Countryside Survey

Countryside Survey:
Headwater Streams Report from 2007

Countryside Survey

CS Technical Report No. 8/07

Headwater Streams Report from 2007

M Dunbar[1], J Murphy[2], R Clarke[3],
R Baker[1], C Davies[1], P Scarlett[1]

Centre for Ecology and Hydrology
(Natural Environment Research Council)

January 2010

[1] Centre for Ecology & Hydrology, Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, Oxfordshire, OX10 8BB
[2] Formerly, Centre for Ecology & Hydrology; Now, River Communities Group, School of Biological and Chemical Sciences Queen Mary, University of London, c/o FBA River Lab East Stoke, Wareham, Dorset, BH20 6BB
[3] Formerly, Centre for Ecology & Hydrology; Now, Centre for Conservation Ecology and Environmental Change, School of Conservation Sciences, Bournemouth University, Christchurch House, Talbot Campus, Poole, Dorset, BH12 5BB

Acknowledgement

The Countryside Survey of 2007 is funded by a partnership of nine government funded bodies led by the Natural Environment Research Council (NERC) and the Department for Environment, Food and Rural Affairs (Defra). The completion of the survey has only been made possible by the support and advice of many dedicated individuals from these and other organisations who provided their time and valuable advice to the project board, the project steering group, and the project advisory groups.

The project Partners would like to thank all the landowners, farmers, and other land managers who gave permission for the field surveyors to collect data and samples from their land. Without such cooperation, scientific field studies like Countryside Survey would not be possible.

The Countryside Survey Partners would like to thank all those who contributed to the work presented in this report, largely in NERC's Centre for Ecology & Hydrology (CEH):

Field surveyors, regional coordinators and QA teams: Nik Aspey, Boris Assyov, Maurice Bailey, Dave Bennett, Caroline Boffey, Katja Busch, Anne Butler, Luciana Carotenuto, Paul Chamberlain, Rebecca Chance, Jake Chant, Hannah Chivers, David Cole, Ceirios Davies, Kathryn Dawson, Jan Dick, Mitzi de Ville, Martin Duncan, Claire Edwards, Richard Ellis, Fiona Everingham, Angus Garbutt, Iain Gunn, Anne Harvey, Adrianna Hawczak, Stuart Hedley, Lynn Heeley, Gale Hodges, Nik Hudson, Sarah Hulmes, Gwilym Jones, Ursula Jones, Jana Kahl, Emma Koblizek, Wendy MacFarlane, Lindsay Maskell, Alain Mauric, Elaine McClymont, Sebastian Meis, Bruce Miller, Ruth Mitchell, Lindsay Moore, Lila Morris, Mike Morecroft, Owen Mountford, John Murphy, Emma Nicklin, Lisa Norton, Peter Nuttall, Judith O'Hare, Martin Page, Denise Pallett, Hristo Pedashenko, Jodey Peyton, Alison Pike, Hannah Price, Maria Ramirez-Jimenez, Amy Rees, Brian Reynolds, Nicola Rivett, Glenn Roberts, Liz Roberts, Patrick Home Robertson, Rob Rose, Martin Rossall, Ed Rowe, Frank Ryan, Stephen Ryder, Pete Scarlett, Dave Scott, Robert Seaton, Luke Sidebottom, Louise Slack, Simon Smart, Tom Smith, Jon Steele, Peter Steward, Michelle Taylor, Sam Thomas, Nicola Thompson, Will Thomson, Annie Truscott, Linda Turner, Jackie Ullyett, Kiril Vasilev, Katy Walker, Kevin Walker, Alistair Watson, Trevor West, James Whiteford, Michael Wilcox, Lorna Wilkie, Geoffrey Wilkinson, Claire Wood.

Statistical, analytical, technical and data management support: John Blackburn, John Davy-Bowker, Mike Brown, Kathy Chandler, Ralph Clarke, Tracy Corbin, Andy Crowe, Cynthia Davies, Charles Duerdoth, Rick Gunn, Adrianna Hawczak, Lee Knight, Jan Kučera, Alan Lawlor, Jeff Robinson, Phil Rowland, Peter Scarlett, Paul Scholefield, Andy Scott, Rod Scott, Silke Skytte-Johannsen, Rick Stuart, Colin Vincent, Helen Vincent, Mike Wilson, John Watkins, Claire Wood, Clive Woods and Simon Wright and staff from APEM Ltd.

Advice and training: Colin Barr, Bob Bunce, Mike Furse, Dave Howard, Steve Marshall, Steve Moss, Dave Wilson and the Environment Agency River Habitat Survey Team.

Project management and administration: Mark Bailey, Mike Brown, Peter Carey, Julie Delve, Mike Dunbar, Bridget Emmett, Les Firbank, Julie Grimshaw, Lindsay Maskell, John Murphy, Lisa Norton, Dan Osborn, Terry Parr, Ian Simpson, Simon Smart and John Watkins.

The authors would also like to thank members of the Countryside Survey Steering Group, Freshwater Topic Group and others who provided valuable comments on the various drafts of this report, especially David Allen, Donald Baird, Phil Boon, Jeremy Biggs, Richard Chadd, François Edwards, Richard Evans, Chris Extence and Ian Simpson.

Executive Summary

This technical report describes methods and results from the headwater streams component of Countryside Survey.

Countryside Survey (CS) consists of a field-based survey of 591 1km x 1km sample squares spread across England, Scotland and Wales, undertaken approximately every eight years. Around 60% of these squares contain at least one linear water feature such as a stream or ditch. Surveys of a headwater stream or ditch/drain site have been undertaken as part of Countryside Survey in 1990, 1998 and 2007. Since 1998, the survey has consisted of three elements: the macroinvertebrates (small aquatic animals visible to the naked eye which live on the stream bed), the macrophytes (larger aquatic plants) and the habitats (the structure of the channel and riparian zone). A single water chemistry sample is taken for supporting information. In 1990, only the macroinvertebrate component of the survey was undertaken.

Compared with larger rivers, headwater streams are relatively poorly covered by the monitoring of national agencies. The data collected in Countryside Survey allow for an integrated description of the changes in ecological status and biodiversity of headwater streams through time, and the description of these changes is the main aim of this report. Additionally, for macroinvertebrates, their status against a minimally-impacted reference condition may be assessed. The vast amount of data available for the terrestrial survey component of Countryside Survey allows many potential linkages to be examined between human activities and stream ecological response. In this report, we detail some of these linkages, which will be elaborated further as part of the Countryside Survey Integrated Assessment to be published later in 2010.

Results show many areas of improvement over the period 1998 to 2007. Notable improvements have occurred to macroinvertebrate status indicators in England, although south east England in particular is starting from a lower baseline of headwater stream biological quality when compared to other parts of Great Britain. Numbers of sites at good or high macroinvertebrate status in south east lowland England are still relatively low (30%). Increases in the number of macrophyte species and habitat quality appear to have occurred throughout Great Britain. Finally, improvements to trophic (nutrient) status, as indicated by the macrophyte communities, have occurred in Scotland. Substantial improvements in macroinvertebrate indicators occurred between 1990 and 1998 for all parts of Great Britain, however part of this observed improvement may be due to drought conditions in 1990.

Declines have been observed in macroinvertebrate status for the Scottish Highlands, which had the highest proportion of sites at good or high status in 1998, but in 2007 this proportion has dropped to a level comparable to that of the rest of Scotland and upland England. Unfortunately it is not currently possible to pinpoint causes of this decline. There is an indication of increased extent of resectioning (engineering of the channel to widen, deepen and straighten), particularly in lowland Scotland, however this may be due to this feature being better recorded in 2007 compared to 1998. The example from Scotland is unusual in that for other indices and countries, there is no evidence for differences in trends between Environmental Zones. Quantification of changes in Wales is limited by the smaller sample size.

A provisional integrated assessment has linked land management characteristics taken from the Countryside Survey square containing each headwater streams site, to an indicator of stream biological quality based on the mean stress sensitivity score of the macroinvertebrate taxa present. This has indicated logical negative relationships between intensive land uses such as arable and improved

grassland and ecological status. Indicators of management of the river channel, such as the extent of resectioning (for land drainage and flood defence purposes), are also negatively associated with ecological status. Characteristics of the riparian zone, such as the amount of woody cover, are positively associated with ecological status.

Overall, the headwater streams component of Countryside Survey is now beginning to build up a picture of the changes occurring to the ecological status of headwater streams. The changes are broadly positive, although some negative changes will need further investigation.

The Headwater Streams Report was produced by the Centre for Ecology and Hydrology CEH), with contributions by Queen Mary University of London (QMUL), and Bournemouth University (BU).

Contents

Tables

Figures

Photographs

1 Introduction

1.1 Countryside Survey

Countryside Survey (CS) is a sample-based study which assesses state and change in the rural environment. Surveys have been undertaken in five years: 1978, 1984, 1990, 1998 and 2007. In 2007 Countryside Survey covered 591 1km x 1km sample squares spread across England, Scotland and Wales. These 591 squares comprise a stratified random sample of all 1km squares in Great Britain. Hence the area covered by Countryside Survey is statistically representative of conditions in the wider countryside. The survey area includes cultivated land and grassland, areas around towns and more remote areas including moorlands, mountains and islands. Squares containing more than 75% of developed land or more than 90% of sea are not included in the field survey. Similarly, within survey squares, urban areas including those directly associated with buildings, are not surveyed.

The UK Results from the 2007 Report (Carey *et al.* 2008) provide further details of the survey methodology and key results; while the country reports (Countryside Survey 2009; Norton *et al.* 2009; Smart *et al.* 2009) provide further results for each country surveyed. These reports contain analysis of headwater stream plant and habitat data which are brought together and expanded upon here. The reports also include analysis of data from vegetation plots located next to streams and other linear water features. Data for the Countryside Survey in 2007 and earlier years have previously been released via the website http://www.countrysidesurvey.org.uk/data.html**.** Previously, results from the 1990 and 1998 surveys were presented in an Environment Agency report (Furse *et al.* 2002).

1.2 Headwater Streams in the Countryside Survey

For each Countryside Survey square, where possible, a single headwater stream[1] site is surveyed, and with a few exceptions, the same site is revisited over time.

The aim of the Headwater Streams component of Countryside Survey is to understand the biological condition of British headwater streams; specifically key evidence of quality and changes to the following attributes of the headwater streams environment:

- The biological status of headwater streams, assessed using macroinvertebrate and aquatic plant communities, to support the European Water Framework Directive;
- Prevalence of animal and plant biodiversity in headwater streams;
- The morphological condition of headwater streams;
- Catchment and riparian land cover adjacent to headwater streams;
- Links between catchment and riparian land cover and vegetation and ecological status of headwater streams.

[1] A **Headwater Stream** is defined in Countryside Survey as a stream of Strahler Order 3 or less (Strahler, 1957). See Section 2 for further details.

Although elements of Countryside Survey are undertaken, with slightly different methods, in Northern Ireland, this does not include freshwater surveys. Hence Countryside Survey as a whole reports for the UK, however this report solely focuses on Great Britain.

One of the main reasons for focusing on headwater streams in Countryside Survey is that they are under-represented in other national monitoring networks, particularly those of the Environment Agency and Scottish Environment Protection Agency, who tend to focus their resources on larger streams and rivers. Surveys of the ecological condition of headwater streams have been undertaken in Countryside Survey in 1990, 1998 and 2007; further details of the quality elements surveyed are given below. The majority of the river length in any catchment will be headwater streams. Some results for the plant and habitat surveys for headwater streams have been presented previously in the UK main and country reports; however, this is the first presentation of the results for the macroinvertebrate survey data.

1.3 The value of headwater streams

Policy drivers and biodiversity

Countryside Survey has been designed to inform and guide decision-making of Government departments and agencies, Non-Governmental Organisations and any other bodies with a responsibility or interest in environmental policy. The temporal and spatial scales of the data collected in these surveys will provide a baseline against which any effects of changes in policy can be assessed. Long-term trends and patterns can be identified to help in any future management decisions. Compliance with a number of international and national policy drivers which exist for freshwater habitats, requires information such as that presented in the Countryside Survey reports.

The European Habitats Directive (Council Directive 92/43/EEC) and European Birds Directive (79/409/EEC) requires EU Member States to create a network of protected wildlife areas across the European Union. This network consists of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), and is part of a range of measures aimed at conserving important or threatened habitats and species. The diversity of species and communities of macroinvertebrates and macrophytes of headwater streams, many of which are seldom surveyed, collectively contributes significantly to the overall biodiversity of the UK (Furse *et al.* 1991).

The Water Framework Directive (Council Directive 2000/60/EC) (WFD) aims to protect all elements of the water cycle and enhance the quality of groundwaters, rivers, lakes, estuaries and coastal waters. A key aim of the WFD is the achievement of at least good ecological status in all surface waters, defined as a slight deviation from a minimally-impacted reference condition. Ecological status of river and stream water bodies is assessed using a combination of biological quality elements (fish, macroinvertebrates, higher plants and algae) and supporting elements of hydromorphology and water chemistry.

The UK Biodiversity Action Plan (1994) (UK BAP) was prepared as part of the UK's response to signing the Convention on Biological Diversity at the Rio Earth Summit in 1992. The UK BAP outlines a programme for the conservation of the national biological diversity with an assessment being carried out every three years. The most recent review in 2007 includes a priority list of 1,150 species and 65 habitats. Data from these reviews and other sources will be used to show how the UK has been progressing towards the Convention's 2010 target to achieve a significant reduction in the rate of biodiversity loss.

The routine monitoring of water bodies, undertaken by the environmental agencies responsible for regulation in the UK, primarily concentrates on those areas where potential impacts from abstraction and point source discharges might be expected to occur. With the improvements that have been recorded in these areas, and the adoption of river basin management under the WFD, focus is shifting to diffuse sources of pollution. Baseline data from headwater streams will be essential to enable any further improvements to be put into context.

The UK's headwater streams, some of which are studied as part of Countryside Survey, comprise a sizeable part of the UK river network. Furthermore, much of the precipitation that makes up the flow in the river network downstream will have passed through these small watercourses first. However, it is not only their influences on those habitats found further downstream that make headwaters important. Even in the UK the habitat, species and community diversity of such streams is considerable, with the geographic range of many being restricted to headwater streams (Furse *et al.* 1991). While headwaters may be upstream of point sources of impact, new disturbances such as hydropower schemes and wind farms may be in addition to impacts from agriculture and forestry. The data collected during Countryside Survey may be used to detect improvements in headwater streams, resulting from changing industrial or land use practices that lead to better air quality, reduced acidification and less agricultural run-off.

Several species found in headwaters are nationally protected under the Wildlife and Countryside Act (1981) as amended. Examples of protected macroinvertebrates include the freshwater pearl mussel (*Margaritifera margaritifera*) and white clawed crayfish (*Austropotamobius pallipes*). However, the importance of headwater streams is not limited to their macroinvertebrate and macrophyte communities alone. Several nationally and internationally important species of fish rely on the typically highly oxygenated, cool and fast flowing waters for breeding including Atlantic salmon (*Salmo salar*), brown trout (*Salmo trutta*), allis shad (*Alosa alosa*), brook lamprey (*Lampetra planeri*) and bullhead (*Cottus gobio*). Other protected species that may depend upon such streams include otter (*Lutra lutra*), and kingfisher (*Alcedo atthis*).

Ecosystem services

Streams and rivers provide multiple ecosystem services. Using terminology from the Millennium Ecosystem Assessment (MA) 2006, these include provisioning services such as fish for food, supporting services such as photosynthesis and nutrient cycling, regulating services such as flood protection and water purification, and cultural services such as recreation. Ecosystem services may be degraded by human activities, and this applies equally to those delivered by headwater streams. This provides a key rationale for their inclusion in Countryside Survey.

Meteorological context for the 1990, 1998 and 2007 surveys

It is important to note that while there may be no such thing as an average year, the years 1990, 1998 and 2007 were all particularly notable in hydrometeorological terms. In England and Wales, 1990 was an exceptionally dry year, whereas in Scotland it was exceptionally wet. 1998 was a warm and wet year, with several exceptional floods occurring in April and October. 2007 again was a wet year, with some extreme flood events occurring in July across England and Wales. This context is referred to in the analyses reported below, particularly in the interpretation of changes in macroinvertebrate indices between 1990 and 1998.

2 Methods

This chapter outlines the rationale and methods used to collect data on headwater streams for Countryside Survey in 2007 and previous surveys. The headwater streams surveys followed a standard protocol which is detailed in Norton *et al.* 2006 and Murphy & Weatherby 2008.

A **Headwater Stream** is defined in Countryside Survey as a stream of Strahler Order 3 or less (Strahler 1957). This definition is based on the arrangement of the stream/river channel network. From a source, a stream is first order. When two first order streams meet, the downstream stream is second order. When two second order streams meet, the downstream stream is third order, and so on.

Only a proportion of Countryside Survey squares contain linear water features (streams, rivers, drains/ditches). In the Countryside Survey field protocol, where possible, a headwater stream site is sampled. Where a suitable headwater stream site does not exist in the square, but **ditches or drains** do, the “headwater stream site” will actually be on a ditch or drain, and highlighted as such. Whether a site is classed as stream or ditch/drain is based primarily on the opinions of the field surveyors, but backed up by later analysis of maps and catchments: this resulted in some sites which were initially classified as ditch/drain by the surveyors being re-classified as stream sites. The analyses presented in this report are presented for stream sites and ditch/drain sites separately. The ditch/drain sites are far fewer in number than the headwater stream sites.

Photo 2-1. A ditch site in the Fens (EZ 1)

A further distinction may be made between headwater streams that are on the river network as drawn on Ordnance Survey 1:50,000 maps, and streams which are upstream of the “source” on these maps. Such streams may be shown on finer scale maps (1:25,000 or 1:10,000), and represent a significant proportion of the total river network, particularly in upland areas. They are more likely to flow intermittently, which may cause sampling difficulties. A proportion of Countryside Survey headwater streams sites fall into this category.

The headwater streams component of Countryside Survey in 2007 has involved the survey of three distinct quality elements of the stream ecosystem:

- The **macroinvertebrates** living on the stream bed. Macroinvertebrates are small animals visible to the naked eye, such as snails, worms, leeches, shrimps, mayflies, dragonflies, water-bugs, beetles, caddis flies and midges. This survey includes the collection of at-site physical data used to run the RIVPACS/RICT model (see below);

- The **macrophytes** (larger aquatic plants) in the stream channel;
- The structure and diversity of in-channel and bankside **habitats**.

In addition, spot water samples were taken and analysed by CEH laboratories. These samples have been used as supporting information in the analysis of the other quality elements. However since they are a single sample taken on a single day within each survey year, they are not considered sufficiently representative for analysis in their own right.

In 1998, the same list of quality elements was surveyed, although fewer water chemistry determinands were collected. However, in 1990, only macroinvertebrates were surveyed.

RIVPACS (River Invertebrate Prediction and Classification System) is a computer model for calculating an expected 'reference' macroinvertebrate community at a stream or river site. It has been developed by CEH, Environment Agency, SEPA, DOENI and their predecessor organisations (Wright *et al.* 2000). The current version of the RIVPACS model is RIVPACS IV, this is implemented within a software tool called **RICT** (River Invertebrate Classification Tool) (Davy-Bowker *et al.* 2008). A notable difference between this version of RIVPACS and previous versions is that there is a single model for England, Wales and Scotland. Previously there were separate models for parts of Scotland.

RIVPACS is calibrated with over 700 macroinvertebrate samples from sites in Britain considered to be at a reference condition; that is, minimally impacted by human activities. The macroinvertebrate communities at these sites vary considerably: the community found in a rocky upland stream will differ from that found in a chalk stream or a lowland clay-bed stream. This variation is natural, however it means that summary indices derived from macroinvertebrate samples at sites which may or may not be at reference condition vary naturally, as well as in response to stressors arising from human activities. RIVPACS takes as input a suite of physical variables for the catchment and sample site, plus alkalinity, and predicts a reference macroinvertebrate community. It thus allows biological status, as quantified by the macroinvertebrate community at any new site of interest to be assessed by comparison with this site-specific reference. The result of this comparison of a raw biological index to a reference or expected value is an Observed / Expected ratio, or **O/E ratio**. In unimpacted sites the observed and expected index values should be very similar and the O/E ratio is about one. As degradation, associated with human impacts increases, the observed index value fails to meet expectations and the value of the ratio falls.

Distance from source, as denoted on 1:50,000 maps, is one of the physical variables used by RIVPACS. Hence RIVPACS can only be used to produce a reference macroinvertebrate community for sites on the 1:50,000 river network, and hence O/E ratios for macroinvertebrate indices cannot be derived for the headwater stream sites above the source denoted on 1:50,000 maps. Furthermore, it is not possible or appropriate to derive RIVPACS O/E ratios for ditch or drain sites.

For reporting purposes the O/E ratio may be used to assign a site to one of a series of status classes of ecological condition. These have been harmonised with the systems adopted for the European Water Framework Directive, and comprise high, good, moderate, poor and bad. RIVPACS contains statistical tests based on prior estimates of typical sampling variation that can be used to assess whether a site has truly changed its biological condition from one survey to the next (Clarke 2000, Clarke *et al.* 2002).

The probability that there has been a real change is assessed as being either unlikely (less than 50% chance), more likely than not (i.e. greater than 50% chance) or almost certain (at least 95% chance).

The Biological Monitoring Working Party (BMWP) Score system provides a method of converting lists of macroinvertebrate taxa sampled from a stream or river on a particular occasion into two numerical indices. In BMWP, 82 different families of macroinvertebrates are given pre-assigned scores from 1-10 that represent their tolerance to organic pollution. Macroinvertebrates that are intolerant are given a high score and those that are tolerant are given a low score. When a sample of macroinvertebrates is collected from a stream, the scores of all the different families of macroinvertebrates present are added together to give the BMWP site score. Two main indices of condition are derived from the BMWP sites score. One is the number of observed macroinvertebrate families which have an allocated BMWP score (this may be known as taxon richness, number of BWMP taxa, or just TAXA). The other is the mean score, and therefore mean tolerance of the animals present (i.e. the site score divided by the taxon richness). This is called the ASPT, or Average Score Per Taxon. Although ASPT was primarily designed to respond to organic pollution, it is also a robust indicator of other general degradation arising from human activities.

