Natural England Research Report NERR005

Surveying terrestrial and freshwater invertebrates for conservation evaluation

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Surveying terrestrial and freshwater invertebrates for conservation evaluation

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Project details

A summary of the findings covered by this report, as well as Natural England's views on this research, can be found within Natural England Research Information Note RIN005 - Surveying terrestrial and freshwater invertebrates for conservation evaluation.

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Summary

The aim of this Natural England Research Report is to provide guidance to surveyors, and those hiring and contracting them, on how to undertake invertebrate surveillance. It gives both specific guidance for direct surveys (rather than proxy habitat surveys) carried out in accordance with Common Standards Monitoring guidelines (in England), as well as generic guidance for a variety of other situations, such as environmental impact assessments, single day visits, regional projects and more. Single-species surveys are not covered.

This Research Report does not aim to give an exhaustive account of sampling, nor to provide a detailed resume of analytical methods. Rather, the authors have attempted to provide a framework that shows how invertebrate surveying can be carried out, using pragmatic techniques, in situations where time and resources might be limited. For those undertaking Common Standards Monitoring, the information in this book should be adequate to quickly determine the exact needs of any field work and subsequent analysis. For other invertebrate surveys, this book should facilitate the planning, survey and evaluation of any programme of works by providing useful and clear guidance.

The introduction outlines the reasons for undertaking a survey and how to determine what is required for any given situation.

The chapter on 'Sampling issues' offers advice on how to get the most out of sampling where time allocation and available resources are the main constraints.

The 'Analysis' chapter details how the ISIS application works*, as well as describing the use of various other analytical techniques. Sampling techniques are described along with suggested protocols for use with ISIS and other Natural England-based projects. In the proceeding chapter, target groups have also been outlined for each assemblage type.

The two final chapters contain practical information on how to set up a survey, and the laboratory methods involved. Along with a useful set of annexes, it is hoped this book will be of invaluable assistance to any worker in the field of entomology.

* The ISIS application is currently under development. It is highly likely that further testing will lead to further refinements and coding detailed in this research report is subject to change.

This first edition is to be produced as a working document, the aim being to update and amend a subsequent edition that will be produced as a stand alone book rather than a research report.

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1 Introduction

1.1 Invertebrates are increasingly being taken into account in conservation as their intrinsic interest and usefulness as indicators of environmental conditions become more widely recognised. Larger insects with popular appeal have always been taken care of, but the many thousands of small species that comprise the bulk of our fauna have usually been ignored. The UK Biodiversity Action Plan changed perceptions markedly by giving prominence to small as well as large species, and by broadening the scope of invertebrate conservation to less well-known groups. Invertebrates have grown up.

1.2 With greater prominence comes a need for better information. For some time, invertebrates have attracted the attention of professional entomologists as indicators of water pollution, and as pests in agriculture, forestry and medicine, and much has been written on survey and analysis in these areas. At the amateur level there is plenty of advice on how to collect and record invertebrates. In between these extremes falls the field of conservation evaluation and site monitoring, which demands a rigorous approach but also has to be undertaken within restricted budgets.

1.3 Despite a general desire to take account of the large range of invertebrates, conservationists quickly come across practical barriers resulting from their sheer number of species and complexities of identification. Lack of guidance on how to set about surveying them is another problem. The most frequently asked questions in planning any survey are:

- What groups should be sampled?
- What methods should be used?
- When should the survey be undertaken?
- Where should samples be taken from?
- How much effort is needed?
- How much will it cost?

1.4 There seems to be a greater lack of confidence in tackling these survey issues for invertebrates than for most other conservation disciplines, and this book provides guidance in answering these questions. It also addresses the analytical methods needed to interpret survey results, including Natural England's method for implementing the Common Standards Monitoring of invertebrates on SSSIs.

Reasons for survey

1.5 Before embarking on a survey, its aims must be clear – these will decide the precise nature of the information required. Once they are clear, the methods of data analysis can be selected, which in turn will decide the survey protocol and the sampling methods. There are several reasons for undertaking a survey:

- site selection (eg as local reserves, SSSIs);
- impact assessment and mitigation;
- assessments at a landscape or regional scale;
- species recovery and action plans;
- management advice; and
- monitoring.

Site selection

1.6 Here the aim is to assess the value of an area of land for invertebrate conservation. The assessment will depend strongly on obtaining the highest feasible values for species rarity, species richness and fidelity to key features. For these reasons the surveyor needs to collect as much data as is practical to be sure of having found a good proportion of any rare and habitat-faithful species. This covers the species aspect of site selection. The other important aspect is the evaluation of the usefulness and extent of habitat features that are of greatest value to invertebrates.

1.7 Site selection surveys can be treated in two phases that correspond to the Phase I and Phase II surveys used in habitat and botanical surveys (Nature Conservancy Council, 1990).

1.8 Phase I surveys are concerned with the type and extent of habitat. The habitat-based classification of invertebrate assemblages (ISIS) discussed in this book provides a framework similar to that used in botanical Phase I. Experienced surveyors can often sum up the features likely to be most importance for invertebrates without sampling them. Less experienced naturalists can also make a rough assessment by following the advice on habitat features of value to invertebrates provided in Kirby (1992) and Fry & Lonsdale (1991).

1.9 Phase II surveys are concerned with species surveys carried out to identify assemblage types and their species richness, and the presence, within-site distribution and – possibly – the population size of noteworthy species. Species names are the currency of this level of survey; nearly all analysis depends upon them. For the well-understood British fauna, there is usually no value in recording to genus or family level.

Impact assessment and mitigation

1.10 Developers are legally required to assess whether their proposals will harm wildlife on a range of types of sites, including those of international or national wildlife importance. Planning guidance PPS9 encourages similar assessments on other wildlife sites of local importance, such as Local Nature Reserves, wildlife sites, ancient woodlands and veteran trees (ODPM, 2005). Invertebrate interest should be included in such environmental assessments (Falk, 1998).A survey cannot ‘suggest’ the presence of a species of conservation concern, it must conclusively demonstrate the presence of such species. It must also indicate the relative value of different habitat features (which to save or sacrifice), and to suggest boundaries that enclose good features and uninteresting ones.

Assessments at a landscape or regional scale

1.11 We often want to find out more about the fauna of a particular habitat across a wide area, for example, looking at the beetles of exposed riverine sediment of whole river catchments, or the insects of chalk grasslands in southern English counties. Usually this starts with a review of existing information, but this runs the risk of being influenced by prejudices intrinsic to data collection methods that were designed for other purposes. Surveys designed to characterise the conservation interest of a habitat across a landscape or region require a more rigorous approach than those used for site selection, notably in using standardised methods that allow comparisons between samples or sites.

Monitoring change

1.12 Sites where conservation is the main driver behind their management should be monitored to check that the interest for which they were chosen is still in good condition. This is a legal requirement for statutorily protected sites and is undertaken through Common Standards Monitoring (see below). Where invertebrates are one of the features for which these sites were notified, these too need to be monitored. The huge scale of this task has led to the development of sampling and evaluation protocols to measure the quality of assemblages within a narrow budget. They are described here as they can be applied to any site.

1.13 There is a difference between 'surveying' and 'monitoring'; they require different approaches and so need careful definition. (Hellawell, 1978). A survey can take place once; if it is then repeated using similar methods it is called 'surveillance'. The exercise becomes monitoring if a threshold is set in the quality or condition of an assemblage or habitat – such as used in Common Standards Monitoring for SSSIs.

1.14 The details of monitoring individual species or small groups such as butterflies and dragonflies is not covered by this book as it is dealt with exhaustively by Pollard & Yates (1993) for butterflies, and Moore & Corbet (1990) for dragonflies. The monitoring of wider invertebrate assemblages is a relatively unexplored area that ISIS is designed to address.

1.15 Monitoring the effects of large scale factors such as climate change will raise different survey design issues to those encountered when monitoring the effects of site management on a specific nature reserve. Climate change will be best reflected in species or groups that are sensitive to temperature and hydrological conditions, but are otherwise fairly robust and widespread; changes in land management will be best reflected in species and groups that are sensitive to structural changes and these are also likely to be more 'pernickety' specialists.

Site management

1.16 One cause of change is site management. Opinions vary on whether a survey is an essential prerequisite to site management.

1.17 One view is that the needs of most species, including specialists, can be provided by following the general principles and advice in Kirby (1992) and Fry & Lonsdale (1991), so that, while desirable, detailed information is not essential to gear management towards invertebrate conservation. In extreme cases, some non-climax habitats change so rapidly that management to conserve sensitive species needs to be undertaken immediately before an adequate survey can be completed. It requires entomological experience to recognise problems and their solutions. However, it is not always clear how invertebrates in general respond to apparently acceptable management practices, and different invertebrate species will react differently to the same management regime.

1.18 This uncertainty has led to the alternative view that the invertebrate interest must be described by a survey before any work can be undertaken to manage a site for that interest. A survey can identify and locate habitat features of particular importance to invertebrates, and locate uncommon species whose requirements can be taken into account. Surveys aimed at monitoring the effects of site management need to compare treatments using statistical analysis. In such cases, many small, well-chosen samples are preferable to a few large ones. It is also important to know that the collected animals came from a particular treatment, so in-situ traps – which collect a large number of vagrants –are less suitable than active methods and pitfall traps.

Inventory

1.19 As a survey aim, a full inventory of species is unrealistic and often adds little value to a properly planned survey that samples the total fauna. Creating a species list is undeniably fun, but is best left to Britain's army of talented amateurs to pursue.

Species recovery and action plans

1.20 This book does not cover surveys of single species since these need to be tailored to each species. However, collecting information on the assemblages to which a species belongs will highlight the ISIS assemblage supporting that species (see 'ISIS').

Common Standards Monitoring

1.21 Common Standards Monitoring (CSM) has been developed by the JNCC in consultation with habitat and species specialists, and the four statutory country agencies (Natural England, the

Countryside Council for Wales, the Environment & Heritage Service (Northern Ireland) and Scottish Natural Heritage).

1.22 CSM does not assess a site as a whole, but only those individual notified features (at both national and international level) for which the site was designated. Conservation objectives (targets) are set for each of these features, and these outline the key attributes that make up or support the feature (eg extent, presence, species richness). Each of these attributes can then be measured against its set target value. An assessment of the overall condition of that feature can then be made based on the target values. Five condition categories are identified within CSM: favourable; unfavourable recovering; unfavourable no change; part destroyed; and destroyed.

