	+	+	+
Chrysops sp.	+	+					+		+	
Tabanus sp.				+				+	+	
Tabanus group			(+)		(+)					
Chelifera group	+	+	+	+	+	+	+	+	+	+
Hemerodromia group	+	+	+	+			+	+	+	+
Clinocera group	+	+	+	+	+	+	+	+	+	+
Wiedemannia group	+	+	+	+	+	+	+	+	+	+
Dolichopodidae	+	+	+	+	+	+	+	+	+	+
Syrphidae						(+)		(+)		
Chryogaster sp.		+	+				+		+	+
Chryogaster hirtella Loew	+	+		+	+		+	+	+	+
Eristalis sp.	+	+					+		+	
Sciomyzidae	+	+	+	+	+	+	+	+	+	+
Ephydridae	(+)	(+)	(+)	(+)		(+)	(+)		(+)	
Hydrellia sp.					+			+		+
Limnophora sp.	+	+	+	+	+	+	+	+	+	+

APPENDIX 2

The occurrence of additional distinct taxa of macro-invertebrates in each of six environmental zones, two country units and two altitude classes in 1990 that were not recorded or identified in 1998. Taxa given in parentheses are inclusive of other taxa identified more precisely in other regions

TAXON	ENVIRONMENTAL ZONE						REGION			
	1	2	3	4	5	6	ENGLAND & WALES	SCOTLAND	LOWLANDS	UPLANDS
Gastropoda										
Zonitoides nitidus (Muller)	+	+		+	+	+	+	+	+	+
Polychaeta										
Nereis diversicolor Muller		+		+			+	+	+	
Oligochaeta										
Stylodrilus brachstylus Hrabe		+					+		+	
Stylodrilus heringianus Claparede	+	+	+	+	+	+	+	+	+	+
Stylodrilus lemani (Grube)		+	+				+		+	+
Lumbriculus group	+	+	+	+	+	+	+	+	+	+
Haplotaxis gordioides (Hartmann)		+					+		+	
Enchytraeus group	+	+	+	+	+	+	+	+	+	+
Uncinais uncinata (Orsted)	+						+		+	
Ophidonais serpentina (Muller)	+	+		+			+	+	+	
Nais alpina Sperber	+	+	+		+	+	+	+	+	+
Nais barbata Muller		+		+			+	+	+	
Nais communis Piguet		+					+		+	
Nais elinguis Muller	+	+	+	+		+	+	+	+	+
Nais pardalis Piguet						+		+		+
Nais communis group	+	+	+	+	+	+	+	+	+	+
Slavina appendiculata (d'Udekem)	+	+	+	+	+	+	+	+	+	+
Vejdovskyella sp.				+				+	+	
Stylaria lacustris (L.)	+	+	+	+			+	+	+	+
Pristina idrensis Sperber		+					+		+	
Pristina menoni (Aiyer)			+				+			+

Taxon	Environmental Zone 1	2	3	4	5	6	Region E&W	Scotland	Upland	Lowland
Tubifex costatus Claparede		+		+			+	+	+	
Tubifex ignotus (Stolc)	+	+					+		+	
Tubifex tubifex (Muller)	+	+	+	+	+		+	+	+	+
Limnodrilus claparedeianus Ratzel	+						+		+	
Limnodrilus hoffmeisteri Claparede	+	+	+	+	+	+	+	+	+	+
Limnodrilus profundicola (Verrill)	+	+					+		+	
Oligochaeta (continued)										
Limnodrilus udekemianus Claparede	+	+		+	+		+	+	+	+
Psammoryctides barbatus (Grube)	+	+					+		+	
Potamothrix bavaricus (Oschmann)				+				+	+	
Potamothrix hammoniensis (Michaelsen)	+	+	+				+		+	+
Potamothrix heuscheri (Bretscher)				+				+	+	
Ilyodrilus templetoni (Southern)		+					+		+	
Spirosperma ferox (Eisen)	+	+	+	+	+		+	+	+	+
Spirosperma velutinus (Grube)	+						+		+	
Aulodrilus limnobius Bretscher		+			+	+	+	+	+	+
Aulodrilus pluriseta (Piguet)	+	+	+	+	+	+	+	+	+	+
Rhyacodrilus coccineus (Vejdovsky)	+	+	+	+	+		+	+	+	+
Eiseniella tetraedra (Savigny)		+	+	+	+	+	+	+	+	+
Hirudinea										
Batracobdella paludosa (Carena)	+	+					+		+	
Decapoda										
Crangon vulgaris Fabricius		+					+		+	
Mysida										
Neomysis integer (Leach)		+					+		+	
Amphipoda										
Sphaeroma hookeri (Leach)		+					+		+	
Sphaeroma rugicauda (Leach)		+					+		+	
Ephemeroptera										
Brachycercus harrisella Curtis			+				+			+
Hemiptera										