Acid Waters Indicator Community (AWIC) (Davy-Bowker *et al.* 2005) is an index which is specifically designed to be sensitive to acidification of streams. AWIC follows similar principles as ASPT, with macroinvertebrate families being assigned a score according to their tolerance to acid conditions and the final AWIC score being the mean of the scores assigned to all groups found at a site.

Sampling protocols are often referred to by acronyms or abbreviations, some of which strictly speaking refer to a broader assessment technique which uses that protocol. Hence the macroinvertebrate sampling protocol is often referred to as a RIVPACS sample. The macrophyte sampling protocol used in Countryside Survey is often referred to as a **Mean Trophic Rank (MTR)** survey, after the name of an index commonly calculated from the survey data. The physical habitat survey is termed **River Habitat Survey (RHS)**.

2.1 Data collection and sample processing

Headwater streams have been included in Countryside Survey since 1990, hence data are available for the years 1990, 1998 and 2007.

The sites surveyed by the headwater streams component have stayed broadly the same in 1990-1998-2007. The main exception to this is that, during preparatory work for the 2007 survey it was discovered that the headwater stream sites in 29 of the squares, which were previously surveyed in 1990 and 1998, were on rivers of Strahler Order four or above and cannot be considered headwaters. Hence at these squares, for 2007 and future surveys, the original survey site was moved to a new location on a smaller watercourse, still within the same square. The fourth order and above sites surveyed in 1990 and 1998 are excluded from all analyses presented here.

For the 2007 survey, the headwater streams data were collected by the Countryside Survey teams. This differed from the 1998 survey, where separate freshwater teams were used. In 2007, as part of their training, the survey teams undertook a one-week course specifically on the freshwater fieldwork components of Countryside Survey. Also in 2007, a freshwater quality assurance exercise was undertaken. A separate freshwater surveyor repeated surveys at 29 sites on a date sometime after the main survey had been undertaken. Further information on the Quality Assurance (QA) exercise, and analysis of results for macrophytes and River Habitat Survey are contained in Murphy *et al.* 2008. Information on the macroinvertebrate element of the QA is contained below.

Tablet computers were used for data capture for the headwater streams surveys in Countryside Survey 2007. Custom-written software was used to capture the site details and survey information, thus maximising efficiency whilst minimising the potential for transcription error.

Headwater stream sites

Where possible, the same site is surveyed in each Countryside Survey. The survey is centred on a macroinvertebrate sampling site (typically 5-15m of stream length); this is bracketed by the macrophyte survey site (total length 100m) and the River Habitat Survey site (total length 500m). The latter two survey sites usually extended an equal distance upstream and downstream of the centre site. Figure 2-1 gives examples of headwater streams sites and their relationship to their catchments and the Countryside Survey square. There is variation in the extent to which the catchment of each headwater stream site is contained within the Countryside Survey Square. In Figure 2-1, the left hand map indicates a site whose catchment is almost entirely within the square, the right hand map indicates a site whose catchment extends well beyond the square.

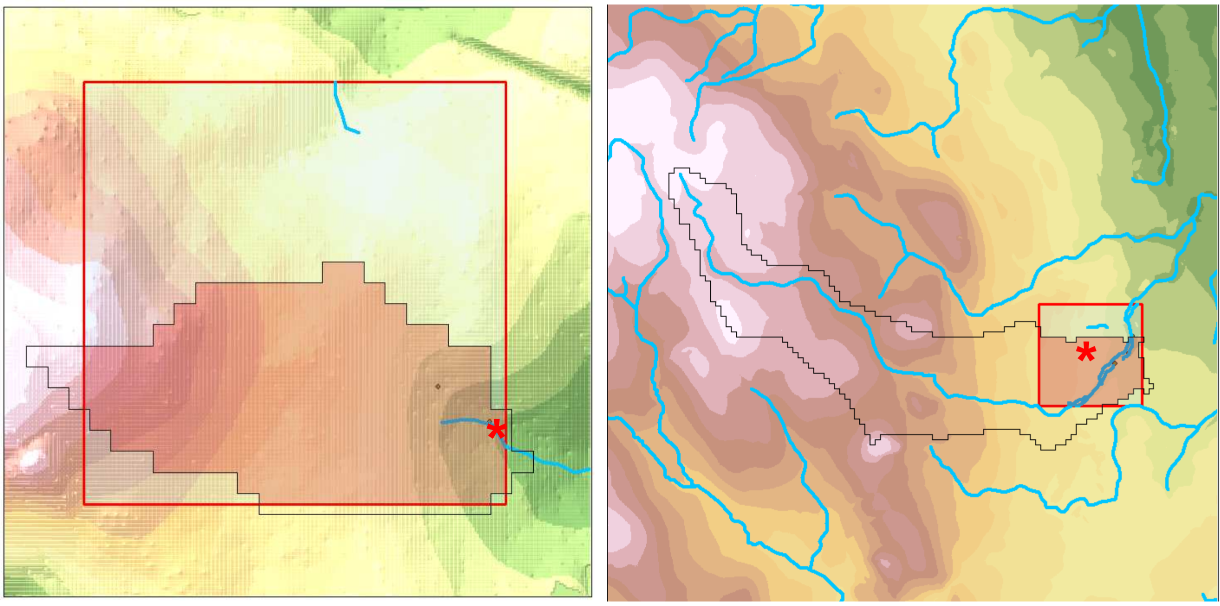


Figure 2-1. Examples of headwater streams sites with CS square and catchment (black outline) superimposed. * denotes the location of the headwater stream sampling site. Red shading indicates the part of catchment contained in the square

In any particular survey year, it is possible for some headwater stream or ditch sites to be dry, or to be non-flowing, but with isolated pools or a damp stream bed. This issue mainly affects data from the 1990 survey which was a dry year. Due to the progressive difficulty in collecting ecological data as flows decrease and channels dry, river habitat surveys were occasionally possible where macrophyte surveys were not, while macroinvertebrate surveys were most likely to be compromised. Additionally, the number of squares surveyed increased between the 1990 and 1998 Countryside Surveys, meaning that streams in new squares were surveyed for the first time in 1998. In 2007 an attempt was made to re-visit all streams surveyed in 1998; in the end 375 were successfully surveyed for one or more elements.

Survey numbers for each quality element for each year are given for all (stream and ditch/drain) sites in Table 2-1, and for stream sites only in Table 2-2.

Table 2-1. Summary of the numbers of surveys undertaken

Survey year	Macroinvertebrates	Macrophytes	River Habitats	Water chemistry
1990	363	NA	NA	NA
1998	406	418	427	426
2007	350	362	375	356

Table 2-2. Summary of the numbers of surveys undertaken (stream sites only)

Survey year	Macroinvertebrates	Macrophytes	River Habitats	Water chemistry
1990	284	NA	NA	NA
1998	321	326	329	329
2007	277	282	292	281

Macroinvertebrates

Macroinvertebrates were sampled using standard protocols (Murray-Bligh 1999; Murphy & Weatherby 2008). The sample area in each stream was a single area of stream-bed whose major habitat types can be sampled within the recommended sampling period of three minutes of active sampling, supplemented by a one minute hand search. The length of river surveyed would normally vary from 5 to 15m, depending on the stream width. Samples were collected using a standard Freshwater Biological Association pattern pond net and returned to CEH for later sorting and identification. Supplemental physical measurements (width, depth, substrate composition) required to run RIVPACS, were recorded. For the 2007 survey, 29 samples from the QA exercise were processed by APEM Laboratories Ltd, as were ten main samples selected for audit, where the initial processing and identification were undertaken by CEH. APEM Laboratories also internally audited the identification of three of the 29 QA samples.

The taxonomic level of identification of macroinvertebrates, and also the method of counting abundances, has changed in the period that headwater streams have been included in Countryside Survey. Furthermore, the underlying taxonomy, i.e. the name that each species is given, has been revised over the same period. For abundances: in 1990 presence/absence was recorded; in 1998 presence/absence was recorded for species, and abundance classes estimated for families and; in 2007 estimated actual abundances were recorded for species. To control for changes in level of identification and underlying taxonomy, the species data were harmonised across all the different surveys to a common modern taxonomy. A second exercise, termed standardisation, was used to derive a mutually exclusive list of taxa for the calculation of species richness.

Macrophytes

Stream macrophytes in Countryside Survey are surveyed using the standard MTR (Mean Trophic Rank) protocol (Holmes *et al.* 1999), which records the presence and extent (on a categorical scale) of macrophytes in a 100m reach. However, a more extensive plant species checklist was used than that required for typical MTR purposes. Occurrence and abundance of these species was recorded on the tablet computers using custom-written software "IRIS".

River Habitats

River habitats were surveyed using the 2003 River Habitat Survey (RHS) protocol (Environment Agency 2003). Physical features of the stream bank and channel are recorded using custom software "RAPID" running on a tablet computer, which mimics the paper survey form. The RAPID software is available for public download via http://www.ceh.ac.uk/products/software/RAPID.html Features are surveyed at ten cross-sections spaced 50m apart, with an additional sweep-up survey. The main elements of the physical habitat which contribute to the scores used in this report, are given in Table 2-3.

Table 2-3. Summary of main attributes surveyed in RHS

Habitat element	Attribute scored
Habitat Modification (HMS)	
Culverts	Number and extent of culverts
Bank and bed reinforcement	Extent of bank and bed reinforcement
Bank and bed resectioning	Extent of bank and bed resectioning: combination of widening, deepening, straightening and re-profiling to increase conveyance (Brookes 1988) (Photo 2-2)
Berms and embankments	Extent of artificial berms and embankments
Weirs dams and sluices	Number and extent of weirs, dams and sluices
Bridges	Number and extent of bridges
Fords	Number and extent of fords
Outfalls and deflectors	Number and extent of outfalls and deflectors
Poached bed and banks	Extent of livestock poaching (trampling of banks and bed)
Habitat Quality (HQA)	
Flow types	Number of flow types
Channel substrates	Number of natural substrate types
Channel features	Presence and extent of exposed bedrock/boulders, vegetated rocks, unvegetated mid-channel bars, vegetated mid-channel bars, mature islands. Numbers of riffles and pools
Bank features	Presence and extent of eroding earth cliffs, stable earth cliffs, unvegetated point bars, vegetated point bars, unvegetated side-bars, vegetated side-bars, natural berms
Bank vegetation	Extent of simple and complex bank face and bank top vegetation
Channel vegetation	Number of morphotypes of in-channel vegetation
Land use	Extent of adjoining broadleaf woodland, coniferous woodland, moorland/ heath, and wetlands
Trees and associated	Tree coverage, overhanging boughs, exposed bankside roots,

Habitat element	Attribute scored
features	underwater tree roots, large (coarse) woody debris and fallen trees
Special features	Braided channels, side channels, natural waterfalls, natural cascades, very large boulders, debris dams, leafy debris, fringing reed-banks, quaking banks, sink holes, backwaters, floodplain boulder deposits, water meadows, fens, bogs, wet woodlands, marshes, flushes, natural open water

Both the HQA and HMS are composed of the sum of a number of different sub-scores (Table 2-3), each indicating separate habitat components. The nine habitat modification sub-scores each quantify a relatively self-contained element, for example number of culverts or bridges, extent of reinforcement, or livestock poaching. Some of the nine habitat quality sub-scores follow this pattern (e.g. scores for channel substrates or flow types), but some sub-scores group disparate elements, e.g. channel features and bank features.

Photo 2-2. An extensively resectioned stream in an arable landscape in EZ1

Photo 2-3. A wooded stream in EZ1

Water chemistry

A single water chemistry sample was taken from the stream during the survey. Water samples were returned to CEH in Lancaster for chemical analysis of alkalinity (at pH 8.3), soluble reactive phosphorus and total oxidised nitrogen. For the 1998 survey, only the first two of these determinands were analysed for. Conductivity and pH were measured in the field using a regularly calibrated field meter.

Data entry

Data from the tablet computers were uploaded to a central database held at CEH. An extensive audit was then undertaken. Macroinvertebrate sample data, which were identified in a laboratory, were recorded on paper sheets, entered onto a database and cross-checked against the original lab paper sheets, with any data-entry errors being corrected.

2.2 Data analysis

Overall approach

The overall analytical approach focuses on changes through time for indices derived from the raw survey data. Data are analysed and presented separately for England, Scotland and Wales. Data are not presented for GB as a whole as there are many cases where there are differences between countries in the direction of trends, which would be lost in a GB-level summary. Results are presented graphically as “stock” estimates of the indices in the survey years, with associated 95% confidence intervals, and tables of change, again with confidence intervals, between the different survey years. In Countryside Survey, England, Scotland and Wales are divided into eight Environmental Zones (EZs) (Figure 2-2, Table 2-4, EZ 7 denotes Northern Ireland), this enables changes across the countries and within habitat types to be compared between geographically different regions. Change from 1998 to 2007 is analysed to test for differences among Environmental Zones within Country. The approach broadly follows that of the Countryside Survey Technical Report 4/07 (Scott 2008), with the exception that the data being considered are indices rather than areas or counts, and are for a specific habitat, headwater streams. No attempt has been made to weight estimates by land classes.

For macroinvertebrates, the analysis of the outputs from RIVPACS/RICT are undertaken using a slightly different approach, described below.

Table 2-4. Environmental Zones and EZ codes used in Countryside Survey

Country	Environmental Zone	Code
England	Easterly lowlands	EZ 1
	Westerly lowlands	EZ 2
	Uplands	EZ 3
Scotland	Lowlands	EZ 4
	Intermediate uplands and islands	EZ 5
	True uplands	EZ 6
Wales	Uplands	EZ 8
	Lowlands	EZ 9

Photo 2-4. Streams from EZ 2 (left) and EZ 4 (right)

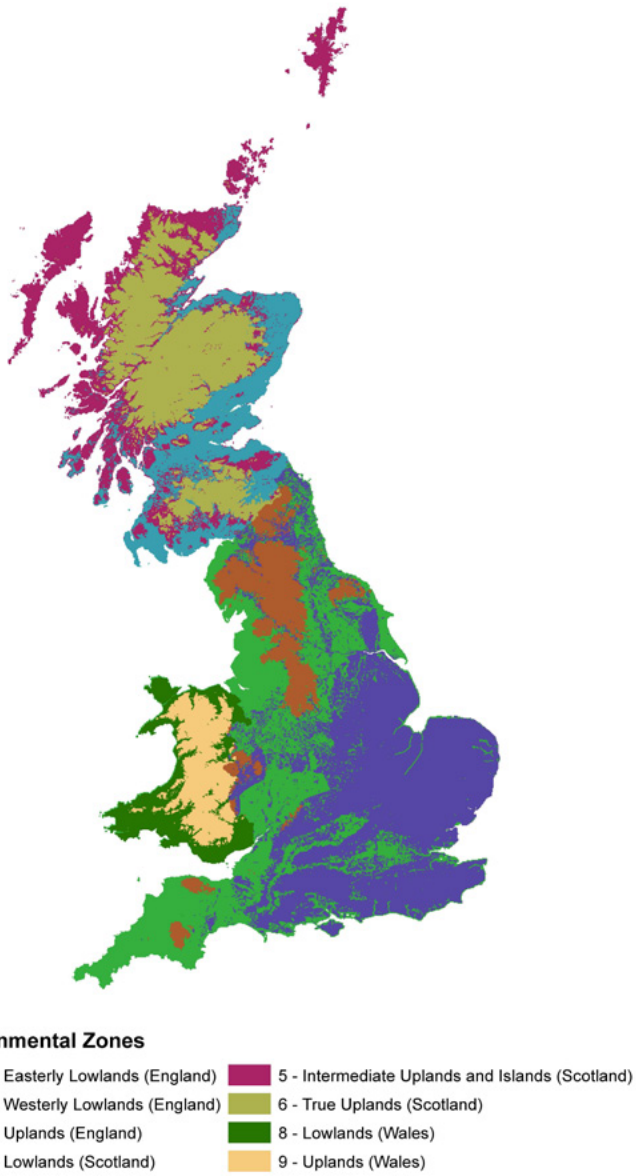


Figure 2-2. Distribution of Countryside Survey Environmental Zones across Great Britain

Some analysis has been undertaken to link observed changes to potential driving variables, in the form of characteristics of the catchment or the terrestrial elements of the survey square. These analyses will be elaborated more fully in the Integrated Assessment Report, to be published later in 2010.

Photo 2-5. Contrasting streams from EZ5

Indices

For macroinvertebrates, the indices used are Average Score Per Taxon (ASPT), number of BMWP Scoring taxa (TAXA), RIVPACS/RICT status class, deviation from RIVPACS reference community, number of species, and Acid Waters Indicator Community (AWIC). For macrophytes, the indices used were Mean Trophic Rank (MTR) and number of macrophyte species. More samples are available for the latter index as not all macrophyte taxa surveyed are assigned a MTR score. For River Habitat Survey, the indices used are Habitat Quality Assessment Score (HQA) and Habitat Modification Score (HMS). In all cases aside from Habitat Modification Score, an increase in the score corresponds to improved status (although see the notes in the discussion regarding taxon richness). For Habitat Modification Score, a higher score corresponds to more modification, hence reduced status. For ASPT, there are some circumstances where a high score can be achieved under impaired conditions, such as from acidification; however, this would be picked up by the AWIC index and does not occur in the data analysed here. Further details of these biological indices are given above .

No attempt has been made to analyse trends in the water chemistry samples in isolation; as spot samples taken on a single day they are likely to be much more variable than the biological indices. The water chemistry samples are considered further as part of the Integrated Assessment studies.

Statistical analysis using mixed models

The data in Countryside Survey have a longitudinal temporal structure, with observations occurring at the same location through time. Hence the data are analysed using linear mixed-effects regression models (Pinheiro & Bates 2000). The models are fitted using the routines in the “nlme” package (Pinheiro & Bates 2000) in the R environment for statistics and graphics (Version 2.9.1) (R Development Core Team 2009). Models are fitted using maximum likelihood (Pinheiro & Bates 2000), and model comparisons are made using the Akaike Information Criterion (Burnham & Anderson 2002).

There are two levels (which also may be referred to as random effects or error terms) to the model: ‘among sites’, corresponding to spatial variation; and ‘within sites’, corresponding to temporal variation[2].

The primary explanatory variable is survey year, treated as a factor with three (1990, 1998, 2007) or two (1998, 2007) levels. Season (spring, summer or autumn) was also used as an explanatory variable, but differences between seasons always appeared minor. The generalised likelihood hypothesis test approach (“glht”: Hothorn *et al.* 2008), is used to provide simultaneous confidence intervals across multiple years, and also to provide simultaneous multiple comparisons between different pairs of years (e.g. 1990-1998, 1998-2007, 1990-2007). Differences in trends between Environmental Zones within a country, are examined by testing for the significance of an interaction term between year and Environmental Zone. For clarity, this analysis is undertaken only between 1998 and 2007.

Mixed models provide a convenient way to use all the data collected across the multiple years of Countryside Survey, and to look at changes between more than two time points in a single statistical model. As noted above, in any one survey year, surveys in particular squares may be missing, and a requirement to have complete series with no missing values will reduce sample size, and thus statistical power. For example for macroinvertebrates for 1990-2007, this requirement would result in the loss of between 7% and 20% of samples which have incomplete series, depending on Environmental Zone. The benefit of this approach will be further realised in future survey years, where potentially the proportion of incomplete time series could increase, as will the number of comparisons between years. Results will potentially be more powerful than the paired sample t-tests used in previous survey reports, but will give identical results if applied to an identical dataset for two time points with no missing values.

As with all other parts of Countryside Survey, caution is needed in interpreting the differences between years of overall levels of indices (the “stock”) with their confidence intervals. These confidence intervals on the “stock” reflect the spatial variability in the index, whereas the confidence intervals of the change between years primarily reflect the variability in the changes from square to square. For example if there was an index whose values varied considerably across England, but which consistently increased from 1998 to 2007 in all squares then the confidence intervals on the stock for each year would be wide, but the confidence intervals on the change would be narrow.

Mixed models also provide further flexibility to include explanatory variables which can explain spatial and / or temporal variation in the indices, this is elaborated further in Section 6.

Analysis of status classes and change in status class using RIVPACS/RICT

The assessment of stream condition using RIVPACS/RICT is based on the standardised ratio (O/E) of observed (O) to expected (E) values of the two BMWP indices: number of taxa (TAXA) and Average Score Per Taxon (ASPT). Each stream site may then be classified in one of five Water Framework Directive status classes, based on its values for each of O/E TAXA and O/E ASPT using the class limits in Table 2-5; the overall class of a site is taken as the worst of the classes based on these two indices. This is the standard practice in UK government agencies’ national assessments of stream condition.

As noted earlier, RIVPACS/RICT is intended primarily to be used for flowing watercourse stretches of adequate width that are found on 1:50,000 Ordnance Survey maps. Therefore, analysis of status

[2] Broadly, site and Countryside Survey square are synonymous, however there are situations where between successive surveys, the site was moved within a square, this is accounted for.

classes for macroinvertebrate condition was restricted to those headwater stream sites downstream of the source marked on 1:50,000 maps. This gave a total of 220 samples in 1990, 251 in 1998 and 257 in 2007. In total 242 squares and sites were sampled in both 1998 and 2007, from which change in biological condition over the past decade was assessed.

Table 2-5 Lower limits of status classes for values of O/E TAXA and O/E ASPT (as used by default in RIVPACS/RICT)

	high	good	moderate	poor
O/E TAXA	0.8879	0.7417	0.5954	0.4910
O/E ASPT	1.0059	0.8918	0.7778	0.6533

Comparison of community (dis)similarity to RIVPACS reference community

In current assessments of stream macroinvertebrate status using RIVPACS, sites are assumed to lose taxa as the level of human impact/stress increases. However the TAXA index is insensitive to changes in community composition that do not result in a change in taxon richness. Such shifts in community composition could be the result of stressors acting on the site.