1.23 CSM identifies changes in condition on individual sites and can also be used to detect wider trends. It is designed to be carried out by many different people using the same methodology.

ISIS

1.24 ISIS is a computer application that Natural England is developing for the recognition and scoring of invertebrate assemblage types. Although it was originally designed to help monitor features of interest on Sites of Special Scientific Interest, ISIS can also readily analyse species lists collected at many different scales – from management compartments to landscape character areas and regions.

1.25 Given this flexibility, Natural England is expecting to use the application for a variety of different projects such as site monitoring, characterising regional invertebrate interest and assisting the site selection process. In summary, it is expected that ISIS will form the basis of Natural England's approach towards invertebrate assemblages for the foreseeable future.

1.26 It must be noted that the development of ISIS is an ongoing process, and that the current application is a working prototype. Although the basic structure is not likely to alter, further investigation into specific and broad assemblage types, particularly those relating to field layers, may lead to some changes.

2 Sampling issues

2.1 Whatever the purpose of a site-based survey, its scope will be constrained by costs: no-one would pay for a complete year-round inventory of every nook and cranny. This chapter looks at ways of reducing effort and costs but still obtaining a reliable site assessment. The types of survey we are interested in fall into two types:

- those that evaluate a site's interest by generating hypotheses (is this land of any interest?); and
- those that test hypotheses using more rigorous methods (how will the fauna change if the management changes?).

2.2 The design of either type of survey raises a number of questions. Is there's a need to collect the data necessary for a statistical analysis, especially where there are cost and time constraints? How can we cut the number of samples and visits to a realistic minimum? What can we do when the worst happens in poor weather? These are examined below.

Two approaches to sampling

Targeted sampling

2.3 Pragmatism and practicality are key factors in the design of evaluation surveys for site selection and environmental impact assessment. Typically, sampling protocols are flexible and a variety of field methods can be employed to suit circumstances at each site. Confidence in the conclusions will be based on expert opinion rather than on faultless survey design and statistical analysis. There are a number of reasons for advocating simplicity and side-stepping statistical considerations:

- The aim is to say whether an area of land has any conservation value. This is unlikely to be determined accurately by failing to concentrate on the features of greatest potential. The evaluation uses judgmentally-loaded criteria, notably rarity, but also characteristic species, which are the bread-and-butter of conservation but not necessarily of academic ecology. Standardised scientific protocols often result in an emphasis on common and widespread species. However, the specialists – which are much more helpful for conservation purposes – are more effectively found by targeted sampling. A survey for site evaluation therefore needs to concentrate on maximising the chances of finding most species and most rarities. Therefore the main driver in selecting points to sample becomes a deliberate bias towards 'promising' patches of habitat – the features of greatest potential. In these cases, representativeness and randomness in point selection are unhelpful.
- Most surveys include semi-natural habitats which are the most heterogeneous part of the British countryside. Vegetation maps show that many SSSIs cannot be quickly stratified into easily sampled equivalent compartments. Consequently, the conditions for the proper use of statistical methods are rarely met, and doing so would make most surveys prohibitively expensive.
- Nearly all the statistically-based advice concerns the counting of individuals; little applies to the numbers of species, which is the currency of an invertebrate survey. The advice for designing surveys to measure species richness ought to be considered during planning (eg Magurran, 2004) but its implementation will often fail since conditions cannot be met within normal budgets.
- Statistical surveys will rarely improve on the results obtained by an experienced surveyor given free reign to use their field craft to the full.

Replicated sampling

2.4 When the survey aim is to compare the conservation interest of different areas, or the same area through time, statistical analysis is important, so the sampling design must meet the conditions for its use. These surveys need strictly defined sampling protocols and standardised, repeatable field methods to produce comparable results.

2.5 There are two reasons for using statistical analysis: to organise the results (eg using classification and ordination to identify assemblages); and to give some confidence in the accuracy of the results (eg when comparing the species-richness of sites). There are three main guiding principles for the design of such surveys:

- Random sampling involves taking samples that are independent of one another. In the real world, this is prohibitively expensive. Consider, for instance, the disappointing and unhelpful results of randomly sampled heathland where it is known that many invertebrates make most use of small areas of bare ground and flowery patches but ignore the vast swathes of heather. However, if the site is divided into more 'uniform' patches (strata), random samples can be taken from the strata of most interest. Greenwood & Robinson (2006) give ways of selecting strata. They are usually chosen on the basis of structural features, environmental gradients, management treatments or vegetation types (eg Phase 1 or National Vegetation Classification, for which vegetation maps are clearly a prerequisite).
- Many small samples are better than a few large ones. Apart from the statistical advantage of increased confidence limits, more small samples will encompass more of a site's heterogeneity.
- The methods used must be standardised so that each sample collects enough animals for estimates of parameters, such as species-richness, to be realistic.

Standardisation of sampling units

2.6 One aim of this book is to promote sampling protocols. Standardised methods will not necessarily provide the most 'accurate' samples, but there are important advantages in using them:

- Different surveyors can contribute to the same projects – notably long-term surveillance.
- Results of surveys and monitoring can be more easily compared with each other.
- Within one survey, samples can be treated as replicate sampling units, so metrics such as species-richness can be directly compared and mean values estimated.
- Results become open to interpretation more quickly as the body of comparable data develops over time.
- More people are likely to be drawn into undertaking surveys, as clear survey guidelines reduce the 'mystique' surrounding surveys and specialised techniques (as shown by the popularity of the Butterfly Monitoring Scheme).

2.7 Difficulties in standardisation arise from the different sampling devices commonly used by entomologists in wildlife surveys, for example, there is no universally accepted equivalent of the botanist's quadrat. However, several approaches have been used to try and standardise the sampling effort:

- timed samples;
- fixed physical effort, eg number of sweeps of a net;
- fixed volumes, eg of litter or moss;
- fixed number of traps;
- collect until no new species are recorded; and
- fixed number of individuals.

2.8 Each of these is valid but some are regarded as more versatile than others. If a protocol is to work in all habitats, it must be able to accommodate the huge heterogeneity of the British countryside. For this reason, timed samples are thought to be most useful for active collecting methods as it allows the surveyor greatest scope for using their field craft within a set period. If the sample time is short enough, many small samples can be obtained in a day's work, thus allowing a wide coverage of habitats and deterring over-enthusiastic collections from single hot-spots.

2.9 Catches can differ surprisingly between people following the same set of written guidelines. The nuances can only be imparted successfully by training or by learning on the job. Hands-on training or demonstrations may be necessary for inexperienced surveyors.

2.10 When surveys are undertaken using a standard procedure, species that are seen or collected casually from a site should not be ignored in the overall evaluation even if – to ensure strict comparability between sites – they are left out of some analyses.

Number of samples

2.11 The currency of site evaluation is species, not individuals. But estimating even the most basic metric – species-richness – is notoriously difficult. Magurran (2004) wisely but a little unhelpfully suggested that, for very diverse assemblages, "the experience of knowledgeable field ecologists, combined with an assessment of the rate at which new species are being encountered, is the best guide to sample size". While this comment was addressing tropical habitats, surveys of small British sites routinely record many hundreds of species, so the issue of high diversity applies here too.

2.12 We give some pragmatic advice that is a compromise between financial constraints and obtaining reasonably accurate results. There is nothing wrong with taking only a few samples but in these cases comparisons with other sites can only result in uncertain conclusions.

2.13 The aims of the survey will help determine the number of samples required. To estimate species richness, Magurran (2004) quotes ten samples as a minimum (a figure recommended by three other authors). The ten samples are from one discrete stratum of the site, not for an entire site with all its heterogeneity. Large or complex sites will need considerably more effort if the aim is to compare their different elements. As the numbers of rare and scarce species is an often-used metric, a minimum of ten samples is also recommended for this measure of species-richness.

2.14 To obtain significant results using ordination, at least 30 samples containing at least five species in each sample is suggested.

2.15 Using ISIS as a monitoring tool requires as few as four samples from each stratum. More precise guidance is given in Table 9.

2.16 The aim of the survey will help determine how the samples should be allocated among the strata. If the aim is to describe the fauna in order to assess its conservation value, it is better to take a few samples from many strata – this will cover more of the site's variation and more species, including rare ones, will be caught. However, if the aim is to understand how to manage elements of a site, or to set up a monitoring scheme, then many replicate samples from a few carefully selected strata or compartments will give results that allow statistically meaningful comparisons.

2.17 A practical consideration is the accidental loss of trap catches. The catch rate can be reduced by poor weather, interference from animals and people, and difficulties in re-locating pitfall traps. Also, traps on wet sites are prone to flooding. A worthwhile safety precaution is to set more traps than required to reduce the danger of inadequate returns. Trap-setting usually takes relatively little time, so this precaution can be cost-effective.

Number of visits

2.18 Most British invertebrates have annual life cycles; most have a marked seasonality as adults; and most can be identified only when mature. Different species are therefore detectable at different times of the year, and the number of species recorded will increase with the number of visits. This fact affects survey design but there can be no hard rule about the minimum number of visits needed to make a reliable assessment, since it will vary with the purpose of the work and the site's assemblage. Many CSM samples will need more than one visit ¬– a number of visits might be needed to ensure that one main taxon has been adequately recorded through the year, and additional separate visits may be needed by experts in more unusual or problematic taxa.

Single visit

2.19 Single visits are acceptable for the following:

- Landscape and regional surveys where the aim is to broadly describe the fauna of a habitat or assemblage (eg beetles of exposed riverine sediment in many rivers). The visit must take place in the period of greatest species-richness for the most important groups. Table 14 will help decide the best window of opportunity.
- The CSM of some assemblages, such as aquatic assemblages, where it is known that reliable conclusions can be reached. Other such assemblages are listed in Table 9.
- Exploratory visits of complex or difficult assemblages, such as those of decaying wood, for which several visits targeted at key areas will be needed later on.
- Where unavoidable constraints dictate a fast response, notably for threatened sites, even when more visits would be better. Acceptable results can be obtained when relevant target groups are chosen and sampled in their appropriate season, in good weather conditions (ideally, non-aquatic habitats should be sampled using more than one method). More confidence can be placed in surveys that record nationally scarce species or produce markedly long species lists; poor results are less reliable as they may be due to poor weather or surveyor incompetence.