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Gerris (Gerris) gibbifer Schummel		+					+		+	
Notonecta obliqua Gallen					+			+		+
Hesperocorixa castanea (Thomson)					+			+		+
Hesperocorixa sahlbergi (Fieber)	+	+	+	+	+		+	+	+	+
Sigara (Vermicorixa) lateralis (Leach)	+	+		+			+	+	+	
Sigara (Paracorixa) concinna (Fieber)	+						+		+	
Coleoptera										
Hyphydrus ovatus (L.)		+					+		+	
Ilybius guttiger (Gyllenhal)		+					+		+	
Rhantus aberratus Gemminger & von Harold					+			+		+
Dytiscus marginalis L.		+			+		+	+	+	+
Laccobius (Laccobius) biguttatus Gerhardt		+					+		+	
Coleoptera (continued)										
Laccobius (Macrolaccobius) atratus Rottenburg			+				+			+
Dryops luridus (Erichson)					+			+		+
Poophagus sisymbrii (Fabricius)				+				+	+	
Neuroptera										
Osmylus fulvicephalus (Scopoli)		+					+		+	
Trichoptera										
Melampophylax mucoreus (Hagen)		+					+		+	
Limnephilus coenosus Curtis						+		+		+
Limnephilus vittatus (Fabricius)					+			+		+
Diptera										
Tipula (Beringotipula) unca Wiedemann				+				+	+	
Tipula (Yamatotipula) solstitialis Westhoff					+			+		+
Paradelphomyia sp.		+					+		+	
Austrolimnophila ochracea Meigen		+				+	+	+	+	+
Limnophila (Euphylidorea) lineola (Meigen)	+	+					+		+	
Pericoma canescens (Meigen)		+		+	+		+	+	+	+
Ptychoptera albimana (Fabricus)				+				+	+	
Ptychoptera lacustris Meigen	+	+		+			+	+	+	

Ptychoptera paludosa Meigen				+				+	+	
Dixa maculata Meigen	+			+			+	+	+	
Dixa nubilipennis Curtis		+	+	+			+	+	+	+
Dixella obscura Loew	+					+	+	+	+	+
Dixella serotina Meigen			+				+			+
Anopheles (Anopheles) claviger (Meigen)	+	+	+	+			+	+	+	+
Simulium (Hellichella) latipes (Meigen)					+			+		+
Clinotanypus nervosus (Meigen)	+						+		+	
Apsectrotanypus trifascipennis (Zetterstedt)	+	+	+	+			+	+	+	+
Macropelopia sp.	+	+	+	+	+	+	+	+	+	+
Procladius sp.	+	+	+	+	+	+	+	+	+	+
Psectrotanypus varius (Fabricius)	+	+		+			+	+	+	
Ablabesmyia sp.	+	+	+		+		+	+	+	+
Arctopelopia sp.		+					+		+	
Conchapelopia sp.	+	+	+	+	+	+	+	+	+	+
Larsia sp.					+			+		+
Natarsia sp.	+	+	+		+	+	+	+	+	+
Nilotanypus dubius (Meigen)					+			+		+
Paramerina sp.			+		+		+	+		+
Rheopelopia sp.					+			+		+

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Diptera (continued)										
Thienemannimyia sp		(+)	(+)	(+)	(+)		(+)		(+)	
Thienemannimyia geijskesi (Goetghebuer)						+		+		+
Trissopelopia longimana (Staeger)	+	+	+	+	+	+	+	+	+	+
Zavrelimyia sp.	+	+	+	+	+	+	+	+	+	+
Tanypus sp.	+	+					+		+	
Diamesa sp.		+	+	+	+		+	+	+	+
Potthastia gaedii group			+		+	+	+	+		+
Potthastia longimana group	+	+	+	+	+	+	+	+	+	+
Pseudodiamesa sp.			+	+		+	+	+	+	+
Prodiamesa olivacea (Meigen)	+	+	+	+	+	+	+	+	+	+
Acricotopus lucens (Zetterstedt)	+	+	+		+		+	+	+	+
Brillia longifurca Kieffer	+	+					+		+	
Brillia modesta (Meigen)	+	+	+	+	+	+	+	+	+	+
Cardiocladius sp.			+				+			+
Cricotopus sp.			(+)			(+)				(+)
Cricotopus (Cricotopus) trifascia Edwards	+	+		+			+	+	+	