An alternative index of deviation from reference condition is a measure of compositional dissimilarity between the observed assemblage and that predicted to occur by RIVPACS. Such indices have been proposed by Clarke *et al.* (1996) and more recently by Van Sickle (2008). Van Sickle tested an index that is effectively an adaptation of the Bray-Curtis dissimilarity index (Bray & Curtis 1957) and as such is referred to as the *BC* index.

$$BC = \Sigma|O_k - P_k| / \Sigma(O_k + P_k)$$

Where O_k is the presence (1) or absence (0) of each of the taxa predicted to occur at the site by RIVPACS and P_k is the probability of occurrence of each of the k taxa. *BC* index values vary from 0 to 1 with values close to 0 indicating that the observed and predicted communities were very similar and hence that the site was in reference condition. Conversely, *BC* index values close to 1 indicate that the observed assemblage bears little resemblance to that expected for that site if it were in reference condition.

RIVPACS generates season-specific predictions, so within each survey year, for each sample, a prediction for the season of the observed data was used. This was either summer or autumn for the vast majority of samples, though there were some late spring samples in 2007.

The *BC* index should be more sensitive than the O/E species richness value and hence describe more subtle shifts in the observed community away from reference condition. We applied the *BC* index only to those sites that had a >1% chance of being of a type represented within the RIVPACS predictive model.

Suitable RIVPACS predictions of the reference state community composition could be generated for 537 of the Countryside Survey samples collected over the three survey years; 1990, 1998 and 2007. Of these, 165 were from 1990, 216 from 1998 and 156 from 2007. For these 537 samples we calculated the *BC* index based on the full list of species with a probability of occurrence >0. We then reported the results by year for the individual countries (there were low numbers of samples in Wales in each of the three years but we still cautiously report results for Wales separately). We also calculated the O/E species richness value for each of the samples based on the full list of species predicted to occur (not based on the BMWP-families predicted to occur, as used in routine RIVPACS assessments and reported above). We can therefore compare the biological quality signals provided by both indices.

We assessed changes in both indices between survey years (1990-1998, 1990-2007, 1998-2007) using a 2-tailed paired t-test on only those sites that had been sampled in both years of each pair wise comparison i.e. not all sites were sampled in all three survey years.

3 Macroinvertebrate status and change

3.1 Numbers of sites and surveys used for analyses

The following tables illustrate the numbers of sites and samples used for the following analyses.

Table 3-1. Numbers of sites used in stream macroinvertebrate analysis, and survey years included

Analysis	Survey years	England	Scotland	Wales	GB
Index analysis	1990-2007	132	168	46	346
Index analysis (difference between Environmental Zones)	1998, 2007	128	165	46	339
RIVPACS stock and overall change	1990-2007	96	139	31	266
RIVPACS status class changes	1998, 2007	96	139	31	266

Table 3-2. Numbers of samples used in stream macroinvertebrate analysis

Analysis	England	Scotland	Wales	GB
Index analysis (country)	320	466	113	899
Index analysis (Environmental Zones)	223	312	78	613
RIVPACS stock and overall change	246	398	84	728
RIVPACS status class changes	179	270	59	508

Table 3-3. Numbers of sites and samples used in ditch/drain macroinvertebrate analysis

	England	Scotland
Sites	36	82
Samples	17	51

3.2 Indices

Figure 3-1 illustrates for stream sites, overall levels for the various indices calculated, Figure 3-2 illustrates the same information for ditch/drain sites. Ditch/drain results are not presented for Wales due to the very small number of sites. Changes between years, with associated significant directional changes, are presented by country for 1990 – 1998, 1998 – 2007 and 1990 – 2007 (Table 3 4).

For stream sites, ASPT has shown a significant increase from 1990 to 1998 in England and Scotland. This trend has continued in England, albeit at a lower rate, from 1998 to 2007. For Scotland, there was no significant difference from 1998 to 2007. There is no evidence of any changes in ASPT in Wales, though this may be due to the lower sample sizes for Wales.

For stream sites for TAXA (number of BMWP-scoring families) and number of species, results for England mirror the results for ASPT; with continuing improvements throughout the survey period, although the increases from 1998-2007 appear relatively stronger for these measures than for ASPT. Both Wales and Scotland show significant increases from 1990-1998. Decreases occur from 1998 to 2007, however only the results for Scotland are significant. Again, this may be due to the relatively low numbers of samples from Wales.

AWIC scores show significant declines from 1990 to 1998 for England and Wales. The result for Wales is notable in that changes for several other indices for Wales are not significant.

In general, for the macroinvertebrate indices, there was no evidence of differences in the changes between Environmental Zones within countries. The one exception to this was for Species Richness in Scotland, where there was some evidence (P~0.05, ΔAIC=1.5) for a significant decline in species richness from 1998 to 2007 for Environmental Zone 6 (Scottish Highlands). Exploratory multivariate analysis (ordination using multidimensional scaling) did not highlight any obvious shift in taxonomic composition associated with this loss of species.

Results for ditch sites are presented in Figure 3-2 and Table 3-5. For Scotland, increases for all indices from 1990 to 1998 are significant, as is the increase in species richness for England from 1990 to 1998. This latter result almost certainly represents the fact that the BMWP scoring system was developed primarily for flowing waters, so is likely to offer lower precision in ditches, because it will ignore a large part of the potential ditch fauna. The increases from 1998 to 2007 for Scotland for TAXA and species richness, although not statistically significant, contrast with the results for the stream sites, which show declines in this period.

No analysis between Environmental Zones has been undertaken for the ditch/drain sites because of the relatively small sample sizes.

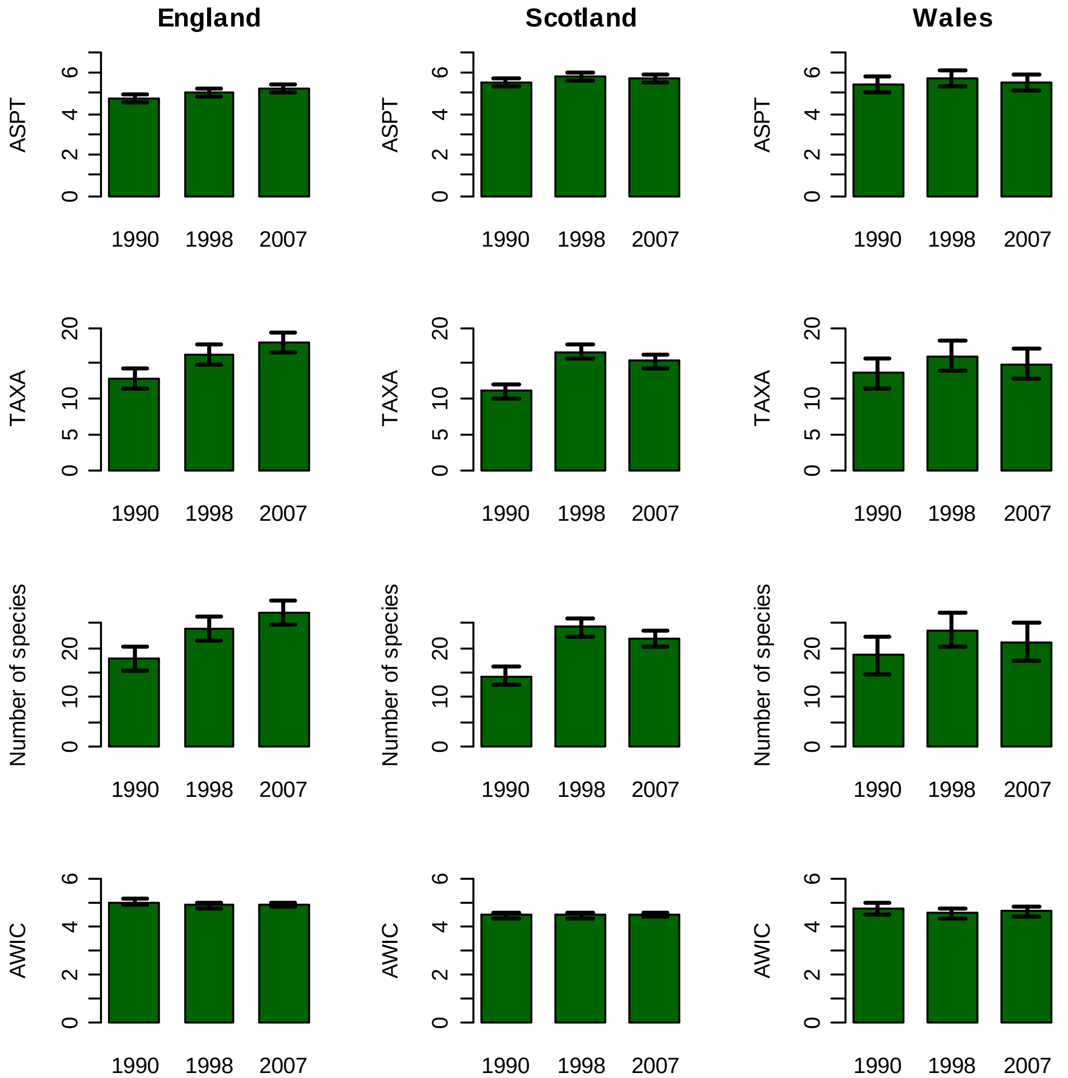


Figure 3-1. Mean values for four macroinvertebrate indices (Average Score Per Taxon (ASPT), number of BMWP scoring taxa (TAXA), number of species and Acid Waters Indicator Community (AWIC)) by country and year for all stream sites. Black bars represent 95% confidence intervals.

Photo 3-1. Streams from Wales: left: EZ8, right: EZ9

Table 3-4. Change in macroinvertebrate indices (Average Score Per Taxon (ASPT), number of BMWP scoring taxa (TAXA), number of species and Acid Waters Indicator Community (AWIC)) by country between pairs of years for stream sites.

Index	Country	Period	Change	Standard Error	$Z^{§}$	*P*	↑↓*
ASPT	England	1990 to 1998	0.32	0.07	4.2	0.000	↑
		1998 to 2007	0.18	0.07	2.5	0.038	↑
		1990 to 2007	0.50	0.08	6.3	0.000	↑
	Wales	1990 to 1998	0.29	0.15	1.9	0.126	
		1998 to 2007	-0.19	0.15	-1.3	0.417	
		1990 to 2007	0.10	0.16	0.6	0.812	
	Scotland	1990 to 1998	0.26	0.07	3.7	0.001	↑
		1998 to 2007	-0.05	0.07	-0.6	0.796	
		1990 to 2007	0.22	0.07	3.0	0.008	↑
TAXA	England	1990 to 1998	3.39	0.54	6.3	0.000	↑
		1998 to 2007	1.69	0.53	3.2	0.004	↑
		1990 to 2007	5.08	0.57	9.0	0.000	↑
	Wales	1990 to 1998	2.45	0.95	2.6	0.026	↑
		1998 to 2007	-1.11	0.96	-1.2	0.476	
		1990 to 2007	1.34	1.01	1.3	0.382	
	Scotland	1990 to 1998	5.46	0.42	12.9	0.000	↑
		1998 to 2007	-1.28	0.43	-3.0	0.008	↓
		1990 to 2007	4.17	0.44	9.6	0.000	↑
Species Richness	England	1990 to 1998	6.10	1.05	5.8	0.000	↑
		1998 to 2007	3.19	1.03	3.1	0.006	↑
		1990 to 2007	9.29	1.10	8.5	0.000	↑
	Wales	1990 to 1998	5.16	1.84	2.8	0.014	↑
		1998 to 2007	-2.42	1.85	-1.3	0.389	
		1990 to 2007	2.73	1.95	1.4	0.338	
	Scotland	1990 to 1998	9.88	0.76	13.1	0.000	↑
		1998 to 2007	-2.27	0.76	-3.0	0.008	↓
		1990 to 2007	7.61	0.78	9.8	0.000	↑
AWIC	England	1990 to 1998	-0.14	0.04	-3.6	0.001	↓
		1998 to 2007	0.02	0.04	0.6	0.845	
		1990 to 2007	-0.12	0.04	-2.9	0.010	↓
	Wales	1990 to 1998	-0.18	0.07	-2.4	0.038	↓
		1998 to 2007	0.08	0.07	1.0	0.560	
		1990 to 2007	-0.10	0.08	-1.3	0.399	
	Scotland	1990 to 1998	0.01	0.04	0.2	0.984	
		1998 to 2007	0.02	0.04	0.6	0.838	
		1990 to 2007	0.03	0.04	0.7	0.748	

§ magnitude of change divided by its standard error

* Direction of significant changes (P<0.05)

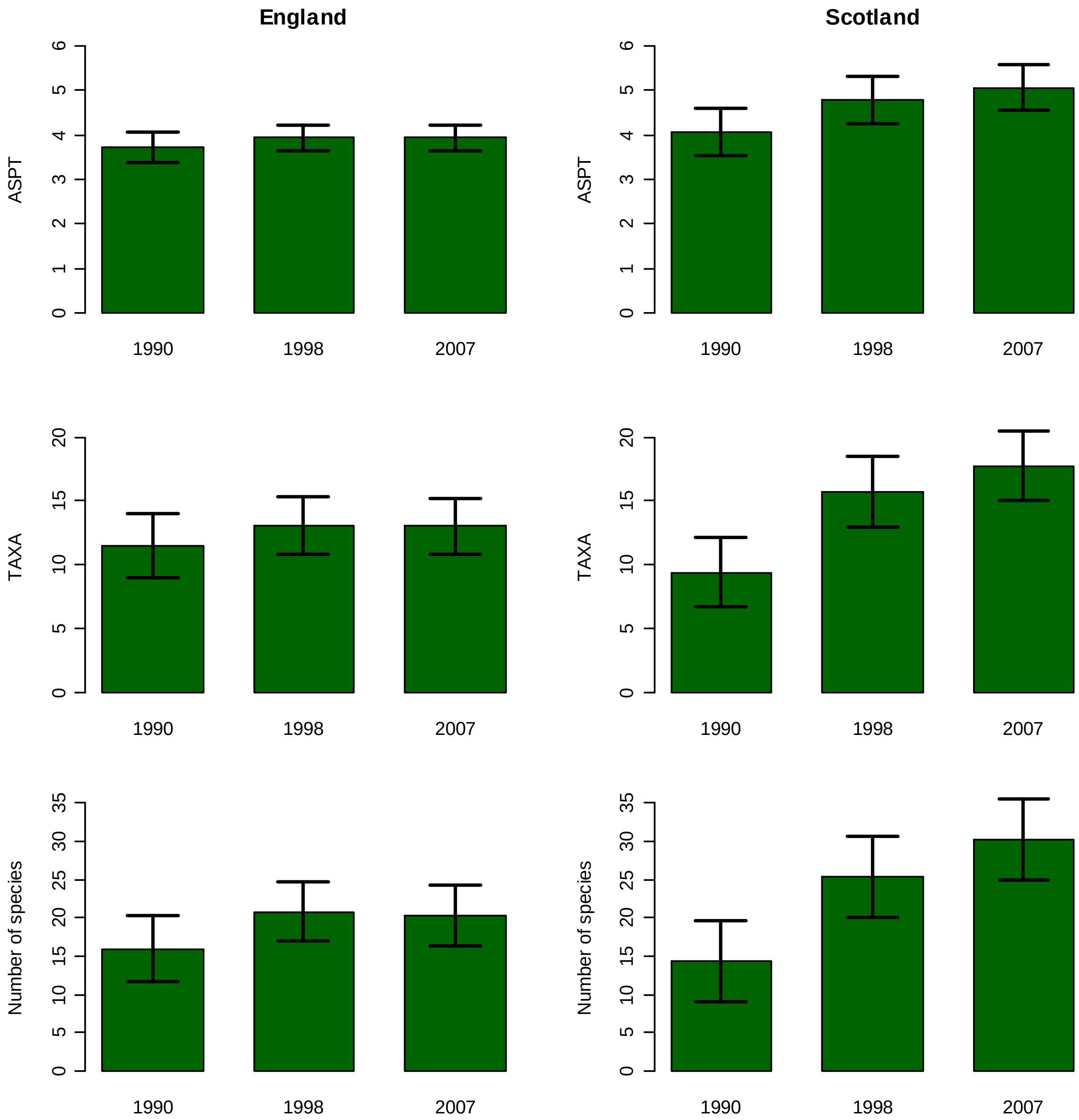


Figure 3-2. Mean values for macroinvertebrate indices (Average Score Per Taxon (ASPT), number of BMWP scoring taxa (TAXA), number of species) by country and year for all ditch/drain sites. Black bars represent 95% confidence intervals.

Table 3-5. Change in macroinvertebrate indices (Average Score Per Taxon (ASPT), number of BMWP scoring taxa (TAXA), number of species) by country between pairs of years for ditch/drain sites.

Index	Nation	Period	Change	SE	$Z^{\S}$	*P*	↑↓*
ASPT	England	1990 to 1998	0.20	0.17	1.2	0.436	
		1998 to 2007	0.01	0.15	0.0	0.999	
		1990 to 2007	0.21	0.17	1.2	0.432	
	Scotland	1990 to 1998	0.74	0.28	2.6	0.023	↑
		1998 to 2007	0.28	0.28	1.0	0.586	
		1990 to 2007	1.02	0.28	3.6	0.001	↑
TAXA	England	1990 to 1998	1.56	1.07	1.4	0.316	
		1998 to 2007	-0.05	1.01	0.0	0.999	
		1990 to 2007	1.51	1.11	1.4	0.364	
	Scotland	1990 to 1998	6.29	1.30	4.8	0.000	↑
		1998 to 2007	2.06	1.30	1.6	0.251	
		1990 to 2007	8.35	1.30	6.4	0.000	↑
Species Richness	England	1990 to 1998	4.82	1.86	2.6	0.025	↑
		1998 to 2007	-0.49	1.74	-0.3	0.958	
		1990 to 2007	4.34	1.92	2.3	0.062	
	Scotland	1990 to 1998	11.12	2.32	4.8	0.000	↑
		1998 to 2007	4.88	2.32	2.1	0.089	
		1990 to 2007	16.00	2.32	6.9	0.000	↑

§ magnitude of change divided by its standard error

* Direction of significant changes ($P<0.05$)

3.3 RIVPACS/RICT status classes (stock and overall changes)

The percentage of sites in each country and Environmental Zone classified to each Water Framework Directive status class in the 2007 survey are summarised in Table 3-6; this is shown for the classification based on values of O/E TAXA alone, O/E ASPT alone and the overall status class.

The percentage of sites classified as being of high or good ecological status is lowest in Environmental Zone 1, which is predominantly in the southern and eastern agricultural lowlands of England. This was especially true when based on O/E ASPT, which is sensitive to nutrient enrichment, organic pollution and physical habitat degradation, a long term problem within such intensively-farmed areas.

The percentage of sites in each country classified to each status class in each of the surveys in 1990, 1998 and 2007 is summarised in Table 3-7. The overall pattern of change in stream condition is shown by the trends between 1990 and 2007 in the percentage of sites in each Environmental Zone which were classified as being of good or high status (Figure 3-3).

Although streams in Environmental Zone 1 are still least likely to be of adequate condition (i.e. 'good or better' status), the estimated percentage in adequate condition has steadily increased from 15% in 1990 to 25% in 1998 and 29% by the time of the 2007 survey.

The general trend for improvements in stream condition from 1990 to 1998 appears to have continued through the last decade. At the time of the 2007 survey, the percentage of stream sites assessed as being of 'good' or better status had increased from the 1998 survey in all three zones in England, in Wales as a whole and in two of the three zones in Scotland. In Environmental Zone 6 in Scotland, the estimated percentage of sites in the top two classes of condition fell from 75% in 1998 (the highest of any zone in any survey) to 60% in 2007. There were some concerns about the reliability of the dramatic improvements in stream condition estimated to have occurred in Environmental Zones 5 and 6 in Scotland between the 1990 and 1998 Countryside Surveys, but detailed checking of the freshwater surveyors and data did not reveal any methodology explanation. Also the high percentage of sites in the top two classes in Zone 5 has been maintained between the 1998 and 2007 surveys.

Table 3-6. Percentage of sites in each ecological status class in 2007, by country and Environmental Zone, based on RIVPACS/RICT (a) O/E for TAXA (b) O/E for ASPT and (c) Overall class.

(a) TAXA	Environmental Zone	Ecological status class based on TAXA				
		high	good	mod.	poor	bad
England	EZ1	32	19	23	23	3
	EZ2	67	15	10	5	3
	EZ3	62	14	5	5	14
	Total	54	16	13	11	5
Scotland	EZ4	64	13	15	0	8
	EZ5	61	10	15	4	10
	EZ6	48	17	15	2	19
	Total	57	13	15	2	13
Wales	Total	33	27	16	7	17
GB	Total	46	17	14	9	14

(b) ASPT	Environmental Zone	Ecological status class based on ASPT				
		high	good	mod.	poor	bad
England	EZ1	19	13	45	23	0
	EZ2	47	25	13	13	2
	EZ3	57	28	10	5	0
	Total	40	22	23	14	1
Scotland	EZ4	46	21	21	10	2
	EZ5	58	17	19	4	2
	EZ6	67	21	8	4	0
	Total	58	19	16	6	1
Wales	Total	37	40	7	13	3
GB	Total	44	25	17	10	4

(c) Overall	Environmental Zone	Overall ecological status class				
		high	good	mod.	poor	bad
England	EZ1	13	16	36	32	3
	EZ2	47	18	13	17	5
	EZ3	52	19	10	5	14
	Total	37	17	20	20	6
Scotland	EZ4	41	25	18	8	8
	EZ5	50	17	17	6	10
	EZ6	37	25	15	4	19
	Total	43	22	16	6	13
Wales	Total	17	40	13	10	20
GB	Total	29	24	19	13	15

Table 3-7 Percentage of sites in each ecological status class by country in 1990, 1998 and 2007 based on RIVPACS/RICT (a) O/E for TAXA (b) O/E for ASPT and (c) Overall class.