Several visits

2.20 A reasonably thorough survey of a terrestrial habitat can be made through seven visits at monthly intervals from April to October (though this will miss a few species active in winter). However, a large amount of duplication will be found between adjacent visits, and four or five visits over this period (or confined from May to September) will capture most species. Such intensity of sampling is needed:

- In some CSM work (the recommended number of visits is given in Table 9 – these are prescriptive because the results must be comparable from year to year and from site to site);
- to provide a strong case for the defence of a threatened site;
- when assessing the effects of proposed or actual major changes in management that may affect elements of the fauna differently; and
- when describing the fauna of species-poor habitats (eg bogs) or habitats where the fauna is hard to find (decaying wood).

2.21 A further reduction in visits is possible, without greatly decreasing the survey's value, by targeting taxonomic groups that have short, but species-rich, peak flight periods, for example, bees and wasps on heathland in late summer. Geographical location can also influence the number of visits needed, the 'season' being compressed into fewer months in the far north and upland areas. Aquatic assemblages can be successfully described using spring and autumn visits because a number of important groups (eg mayflies, caddis flies) can be sampled and identified successfully in their larval stages, and others (eg beetles, snails, leeches) remain as identifiable mature individuals for long periods.

2.22 If the survey is being carried out to produce a thorough species list, this can be achieved more cost-effectively by making several shorter visits throughout the year, rather than spend the same time collecting more samples during one long visit. However, if the aim is to compare sites (eg different management treatments) then better statistical information will be collected by taking more genuine replicate sampling units during a single visit.

Pre-survey reconnaissance

2.23 Reconnaissance of a site before sampling (the 'walk-about') has several uses:

- Environmental Impact Assessments should ideally start with a walk-about since non-entomologists may not appreciate that there are features of interest that need greater species-level scrutiny. On the other hand, it may save clients money if it is obvious that a site lacks any feature of value since this means there's no need for a species-level survey. However, either assessment requires that the surveyor can recognise important features as well as identify invertebrates. Sources of information on desirable features are found in Kirby (1992) and Fry & Lonsdale (1991).
- Small-scale features are important to invertebrates, so it can be useful to walk quickly around a site, identify features of potential value and distribute the sampling effort accordingly. This will help to partition the survey time so that all important features are sampled. It also reduces the temptation to spend too long sampling a limited number of 'hot-spots'.
- Access and crossing points can be identified.

Making the best of a bad job

Out-of-season surveys

2.24 Terrestrial surveys undertaken outside the period mid-April to September/October are likely to produce poor results since most adult insects are not available for sampling in cold months. In addition, results may be difficult to put into context because there will be few other surveys to compare them with. Although long species lists can be obtained in cold months, they may not include scarce species, even from sites of actual high value. However, threatened sites often have to be surveyed at inappropriate times of year, so some guidance is given here:

- Firstly, existing data should be examined. This may give more useful information than an out-of-season survey alone.
- Habitat features should be assessed with more care.
- Groups most likely to give useful results include water and terrestrial beetles, heteropteran bugs, ants, molluscs, woodlice, centipedes, millipedes and spiders. The larvae of a few groups are sufficiently well-known to make them worth sampling, for example, several aquatic insect groups and some beetles living in dead wood. Hibernation sites need to be searched for many of these species, for example, under bark, stones, logs and other shelter, and in tussocks, leaf litter, moss and dead wood.
- Table 14 gives an indication of the time of year when a group reaches its greatest species-richness. This may help select groups for spring and autumn surveys.
- Passive trapping methods are usually better than active ones (eg sweep-netting, suction sampling) since wet weather or wet vegetation make active methods less effective. Even passive traps are ineffective in prolonged cold or wet weather as it reduces invertebrate activity. Passive traps may also be inappropriate for the target group.
- The protection of nesting birds and young deer in deer parks will usually take precedence over invertebrate surveys, and this can lead to sampling at times that are inappropriate for the target groups. Using passive trapping methods rather than active ones reduces any disturbance. Visits must be made in reasonably dry weather so that affected eggs and nestlings are not chilled or soaked when vegetation is disturbed.

Poor weather

2.25 Poor weather during the main field season is the surveyor's nightmare. Most active methods (eg sweep-netting, suction sampling) fail on damp vegetation. Cool and windy weather depresses the activity of many species, even ground-dwelling invertebrates. Hot weather also has its problems: it reduces nectar flow so fewer diurnal flower-visiting insects can feed. Surveying in the heat of the day, especially the late afternoon, can often give poorer results than surveys carried out in cooler times of the same day. Hot dry summers reduce the abundance of many species, especially those of wetlands, grasslands and heathlands, so collections in late summer can be poor for non-xerophilic species. However, the real victim is the surveyor – sampling efficiency plummets!

2.26 It is not possible to obtain scientifically rigorous results in poor weather, but some surveys have to go ahead, notably ecological impact assessments.

2.27 Possible ways around poor weather:

- Try to avoid it. As well as daily forecasts on radio and television, the Met Office and BBC websites give regional forecasts for up to three days (although these are often unreliable).
- Bring forward work that is less affected by poor weather and adapt working practices. Some aquatic sampling may be unaffected, but bank-sorting becomes inefficient in wet weather.
- In hot dry summers, get out early and finish late, but rest during the hottest part of day.
- Set traps, even just for a single day.
- In the cold, include taxa that are less affected by cool weather. Aquatic groups are scarcely affected, and ground-living insects are probably the easiest to sample in poor weather. Thermophilic groups such as aculeates, hoverflies and many 'larger Brachycera' will disappear while several families of small flies can still be collected by sweeping.
- Mention weather conditions when writing up.
- Go out anyway, as conditions may not be as bad as predicted – this is the best practice for quick exploratory visits such as walk-through surveys for certain development projects. Any survey will be better than none at all.

Interference

2.28 People and large animals can disrupt survey work. Reducing interference may involve changing the target groups and method:

- Use active methods rather than traps.
- Select target taxa suitable for pitfall traps (mostly unseen by people) rather than those caught in water traps, flight-interception traps and Malaise traps.
- Make more frequent visits to check traps so that lost catches can be partly replaced.
- Peg wire mesh firmly over traps (this is ineffective against vandals, livestock and foxes, but will deter birds).

3 Analysis

Recognition of information needs

3.1 Once the survey aims are clear, it is necessary to define what information the survey needs to generate. The information may relate to habitat quality, to the presence or absence of certain categories of desirable species, or to the quality of invertebrate assemblages found on site.

3.2 Required assemblage information usually relates to one or more of the following:

- Species diversity – describes the richness of a recorded assemblage in terms of numbers of species it contains and sometimes the evenness of the distribution of individuals between these species.
- Rarity – relates to the number of rare species belonging to an assemblage.
- Typicalness – a measure of how similar the assemblage is to an ecological category, usually defined by habitat. Indicators of ecological continuity can be used to gauge whether an assemblage is typical of sites with a long history of good quality habitat.

3.3 All these attributes are included in the outputs of ISIS, so this chapter starts by describing this application. Further aspects of measuring, or using, each of these attributes follow later, along with some other frequently used methods.

ISIS

3.4 ISIS is a computer application developed by Natural England. ISIS interprets species lists by recognising assemblage types within a list and scoring each type according to its conservation value (see Tables 1 & 2). This can be done at a variety of geographic scales, from individual management units, through SSSIs, to landscape character areas. It was primarily designed for Common Standards Monitoring (as described previously), but can be used for a much wider range of purposes.

3.5 ISIS is currently only available in spreadsheet format, but it is due to be programmed for translation into a web-based system. Some of the following is relevant only to the current spreadsheet version.

Table 1 Example of ISIS output using four samples taken from the River Till in Northumberland (the specific assemblage types represented in this list are as follows)

SAT code	SAT name	Weighted species score	No. spp.	Condition	Percentage of national species pool
W111	shingle bank	18	14	fav	26
W122	riparian sand	6	6	fav	17
W112	Stony river margin	4	4	fav	10
W121	sandy river margin	2	2		10

Table 2 Example of ISIS output using four samples taken from the River Till in Northumberland (the broad assemblage types represented in this list are as follows)

BAT code	BAT name	Representation (1–100)	Rarity score	Condition	BAT species richness
W11	fast-flowing water	38	185	fav	42
W12	slow-flowing water & seepage	29	203	fav	24

3.6 Four Specific Assemblage Types (SATs) and two Broad Assemblage Types (BATs) are recognised. Three of the specific assemblage types and both broad assemblage types would be assessed as being in 'favourable' condition for Common Standards Monitoring.

Assemblage type classification

3.7 ISIS is based on a definition of an assemblage as a suite of species occurring in the same piece of homogeneous habitat. Assemblage types are defined by species composition, but labelled according to their favoured habitat in terms that are meaningful to non-specialists. The classification reflects real variations in nature, which were elucidated by analysing data – generated by standardised sampling methods – focused on defined areas of homogeneous habitat. The methods of analysis included 'Detrended correspondence analysis' (DECORANA) (Hill, 1979) and analysis of similarity (eg PISCES Conservation, 2004). Expert opinion was also used to identify assemblage types that are of intrinsic value for nature conservation. Two levels of assemblage type are recognised:

- Broad Assemblage Types. There are 14 Broad Assemblage Types (BATs) and these are characterised by species that are more widespread. BATs can be found in a wide range of sites. Their classification reflects environmental factors such as hydrology and disturbance cycles that have an important effect on invertebrate assemblages.
- Specific Assemblage Types. There are 28 Specific Assemblage Types (SATs). These are characterised by stenotopic species and are considered to have an intrinsic conservation value, as such they are generally only found in sites with conservation value. SATs are more narrowly defined than BATs and each SAT is nested within a parent BAT.