Taxon	Environmental Zone						Region			
	1	2	3	4	5	6	E&W	Scotland	Upland	Lowland
Cricotopus (Isocladius) sp.					+			+		+
Eukiefferiella sp.		(+)								
Eukiefferiella brevicalcar (Kieffer)			+	+	+	+	+	+	+	+
Eukiefferiella claripennis (Lundbeck)			+	+	+		+	+	+	+
Eukiefferiella ilkleyensis (Edwards)			+		+	+	+	+		+
Eukiefferiella minor (Edwards)			+		+	+	+	+		+
Heterotanytarsus apicalis (Kieffer)		+	+	+	+	+	+	+	+	+
Heterotrissocladius sp.	+	+	+	+	+	+	+	+	+	+
Nanocladius sp.				(+)				(+)		
Nanocladius rectinervis (Kieffer)		+					+		+	
Orthocladius (Symposiocladius) lignicola (Kieffer)		+	+	+		+	+	+	+	+
Paracladius conversus (Walker)	+	+					+		+	
Paratrichocladius sp.			+			+	+	+		+
Psectrocladius sp.		(+)				(+)				
Psectrocladius (Allopsectrocladius) sp.	+		+	+	+		+	+	+	+
Psectrocladius (Psectrocladius) psilopterus Kieffer				+				+	+	
Rheocricotopus sp.	+	+	+	+	+	+	+	+	+	+
Synorthocladius semivirens (Kieffer)	+		+	+			+	+	+	+
Tvetenia calvescens (Edwards)			+	+	+	+	+	+	+	+
Tvetenia discoloripes group	+	+		+	+	+	+	+	+	+
Zalutschia sp.			+				+			+
Bryophaenocladius sp.					+			+		+
Chaetocladius sp.	(+)			(+)						
Chaetocladius melaleucus (Meigen)		+	+		+	+	+	+	+	+
Corynoneura sp.	+	+	+	+	+	+	+	+	+	+
Epoicocladius flavens (Malloch)	+		+				+		+	+
Heleniella ornaticollis (Edwards)		+	+				+		+	+
Diptera (continued)										
Limnophyes sp.	+	+	+	+	+	+	+	+	+	+
Metriocnemus hygropetricus (Kieffer)	+	+	+	+	+	+	+	+	+	+
Parametriocnemus stylatus (Kieffer)	+	+	+	+	+	+	+	+	+	+
Paraphaenocladius sp.	+	+	+				+		+	+
Paratrissocladius excerptus (Walker)	+	+	+	+			+	+	+	+
Pseudorthocladius sp.			+			+	+	+		+
Pseudosmittia sp.	+		+			+	+	+	+	+
Smittia sp.			+				+			+
Thienemanniella sp.		+	+	+	+		+	+	+	+

Chironomus sp.	+	+	+	+	+	+	+	+	+	+
Cryptochironomus sp.	+						+		+	
Dicrotendipes sp.	+	+					+		+	
Endochironomus sp.		+		+			+	+	+	
Glyptotendipes sp.	+						+		+	
Microtendipes sp.	+	+	+	+	+	+	+	+	+	+
Parachironomus sp.	+	+			+		+	+	+	+
Parachironomus frequens group					+			+		+
Paracladopelma sp.	+	+					+		+	
Paratendipes sp.	+	+		+			+	+	+	
Phaenopsectra sp.	+	+		+			+	+	+	
Polypedilum sp.	+	+	+	+	+	+	+	+	+	+
Stictochironomus sp.	+	+			+		+	+	+	+
Cladotanytarsus sp.	+						+		+	
Micropsectra sp.	+	+	+	+	+	+	+	+	+	+
Paratanytarsus sp.	+	+	+	+	+	+	+	+	+	+
Rheotanytarsus sp.	+	+	+	+	+	+	+	+	+	+
Stempellina bausei (Kieffer)	+	+			+		+	+	+	+
Stempellinella group		+	+	+	+		+	+	+	+
Tanytarsus brundini Lindeberg	+	+	+	+	+	+	+	+	+	+
Virgatanytarsus sp.			+		+	+	+	+		+
Stratiomyidae				+	+			+	+	+
Odontomyia tigrina (Fabricius)		+					+		+	
Orthoneura splendens (Meigen)		+					+		+	
Phaeonia group	+	+		+	+		+	+	+	+