(a) TAXA	Survey	Ecological status class based on TAXA				
		high	good	mod.	poor	bad
England	1990	31	22	12	12	22
	1998	43	21	18	9	9
	2007	54	16	13	11	5
Scotland	1990	24	18	14	15	29
	1998	64	15	10	5	6
	2007	57	13	15	2	13
Wales	1990	32	12	16	12	28
	1998	45	14	17	10	14
	2007	33	27	17	7	17
GB	1990	27	19	14	14	27
	1998	55	17	14	7	8
	2007	53	16	14	6	11
(b) ASPT		Ecological status class based on ASPT				
		high	good	mod.	poor	bad
England	1990	31	19	25	12	12
	1998	31	29	17	20	3
	2007	40	22	23	14	1
Scotland	1990	41	27	17	9	6
	1998	53	29	13	4	1
	2007	58	19	16	6	1
Wales	1990	44	24	16	12	4
	1998	45	28	17	10	0
	2007	37	40	7	13	3
GB	1990	38	24	20	10	8
	1998	44	29	15	10	2
	2007	49	23	17	10	2
(c) Overall		Overall ecological status class				
		high	good	mod.	poor	bad
England	1990	18	18	25	13	25
	1998	23	26	22	20	9
	2007	37	17	20	20	7
Scotland	1990	10	28	16	16	30
	1998	42	24	19	9	6
	2007	43	22	16	6	13
Wales	1990	24	16	20	12	28
	1998	28	21	21	17	14
	2007	17	40	13	10	20
GB	1990	14	24	20	15	28
	1998	34	25	20	14	8
	2007	38	23	17	11	11

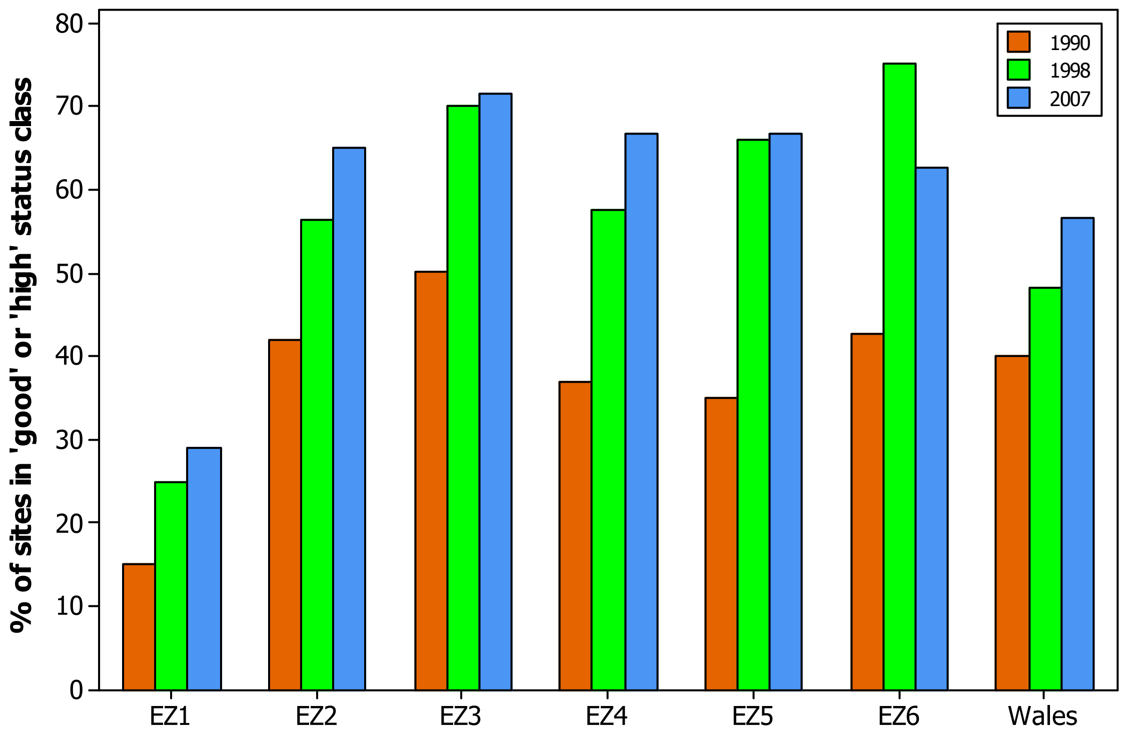


Figure 3-3 Percentage of stream sites in the two best classes ('good' and 'high') of overall ecological status, by Environmental Zone and survey year.

3.4 RIVPACS status classes (changes of individual sites)

The estimate of stream condition in any one year for individual Countryside Survey squares is based on a single macroinvertebrate sample taken from one stream site, using the standardised RIVPACS sampling and sample processing procedures. Stream sites are re-sampled in each survey year wherever possible and providing the watercourse has not dried up at the time of the field survey visit. This helps improve the precision of estimates of change in stream condition by minimising the effects of variation in condition between streams.

However, taking a different macroinvertebrate sample from the same stream site on the same day, and especially on a different day in the same survey year would usually record a partially different macroinvertebrate community and different values for the indices TAXA and ASPT. RIVPACS allows for this by using previously-obtained estimates of typical variation in index values due to replicate sampling. RICT allows for both replicate sampling variation and previously-estimated seasonal temporal variability. RIVPACS/RICT provides tests that can be used to calculate the probability that an individual site has changed its status class of biological condition after sampling and methodological variation has been discounted.

When RIVPACS/RICT was used to compare the results of the Countryside Surveys of 1998 and 2007, it was found that 28% of the stream sites in Great Britain sampled in both surveys had more likely than not (i.e. with probability >50%) improved in status class (Table 3-8). Furthermore, 12% of sites had 'almost certainly' (i.e. with probability ≥ 95%) improved in status class. Overall, a similar percentage (26%) of sites had more likely than not deteriorated in status class and 12% of sites had almost certainly deteriorated in class. For nearly half (46%) of all stream sites, it was most likely that no real change in site condition class had occurred, in that the amount of change in O/E TAXA and O/E ASPT and the resulting status class was not beyond that which might occur by chance due to natural sampling variability within a season.

Table 3-8 Percentage of stream sites in each Environmental Zone and country that have changed their class of ecological condition between 1998 and 2007, after allowing for uncertainty due to natural sampling variability.

Country and Environmental Zone		sites	Downgraded		Stayed the same class	Upgraded	
			"almost certainly"	"more likely than not"		"more likely than not"	"almost certainly"
England	EZ1	27	0	30	33	37	15
	EZ2	37	5	19	46	35	19
	EZ3	19	5	16	47	37	5
	Total	83	4	22	42	36	14
Scotland	EZ4	38	18	29	42	29	13
	EZ5	46	13	22	57	22	11
	EZ6	47	19	43	38	19	6
	Total	131	17	31	46	23	10
Wales	Total	28	11	18	57	25	11
GB	Total	242	12	26	46	28	12

Very few (4%) Countryside Survey stream sites in England had almost certainly deteriorated in status class. In contrast, in Scotland 17% of sites had almost certainly deteriorated in class and declines were most common in Environmental Zone 6 where 43% of stream sites had more likely than not deteriorated in status class.

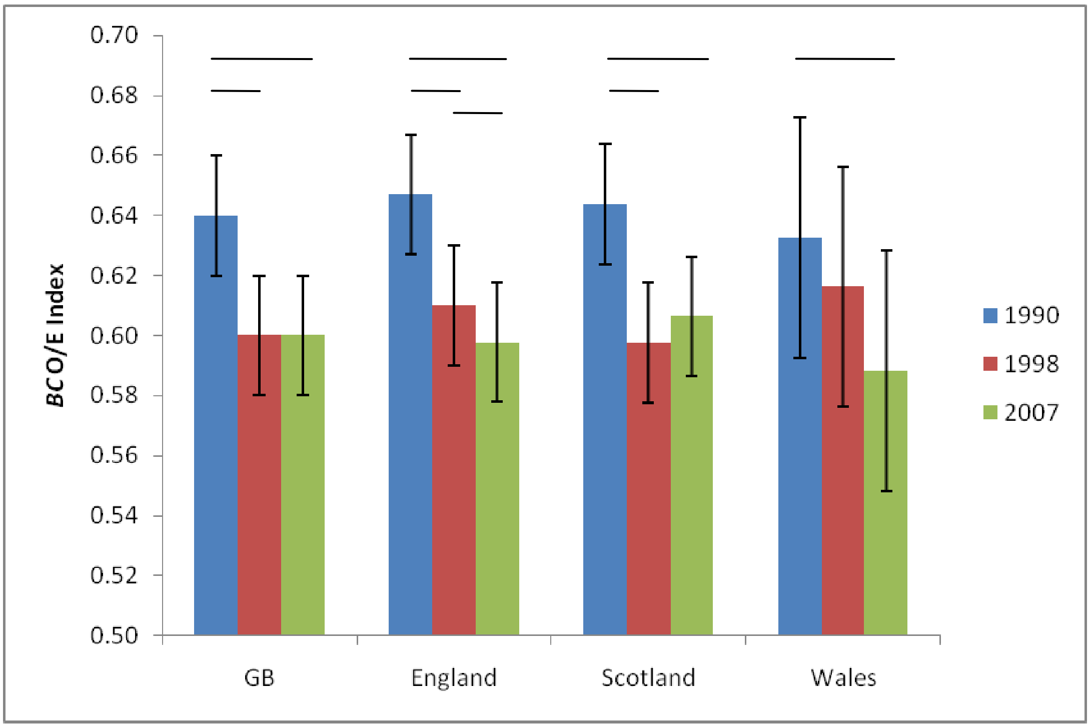
In all zones in England and in Wales as a whole, more sites had more likely than not improved in status than deteriorated in status (Table 3-8).

3.5 Comparison of community (dis)similarity to RIVPACS reference condition

There has been a significant decrease in dissimilarity (i.e. an increase in similarity) between observed and expected stream macroinvertebrate community composition between 1990 and 2007 in all three countries (Table 3-9, Figure 3-4). The shift in assemblage composition towards reference conditions occurred mainly between 1990 and 1998, with only England having a further significant change detected between 1998 and 2007.

There has, likewise, been a significant improvement in stream condition, as assessed by the O/E species richness index, across GB as a whole, and in England and Scotland, between 1990 and 2007 (Table 3-9, Figure 3-4). The increase in O/E species richness occurred mainly between 1990 and 1998, with only England having a further significant increase between 1998 and 2007.

(a)



(b)

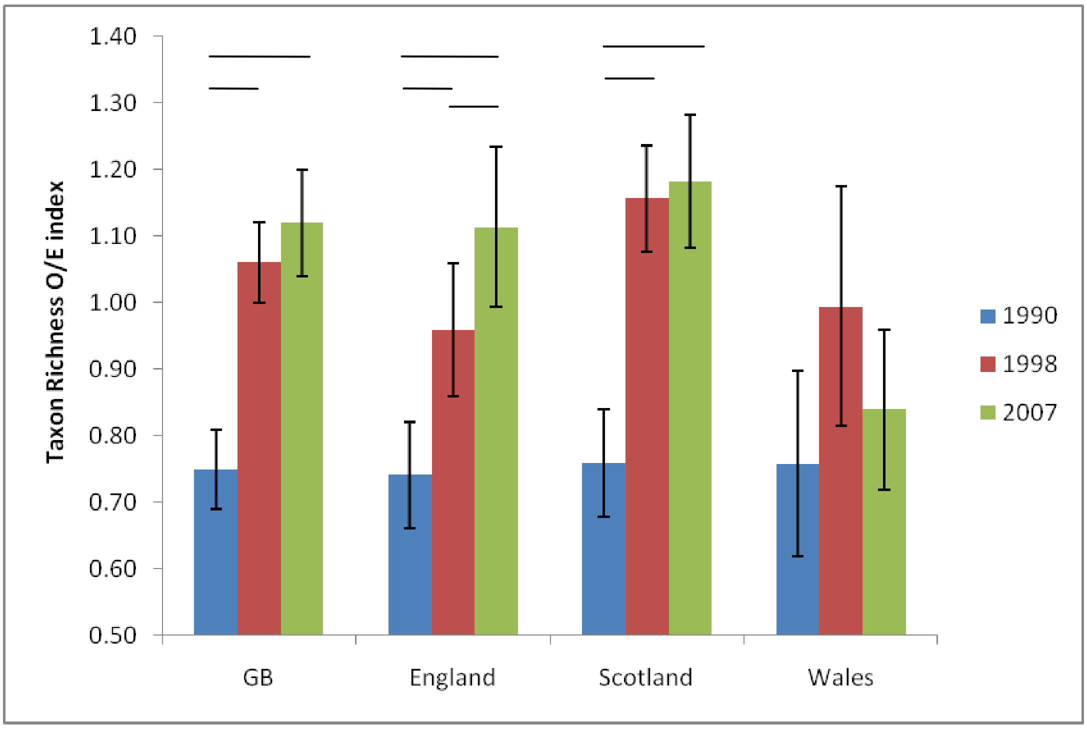


Figure 3-4. Mean (+ 95% confidence interval) of (a) *BC* (Bray-Curtis) and (b) Species (taxon) richness O/E index values for stream sites across GB and in individual countries for all three Countryside Survey years. Horizontal lines above pairs of columns with each region indicate years with statistically significant changes (*P* <0.05) in mean index values, as assessed by a 2-tailed paired t-test on only those sites sampled in both years of each pair wise comparison.

Table 3-9. Mean (+ SE) *BC* (Bray-Curtis) and species richness O/E index values for stream sites across GB and in individual countries for all three Countryside Survey years.

	BC O/E Index							Species richness O/E Index					
	1990		1998		2007			1990		1998		2007	
	mean	SE	mean	SE	mean	SE		mean	SE	mean	SE	mean	SE
GB	0.64	0.01	0.60	0.01	0.60	0.01		0.75	0.03	1.06	0.03	1.12	0.04
England	0.65	0.01	0.61	0.01	0.60	0.01		0.74	0.04	0.96	0.05	1.11	0.06
Scotland	0.64	0.01	0.60	0.01	0.61	0.01		0.76	0.04	1.16	0.04	1.18	0.05
Wales	0.63	0.02	0.62	0.02	0.59	0.02		0.76	0.07	0.99	0.09	0.84	0.06

3.6 Changes in prevalence of macroinvertebrate taxa between survey years

For each country, prevalence of individual species (or higher taxonomic unit where species identification is not routinely possible) was calculated. Prevalence (or frequency of occurrence) was defined as the proportion of survey sites at which that species was observed in an individual survey year. A cut-off of 0.1 (10%) was used, so that only species which occurred in 10% of the total number of samples (across all three survey years) for a country were included (although numbers may be lower than 10% in any individual year). The rationale for this is that as taxa become rarer in the samples, change in prevalence will be estimated more imprecisely. This produced lists of 63 species for England, 63 for Scotland and 64 for Wales. Tables of prevalence in each survey year for each country are provided in the Appendix. Graphs of changes in prevalence for the periods from 1990 to 1998, 1998 to 2007, and 1990 to 2007 are also provided. A change in prevalence of 0.1 corresponds to a change in prevalence from for example 0.2 (20%) to 0.3 (30%), or from 0.4 to 0.5 etc. It is important to note that these results are presented without confidence intervals, and should be interpreted with care since natural variability in macroinvertebrate populations is often high. Furthermore, it is important to emphasise that the results presented are for prevalence, not abundance.

Across all countries, there is a broad trend for the prevalence to increase for most taxa under consideration. In many cases, the changes from 1998 to 2007 partially balance out the changes from 1990 to 1998, mirroring the results from the analysis of numbers of species presented above.

In England, the changes in prevalence of taxa associated with faster-flowing waters, such as the caseless caddis *Rhyacophila dorsalis*, the riffle beetle *Elmis aenea* and the blackflies Simuliidae, are consistent with 1990 being a drought year, and 1998 having much higher flows (Figure 10-1,

Table 10-1). However, ongoing increases in prevalence for these taxa from 1998 to 2007, suggest that there may be other influences on their distribution, such as land and habitat management changes. The freshwater shrimp *Gammarus pulex,* another good indicator of higher flow conditions, shows increases in prevalence from 1998 to 2007, but no associated increase from 1990 to 1998. This may be because the shrimps were still recovering from the 1996/7 drought. Water beetle taxa in the family Dytiscidae (*Ilybius sp*. and *Platambus maculatus*) are among the few common taxa to show net decreases from 1990 to 2007 (Figure 10-2), this trend has also been observed in Environment Agency monitoring data (Orr *et al.* 2010). Another species showing a reduction in prevalence is the Isopod crustacean *Proasellus meridianus*, however another member of the same family, *Asellus aquaticus,* which is thought to be more tolerant to organic pollution and biocides than its counterpart, shows a much larger increase in prevalence over the same period. The alderfly S*ialis lutaria,* which is strongly associated with fine sediments is the only other common species to show a decrease from 1990 to 2007. Unlike in Scotland and Wales, there was only a very weak negative correlation between change from 1990 to 1998 and change from 1998 to 2007 (Figure 10-3).

In Scotland, there is an extremely strong pattern, which mirrors the total species richness results above, whereby there are strong increases in prevalence in all considered taxa from 1990 to 1998, and less strong decreases in prevalence in taxa from 1998 to 2007 (Figure 10-4, Table 10-2, Figure 10-6). The trend for *Gammarus pulex* is the opposite of that observed for England, while the trend for *Elmis aenea* is comparable, as are those for *Rhyacophila dorsalis* and the mayfly *Baetis rhodani*. Craneflies in the genus *Dicranota* show very strong increases from 1990 to 1998, and decreases from 1998 to 2007. Two of the strongest increases are shown by the water mites Hydracarina, and the water cricket *Velia* sp. The latter is potentially difficult to sample consistently due to its surface dwelling habit. Effectively no taxa in Scotland show a decrease in prevalence over the entire period from 1990 to 2007 (Figure 10-5).

Compared to England and Scotland, the taxa considered in Wales show a more even balance of increases and decreases in prevalence for 1990 to 1998 versus 1998 to 2007 (Figure 10-7, Table 10-3), although overall for 1990 to 2007 there are slightly more increases than decreases (Figure 10-8). As with Scotland, there is a noticeable negative correlation between changes from 1990 to 1998 and 1998 to 2007 (Figure 10-9). It is worth re-emphasising the lower sample sizes in Wales compared to England or Scotland, which could lead to more variability in observed sample data. As in England, the diving beetles (Dytiscidae) show decreases from 1990 to 1998 and overall from 1990 to 2007, the decreases being more marked in Wales. *Gammarus pulex* shows a decrease from 1998 to 2007, and an overall decrease from 1990 to 2007, in contrast to the pattern in England.

3.7 Occurrences of rare or endangered taxa in 2007

As noted above and in Carey et al. 2008, care is needed in interpreting occurrence of rare taxa and habitats in Countryside Survey. For reference, Table 3-10 lists the numbers of occurrences of nationally notable and Red Data Book macroinvertebrate taxa in the 2007 survey samples for both headwater streams and ditches/drains.

Table 3-10. Occurrences of notable and red data book macroinvertebrate taxa in Countryside Survey 2007 samples.

Status	Common name	Taxon name	Occurrences
RDB2 (vulnerable)	Beetles	*Hydraena palustris* Erichson, 1837	2
RDB3 (rare)	Beetles	*Hydraena pygmaea* Waterhouse, 1833	1
Notable	True-flies	*Tipula* (*Savtshenkia*) *cheethami* Edwards, 1924	2
Notable	Caddisflies	*Tinodes unicolor* (Pictet, 1834)	1
Notable	Beetles	*Riolus subviolaceus* (Müller, 1817)	5
Notable	Beetles	*Riolus cupreus* (Müller, 1806)	1
Notable	Caddisflies	*Rhyacophila fasciata* Hagen, 1859	2
Notable	True-flies	*Phalacrocera replicata* (Linnaeus, 1758)	2
Notable	Beetles	*Ochthebius exsculptus* (Germar, 1824)	1
Notable	Beetles	*Ochthebius bicolon* Germar, 1824	1
Notable	Beetles	*Noterus crassicornis* (O.F. Müller, 1776)	1
Notable	Beetles	*Limnebius papposus* Mulsant, 1844	1
Notable	Dragonflies	*Leucorrhinia dubia* (Vander Linden, 1825)	1
Notable	Caddisflies	*Hydropsyche fulvipes* (Curtis, 1834)	1
Notable	Beetles	*Hydroporus obsoletus* Aubé, 1838	1
Notable	Beetles	*Hydroporus longicornis* Sharp, 1871	1
Notable	Beetles	*Hydroporus ferrugineus* Stephens, 1829	1
Notable	Beetles	*Hydraena rufipes* Curtis, 1830	2
Notable	Beetles	*Hydraena nigrita* Germar, 1824	3
Notable	True-flies	*Dixella attica* (Pandazis, 1933)	4
Notable	Beetles	*Deronectes latus* (Stephens, 1829)	1
Notable	Caddisflies	*Chimarra marginata* (Linnaeus, 1761)	1
Notable	Beetles	*Agabus melanarius* Aubé, 1837	2
Notable	Beetles	*Agabus biguttatus* (Olivier, 1795)	1

3.8 QA (replicate sampling) and audit of macroinvertebrate taxonomy

Figure 3-5 illustrates, for two indices (TAXA and ASPT) the relationship between main and QA samples for 27 squares (for two squares there was a problem obtaining a main sample). The black line illustrates a 1:1 relationship. There is no significant difference in ASPT scores between main and QA samples, the blue line is a regression predicting QA ASPT from main ASPT. There is a significant difference between the result for numbers of taxa, with there being, for lower numbers of taxa, more taxa in the QA sample (blue line). On examining the lists of taxa identified in each sample, the lists of taxa were comparable, apart from one sample from upland Wales, where differences between the samples could not be accounted for. This square is highlighted blue in Figure 3-5; 20 taxa were identified in the QA sample and seven in the main sample, there was minimal overlap between the taxa identified. Removing this one influential site gives a relationship between main and QA samples indistinguishable from 1:1, as illustrated by the green line.