Table 3 ISIS assemblage type classification (BATs are in the left-hand column, SATs are in the right hand column. Numbers of characteristic species are given in brackets)

Broad Assemblage Types	Specific Assemblage Types
a)Arboreal assemblage types	
A11 arboreal canopy (856)	
A21 wood decay (1119)	A211 heartwood decay (175)
	A212 bark & sapwood decay (502)
	A213 fungal fruiting bodies (89)
	A215 epiphyte fauna (20)

Table continued…

Broad Assemblage Types	Specific Assemblage Types
b)Field layer assemblage types	
F11 unshaded early successional mosaic (1166)	*F111 bare sand & chalk (436)
	*F112 open short sward (98)
	*F113 exposed sea cliff (41)
F21 grassland & scrub matrix (990)	*F211 herb-rich dense sward (63)
	*F212 scrub edge (148)
F22 scrub-heath & moorland (315)	F221 montane & upland (111)
	F222 mature heath & dry scrub mosaic (41)
F31 shaded field & ground layer (545)	
c)Wetland	**assemblages**
W11 fast-flowing water (321)	W111 shingle bank (54)
	W112 stony river margin (41)
	W113 fast flowing streams & waterfalls (21)
W12 slow-flowing water & seepage (361)	W121 sandy river margin (20)
	W122 riparian sand (36)
	W124 soft rock seepage (21)
	W125 slow flowing rivers (25)
	W126 seepage (47)
W21 mineral marsh & open water (228)	W211 open water on disturbed sediment (36)
	W212 northern lakes & lochs (18)
W22 litter-rich fluctuating wetland (138)	W221 undisturbed fluctuating marsh (36)
W31 permanent wet mire (957)	W311 open water in acid mire (17)
	W312 acid mire (98)
	W313 mesotrophic fen (45)
	W314 rich fen (104)
d)Seashore assemblages	
W51 rocky shore (20)	
W52 sandy shore (82)	W521 sandy beaches (34)
W53 saltmarsh, estuary & mud flat (214)	W531 saltmarsh & transitional brackish marsh (118)

* These assemblages are under review and may be changed.

Coding system

3.8 Assemblage types are linked to species by a common coding system that carries information on the closeness of their relationship. BATs are identified by a three digit code; SATs are identified by a four digit code; and species are identified by a five digit code. The first three digits of the SAT code identify the parent BAT.

3.9 10,574 invertebrate species have been coded. Species that are characteristic of a particular BAT or SAT share the same digits at the beginning of their code. The fifth digit in the species code is a weighting factor that carries information about the fidelity of that species to a particular SAT. Some species are characteristic of more than one BAT, but the information at the beginning of their codes can still link them to a group of related BATs.

3.10 Currently, 1,756 species cannot be linked to an ISIS assemblage type. This may because we do not have enough information about them, or they are vagrants, or their habitats just do not fit into the classification.

The ISIS spreadsheet application

3.11 In order to assess an assemblage, a species list must be pasted into the first column of the ISIS 'data entry' sheet. Only scientific binomial names are accepted. It is important to delete any previous species lists first as contamination of the new list by the old may lead to serious errors. When assessing an assemblage from an SSSI for CSM, this species list would normally be produced by combining four separate samples.

3.12 In the data entry sheet, ISIS gives information on each species relating to its BAT, SAT and rarity score. If there is an error message, there could be two reasons. Firstly, the species name may belong to a taxonomic group that is not represented in the species index. In this case, no further action need be taken. Secondly, the species name may have been mistyped or a non-standard name used. In either case, the name should be corrected before proceeding.

3.13 Once a species list has been successfully entered, the results can be viewed in the ISIS 'results' sheet. The SAT table gives the code and the name of any SATs that have been recognised in the species list, together with a series of scores.

Scores used by ISIS

3.14 The following scores are generated for SATs:

- The 'weighted species score' is used for setting CSM targets. ISIS identifies any assemblage type whose score meets the default threshold for assessing assemblage types in favourable condition. The 'weighted species score' is usually equal to the number of species coded to that SAT, but in some SATs species are weighted for their fidelity to the SAT.
- The 'No. spp.' score is a simple count of the species coded to that SAT.
- The 'percentage of national species pool' score is the 'No. spp.' count divided by the total number of species coded to that SAT.
- The 'related BAT rarity score' is the rarity score of the parent BAT (a score that is also returned in the BAT table).

3.15 Low-scoring SATs in the table can be made invisible by adjusting the visibility threshold, but in practice the threshold is normally set to zero.

3.16 The BAT table returns the code and name of all the BATs that have been recognised in the species list together with a series of scores.

3.17 A different set of scores are generated for BATs:

- The 'representation score' measures the relative importance of the BAT in the species list on a scale of 1 to 100. It is designed as a coarse measure of ecological change at a small scale, for example in management units. The first visibility threshold can usefully be reduced to a lower value for this purpose. At larger scales it is influenced by sample site selection and merely reports which habitats have been sampled. The second visibility threshold prevents the expression of BATs whose 'representation score' might be inflated by closely related BATs.

- The ‘rarity score’ is the average of all the individual species rarity scores in the assemblage. The rarity scores of individual species are often derived from their designated conservation status, but in some groups it is taken from an analysis of the number of 10 km squares the species occupies, according to data held in the appropriate national recording scheme. It is therefore a version of the Species Quality Index (see below).
- ‘BAT species richness’ is the number of recorded species that are characteristic of that BAT.
- ‘IEC’ is the Index of Ecological Continuity, a score that is used exclusively for saproxylic assemblages (see below).

3.18 It is recommended that SATs rather than BATs should be used as features of interest for CSM. However, some invertebrate assemblages of interest are not found in SATs and these can be covered by the more comprehensive BAT classification. In these cases the BAT ‘rarity score’ should be used to assess condition. If this score meets the default threshold, ‘fav’ is returned in the ‘Condition‘ column. Over fifteen species must be used in the calculation to produce a robust BAT ‘rarity score’. A score based on a smaller number of species runs the risk of being unduly influenced by the presence of just one very rare species. Therefore, it is recommended that the first visibility threshold is set to 15 when interpreting species lists for CSM.

Use of ISIS for CSM

3.19 SATs are designed to be used as identified features of interest on SSSIs. They have an intrinsic conservation value and the SAT quality score can be used to set conservation objectives for each SAT present on an SSSI. The setting of a target score as a conservation objective provides a measure to assess favourable or unfavourable condition, but a series of measurements are needed to use the quality score to assess whether an assemblage in unfavourable condition is recovering or not.

3.20 A default conservation objective across all SSSIs has been set for each SAT. This is based on the presence on each SSSI of a certain percentage of the national species pool of characteristic species (Table 2). The default thresholds should be varied to cater for regional variations and factors such as the size and habitat diversity of individual SSSIs.

Table 4 Default thresholds for assessing SATs in favourable condition

SAT code	Description	CSM objective (species quality score)	Proportion of national species pool
A211	Heartwood decay	7	4%
A212	Bark & sapwood decay	20	4%
A213	Fungal fruiting bodies	8	9%
A215	Epiphyte fauna	not set	
*F111	Bare sand & chalk	25	6%
*F112	Open short sward	10	10%
*F113	Exposed sea cliff	4	10%
*F121	Herb-rich dense sward	3	5%
*F122	Scrub edge	5	3%
F221	Montane & upland	4	4%
F222	Mature heath & dry scrub mosaic	4	10%

Table continued…

SAT code	Description	CSM objective (species quality score)	Proportion of national species pool
W111	Shingle bank	9	17%
W112	Stony river margin	4	10%
W113	Fast-flowing streams & waterfalls	3	19%
W121	Sandy river margin	3	15%
W122	Riparian sand	6	17%
W124	Soft rock seepage	3	14%
W125	Slow-flowing rivers†	4	16%
W126	Seepage	5	11%
W211	Open water on disturbed sediment	4	11%
W212	Northern lakes & lochs	2	11%
W221	Undisturbed fluctuating marsh	7	19%
W311	Open water in acid mire	2	12%
W312	Acid mire	6	6%
W313	Mesotrophic fen	7	16%
W314	Rich fen	10	10%
W521	Sandy beach	4	12%
W531	Saltmarsh and transition to brackish marsh	10	8%

* These assemblages are under review and may be changed.

† Associated W122 score should also be considered in the assessment of this assemblage type.

The SAT quality score is dependent on the sampling effort and related factors such as sampling efficiency. These thresholds should only be applied to species lists produced using standard CSM survey protocols.

3.21 It is preferable to use SATs rather than BATs as features of interest because they have intrinsic conservation value and are generally cheaper to monitor. However, some important invertebrate assemblages on SSSIs will not fit into the SAT schedule and must be covered by the more comprehensive BAT classification. BATs do not have intrinsic conservation value and their quality must be measured by some attribute other than the number of characteristic species. ISIS uses the BAT 'rarity score'. The use of a rarity index to set conservation objectives has several theoretical drawbacks. Rarity is affected by a number of factors unrelated to underlying conservation aims. In addition, if conservation action is successful, the target species become less rare and lose their perceived value.

3.22 However, rarity status is widely used to assess the conservation status of invertebrate species and the rarity index represents a widely accepted measure of assemblage quality.

3.23 A default conservation objective across all SSSIs has been set for each BAT (Table 5). As with the SAT thresholds, these can to be varied to suit local circumstances. Over fifteen species must be used in the calculation to produce a robust BAT 'rarity score'.

Table 5 Default thresholds for assessing BATs in favourable condition

BAT code	Description	CSM objective
A11	Arboreal canopy	none set
A21	Wood decay	190
F11	Unshaded early successional mosaic	180
F21	Grassland & scrub matrix	160
F22	Scrub-heath & moorland	none set
F31	Shaded field & ground layer	none set
W11	Fast-flowing water	150
W12	Slow-flowing water & seepage	170
W21	Mineral marsh & open water	170
W22	Litter-rich fluctuating wetland	180
W31	Permanent wet mire	160
W51	Rocky shore	none set
W52	Sandy shore	none set
W53	Saltmarsh, estuary and mud flat	200

Other uses of ISIS

3.24 ISIS can be used to interpret data and identify assemblage types as features of interest as part of an initial assessment of invertebrate interest on an SSSI. In a similar way, it can be used to identify conservation priorities for landscape character areas (Figure 1). It can also be used to compare individual assemblage types on different SSSIs or river systems.

3.25 The BAT representation score can be used to monitor the effects of site management on individual management units. If used as part of a carefully planned sampling programme, ISIS can also be used to monitor environmental change on a wider scale, for example the effects of flood alleviation schemes on floodplain assemblages, or the effects of climate change on montane and upland assemblages.