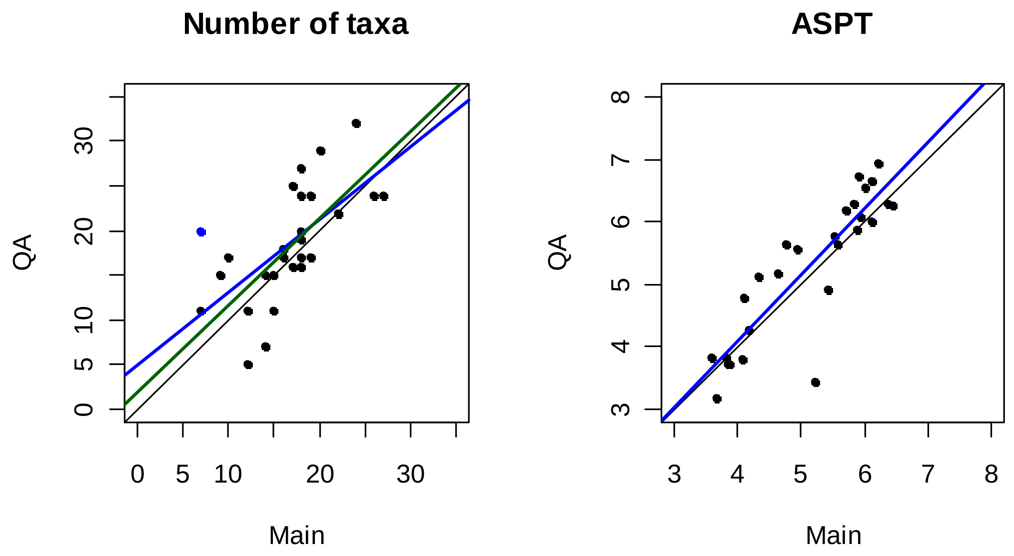


Figure 3-5. Relationship between main and QA samples for macroinvertebrate samples. Black line illustrates 1:1, other lines described in text.

Figure 3-6 illustrates, for the same two indices as above, the relationship between the primary lab identification and the audit identification for 13 samples. Note that there is some over-plotting in the number of taxa graph (numbers of taxa can only be whole numbers). Again, the black lines illustrate a 1:1 relationship, main samples (those processed initially by CEH and then independently audited) are coloured black and QA samples (those processed initially and then internally audited by the same lab) coloured red. The plots indicate a very high degree of concordance.

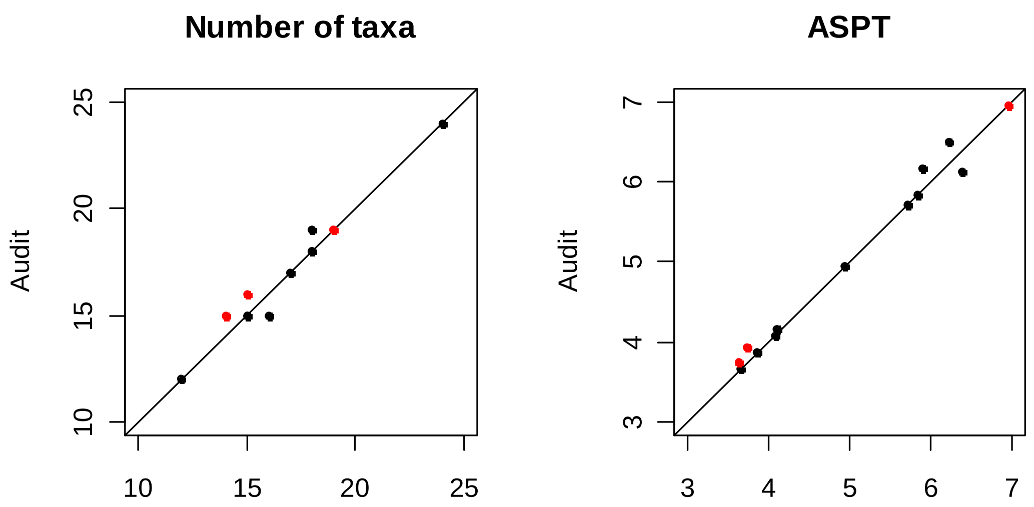


Figure 3-6. Relationship between primary (x-axis) and audit samples. Black dots are for main samples, red dots are for internal QA samples.

4 Macrophyte status and change

The numbers of sites and samples used for the analyses of macrophyte status and change is given for streams and ditches/drains in Tables 4-1 and 4-2 respectively. The analyses in the following section use more surveys, and a different, more powerful analytical model than the analyses presented in the UK and country reports. Hence there are slight differences in the numbers presented, but the conclusions are unchanged.

Table 4-1. Numbers of sites used in stream macrophyte analysis

	Analysis	England	Scotland	Wales	GB
Sites	MTR	85	139	29	253
	Species Richness	134	166	46	346
Samples	MTR	139	250	50	439
	Species Richness	242	319	80	641

Table 4-2. Numbers of sites and samples used in ditch/drain macrophyte analysis

	Analysis	England	Scotland
Sites	MTR	21	15
	Species Richness	34	18
Samples	MTR	33	24
	Species Richness	62	35

Figure 4-1 illustrates for stream sites, overall levels for the various indices calculated, with 95% confidence intervals, Figure 4-2 illustrates the same information for ditch/drain sites. Ditch/drain results are not presented for Wales due to the very small number of sites. Values for change between years are presented by country for 1998 – 2007 (Table 4-1). For streams, there are significant increases in species richness for England, Scotland and Wales, and for MTR in Scotland. For ditches, there are significant increases in both indices for Scotland. As with the analysis for macroinvertebrates, the observed non-significant changes for Wales may relate to the sample size; for example the observed (non-significant) increase in MTR for Wales (4.1), is only slightly lower than the (significant) increase for Scotland (4.6).

For the stream sites, there was no evidence for any difference in response of either plant index for Environmental Zones within country. As noted for macroinvertebrates above, ditch/drain sites were not tested due to small sample sizes.

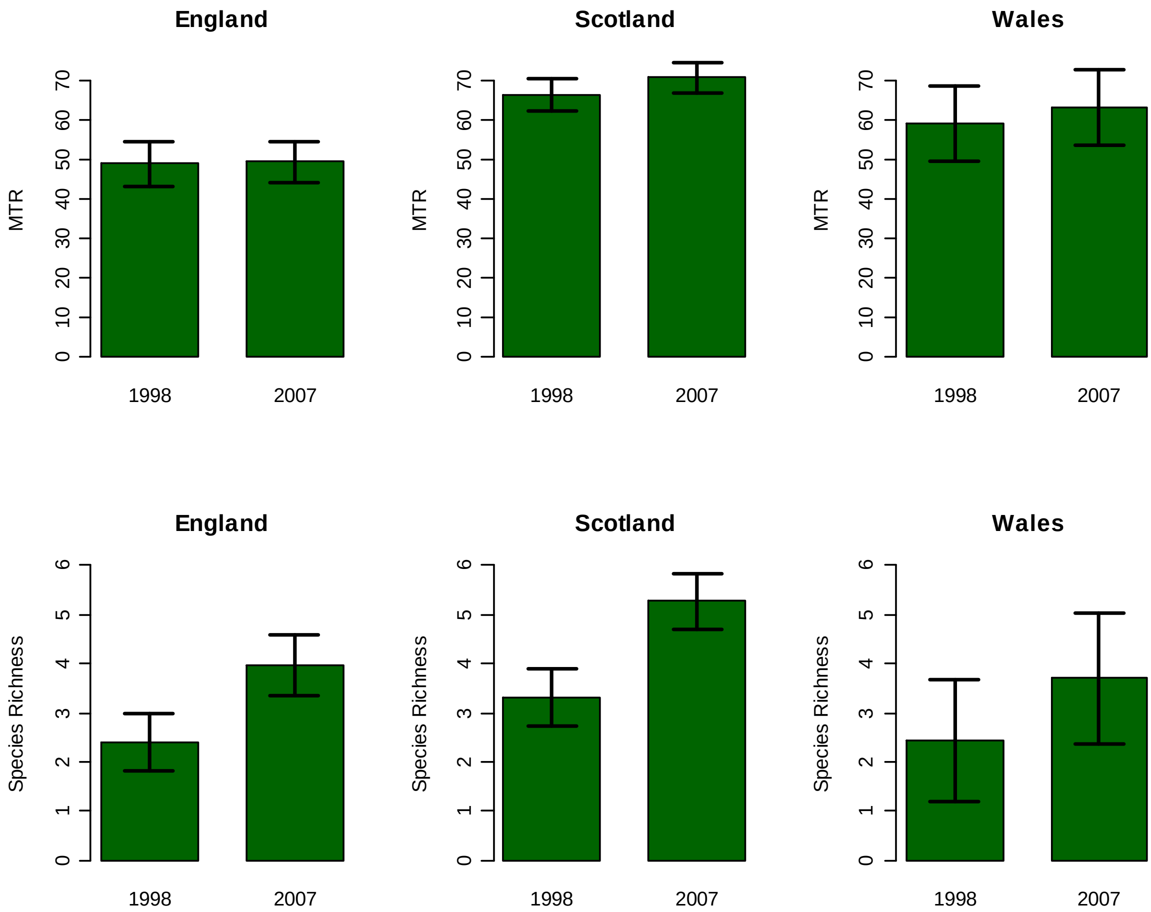


Figure 4-1. Mean values for two macrophyte indices (Mean Trophic Rank (MTR) and species richness) by country and year for all stream sites. Black bars represent 95% confidence intervals.

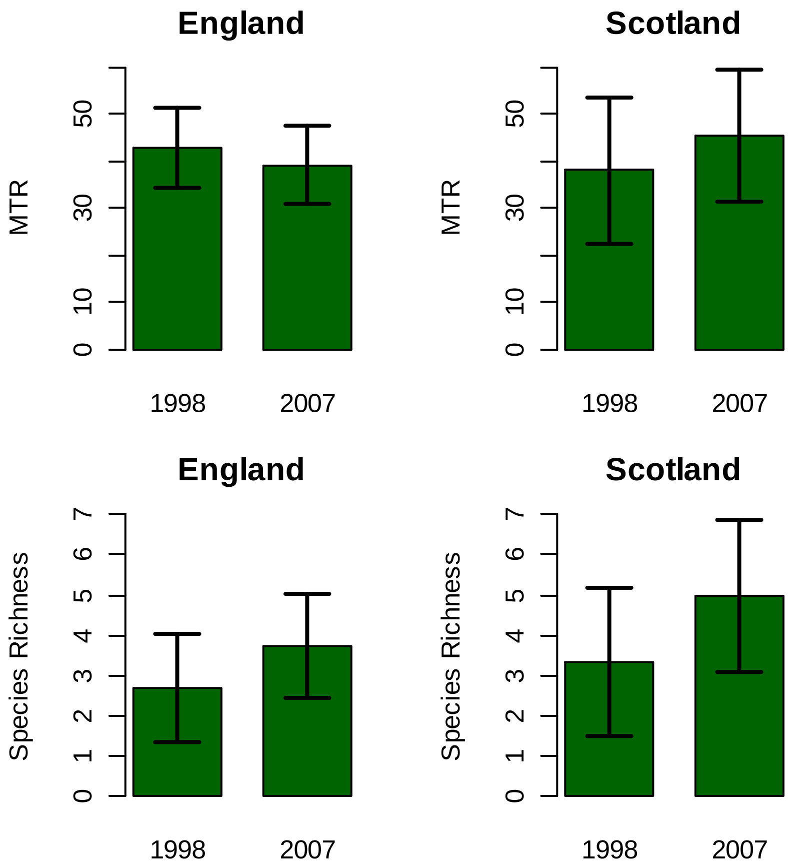


Figure 4-2. Mean values for two macrophyte indices (Mean Trophic Rank (MTR) and species richness) by country and year for all ditch/drain sites. Black bars represent 95% confidence intervals.

Table 4-3. Direction of change from 1998 to 2007 for macrophytes indices for stream and ditch/drain sites.

Set	Index	Country	Change	Standard error	$Z^{§}$	*P*	↑↓*
Streams	MTR	England	0.46	2.36	0.19	0.846	
		Scotland	4.60	1.62	2.84	0.004	↑
		Wales	4.11	4.83	0.85	0.395	
	Species Richness	England	1.65	0.28	5.94	0.000	↑
		Scotland	2.16	0.29	7.38	0.000	↑
		Wales	1.74	0.72	2.40	0.017	↑
Ditches/drains	MTR	England	-3.87	4.4	-0.9	0.377	
		Scotland	7.49	6.2	1.2	0.229	
	Species Richness	England	1.04	0.72	1.43	0.152	
		Scotland	1.65	0.92	1.78	0.075	

§ magnitude of change divided by its standard error

* Direction of significant changes (*P*<0.05)

5 River habitat status and change

The following table illustrates the numbers of sites and samples used for the analyses of stream sites below. The analyses in the following section use more surveys, and a different, more powerful analytical model than the analyses presented in the UK and country reports. Hence there are slight differences in the numbers presented, but the conclusions are unchanged.

Table 5-1. Numbers of sites and surveys used in river habitats analysis.

Analysis	England	Scotland	Wales	GB
Numbers of sites	150	171	47	368
Numbers of surveys	264	325	81	670

Figure 5-1 illustrates for stream sites, overall levels for River Habitat Survey Habitat Modification Score (HMS) and Habitat Quality Assessment Score (HQA) in both 1998 and 2007. Values for change between years are presented by country for 1998 – 2007 (Table 5-2). For streams, there are significant increases in HQA scores in England, Scotland and Wales, and a significant increase in HMS in Scotland. Confidence intervals are relatively wide for overall HMS as the index is not normally distributed, it may range from zero up to 3000+, but mean values tend to be below 1000. However, this should not affect the precision of the change estimates as the differences in HMS between sites tend to be approximately normally distributed.

Table 5-2. Direction of change from 1998 to 2007 for two River Habitat Survey indices (Habitat Modification Score – HMS, and Habitat Quality Assessment Score – HQA), for stream and ditch sites.

Index	Country	Change	Standard error	$Z^{§}$	*P*	↑↓*
HMS	England	71.3	72.6	1.0	0.326	
	Scotland	262.5	53.8	4.9	0.000	↑
	Wales	174.3	118.1	1.5	0.140	
HQA	England	5.6	0.9	6.2	0.000	↑
	Scotland	2.7	0.9	2.9	0.004	↑
	Wales	6.8	2.1	3.3	0.001	↑

* direction of significant changes (P<0.05)

§ magnitude of change divided by its standard error

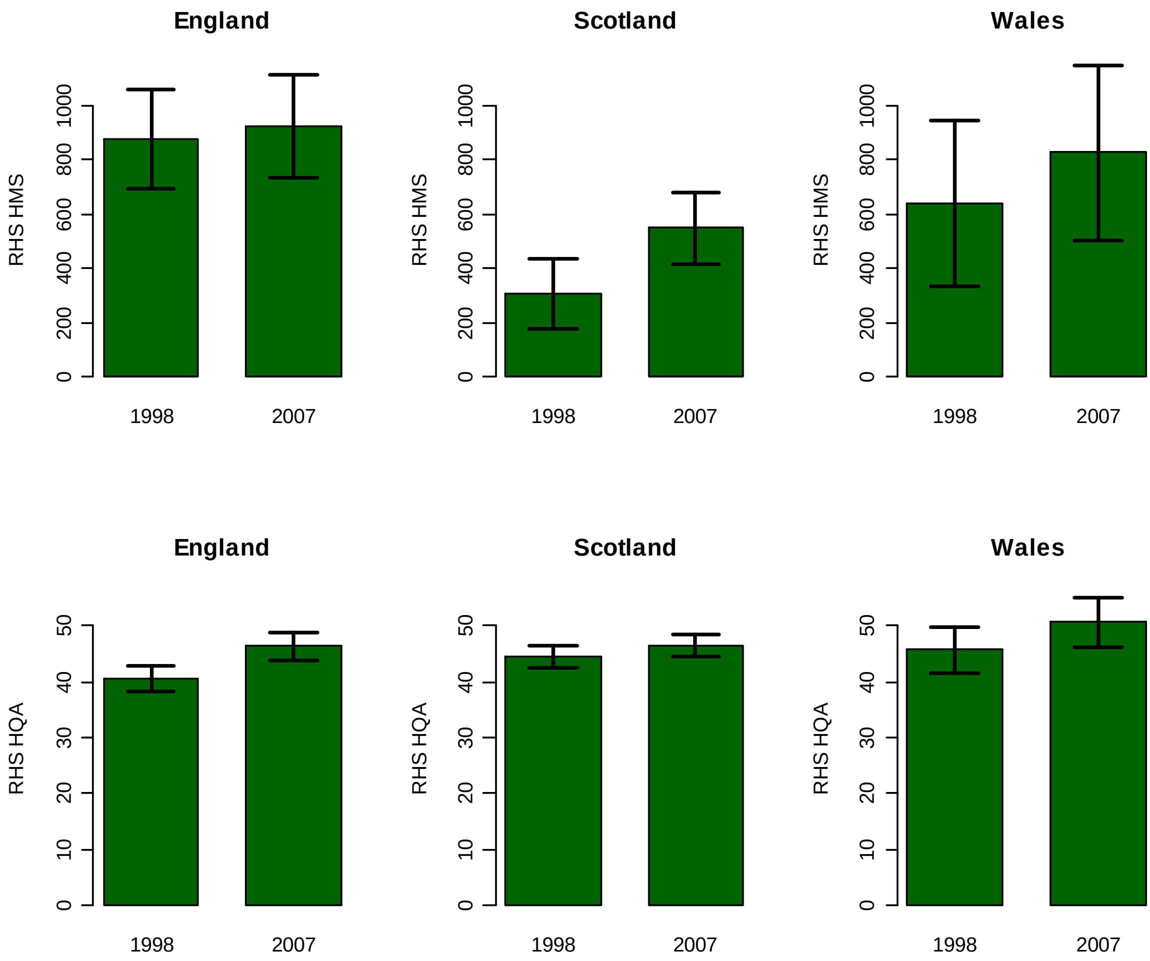


Figure 5-1. Mean values for two River Habitat Survey indices (Habitat Modification Score – HMS, and Habitat Quality Assessment Score – HQA), by country and year for all stream sites. Black bars represent 95% confidence intervals.

In general, changes in HMS and HQA were not significantly different between Environmental Zones. The one exception to this was for HMS for Scotland which did show significant differences. This manifests itself as an increase in HMS of around 600 units in EZ4 (lowlands), and decreases of around 200 units in EZ5 (intermediate uplands and islands) and EZ6 (true uplands). Hence the overall increase in HMS noted for Scotland is dominated by the increases in HMS in EZ4 (lowlands). It is worth noting that this pattern does not seem to match with the differences in the macroinvertebrate scores between Environmental Zones in Scotland.

An analysis of the changes in the HMS and HQA sub-scores was undertaken. This focused on where significant changes had been observed in the overall indices: i.e. at the Great Britain level for HQA, and at the Scotland level for HMS. This analysis should be treated as indicative rather than definitive; it needs to be treated with caution in several respects. Firstly, the effective number of separate statistical tests being undertaken has increased. There are 18 sub-scores in total, hence 18 tests. Because they are all tested in separate models, it is not straightforward to correct for this multiple comparison problem, without drastically reducing the effective power of the analysis (the ability of the analysis to detect true on the ground differences with the sample of data collected). Secondly, the sub-scores tend to be quite variable, and as some represent counts, they may not follow an underlying normal distribution. As with the same issue for overall HMS score, this may not be a problem for the change estimates, but it is worth noting, as the issue has not been examined in any detail for the sub-scores. Finally, it is important to note that several of the HQA sub-scores, channel and bank vegetation, and land use, are quantified elsewhere in Countryside Survey, albeit with a different survey extent and technique. This is also true to some extent for the trees and associated features sub-score.

Table 5-3 illustrates, on average, the changes occurring in each of the sub-scores, along with the percentage that each sub-score contributes to the total. The overall increase in HQA across Great Britain between 1998 and 2007 is the product of an increase in several of the sub-scores, which outweighs decreases in several other sub-scores. In absolute terms, the largest increases are for bank features and special features, the latter also increasing its contribution to the overall score from 3% to 6%. The largest absolute decrease is for the bank vegetation sub-score.

Table 5-3. Summary of changes in RHS habitat quality sub-scores on Great Britain dataset. See caveats in text regarding this analysis.

HQA sub-score	1998	change	2007	Percentage in 1998	Percentage in 2007
Flow types	8.0	-0.32	7.7	19%	16%
Substrate	6.1	0.02	6.1	14%	13%
Channel features	3.7	0.60	4.3	9%	9%
Bank features	3.0	1.45	4.4	7%	9%
Bank vegetation	10.2	-0.71	9.5	24%	20%
Channel vegetation	3.5	0.20	3.7	8%	8%
Land use	2.5	0.84	3.3	6%	7%
Trees and associated features	4.9	0.82	5.7	11%	12%
Special features	1.1	0.96	2.1	3%	4%
Total HQA	43.1		46.9		

For Scotland, the changes in overall HMS, noted particularly for Environmental Zone 4, is due largely to an increase in the score for resectioned bed and banks. There is also a net increase in the culverts score, but this is offset by a decrease in the bridges score, suggesting differences between the 1998 and 2007 surveys in how surveyors distinguished between these two features. Overall, the aggregate bridges plus culverts scores indicates a significant increase in EZ4. Other sub-scores are largely unchanged. The increase in score for resectioned bed and banks was investigated during analysis for the UK main and Scotland reports, photographs from the two different surveys were compared. It was concluded that this may be a surveyor effect: there was no clear evidence from the photographs that the extent of resectioning had increased.