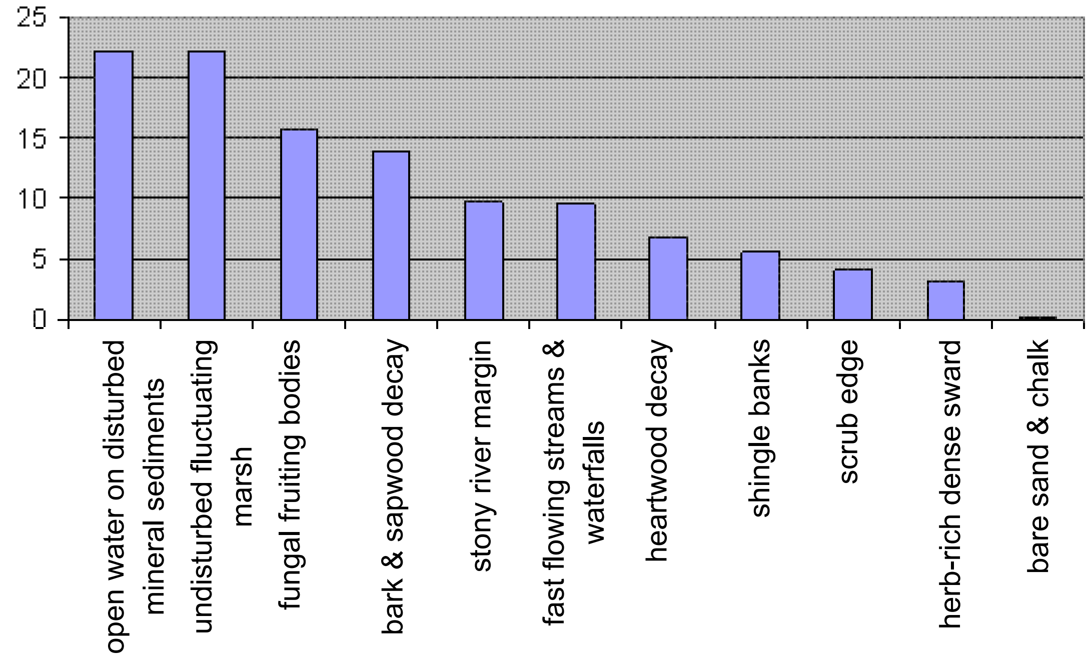


Figure 1 SATs represented in Charnwood Landscape Character Area, Leicestershire, scored according to the percentage of the national species pool represented in the area

Other methods of analysis

Species diversity

3.26 Species diversity has many guises. Its simplest form is the total number of species, whether the total of all species in a unit or just those with particular characteristics, such as rare ones. As rarity is given high status in conservation evaluation, methods have been devised to express this in a single value, giving rise to several scoring methods for measuring the conservation 'quality' of a sample. Finally, the relative numerical contribution of each species to the unit is taken into account using species diversity indices. These different ways of re-interpreting the same raw data are discussed here.

Species richness

3.27 Species richness is simply the total number of species in any unit, for example, a single sample, or combined samples from a whole site. Species may be treated as having equal value, or counts may be taken of species that have been selected for particular attributes, such as their assemblage type or rarity. It is the most easily understood measure of biological diversity, although its measurement is more complex than might be expected.

3.28 Drawbacks to using species richness as a bald figure are:

- Its value rises with sampling effort.
- Comparisons can be made only for data from the same suite of higher taxa, similar habitats and same geographic area.

3.29 The effects of uneven sampling effort can be reduced by the following:

- Use standardised sample sizes so that, within one survey, samples collected using comparable effort are compared.
- Convert species in different categories (eg each rarity or habitat indicator class) to a percentage of the total.

- Calculate mean species richness per sample where the sample effort per sample is constant but different numbers of samples have been taken in each area. Species may not be distributed randomly within samples, even if the sampling units have been taken at random (Pielou, 1975), however there seems to be no advice on how to decide whether this is true. It is probably safe to assume the species data are normally distributed, so results can be expressed as a mean value with confidence limits, without the need for transformation.

Estimators of total species richness

3.30 When a moderately large series of equivalent samples has been taken, there are several ways of estimating the total number of species in the community. They are all based on a curve of the various measures of species abundance plotted against the sampling effort, and the estimate of total species richness is where the curve reaches an asymptote or converges to a steady unvarying point. These methods are particularly useful for survey data of the kind discussed in this book because they use number of samples rather than the numbers of individuals as the measure of effort. Magurran (2004) gives a clear account of the methods; PISCES Conservation (2006) provides software to calculate the more complex measures.

3.31 The simplest method is a species accumulation curve – the cumulative number of species plotted against cumulative sampling effort. A smoother curve with more points and therefore reduced error can be obtained by using all possible combinations of samples for each number of samples, or at least taking a random selection of values for each X-axis point if a large number of samples have been taken. For example, if four samples are taken, there are four values for the first unit of sampling effort, six for all combinations of two samples, and so on. If the sampling effort is inadequate, only the beginning of the curve may be represented and the data could fit a linear, exponential or asymptotic curve with equal probability. No estimate of total richness is then possible.

3.32 Other methods use a parameter of an underlying mathematical model of species distribution to estimate species richness. Non-parametric estimators of species richness appear to provide a reliable alternative to these. By side-stepping the parametric element, they make far fewer assumptions about the form of species abundance models.

3.33 Chao 1, named by Colwell and Coddington (1994) after its originator (Chao, 1987), is the simplest method and needs the least additional effort in gathering data. It is based on the numbers of infrequent species in the sample, and given by:

SChao1 = Sobs + F12 / 2 F2

where Sobs = the number of species in the sample, F1 = the number of species represented by a single individual (singletons), and F2 = the number of species represented by two individuals (doubletons). So, when identifying the catch, a note is made of the number of singletons, doubletons and those with three or more individuals.

3.34 The main disadvantage with Chao 1 is that most existing survey data notes only presence / absence, so the method can rarely be used retrospectively when comparing new datasets with older ones.

3.35 However, Chao 2 is a similar estimator that works moderately well with presence / absence data in a series of samples. It does this by using the number of species found in only one sample (Q1≡ F1) and those in two samples (Q2≡ F2). The formula is the same as for Chao 1:

SChao2 = Sobs + Q12 / 2 Q2

3.36 Like the Chao 2 estimator, Jackknife estimators need only presence / absence data. The simpler version, Jackknife 1, uses only the number of species that occur in one sample; Jackknife 2 uses both this value and the number of species occurring in two samples:

SJack 1 = Sobs + Q1 (m-1/m)

SJack 2 = Sobs + [Q1 (2m-3)/m – Q2 (m-2)2 / m (m-1)]

where m is the number of samples.

3.37 Other non-parametric methods have been described. Discussion of the performance of these by Magurran (2004) suggests that Chao and Jackknife estimators are likely to be as good as other methods when interpreting most British wildlife surveys. Chao 2 appears to give more realistic results where there is a small numbers of samples and small sample sizes. All Chao and Jackknife methods give increasing estimates of the total species richness as the sampling effort increases. All give less reliable results as 'patchiness' increases or when there are many infrequent species (as happens when sampling includes different assemblages, since more unique species will be found) although Chao 2 seems to perform better than Chao 1 as patchiness increases. In fact, the only assumption that the methods make is that sampling is from a homogenous background – this is the only restriction to be born in mind when estimating total species richness.

Species diversity indices

3.38 These take into account both the number of species and how individuals are distributed among them. The most likely reason for wanting to estimate a diversity index is to demonstrate that the fauna has been affected (for better or worse) by environmental change. This is based on the assumption that individuals are distributed more evenly among all the species in a pristine community but disturbed communities are dominated by a few very abundant species. For example, a community of aquatic invertebrates affected by pollution will tend to be dominated by a small number of tolerant species and have a lower species diversity than one in an equivalent, unpolluted environment.

3.39 Magurran (2004) strongly recommends only two indices:

- Simpson's index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species. It is both meaningful and robust compared with a large number of other measures and, being a non-parametric estimator, does not depend on the data having to fit a particular mathematical model.
- The Berger-Parker index of dominance expresses the proportional abundance of the most abundant species. It is perhaps most useful in conservation evaluation if there is a need to show a large change towards the dominance of a few species.

3.40 Diversity indices are useful as they are moderately independent of sample size, this means the problem of sampling effort is partly overcome. However, a major disadvantage is that their calculation requires abundance data which is not usually recorded in old surveys. Further disadvantages are that the value is difficult to interpret biologically and in some naturally species-poor habitats, such as bogs, a low value does not equate to a 'less natural' system. They are, therefore, not recommended as a primary tool in site evaluation.

Threatened species

3.41 Much invertebrate conservation evaluation hinges on nationally threatened and scarce species. Conservation statuses (see Appendices 1 and 2 for definitions) have been allocated to many British invertebrates by the JNCC, based on the collective expert opinion of many specialists working outside the statutory agencies (Ball, 1994a). Problems arise from the fact that the status of many invertebrate groups has not been revised recently, and there are an increasing number of unjustified statuses that will lead to imperfect conclusions if used without critical consideration. Statuses listed below (except for local and subspecies) can be found in biological recording packages and the JNCC website (Appendix 3).

3.42 Categories to consider are:

- Internationally rare species, some of which are included in the EC Habitats & Species Directive (Annex II) and in the Berne Convention (Appendix b).
- Endemic species, for which there is an international obligation to protect populations. Few species are known from only Britain, and many of these are small populations and found in little-studied microhabitats or in poorly recorded groups.
- Statutorily protected species listed in Schedule 5 of the Wildlife and Countryside Act 1981 and updated in quinquennial reviews. These include some species that are protected against trade only (all but 6 of the 25 butterflies) so they cannot be accorded the same importance in site evaluation as species given full protection.
- Nationally rare and threatened species listed in Red Data Books (Shirt, 1987; Bratton, 1991) and updated by the JNCC in national reviews. If there has been a change in status, the status given in the reviews published after the Red Data Books takes priority. IUCN criteria and statuses are gradually replacing the British Red Data Book system. The two systems use different criteria but will run in parallel for some time. Approximate equivalent statuses are given in Table 4 but it is not strictly legitimate to mix the two systems, thus making analysis clumsy.
- Nationally scarce (often called Notable) species, listed in JNCC national reviews. In some orders, scarce species are divided into two levels, Notable A (Na) and Notable B (Nb), based on their presumed rarity.
- Regionally scarce (or notable) species, whose statuses are available from the JNCC Recorder for some species in some regions. There has been no thorough assessment of regional rarity so its value in describing the fauna is limited. However, it is clearly important since many species common in the south of Britain are scarce or absent further north.
- Local species (as listed in the Recorder). The ‘local’ label has no formal status and is sometimes applied at a national level, so it may be meaningless at a regional level where a species may have a different status. It is therefore unwise to stress the importance of species with this status unless there is good reason to do so.
- Subspecies and races. These are defined mainly for Lepidoptera. Many appear to be endemic to Britain but it is not proposed that common British subspecies should be given special status in site evaluation. The species conservation handbook (English Nature, 1994) lists subspecies.

3.43 A few county Red Data Books or lists that indicate county status have been published for some groups. Some define criteria for county status, and these may be adapted for other counties to assess sites that may not meet SSSI standard. For example, Lott (1995) gives three criteria (apart from those for national statuses):

- Rare species, ie those recorded from three or fewer 10 km square in the county.
- Species that are restricted to endangered sites and habitats that are expected to be adversely affected by modern management practices, such as flood alleviation schemes and intensive agriculture.
- Declining species, ie those that can be shown to have declined in the county to an extent whereby their long-term survival is doubtful if the present trend continues.

Table 6 Equivalence between Red Data Book rarity status and IUCN threat status

IUNC		Red Data Book	Issues arising
Threatened	Critically Endangered (CR)	no equivalent	
	Endangered (EN)	Endangered (RDB1)	same name but different criteria; confusion possible as a species may be in different categories in the two systems.
	Vulnerable (VU)	Vulnerable (RDB2)	as for Endangered
Lower Risk (LR)	conservation dependent (cd)	no equivalent	
	near threatened (nt)	Rare (RDB3)	mostly equivalent; some 'RDB' species are IUCN Vulnerable
	nationally scarce (ns)	Notable A Notable B	directly equivalent
	no equivalents	Indeterminate (RDBI) Insufficiently Known (RDBK)	
	Data Deficient	no equivalent	

Biodiversity Action Plan (BAP) species

3.44 Species are included on the BAP for various reasons, although they need to meet criteria that include a recent decline in status. Thus most BAP invertebrates are scarce or threatened, so this element is already included in assessment when discussing rarity. And while some BAP species are very rare, others are included for their 'flagship' status and political usefulness. Any assessment should mention BAP species, since obtaining better information on their distribution is often an action in these plans. However, in any scientific approach, these species do not necessarily warrant highlighting compared to equally rare but politically less favoured species.

Species with unusual distributions

3.45 Some species recorded in a survey may be of interest because their discovery in the survey area is unexpected. However, this aspect should not be over-played since species' ranges do change, and our information may be inaccurate for species in poorly recorded groups.

Species at the edge of their range

3.46 Species at the edge of their climatic range often need special consideration because they often have more exacting ecological requirements. Sites where a number of such species occur are likely to be special. Distribution atlases sometimes give a misleading impression about the real edge of a range. For example, some species may occur a long way north along the coast but cannot survive inland at lower latitudes. Written comments in some atlases often clarify this.

Species outside their normal range

3.47 This situation is probably the result of habitat fragmentation in the countryside, meaning that the 'normal' range of a species is not known. One of the Ramsar criteria (2b) is pertinent here and could be paraphrased to apply to any habitat, ie the habitat should be considered important if it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of fauna.

Species whose range is contracting

3.48 This information is well recorded for butterflies whose annual population fluctuations are known from the Butterfly Monitoring Scheme (Pollard & Yates, 1993; Fox et al., 2006). The Red Data Books, JNCC national reviews and BRC atlases are the best sources of information for other species.

Species of possibly low interest

3.49 Resident species are those that depend on a site for the completion of their life cycle; non-residents (vagrants, tourists) are dispersing through the area of the site or are making only casual use of it. While analysis is more robust if these species are excluded, there is no practical way of distinguishing them except for small well-studied groups where the animal's known requirements can be shown to be absent from the survey site. Also, the division into residents and vagrants can become arbitrary, for instance, feeding at flowers cannot be considered a casual use of a site yet many strongly flying insects use flowers well away from their larval site. And do dragonflies hawking in a woodland ride count as an essential part of the woodland fauna, given that the ride is undoubtedly important in completing the life cycle of the adult?

3.50 Recently introduced, synanthropic and migrant species play no part in evaluation unless a rare migrant establishes a permanent population, when it may justifiably be treated as a rare native species.

Rarity indices and the Species Quality Index (SQI)

3.51 Problems in the application of rarity as a conservation criteria have been widely discussed (Gaston, 1994). Nevertheless, rarity remains a widely used measure of conservation interest that is readily accepted by people outside the conservation industry. Rarity indices reduce information on the rarity of species in an assemblage to a single value. The one most frequently used is the Species Quality Index (SQI).

3.52 There are several versions of SQI which are based on allocating scores on a geometric scale from 1, for the most widespread species, to 16, 32 or 64, for the most localised, depending on the author. The scores are summed to give a total (the Species Quality Score, SQS) that is clearly dependent on sampling effort but may be used to compare sites where the sampling effort was similar. Taking the average of this score (SQI = SQS ÷ total number of species) largely corrects for sampling effort. The index takes all species into account so that widespread species contribute to the assessment. It appears to have originated from the WETSCORE (WETland Site COleoptera Record Evaluation) method, developed for water beetles using data collected for the national recording scheme (Foster, 1987; Foster et al. 1990; Foster & Eyre, 1992).

3.53 The basis for allocating an SQS varies between authors, although they all use geometric scores which emphasise rarity more than linear scores. For example, Foster (1987) based water beetle scores on the number of 10 km squares in which the species was recorded within a geographic region, and then modified the score using: knowledge of the difficulties of catching and identifying each species; evidence of decline or increase; and by other adjustments to smooth the distribution of points to species. Recently it has become commonplace to use national conservation status as a surrogate for rarity (Ball, 1992; Archer, 1993; Fowles et al. 1999).

Table 7 Conservation designation and associated species score

Conservation designation	Score
common	1
local	2

Table continued…

Conservation designation	Score
regionally Notable	4
nationally scarce categories Nb and unclassified Notable	8
nationally scarce category Na	16
Red Data Book	32

3.54 The system has been adapted for assemblages of species showing fidelity to particular habitats. So far dead wood and Exposed Riverine Sediments (ERS) have been treated but there is no reason why the concept should not proliferate unmanageably to all assemblages (Fowles, 1997, 2003; Fowles et al. 1999; Sadler & Bell, 2002). Habitat-faithful species are first defined (see below for definitions in Fidelity Indices) and scores – given below – are allocated only to species having at least moderate fidelity to the habitat. The average score per taxon is multiplied by 100 to give an index (this is not done for the ordinary SQI).

Table 8 Conservation designation, description and associated species score

Conservation designation	Description	Score
common		1
local		2
very local		4
with an uncertain distribution	unevaluated	4
nationally notable (N-)	either Na or Nb	8
nationally notable B (Nb)	range < 100 x 10 km squares	8
nationally notable A (Na)	range < 30 x 10 km squares	16
Red Data Book K (RDBK / RK)	insufficiently known	16
Red Data Book I (RDBI)	indeterminate	24
Red Data Book list 3 (RDB3)	rare (range < 15 x 10 km) squares)	24
Red Data Book list 2 (RDB2)	vulnerable	32
Red Data Book list 1 (RDB1)	endangered	32

3.55 Care is needed when using SQI. The geometric score deliberately accentuates rarity, but extending the score to high values (32, 64) leads to distorted results in small samples containing very rare species, and in sites where rare species are concentrated (eg ancient trees in landscapes with a few young trees). The score should be applied only to samples with at least 15 species per sample; for saproxylic assemblages, a list of 40 qualifying dead-wood beetles is the recommended minimum to produce a reliable SQI.

3.56 A number of different ways of allocating scores to species have been used and one system may not be comparable with another (eg Archer, 1993; Crossley, 1996; Eyre & Luff, 2002). Even if a standard approach could be adopted, problems remain regarding compatibility between different taxonomic groups, because the criteria for their conservation status have been applied inconsistently to different orders and even families. In addition, species statuses are changed, and species are added or removed from habitat-faithful subsets, which often necessitates the recalculation of scores between surveys.

3.57 Foster & Eyre (1992) suggested that, using their scores for water beetles, a species quality score of 2 or more usually indicates a "good" site (their quotes), but this should not be taken as more than a qualifying statement; while it may represent a threshold for sites worthy of further consideration, it is untested as a threshold for SSSI standard.

3.58 Despite all these problems, SQI is becoming an increasingly popular way of assessing and comparing site quality.

Fidelity indices

3.59 Species can be allocated to categories other than those relating to rarity, and an index developed to express the desired quality. This is no different in principle from classing species according to rarity, but it is treated separately here to highlight a different aspect of species that helps interpret and evaluate conservation interest, ie that of fidelity to particular habitats. This is the basis of ISIS but it has been developed in particular for species of dead wood and Exposed Riverine Sediment (ERS). An older use is the Biological Monitoring Working Party (BMWP) score that uses the pollution-tolerance of different groups of aquatic invertebrates as a measure of potable water quality.

ERS fidelity grades

3.60 The following grade definitions are applied to ERS beetles (Sadler & Bell, 2002; Fowles, 2003):

Grade 1
Species that are dependent for at least some stage in their life cycle on bare, or sparsely vegetated, sediments on the banks of rivers. Some of these species may also inhabit exposed lacustrine sediments, particularly where wave action forms banks of sediment on lake shores as these features are in many ways ecologically similar to riverine shoals.

Grade 2
Species strongly associated with ERS for at least some stage of their life cycle, but also characteristically found in other habitat types where extensive deposits of wet or dry bare sediments are present, such as sand dunes, soft rock cliffs, sand or gravel pits.

Grade 3
Species associated with ERS, but also occurring in a wide range of habitat types, such as flushes, seepages, pond margins, etc, where the presence of bare sediment is of fundamental importance for some stage of their life cycle.

Grades 4 and 5
These species may be found on ERS but are not ERS specialists. Many of these are wetland specialists and aquatic species (notably elmid beetles).