6 Relationships with environmental variables

Some notable changes have occurred in the headwater stream quality elements between 1990 and 1998 and between 1998 and 2007. Some proportion of the improvements observed from 1990 to 1998 will be related to the fact that 1990 was a drought year, and 1998 a wet year. Ongoing hydrological modelling of CS headwater stream sites being undertaken as part of the Integrated Assessment work should help this understanding.

As reported in the Countryside Survey UK and Country Reports, there were notable changes in the character of the riparian vegetation from 1990 to 2007. In particular, there was evidence of increases in cover of woody species. It is almost axiomatic that land use and land management activities can have a negative effect on stream ecosystems, and other studies have demonstrated links between catchment land use, and particularly the quality of the riparian corridor and stream ecological status (Strayer *et al.* 2003; Allan 2004). However, such studies are generally based exclusively on spatial rather than temporal data. Multiple confounding variables and inter-correlations, both observed and unobserved make it extremely difficult to separate out the effects of specific activities or land uses. Hence it is of considerable interest to see what patterns exist in the Countryside Survey data.

Some preliminary modelling was undertaken to examine whether observed changes in stream macroinvertebrate quality, as measured by the RIVPACS/RICT observed/expected ratio for ASPT, could be explained by the following variables:

- Proportions of selected Broad Habitat types in the 1km Countryside Survey square containing the headwater streams site: arable, improved grassland and urban;
- Proportion of cover of riparian woody species (averaged for all streamside vegetation plots in the square);
- Cover weighted riparian canopy height (averaged for all streamside vegetation plots in the square);
- Extent of resectioned bed and banks, as quantified by the River Habitat Survey.

The use of an observed / expected ratio is important, as there are well-known natural spatial variations in ASPT. These variations mean that in a dataset such as Countryside Survey, variables such as % arable land use will correlate with observed ASPT, however part of this correlation is because there is more arable land use in the lowlands compared to the uplands, and expected ASPT values are lower in the lowlands compared to the uplands. ASPT was originally designed to index the effect of organic pollution on macroinvertebrates, but it is also considered to be a robust indicator of general degradation.

A subset of data was created for which RIVPACS O/E ASPT values were available, and for which there were surveys in two or three of the survey years (1990, 1998, 2007), and for which all of the above variables, except RHS data (for resectioning score), were available[3]. This dataset contained 704 samples from 249 sites. A second subset was created which met the above criteria, but which also had RHS data for both 1998 and 2007. This dataset contained 478 samples from 243 sites. In each case, two versions of the explanatory variable were used, the value for the square for the survey year, and the value for the square averaged across the three (occasionally two) survey years. The latter can only explain spatial variation in the response, while the former effectively explains temporal variation in the model.

[3] RHS was not undertaken in 1990, indeed it was only developed in the early 1990s.

The statistical modelling is a direct extension of the mixed models described above, with the mean variables acting at the site level, and the raw variables acting at the sample level. Variables were selected using a backwards selection procedure, starting with all variables in the model, then removing the least significant, and so on. Significance testing in mixed models is generally approximate; hence multiple lines of evidence were used to select variables, including changes in AIC values, t-tests for individual parameters when added to the model last, and likelihood ratio tests between nested models. The models described are multiple regression models, hence each of the variables in the minimal set of variables described is influential in the presence of the other explanatory variables.

There are several caveats to this preliminary analysis. Most notably, the use of RIVPACS/RICT O/E ASPT effectively excludes the smallest headwater streams, for which a RIVPACS Expected ASPT score is not available. However, it is the smallest headwater streams for which the Countryside Survey square represents the largest proportion of its catchment, and for which land-use controls might be expected to dominate ecological response.

The results, which will be published in the Integrated Assessment Report later in 2010, indicate that most of the above variables appear to influence O/E ASPT scores. Much of this variation appears to be spatial in nature and is associated with the mean values for the explanatory variables averaged across time for each square. In particular, between squares, increases in mean % arable, % improved grassland, % urban and cover weighted canopy height in streamside plots, are associated with decreases in O/E ASPT. Furthermore, there is a positive relationship between mean % woody cover in streamside plots and O/E ASPT. Only two variables which were time-variant, % woody cover and % arable, were influential. These acted in a different manner. Time-variant woody cover acted in the same manner as mean woody cover, it was positively associated with O/E ASPT. However, time-variant % arable acted in the opposite direction to mean % arable, the former has a positive relationship with O/E ASPT, the latter negative.

Considering just the 1998 to 2007 data, and beginning with the same significant explanatory variables noted in the previous paragraph, there was a negative spatial (time-invariant) relationship between extent of bed and bank resectioning and O/E ASPT. It is also worth noting that with this smaller dataset, the other variables all had the same relative pattern of influence. Time-variant woody cover was not significant in this model, but this may simply be due to the smaller sample size. Overall Habitat Quality Assessment Score (HQA) increased in all three countries from 1998 to 2007. There was a positive relationship between O/E ASPT and HQA, but as with other variables, this tended to be a spatial rather than temporal effect: there did not appear to be any strong evidence that improvements in HQA from 1998 to 2007 were specifically associated with improvements in O/E ASPT, although this may simply be a lack of statistical power.

7 Discussion

Countryside Survey includes an integrated survey programme of headwater streams. It has shown that for England, there has been an ongoing improvement in multiple indicators of stream ecological status over the past 17 years. These improvements probably have multiple causes, and particularly considering the 1990 and 1998 data, inter-annual climatic factors have potentially played a part. As we are currently without specific hydrological data for each headwater stream catchment, it is perhaps best to focus more on the changes from 1998 to 2007, which are more comparable years in hydrometeorological terms. A general lowering in the intensity of land management, including nutrient inputs and management of riparian vegetation are also likely to have contributed to the observed trends.

For Scotland, the picture is slightly more mixed. Plant species richness increased from 1998 to 2007 as it did in England and Wales, and macroinvertebrate indices increased from 1990 to 1998, again following the national trend. Scotland was alone in showing an improvement in Mean Trophic Rank scores from 1998 to 2007, at both stream and ditch/drain sites. However, other indices have either shown no improvement, or have declined. These declines varied regionally within Scotland, with there being declines in macroinvertebrate species richness in Environmental Zone 6 (Highlands), and increases in habitat modification in Environmental Zone 4 (Lowlands). At this time, although several potential causes of this have been ruled out, it is not possible to ascribe these declines to any individual cause. The observed significant increases in Habitat Modification Score in Scotland may simply be due to better identification of resectioning by the surveyors in 2007 compared to 1998. Resectioning, especially if it had occurred many years ago, can be difficult to identify, and the Environment Agency River Habitat Survey team have put considerable effort into consistency of training of surveyors in recent years, including guidance on the identification of resectioning. Hence, although caution is warranted in interpreting the change figures for Habitat Modification Score, the 2007 estimates should be considered a more realistic estimate of modification than the 1998 figures.

Differences can also arise from slight changes in the location of the survey reach from year to year, these changes will be minimised in future surveys through the ongoing use of GPS locations. It is notable that overall macroinvertebrate status, as measured by numbers of sites in the high or good status categories, is still no lower in EZ6 than any other EZ. Improvements in MTR score suggest reductions in levels of inorganic nutrients in waters across Scotland (there was no difference between Environmental Zones in Scotland).

For Wales, similar patterns for plant species richness and macroinvertebrate indices exist as for Scotland, however the declines observed for macroinvertebrate taxon richness in Scotland from 1998 to 2007 are not apparent in the data for Wales. Other patterns in Wales appear to follow either those in England or Scotland, but are not significant for Wales alone due to the lower sample size in Wales. Although sample size was increased for the 2007 terrestrial surveys in Wales, the freshwater survey squares remained the same as 1998, and this has undoubtedly affected statistical power to detect change.

Analysis of changes in prevalence of individual macroinvertebrate taxa is potentially subject to a number of confounding factors, including differences in numbers of sites sampled in the different survey years, difficulties in consistently sampling very small and/or surface dwelling taxa, and inherent variability in populations. It is possible that the choice of the most prevalent taxa (those present in at least 10% of samples in individual countries) may bias results, in the sense that more prevalent taxa may be considered to be more cosmopolitan in their preferences. However, the taxa chosen include many with well known affinities for faster flowing and clean water. Moving into the rarer taxa will doubtless demonstrate further variability in prevalence changes, but with considerable added uncertainty arising from small sample sizes. This is a general issue with the Countryside Survey sampling design: it is an unbiased census rather than a survey for specific rare taxa and has been recognised in the caveats in using Countryside Survey data on Priority Habitats (Carey *et al.* 2008).

Numbers of ditch/drain sites are relatively small, and do not generally show significant changes, although the macroinvertebrate indices often follow the same patterns as for the stream sites, and the MTR scores for Scotland again follow the pattern of the Scottish stream sites. It is notable that the declines in species richness observed for streams in Scotland EZ6 do not appear to occur at the ditch/drain sites, where there is a significant increase. It is likely that ditch/drain sites have a more uniform physical habitat, and hence may be less sensitive to small changes in sampling location than the stream sites, however it is unlikely that small changes in the locations of stream survey sites in 2007 would explain the overall decline. This is the first time that the ditch/drain data have been analysed and compared to the streams data and, despite the much small numbers of sites, indications are that they are a valuable complement and contrast to the streams data.

Results from the quality assurance and taxonomy audit exercises for macroinvertebrates have shown good agreement in taxonomy audit, but have illustrated that there have been issues with relocating sites in surveys nearly ten years apart. With the improvements in mapping and use of GPS technology in 2007, it is less likely that such problems will reoccur in future surveys.

Countryside Survey has provided the opportunity for some methodological development, particularly to address the issue that changes in species richness measures need careful interpretation. For macroinvertebrates, the index based on community dissimilarity showed less improvement than that based on numerical species richness. This suggests that some of the taxa that were gained at sites between 1990 and 2007 were not necessarily ones that were expected to occur at those sites under reference conditions. This highlights a potential weakness with the use of the RIVPACS/RICT O/E TAXA index as an index of general degradation in routine biomonitoring. It is not always desirable to just have a greater richness of taxa at a studied site. For example, an increase in species richness beyond what would be expected for a nutrient-poor mountain stream many indicate degradation. What is more important is that the assemblage of observed taxa is similar to that found at comparable reference sites. It may be that the streams are recovering from their previous degraded state but the recovery path is leading them to a different community than that expected by RIVPACS/RICT. However, this analysis has been novel and provisional, further investigation will be required to understand what processes are behind these patterns.

The results presented in Section 6 will be expanded in the ongoing Integrated Assessment work to cover more explanatory variables, at multiple spatial scales. However, the results so far are extremely promising, and illustrate the power of integrated analyses involving the Countryside Survey dataset. Most of the results so far are as might be expected. The main exception to this is the positive relationship between time-varying % arable land and O/E ASPT, which will need some further investigation. There are several potential factors by which woody cover could be influential, including its association with wood in the stream channel, and also the use of tree cover by adult aquatic insects which tend to score highly under the BMWP system. The negative relationship between cover weighted canopy height and O/E ASPT is interesting, this could relate to this variable being an indicator of nutrient enrichment. Despite the relatively simple approach taken in this preliminary work, they demonstrate strong potential relationships between land management and freshwater quality. The results are undoubtedly helped by the extensive scope of the Countryside Survey, and the fact that the same surveys are repeated through time. Further relationships are likely to emerge as part of the Countryside Survey Integrated Assessment activity.

8 Conclusions

- Trends in headwater stream ecological status between 1990 and 2007 are broadly positive.
- As reported previously, headwater stream macroinvertebrate status improved in all countries from 1990 to 1998, it is likely that part of this improvement is related to climatic conditions in the survey years.
- For 1998 to 2007, the results are slightly more mixed, with the majority of indicators showing ongoing improvements in England, either no change or declines in Scotland, and improvements or no change in Wales.
- For England, on average, there have been ongoing improvements in stream macroinvertebrate status indicators, and increases in numbers of aquatic plant species.
- For south east lowland England, the proportion of sites at good or high ecological status is still low (30%).
- For Scotland, macroinvertebrate indices did not improve from 1998 to 2007, but there were improvements in nutrient status, as measured by aquatic plants.
- In many cases, there were no regional differences in the trend patterns within countries, however there were two exceptions in Scotland, where there was a decline in macroinvertebrate species richness for Environmental Zone 6 (Highlands) and an increase in habitat modification in Environmental Zone 4 (Lowlands). This latter result may reflect improvements in surveyors' ability to identify certain modifications.
- Numbers of ditch/drain sites are relatively small, and do not generally show significant changes.
- There is some evidence that increases in the numbers of macroinvertebrate species, which are associated with degraded sites moving towards a minimally-impacted reference state, may not completely correspond to the actual taxa expected to occur at that reference state.
- Analysis of changes in prevalence of the more common individual taxa has shown a balance of more taxa increasing in prevalence than decreasing.
- Provisional analysis, relating biological responses to characteristics of land cover from Countryside Survey squares has demonstrated negative effects associated with intensive land uses (arable, improved grassland and urban). There is a positive effect associated with cover of woody species.

9 References

All Countryside Survey reports are available from http://www.countrysidesurvey.org.uk/outputs.html

Allan J.D. (2004) Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. *Annual Review of Ecology, Evolution, and Systematics,* **35,** 257-284.

Bray J.R. & Curtis J.T. (1957) An ordination of the upland forest communities in southern Wisconsin. *Ecological Monographs,* **27**.

Brookes A. (1988) *Channelised Rivers: Perspectives for Environmental Management,* John Wiley & Sons, Chichester.

Burnham K.P. & Anderson D.R. (2002) *Model Selection and Multi-model Inference: A Practical Information-theoretic Approach,* Springer-Verlag, New York.

Carey P.D., Wallis S., Chamberlain P.M., Cooper A., Emmett B.A., Maskell L.C., Mccann T., Murphy J., Norton L.R., Reynolds B., Scott W.A., Simpson I.C., Smart S.M. & Ullyett J.M. (2008) *Countryside Survey: Results from 2007,* NERC/Centre for Ecology & Hydrology, CEH Project Number: C03259.

Clarke R.T. (2000) Uncertainty in estimates of river quality based on RIVPACS. In: *Assessing the biological quality of freshwaters: RIVPACS and similar techniques.* (Eds J.F. Wright & D.W. Sutcliffe & M.T. Furse), pp. 39-54. Freshwater Biological Association, Ambleside.

Clarke R.T., Furse M.T., Gunn R.J.M., Winder J.M. & Wright J.F. (2002) Sampling variation in macroinvertebrate data and implications for river quality indices. *Freshwater Biology,* **47,** 1735-1751.

Clarke R.T., Furse M.T., Wright J.F. & Moss D. (1996) Derivation of a biological quality index for river sites: comparison of the observed with the expected fauna. *Journal of Applied Statistics,* **23,** 311-332.

Countryside Survey (2009) *Countryside Survey: England Results from 2007,* NERC/Centre for Ecology & Hydrology, Department for Environment, Food and Rural Affairs, Natural England, (CEH Project Number: C03259).

Davy-Bowker J., Clarke R.T., Corbin T.A., Vincent H., Pretty J.L., Hawczak A., Murphy J. & Jones J.I. (2008) *River invertebrate classification tool: Final Report. ,* Scottish and Northern Ireland Forum for Environmental Research (SNIFFER Project WFD72c). Edinburgh, UK.

Davy-Bowker J., Murphy J.F., Rutt G.R., Steel J.E.C. & Furse M.T. (2005) The development and testing of a macroinvertebrate biotic index for detecting the impact of acidity on streams. *Archiv fűr Hydrobiologie,* **163,** 383-403.

Environment Agency (2003) *River Habitat Survey in Britain and Ireland. Field Survey Guidance Manual: 2003 version* Environment Agency, Bristol , UK.

Furse M.T., Davy-Bowker J., Dawson F.H., Gunn R.J.M., Blackburn J.H., Gunn I.M., Winder J.M., Scarlett P.M., Gravelle M., Kneebone N., Nesbitt I., Amarillo M., Brereton C., Cannan C., Collett G., Collier D., Cooper G., Dent M., Fairfax C.M., Hardie D., Henville P., Hilton C., James B., Moorhouse C., Randle Z., Shirley C., Small S.R., Vowles K.E., Clarke R.T. & Watkins J.W. (2002) *Countryside Survey 2000. Module 2: Freshwater Studies,* Environment Agency R&D Technical Report E1-038/TR1.

Furse M.T., Winder J.M., Symes K.L. & Clarke R.T. (1991) *The faunal richness of headwater streams. A review of existing information. ,* Institute of Freshwater Ecology report to the National Rivers Authority, R&D Project 242, publication reference P-96.

Holmes N.T.H., Newman J.R., Chadd S., Rouen K.J., Sharp L. & Dawson F.H. (1999) *Mean Trophic Rank: A users' manual. ,* R&D Technical Report No E38. Bristol: Environment Agency.

Hothorn T., Bretz F. & Westfall P. (2008) Simultaneous Inference in General Parametric Models. *Biometrical Journal,* **50,** 346-363.

Millennium Ecosystem Assessment (Ma) (2006) *Millennium Ecosystem Assessment Synthesis Reports*.

Murphy J. & Weatherby A. (2008) *CS Technical Report No.5/07. Freshwater Manual,* NERC/Centre for Ecology and Hydrology. CEH Project Number: C03259.

Murphy J., Williams P., Scarlett P. & Clarke R.T. (2008) *Quality Assurance Report: surveying condition of headwater streams and ponds,* NERC/Centre for Ecology and Hydrology. CEH Project Number: C03259.

Murray-Bligh J. (1999) *Procedures for collecting and analysing macroinvertebrate samples - BT001,* Environment Agency, Bristol.

Norton L., Smart S., Murphy J., Weatherby A., Maskell L. & Carey P. (2006) *Countryside Survey 2007 Field Handbook*.

Norton L.R., Murphy J., Reynolds B., Marks S. & Mackey E.C. (2009) *Countryside Survey: Scotland Results from 2007. ,* NERC/Centre for Ecology & Hydrology, The Scottish Government, Scottish Natural Heritage. CEH Project Number: C03259.

Orr H.G., Jacobs R. & Dunbar M.J. (2010) *Freshwater ecological response to recent climate change in England and Wales,* Environment Agency Science Report SC080009/SR.

Pinheiro J.C. & Bates D.M. (2000) *Mixed-effects Models in S and S-Plus,* Springer-Verlag, New York.

R Development Core Team (2009) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria, ISBN 3-900051-07-0.

Scott W.A. (2008) *CS Technical Report No.4/07: Statistical Report,* Centre for Ecology and Hydrology.

Smart S.M., Allen D., Murphy J., Carey P., Emmett B.A., Reynolds B., Simpson I.C., Evans R.A., Skates J., Scott W.A., Maskell L.C., Norton L.R., Rossall M.J. & Wood C. (2009) Countryside Survey: Wales Results from 2007. . p. 94. NERC/Centre for Ecology & Hydrology, Welsh Assembly Government, Countryside Council for Wales, pp. (CEH Project Number: C03259).

Strahler A.N. (1957) Quantitative analysis of watershed geomorphology. *Transactions of the American Geophysical Union,* **8,** 913-920.

Strayer D.L., Beighley R.E., Thompson L.C., Brooks S., Nilsson C., Pinay G. & Naiman R.J. (2003) Effects of Land Cover on Stream Ecosystems: Roles of Empirical Models and Scaling Issues. *Ecosystems,* **6,** 407-423.

Van Sickle J. (2008) An index of compositional dissimilarity between the observed and expected assemblage. *Journal of the North American Benthological Society,* **27,** 227-235.

Wright J.F., Sutcliffe D.W. & Furse M.T. (2000) *Assessing the Biological Quality of Fresh Waters: RIVPACS and other techniques,* Freshwater Biological Association, Ambleside, UK.

10 Appendix

Table 10-1. England: proportions of sampled sites at which selected macroinvertebrate taxa were observed in 1990, 1998 and 2007. Taxa shown which occur in 10% or more samples in England.