Habitat-fidelity index

3.61 The concept behind species quality scores has been applied to habitat fidelity in order to give a single measure of fidelity. Scores are allocated on a geometric scale to all species from 1 – for species with no affinity to the habitat, to 32 – for those with greatest fidelity. It has been used by Eyre & Luff (2002) who give fidelity scores for carabid beetles, and is an extension of the simpler scoring system devised by Eyre & Lott (1997) and refined by Sadler & Bell (2002) and Fowles (2003).

Dead wood Index of Ecological Continuity

3.62 The saproxylic beetle Index of Ecological Continuity (IEC) was developed to produce a simple statistic that could be used in grading a site for its significance to the conservation of saproxylic beetles based on ecological consideration rather than rarity (Alexander, 1988). The index is based on a listing of the species thought likely to be the remnants of saproxylic beetle assemblages found in Britain's post-glacial wildwood, and which have survived through a history of wood pasture management systems in certain refugia.

3.63 Saproxylic beetles are grouped according to the extent to which they have been consistently recorded from areas of ancient woodland with continuity of dead-wood habitat, particularly pasture-woodland:

- Group 1: Species that are known to have occurred in recent times only in areas believed to be ancient woodland, mainly pasture-woodland.
- Group 2: Species that occur mainly in areas believed to be ancient woodland with abundant dead-wood habitat, but which also appear to have been recorded from areas that may not be ancient woodland or for which the locality data are imprecise.
- Group 3: Species which occur widely in wooded land, but which are collectively characteristic of ancient woodland with dead-wood habitats.

3.64 The IEC is the sum of the scores for a site. The thresholds for assessing a site are:

- >80 = international importance;
- >25 = regional importance; and
- >15 = regional importance.

3.65 Several visits are needed to get a reasonable list of species (see Wood decay assemblages in target methods for taxa and assemblages page 66). IEC has an advantage over SQI in that only specialist species need be collected (in contrast, all SQI scores require complete lists).

3.66 Alexander (2004) gives a revised list of all beetles recognised as saproxylic and those qualifying for the IEC, and a list of British sites with IEC values of 20 or more.

Population size and individuals' abundance

3.67 Population size is one of the criteria for selecting SSSI for invertebrates (NCC, 1989). In practice this can be done only for some large and conspicuous species and groups (eg butterflies, dragonflies) but plays little useful role in most site assessments for invertebrates. The abundance of individual insect species is often extremely variable from year to year and this figure can be an irrelevant statistic. Furthermore, the methods described in this book are qualitative and unsuitable for estimating population density (numbers of individuals per unit area or volume) or absolute population size. Animals may be counted, but this can add hugely to the time needed for identification and, for evaluation surveys, gives lots of information that is rarely used.

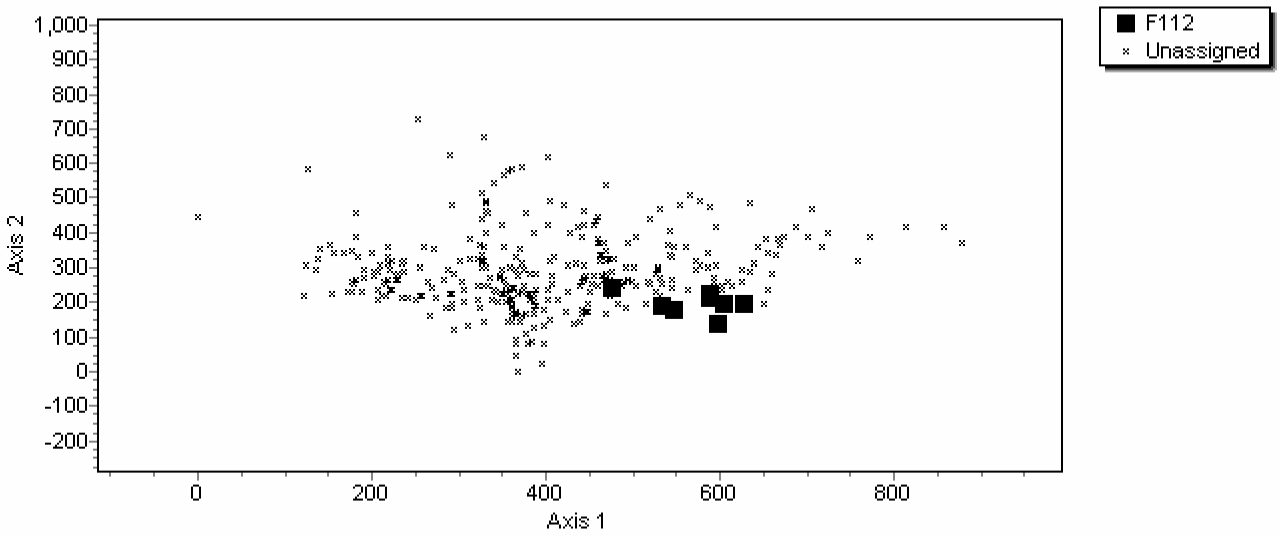
3.68 An approximate estimate of relative abundance can sometimes be useful in site evaluation, for example, to demonstrate that nationally rare species are locally common, or to improve on presence-absence when using multivariate analyses. Estimates of abundance made 'by eye' will be inaccurate, so a fine scale will give more false information than a crude one. It seems sensible to limit measures of relative abundance to four levels. The following is a suggested scale with a great deal of approximation to stop it appearing as genuinely quantitative:

- present (1 to about 9 individuals);
- several (about 10 to about 30 individuals);
- frequent (about 30 to about 100 individuals); and
- abundant (>100 individuals).

3.69 One method for estimating total population size relies on counting the number of species represented by either one, two or more than two individuals (Chao, 1984). This entails a little more effort than noting only presence-absence or rough abundance but can yield another useful statistic on species-richness.

Ordination

3.70 Finding ecological patterns is often an important aspect of landscape and regional surveys. Ordination and classification are commonly used methods, the former for identifying trends and the latter for groups. Ordination is the scoring of samples for comparative purposes so, in effect, all the scoring systems mentioned here so far are types of ordination. However, the term is most often applied to the use of statistical programmes that separate assemblage samples along axes of variation in species composition. Usually, only the first two or three axes give interpretable results and the results are usually presented in the form of an ordination plot. Ordination plots can also show the interrelations of species; those that coexist in samples will appear close together in ordination space (Figure 2 gives an example).



Species assigned to the ISIS 'open short sward' assemblage type (F112) occur in assemblages with a similar species composition.

Figure 2 Example DCA ordination plot of 576 species present in suction samples from grasslands on 11 SSSIs in England

3.71 Different ordination programmes use different models of the variation of species abundance along environmental gradients. Detrended Correspondence Analysis (DCA or DECORANA) assumes a unimodal distribution and is the most commonly used programme. However, for data sets with small variations in species composition, Principal Components Analysis (PCA) is a more appropriate option, because this assumes a linear relationship between species abundance and environmental gradients.

3.72 DCA is useful for generating hypotheses about what is influencing the composition of assemblage species. The arrangement of samples or species in ordination space can often suggest the relative importance of different environmental factors. It works best in conjunction with sampling protocols that are well defined in terms of spatial scale and sample site selection. Habitat homogeneity within the sampling area and the stratification strategy in sample site selection are both critical factors. Consequently, ordination of casually collected data, for example data from national recording schemes, rarely gives satisfactory results.

3.73 If environmental data are associated with each sample, this can be correlated with their ordination axes scores to explore the relationship between species composition and environmental gradients. However, this can be achieved more directly by using Canonical Correspondence Analysis (CCA or CANOCO) which is specifically designed to test hypotheses about relationships between variations in species composition and a particular set of environmental gradients (Figure 3 gives an example).

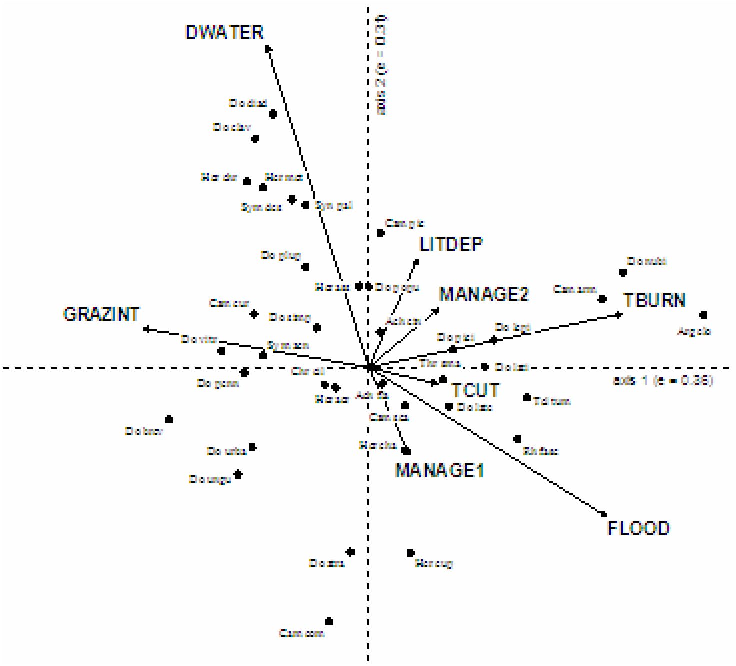


Figure 3 Example CCA biplot showing the response of dolichopodid species (long-legged flies) to hydrological and management variables in East Anglian fens

DWATER is a measure of water level fluctuations, FLOOD is a measure of overall wetness, LITDEP is a measure of litter depth, GRAZINT, TBURN, TCUT, MANAGE1 and MANAGE2 are all management variables. Water level fluctuations have an important influence on the species composition of dolichopodid assemblages. Dolichopus claviger and D. diadema show a positive response to water level fluctuations while Campsicnemus compeditus and Hercostomus cupreus show a negative response.

Classification

3.74 Classification of samples can be done from the top-down by repeatedly looking for the major divisions in the data, or from bottom-up by grouping the most similar samples into larger and larger clusters based on comparing similarity indices between pairs of samples. Divisive methods are reputedly better at finding large real groupings, and clustering methods are better at finding small groups (Fielding, 2007).

3.75 Two-way indicator species analysis (TWINSPAN) is a programme that classifies samples into end groups by repeatedly dividing ordination space into two groups (Hill, 1979b). Fuzzy Set Classification uses similar techniques, but the membership of a sample to a particular end group is expressed as a likelihood rather than a definite yes or no (Pisces Conservation, 2005).