Common name	Family	Taxon Name	1990	1998	2007
Alderflies	Sialidae	*Sialis lutaria* (Linnaeus, 1758)	0.15	0.11	0.10
Beetles	Dytiscidae	*Ilybius sp.*	0.19	0.11	0.15
Beetles	Dytiscidae	*Platambus maculatus* (Linnaeus, 1758)	0.15	0.10	0.12
Beetles	Elmidae	*Elmis aenea* (Müller, 1806)	0.23	0.36	0.45
Beetles	Elmidae	*Limnius volckmari* (Panzer, 1793)	0.13	0.22	0.20
Beetles	Elmidae	*Oulimnius sp.*	0.08	0.14	0.27
Beetles	Helophoridae	*Helophorus (Rhopalohelophorus) brevipalpis* Bedel, 1881	0.20	0.06	0.19
Beetles	Hydrophilidae	*Anacaena globulus* (Paykull, 1829)	0.18	0.14	0.19
Beetles	Scirtidae	*Elodes* group	0.19	0.30	0.35
Bugs	Veliidae	*Velia sp.*	0.15	0.21	0.40
Caddisflies	Glossosomatidae	*Agapetus sp.*	0.06	0.13	0.17
Caddisflies	Hydropsychidae	*Hydropsyche siltalai* Döhler, 1963	0.08	0.12	0.15
Caddisflies	Limnephilidae	*Chaetopteryx villosa* (Fabricius, 1798)	0.13	0.13	0.15
Caddisflies	Limnephilidae	*Micropterna sp.*	0.06	0.22	0.08
Caddisflies	Limnephilidae	*Potamophylax sp.*	0.07	0.09	0.10
Caddisflies	Odontoceridae	*Odontocerum albicorne* (Scopoli, 1763)	0.06	0.09	0.15
Caddisflies	Polycentropodidae	*Plectrocnemia conspersa* (Curtis, 1834)	0.14	0.26	0.20
Caddisflies	Rhyacophilidae	*Rhyacophila dorsalis* (Curtis, 1834)	0.08	0.17	0.22
Caddisflies	Sericostomatidae	*Sericostoma personatum* (Spence in Kirby & Spence, 1826)	0.13	0.17	0.15
Flatworms	Planariidae	*Polycelis felina* (Dalyell, 1814)	0.06	0.18	0.24
Flatworms	Planariidae	*Polycelis nigra* group	0.07	0.16	0.17
Freshwater shrimps	Crangonyctidae	*Crangonyx pseudogracilis* Bousfield, 1958	0.07	0.10	0.17
Freshwater shrimps	Gammaridae	*Gammarus pulex* (Linnaeus, 1758)	0.57	0.57	0.69
Leeches	Erpobdellidae	*Erpobdella octoculata* (Linnaeus, 1758)	0.20	0.22	0.20
Leeches	Glossiphoniidae	*Glossiphonia complanata* (Linnaeus, 1758)	0.27	0.40	0.37
Leeches	Glossiphoniidae	*Helobdella stagnalis* (Linnaeus, 1758)	0.11	0.13	0.19
Mayflies	Baetidae	Alainites *muticus* (Linnaeus, 1758)	0.12	0.09	0.24
Mayflies	Baetidae	*Baetis rhodani* (Pictet, 1843-1845)	0.23	0.45	0.51
Mayflies	Baetidae	*Baetis scambus* group	0.08	0.06	0.10
Mayflies	Baetidae	*Baetis vernus* Curtis, 1834	0.12	0.11	0.20
Mayflies	Ephemerellidae	*Serratella ignita* (Poda, 1761)	0.11	0.12	0.22
Mayflies	Ephemeridae	*Ephemera sp.*	0.12	0.10	0.13
Mayflies	Heptageniidae	*Ecdyonurus sp.*	0.15	0.18	0.20
Mayflies	Heptageniidae	*Rhithrogena sp.*	0.07	0.14	0.14
Mayflies	Leptophlebiidae	*Habrophlebia fusca* (Curtis, 1834)	0.04	0.09	0.21
Mussels & Cockles	Sphaeriidae	*Pisidium sp.*	0.46	0.64	0.63
Mussels & Cockles	Sphaeriidae	*Sphaerium* group	0.08	0.09	0.08
Segmented Worms		Oligochaeta	0.73	0.86	0.93
Snails & Limpets	Hydrobiidae	*Potamopyrgus antipodarum* (J.E.Gray, 1843)	0.42	0.46	0.49
Snails & Limpets	Lymnaeidae	*Radix balthica* (Linnaeus, 1758)	0.31	0.32	0.31
Snails & Limpets	Planorbidae	*Ancylus fluviatilis* O.F. Müller, 1774	0.10	0.19	0.17
Snails & Limpets	Planorbidae	*Anisus (Disculifer) vortex* (Linnaeus, 1758)	0.08	0.08	0.11
Stoneflies	Leuctridae	*Leuctra fusca* (Linnaeus, 1758)	0.13	0.14	0.25
Stoneflies	Nemouridae	*Nemurella picteti* Klapálek, 1900	0.11	0.11	0.11
Stoneflies	Perlodidae	*Isoperla grammatica* (Poda, 1761)	0.07	0.11	0.14
True-flies		Chironomidae	0.82	0.83	0.96
True-flies	Ceratopogonidae	Ceratopogonidae	0.16	0.28	0.47
True-flies	Dixidae	*Dixa maculata* complex	0.11	0.12	0.17
True-flies	Empididae	*Chelifera* group	0.06	0.12	0.15
True-flies	Empididae	Clinocerinae	0.07	0.15	0.20
True-flies	Ephydridae	Ephydridae	0.06	0.09	0.14
True-flies	Limoniidae	*Eloeophila sp.*	0.14	0.24	0.22
True-flies	Limoniidae	*Pilaria sp.*	0.06	0.14	0.09
True-flies	Pediciidae	*Dicranota sp.*	0.29	0.45	0.46
True-flies	Psychodidae	*Pericoma* group	0.24	0.36	0.40
True-flies	Ptychopteridae	*Ptychoptera sp.*	0.08	0.12	0.13
True-flies	Simuliidae	*Simulium (Eusimulium) aureum* group	0.08	0.08	0.20
True-flies	Simuliidae	*Simulium (Nevermannia) cryophilum* group	0.14	0.18	0.26
True-flies	Simuliidae	*Simulium (Simulium) ornatum* group	0.12	0.29	0.34
True-flies	Tipulidae	*Tipula (Yamatotipula) montium* group	0.12	0.19	0.16
Water mites		Hydracarina	0.18	0.20	0.36
Waterslaters	Asellidae	*Asellus aquaticus* (Linnaeus, 1758)	0.23	0.29	0.38
Waterslaters	Asellidae	*Proasellus meridianus* (Racovitza, 1919)	0.15	0.17	0.10

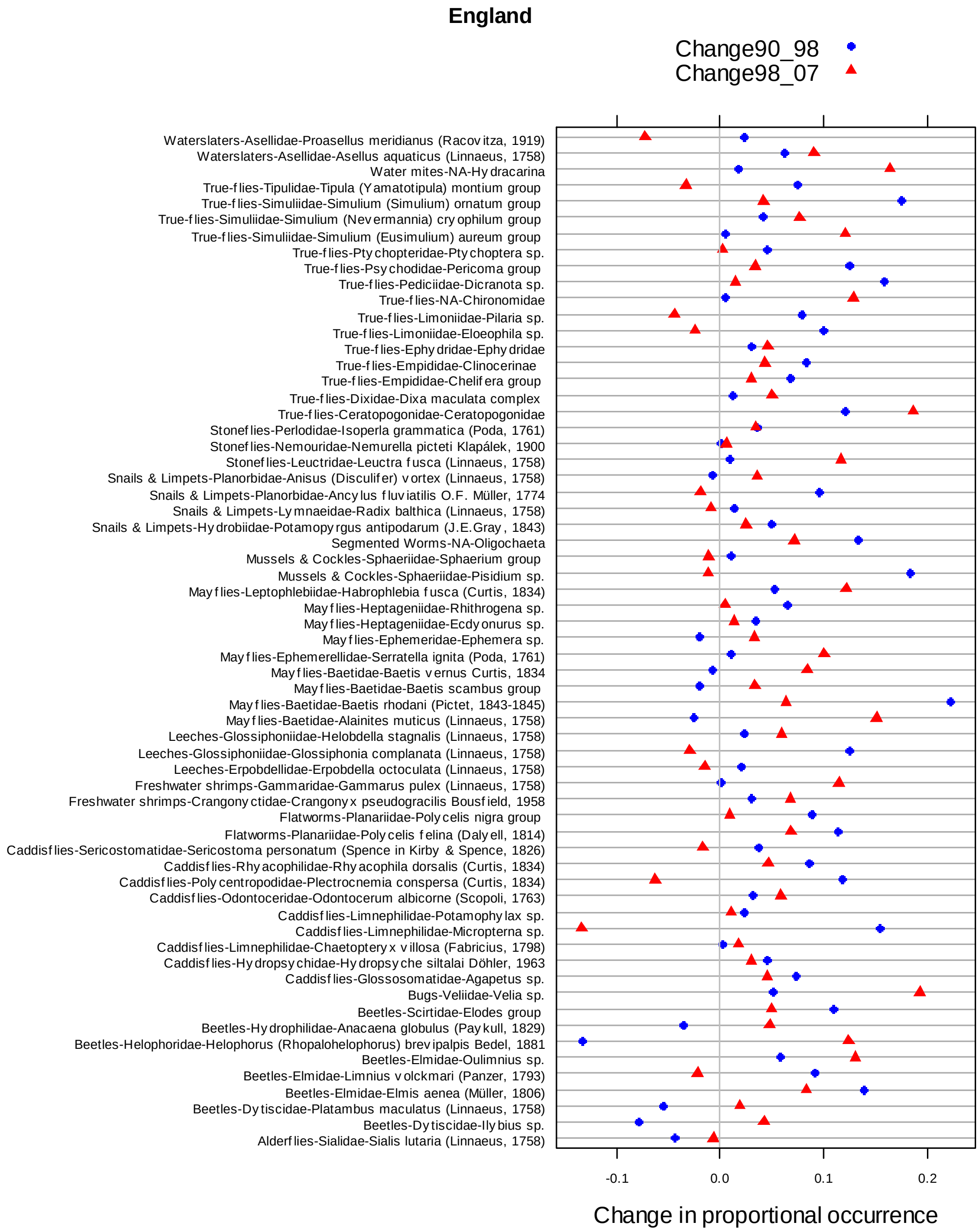


Figure 10-1. England: change in proportional occurrence for selected macroinvertebrate taxa for 1990 to 1998 (blue) and 1998 to 2007 (red) for taxa which occur in 10% or more of all samples in England.

Figure 10-2. England: change in proportional occurrence for 1990 to 2007 for taxa which occur in 10% or more of all samples in England.

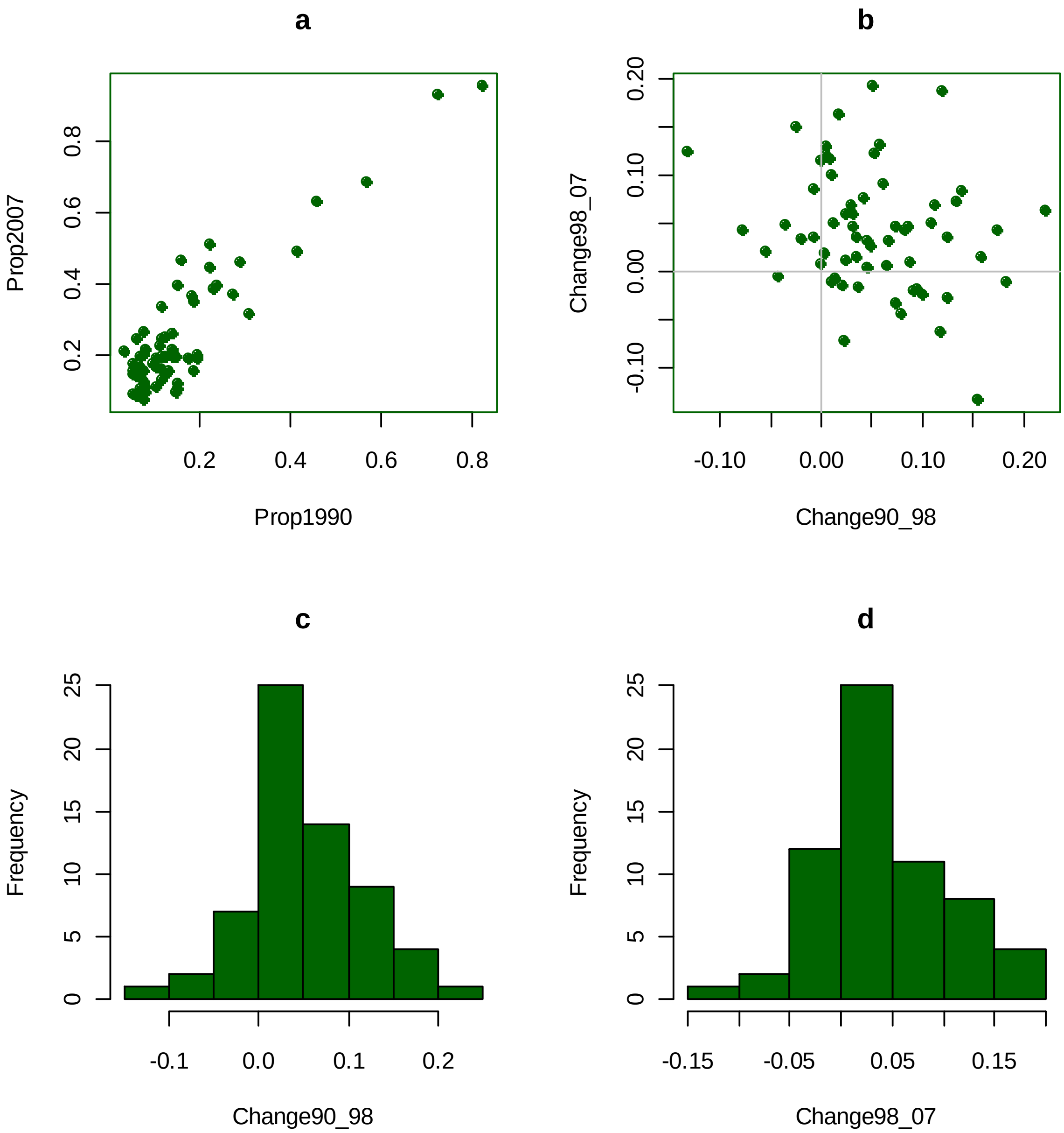


Figure 10-3. England – selected macroinvertebrate taxa (which occur in 10% or more samples in England): a. relationship between proportion of occurrence for 1990 and 2007, b. relationship between change in proportion of occurrence from 1990 to 1998 and 1998 to 2007, c. histogram for 1990 to 1998 change, d. histogram for 1998 to 2007 change.

Table 10-2. Scotland: proportions of sampled sites at which taxa were observed in 1990, 1998 and 2007. Taxa shown which occur in 10% or more samples in Scotland.

Common name	Family	Taxon Name	1990	1998	2007
Beetles	Dytiscidae	*Oreodytes sanmarkii* (C.R. Sahlberg, 1826)	0.16	0.12	0.17
Beetles	Elmidae	*Elmis aenea* (Müller, 1806)	0.29	0.49	0.54
Beetles	Elmidae	*Limnius volckmari* (Panzer, 1793)	0.22	0.37	0.33
Beetles	Elmidae	*Oulimnius sp.*	0.12	0.22	0.41
Beetles	Hydraenidae	*Hydraena gracilis* Germar, 1824	0.06	0.20	0.25
Beetles	Hydrophilidae	*Anacaena globulus* (Paykull, 1829)	0.20	0.23	0.29
Beetles	Scirtidae	*Elodes* group	0.23	0.42	0.34
Bugs	Veliidae	*Velia sp.*	0.30	0.40	0.62
Caddisflies	Glossosomatidae	*Agapetus sp.*	0.06	0.15	0.12
Caddisflies	Goeridae	*Silo pallipes* (Fabricius, 1781)	0.07	0.11	0.15
Caddisflies	Hydropsychidae	*Hydropsyche siltalai* Döhler, 1963	0.11	0.19	0.18
Caddisflies	Hydroptilidae	*Hydroptila sp.*	0.10	0.14	0.17
Caddisflies	Hydroptilidae	*Oxyethira sp.*	0.07	0.16	0.15
Caddisflies	Limnephilidae	*Chaetopteryx villosa* (Fabricius, 1798)	0.13	0.17	0.13
Caddisflies	Limnephilidae	*Drusus annulatus* (Stephens, 1837)	0.09	0.17	0.14
Caddisflies	Limnephilidae	*Micropterna sp.*	0.02	0.18	0.11
Caddisflies	Limnephilidae	*Potamophylax sp.*	0.08	0.18	0.09
Caddisflies	Philopotamidae	*Philopotamus montanus* (Donovan, 1813)	0.07	0.14	0.17
Caddisflies	Polycentropodidae	*Plectrocnemia conspersa* (Curtis, 1834)	0.34	0.50	0.40
Caddisflies	Polycentropodidae	*Polycentropus flavomaculatus* (Pictet, 1834)	0.13	0.19	0.12
Caddisflies	Rhyacophilidae	*Rhyacophila dorsalis* (Curtis, 1834)	0.22	0.35	0.27
Caddisflies	Sericostomatidae	*Sericostoma personatum* (Spence in Kirby & Spence, 1826)	0.09	0.15	0.11
Flatworms	Planariidae	*Polycelis felina* (Dalyell, 1814)	0.03	0.13	0.14
Shrimps	Gammaridae	*Gammarus pulex* (Linnaeus, 1758)	0.24	0.34	0.34
Leeches	Glossiphoniidae	*Glossiphonia complanata (*Linnaeus, 1758)	0.11	0.18	0.15
Leeches	Glossiphoniidae	*Helobdella stagnalis* (Linnaeus, 1758)	0.08	0.16	0.07
Mayflies	Baetidae	*Alainites muticus* (Linnaeus, 1758)	0.09	0.18	0.24
Mayflies	Baetidae	*Baetis rhodani* (Pictet, 1843-1845)	0.49	0.67	0.68
Mayflies	Baetidae	*Baetis vernus* Curtis, 1834	0.13	0.19	0.20
Mayflies	Ephemerellidae	*Serratella ignita* (Poda, 1761)	0.14	0.20	0.28
Mayflies	Heptageniidae	*Ecdyonurus sp.*	0.18	0.31	0.27
Mayflies	Heptageniidae	*Electrogena sp.*	0.11	0.25	0.18
Mayflies	Heptageniidae	*Rhithrogena sp.*	0.15	0.30	0.29
Mussels & Cockles	Sphaeriidae	*Pisidium sp.*	0.32	0.49	0.46
Segmented Worms		Oligochaeta	0.77	0.94	0.90
Snails & Limpets	Hydrobiidae	*Potamopyrgus antipodarum* (J.E.Gray, 1843)	0.13	0.21	0.25
Snails & Limpets	Lymnaeidae	*Radix balthica* (Linnaeus, 1758)	0.22	0.27	0.23
Snails & Limpets	Planorbidae	*Ancylus fluviatilis* O.F. Müller, 1774	0.11	0.23	0.18
Stoneflies	Chloroperlidae	*Siphonoperla torrentium* (Pictet, 1841)	0.11	0.18	0.21
Stoneflies	Leuctridae	*Leuctra fusca* (Linnaeus, 1758)	0.24	0.42	0.39
Stoneflies	Leuctridae	*Leuctra hippopus* Kempny, 1899	0.16	0.34	0.21
Stoneflies	Leuctridae	*Leuctra inermis* Kempny, 1899	0.08	0.18	0.13
Stoneflies	Leuctridae	*Leuctra nigra* (Olivier, 1811)	0.06	0.13	0.12
Stoneflies	Nemouridae	*Amphinemura sulcicollis* (Stephens, 1836)	0.11	0.16	0.12
Stoneflies	Nemouridae	*Nemurella picteti* Klapálek, 1900	0.08	0.12	0.12
Stoneflies	Nemouridae	*Protonemura meyeri* (Pictet, 1841)	0.11	0.20	0.18
Stoneflies	Nemouridae	*Protonemura praecox* (Morton, 1894)	0.12	0.15	0.11
Stoneflies	Perlodidae	*Isoperla grammatica* (Poda, 1761)	0.18	0.33	0.24
Stoneflies	Perlodidae	*Perlodes microcephalus* (Pictet, 1833)	0.08	0.16	0.15
True-flies		Chironomidae	0.81	0.96	0.94
True-flies	Ceratopogonidae	Ceratopogonidae	0.07	0.21	0.28
True-flies	Empididae	*Chelifera* group	0.07	0.14	0.14
True-flies	Empididae	*Clinocerinae*	0.12	0.32	0.22
True-flies	Limoniidae	*Eloeophila sp.*	0.14	0.32	0.22
True-flies	Pediciidae	*Dicranota sp.*	0.40	0.68	0.57
True-flies	Psychodidae	*Pericoma* group	0.15	0.28	0.33
True-flies	Simuliidae	*Simulium (Eusimulium) aureum* group	0.08	0.16	0.14
True-flies	Simuliidae	*Simulium (Nevermannia) cryophilum* group	0.26	0.40	0.30
True-flies	Simuliidae	*Simulium (Nevermannia) vernum* group	0.02	0.17	0.17
True-flies	Simuliidae	*Simulium (Simulium) argyreatum* group	0.08	0.17	0.20
True-flies	Simuliidae	*Simulium (Simulium) ornatum* group	0.19	0.42	0.36
True-flies	Tipulidae	*Tipula (Yamatotipula) montium* group	0.08	0.19	0.09
Water mites		Hydracarina	0.11	0.25	0.40

Figure 10-4. Scotland: change in proportional occurrence for 1990 to 1998 (blue) and 1998 to 2007 (red) for taxa which occur in 10% or more of all samples in Scotland.

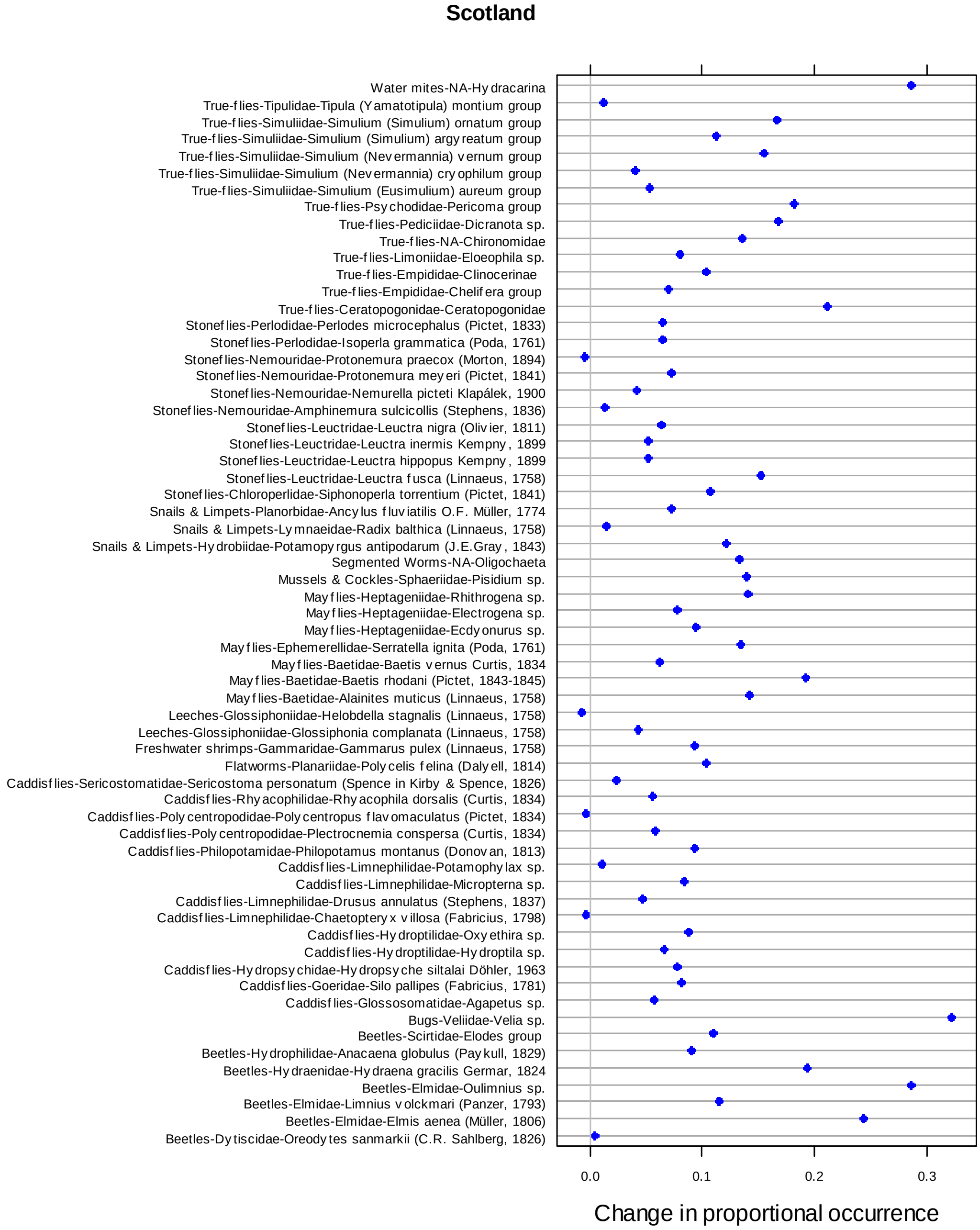


Figure 10-5. Scotland: change in proportional occurrence for 1990 to 2007 for taxa which occur in 10% or more of all samples in Scotland.

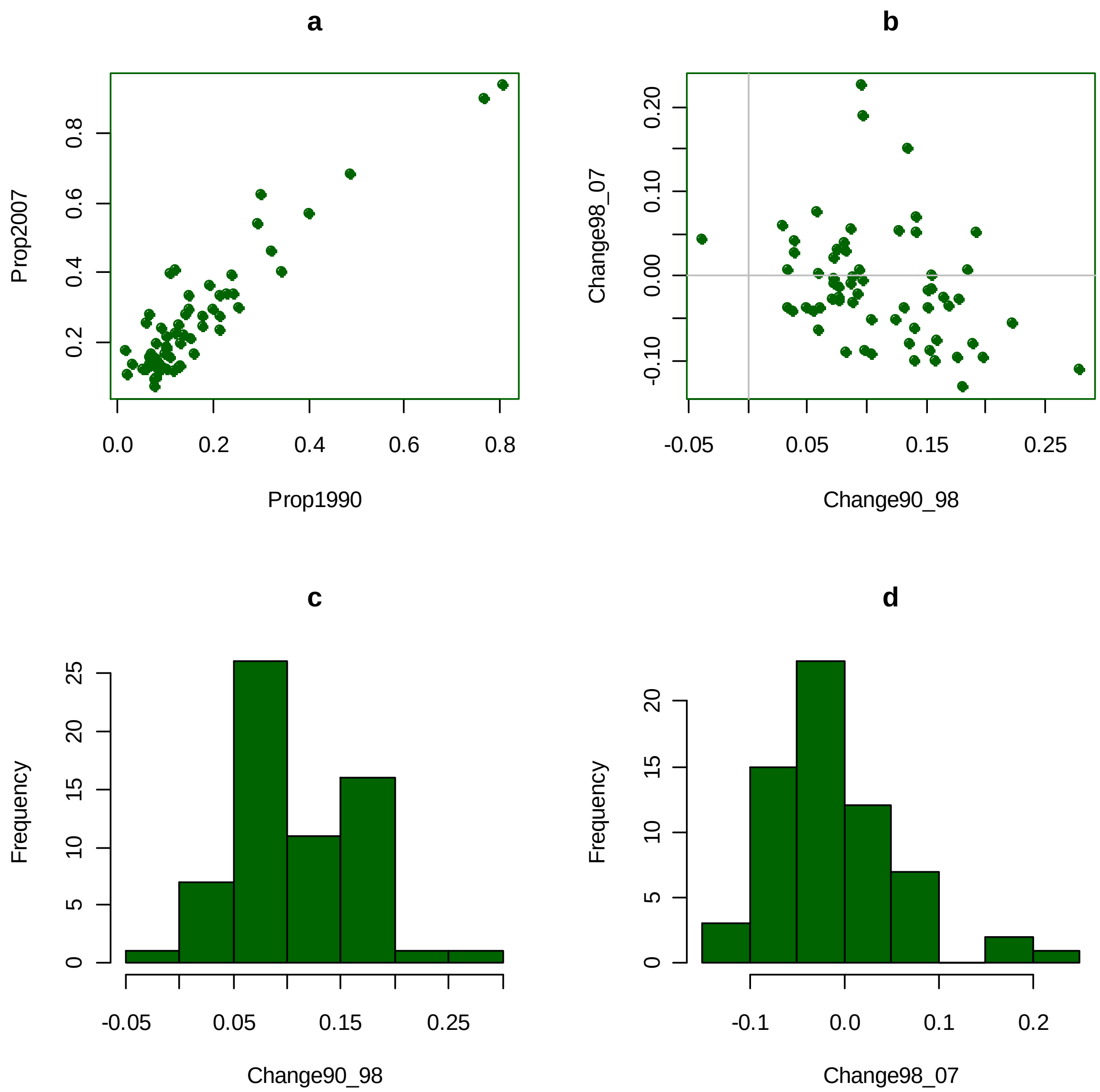


Figure 10-6. Scotland – selected macroinvertebrate taxa (which occur in 10% or more samples in Scotland): a. relationship between proportion of occurrence for 1990 and 2007, b. relationship between change in proportion of occurrence from 1990 to 1998 and 1998 to 2007, c. histogram for 1990 to 1998 change, d. histogram for 1998 to 2007 change.

Table 10-3. Wales: proportions of sampled sites at which taxa were observed in 1990, 1998 and 2007. Taxa shown which occur in 10% or more samples in Wales.

Common Name	Family	Taxon_Name	1990	1998	2007
Beetles	Dytiscidae	*Oreodytes sanmarkii* (C.R. Sahlberg, 1826)	0.28	0.06	0.16
Beetles	Dytiscidae	*Platambus maculatus* (Linnaeus, 1758)	0.23	0.06	0.11
Beetles	Elmidae	*Elmis aenea* (Müller, 1806)	0.33	0.36	0.42
Beetles	Elmidae	*Limnius volckmari* (Panzer, 1793)	0.18	0.23	0.37
Beetles	Elmidae	*Oulimnius sp.*	0.08	0.17	0.29
Beetles	Helophoridae	*Helophorus (Rhopalohelophorus) brevipalpis* Bedel, 1881	0.18	0.09	0.18
Beetles	Hydraenidae	*Hydraena gracilis* Germar, 1824	0.23	0.11	0.18
Beetles	Hydrophilidae	*Anacaena globulus* (Paykull, 1829)	0.13	0.09	0.13
Beetles	Scirtidae	*Elodes* group	0.33	0.40	0.29
Bugs	Veliidae	*Velia sp.*	0.36	0.21	0.16
Caddisflies	Glossosomatidae	*Agapetus sp.*	0.23	0.30	0.18
Caddisflies	Goeridae	*Silo pallipes* (Fabricius, 1781)	0.10	0.23	0.11
Caddisflies	Hydropsychidae	*Diplectrona felix* McLachlan, 1878	0.08	0.19	0.05
Caddisflies	Hydropsychidae	*Hydropsyche instabilis* (Curtis, 1834)	0.15	0.13	0.08
Caddisflies	Hydropsychidae	*Hydropsyche siltalai* Döhler, 1963	0.15	0.17	0.18
Caddisflies	Limnephilidae	*Chaetopteryx villosa* (Fabricius, 1798)	0.18	0.15	0.11
Caddisflies	Limnephilidae	*Potamophylax sp.*	0.03	0.19	0.18
Caddisflies	Odontoceridae	*Odontocerum albicorne* (Scopoli, 1763)	0.15	0.21	0.18
Caddisflies	Philopotamidae	*Philopotamus montanus* (Donovan, 1813)	0.13	0.19	0.18
Caddisflies	Philopotamidae	*Wormaldia sp.*	0.05	0.13	0.16
Caddisflies	Polycentropodidae	*Plectrocnemia conspersa* (Curtis, 1834)	0.23	0.32	0.11
Caddisflies	Rhyacophilidae	*Rhyacophila dorsalis* (Curtis, 1834)	0.36	0.38	0.37
Caddisflies	Sericostomatidae	*Sericostoma personatum* (Spence in Kirby & Spence, 1826)	0.26	0.21	0.37
Flatworms	Planariidae	*Polycelis felina* (Dalyell, 1814)	0.10	0.06	0.16
Freshwater shrimps	Gammaridae	*Gammarus pulex* (Linnaeus, 1758)	0.49	0.49	0.37
Leeches	Erpobdellidae	*Erpobdella octoculata* (Linnaeus, 1758)	0.05	0.15	0.13
Leeches	Glossiphoniidae	*Glossiphonia complanata* (Linnaeus, 1758)	0.10	0.19	0.13
Mayflies	Baetidae	*Alainites muticus* (Linnaeus, 1758)	0.13	0.15	0.24
Mayflies	Baetidae	*Baetis rhodani* (Pictet, 1843-1845)	0.49	0.51	0.61
Mayflies	Baetidae	*Baetis vernus* Curtis, 1834	0.23	0.15	0.16
Mayflies	Ephemerellidae	*Serratella ignita* (Poda, 1761)	0.18	0.09	0.24
Mayflies	Ephemeridae	*Ephemera sp.*	0.15	0.15	0.08
Mayflies	Heptageniidae	*Ecdyonurus sp.*	0.26	0.32	0.34
Mayflies	Heptageniidae	*Rhithrogena sp.*	0.18	0.30	0.21
Mussels & Cockles	Sphaeriidae	*Pisidium sp.*	0.31	0.57	0.47
Segmented Worms		Oligochaeta	0.79	0.87	0.97
Snails & Limpets	Hydrobiidae	*Potamopyrgus antipodarum* (J.E.Gray, 1843)	0.26	0.28	0.32
Snails & Limpets	Lymnaeidae	*Radix balthica* (Linnaeus, 1758)	0.15	0.13	0.13
Snails & Limpets	Planorbidae	*Ancylus fluviatilis* O.F. Müller, 1774	0.15	0.23	0.16
Stoneflies	Chloroperlidae	*Siphonoperla torrentium* (Pictet, 1841)	0.10	0.13	0.16
Stoneflies	Leuctridae	*Leuctra fusca* (Linnaeus, 1758)	0.41	0.26	0.32
Stoneflies	Leuctridae	*Leuctra hippopus* Kempny, 1899	0.15	0.23	0.32
Stoneflies	Leuctridae	*Leuctra nigra* (Olivier, 1811)	0.15	0.11	0.13
Stoneflies	Nemouridae	*Nemoura cambrica* group	0.05	0.13	0.13
Stoneflies	Nemouridae	*Protonemura meyeri* (Pictet, 1841)	0.15	0.17	0.18
Stoneflies	Nemouridae	*Protonemura praecox* (Morton, 1894)	0.08	0.15	0.08
Stoneflies	Perlodidae	*Isoperla grammatica* (Poda, 1761)	0.05	0.30	0.21
Stoneflies	Perlodidae	*Perlodes microcephalus* (Pictet, 1833)	0.10	0.17	0.08
True-flies		Chironomidae	0.87	0.83	1.00
True-flies	Ceratopogonidae	Ceratopogonidae	0.15	0.32	0.29
True-flies	Dixidae	*Dixa maculata* complex	0.15	0.09	0.08
True-flies	Empididae	*Chelifera* group	0.23	0.23	0.18
True-flies	Empididae	Clinocerinae	0.15	0.21	0.26
True-flies	Limoniidae	*Eloeophila sp.*	0.13	0.23	0.26
True-flies	Pediciidae	*Dicranota sp.*	0.46	0.53	0.50
True-flies	Pediciidae	*Pedicia sp.*		0.23	0.13
True-flies	Psychodidae	*Pericoma* group	0.10	0.26	0.29
True-flies	Simuliidae	*Simulium (Eusimulium) aureum* group	0.13	0.23	0.08
True-flies	Simuliidae	*Simulium (Nevermannia) cryophilum* group	0.26	0.40	0.32
True-flies	Simuliidae	*Simulium (Simulium) argyreatum* group	0.13	0.19	0.16
True-flies	Simuliidae	*Simulium (Simulium) ornatum* group	0.26	0.45	0.29
True-flies	Tipulidae	*Tipula (Yamatotipula) montium* group	0.10	0.23	0.08
Water mites		Hydracarina	0.13	0.15	0.32
Waterslaters	Asellidae	*Asellus aquaticus* (Linnaeus, 1758)	0.13	0.13	0.24

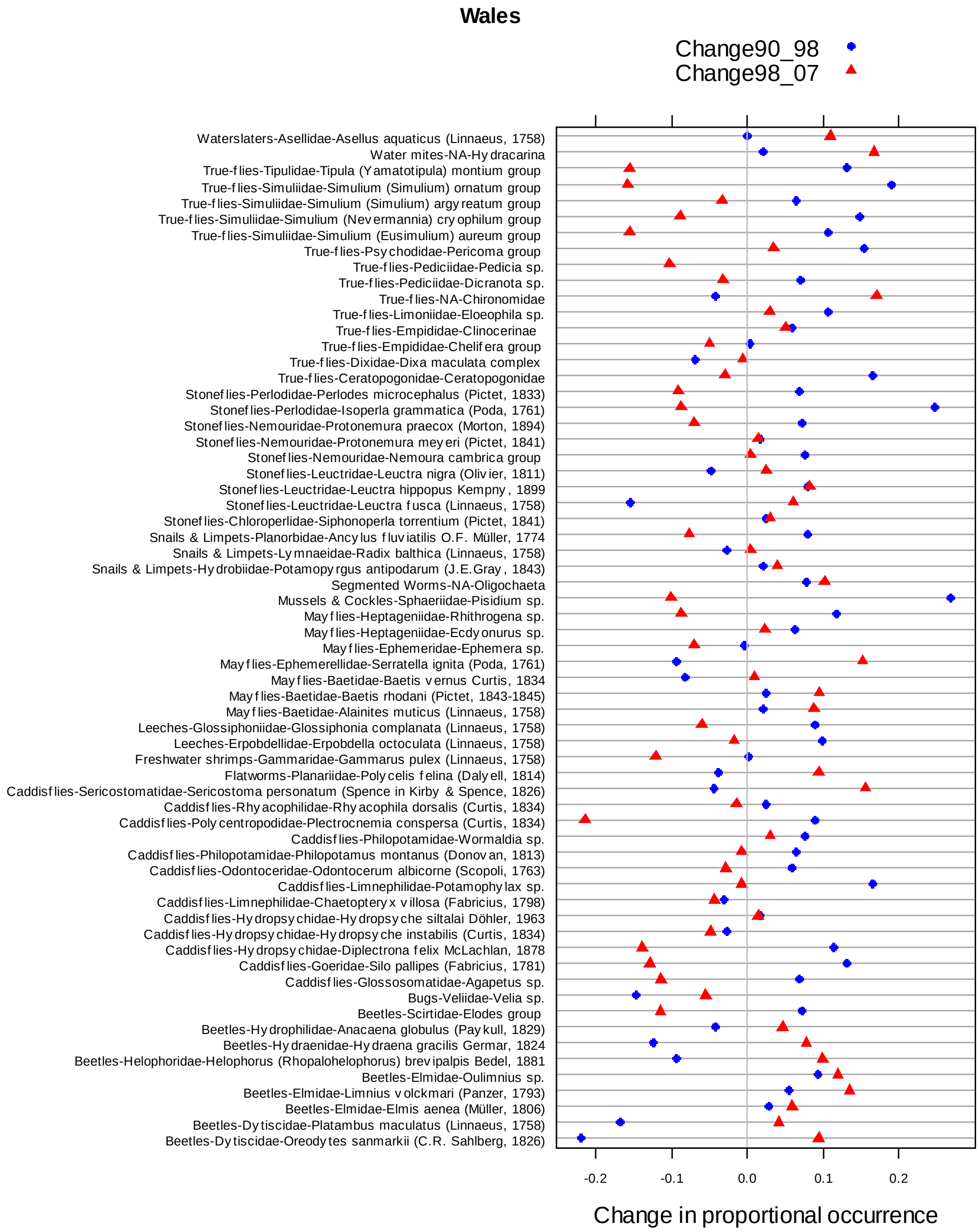


Figure 10-7. Wales: change in proportional occurrence for 1990 to 1998 (blue) and 1998 to 2007 (red) for taxa which occur in 10% or more of all samples in Wales.

Figure 10-8. Wales: change in proportional occurrence for 1990 to 2007 for taxa which occur in 10% or more of all samples in Wales.

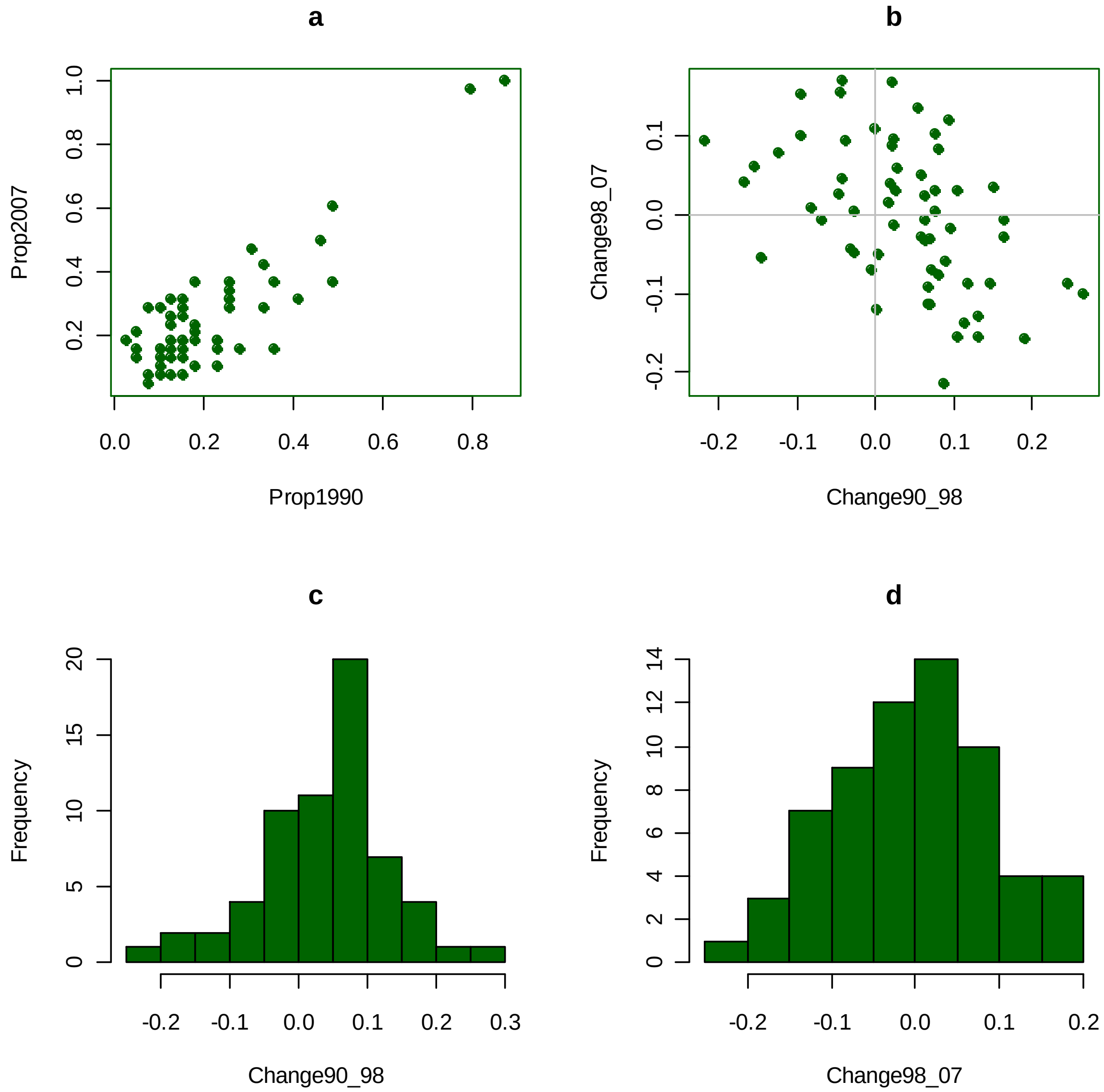


Figure 10-9. Wales – selected macroinvertebrate taxa (which occur in 10% or more samples in Wales): a. relationship between proportion of occurrence for 1990 and 2007, b. relationship between change in proportion of occurrence from 1990 to 1998 and 1998 to 2007, c. histogram for 1990 to 1998 change, d. histogram for 1998 to 2007 change.

Dunbar, M., Murphy, J., Clarke, R., Baker, R., Davies, C., Scarlett, P. 2010 Countryside Survey: Headwater Streams Report from 2007. Technical Report No. 8/07 NERC/Centre for Ecology & Hydrology 67pp. (CEH Project Number: C03259).

For further information on Countryside Survey see www.countrysidesurvey.org.uk

Or contact: Countryside Survey Project Office, Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP

Telephone: 01524 595811; *Email:* enquiries@ceh.ac.uk

Countryside Survey in 2007 was funded by a partnership of government-funded bodies led by the Natural Environment Research Council (NERC) and the Department for Environment, Food and Rural Affairs (Defra).