3.76 Ordination is demonstrably a powerful technique because it often gives similar results on different data sets. Species ordinations are well correlated between data sets collected in different regions and at different scales. By comparison, end groups of classification methods often vary in character between datasets, especially in the finer divisions. End groups can also be difficult to interpret if too many groups are chosen, although the first two or three divisions of TWINSPAN often give species-groups that are recognisable ecological units. Although further quantitative analysis, such as correlation with environmental variables, cannot be undertaken on the end groups, they can be described in terms of the most frequently occurring and characteristic species, and their environmental characteristics quantified, or at least described verbally. The least satisfactory aspect of TWINSPAN (when used with invertebrate data) is that it cannot be assumed that the selected indicator species can be used as a guide to group membership in future studies. Another unsatisfactory feature is that it cannot be assumed that the same species will always share the same group; dominant species (other than ubiquitous generalist) often fall out together in different datasets but species occurring infrequently in a dataset may not be accurately placed.

3.77 When used with discretion, divisive classification can be useful in highlighting major ecological groups, but common sense and an understanding of the ecological requirements of many species have to be brought to bear on the results of this ‘blind’ mathematical process.

3.78 Analysis of Similarity and Dissimilarity (eg Pisces Conservation, 2002), which compares indices of similarity within and between groups of samples is a useful method of testing the validity of previously defined classifications.

Coming to a conclusion

3.79 Analysis does not end with lists of rarities or numbers. A value judgment is needed to assess the quality of the site or assemblage. This can be made either by comparison with other sites or assemblages, or by using the thresholds set for assemblages in ISIS, but it also needs the surveyor’s opinion based on experience.

3.80 The importance of a site or assemblage should be rated on the following scale:

- Little or no importance.
- Local or county importance. This is measured using County Wildlife Site guidelines. These sites are recognised in the planning process.
- Regional importance. This is intermediate between local and national importance. It can be difficult to assess as it can only be measured by comparison with data collated at a regional scale. It can be useful if a site is unique to a region, or if the area of search has to be made wider than a county.
- National importance. These have similar value to SSSIs. However, this does not mean that such sites or assemblages necessarily qualify for notification, since SSSIs are selected on a range of criteria and conservation interests.
- European importance. The invertebrate features have similar value to sites with international designations (eg Ramsar, Habitats and Species Directive).

3.81 The data needed to make these comparisons become increasingly difficult to collate as the area searched for comparative sites increases. Up to now this exercise has been fraught, since the data usually do not exist in an easily accessed form. Collating data in paper records is prohibitively time-consuming, but the amount of accessible site data available on the web is increasing rapidly. It is also unrealistic to pretend that good comparisons can be made in many cases. The most common sources of data for local or regional comparisons are local record centres, which may hold data on previous surveys of similar habitats within the county or region. The area of search may have to extend further than a county to make ‘county’ comparisons, and this can make ecological sense when habitats stray unchanged across political boundaries. Information for national comparisons can be obtained from the Invertebrate Site Registers of the country agencies, although the quality of data from these sources is often unreliable. In all cases, the most accessible data sources will be websites, and the rapidly developing NBN gateway (see appendix 3) has a growing potential to meet comparative data needs in the future. For saproxylic assemblages, a web-based national register of sites and their Index of Ecological Continuity will allow new sites to be placed in rank order (Appendix 3).

3.82 ISIS tries to overcome some of the issues of comparing existing data by giving thresholds that indicate whether a site or assemblage is a ‘good’ example. However, some thresholds have been set for a precisely prescribed sampling effort and could result in unreliable conclusions if old data are tested uncritically using ISIS.

3.83 A common problem when comparing data is that the sampling effort and target groups are scarcely ever the same in different surveys. This can be partly taken into account by using rarity indices, expressing numbers of species (eg of different rarity classes) as percentages of the total catch, and by using mean values if replicate sampling units are taken (a rare occurrence). An indication that a site has at least moderate interest is the proportion of rare and scarce species.

At least 5% of species from a full species list from many SSSIs will be rare or scarce species, although this figure is an untested guide.

3.84 Surveyors should always link invertebrate species interest to habitat features. Their opinion of the quality of the habitat features is important. This is the information that most land managers want because they can understand it and know how to change the habitat, whereas they often have no clue how to act when faced with abstruse data on assemblage or species. A surveyor's opinion of habitat quality is also necessary to identify 'sink' sites, ie those that apparently have good faunas but whose presence and future actually depend on invertebrate immigration from neighbouring areas of genuine high quality.

4 Sampling protocols

4.1 This chapter sets out preferred protocols for commonly used sampling methods that should give data adequate for conservation assessments. A standard sampling method is a pre-requisite for getting replicated samples, but there is a bewildering array of techniques to choose from. Each collecting method samples a different fraction of the total fauna and it is sometimes necessary to use more than one. The most cost-effective approach is to use methods that have the least overlap in what they collect (Figure 4), and this has guided the choice of methods discussed here. Logistics have also been considered, among which are the ease of use of equipment, its portability and inconspicuousness to people and large animals.

4.2 The methods selected here have a long history and proven track record of effectiveness. They will not collect all invertebrate taxa, and some specialists may feel that their group has been unfairly dismissed. No judgment is intended; rather we seek a pragmatic approach that is affordable and delivers realistic answers. Other equally effective sampling methods have been excluded simply because another way of catching the same fraction of the fauna has been described. The strengths and foibles of a larger range of sampling methods can be read about in the texts listed in 'References'. Nor are specific methods for Lepidoptera and Odonata discussed, since butterflies and dragonflies are best surveyed by watching, and macro-moths by light trapping. This handbook can add nothing to text such as Fry & Waring (2001) on light traps, to Whalley (1980) and Pollard & Yates (1993) for butterflies, and Brookes (1993) for dragonflies.

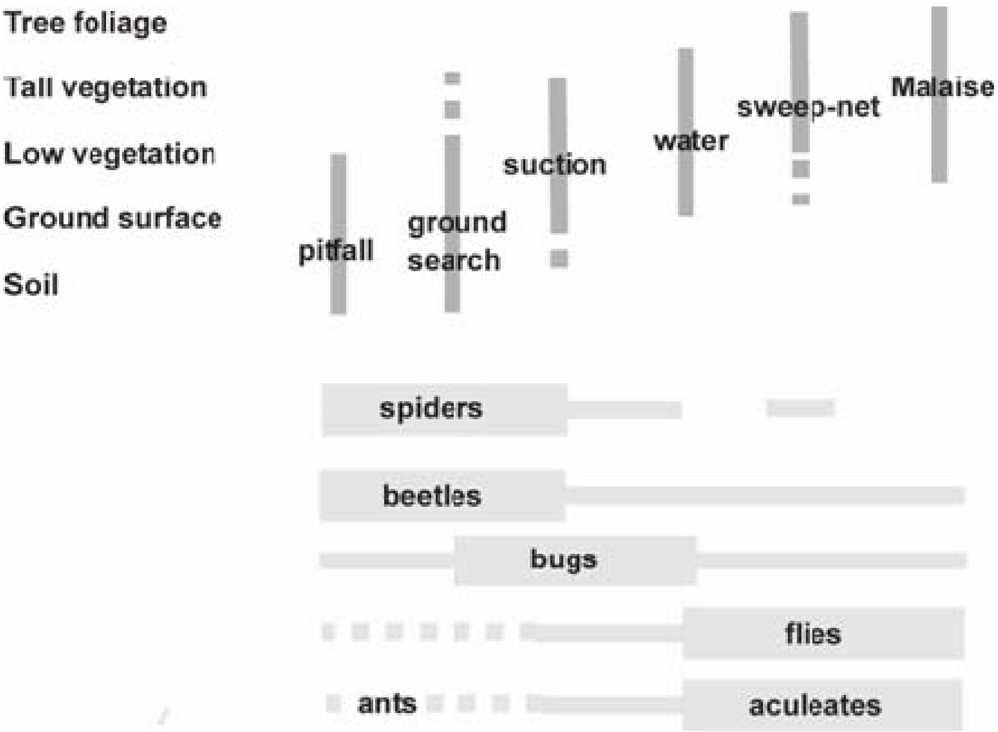


Figure 4 Approximate fraction of the fauna and habitat sampled by different collecting methods

Sampling protocols for ISIS

4.3 ISIS is an analytical tool that can be put to a wide range of uses. The appropriate sampling protocol for any application of ISIS depends on what it will be used for. ISIS can provide an initial assessment of an area using casually collected data from sources such as national recording schemes. However, an assessment will be more accurate if the data used is the result of a properly planned survey dedicated to that purpose. Sampling protocols for Common Standards

Monitoring (CSM) must be followed so that results from different survey periods can be compared, and to compare results against common thresholds for condition assessment.

Specific Assemblage Type (SAT) assessments for CSM

4.4 Appropriate target groups for assessing SAT quality can be selected for each SAT by determining the proportion of characteristic species in each taxonomic order or family. The most important target groups for each SAT are listed in Table 9. If a characteristic species from a non-target group is known to occur on a site, the sampling protocol can be amended appropriately. More detailed information on the distribution of taxonomic groups between assemblage types can be found in the chapter ‘Target taxa and methods for assemblages’.

4.5 Once the target groups have been chosen, the appropriate fieldwork methods and optimum season for fieldwork for each group can be selected. The SAT quality score is influenced by sampling effort, so it is important to assess each SAT on an SSSI by aggregating a standard number of samples. Four samples have been found to be adequate for recognising assemblages in favourable condition across a wide range of assemblage types. However, selecting the ‘right’ four sampling sites is critical because the quality scores of individual samples can vary widely. The sampling sites should be in representative habitats and spatially separated across the SSSI. It is best to cover a range of those optimal habitats most likely to be occupied by the SAT being assessed. Sampling sites in suboptimal habitats will tend to give results that depress the overall score.

4.6 A summary of recommended sampling protocols for each SAT is given in Table 9. The fieldwork methods should conform to the methodologies described later.

Table 9 Sampling protocols recommended for condition assessments of SATs

SAT	Target groups	Fieldwork methods	Alternative methods
A211 A212 A213	Col.	Beating & targeted search	
A215	Het., Lep.	Beating & targeted search	
F111	Col., Het.,	Ground searching (Apr. / May)	Pitfall traps
	Dip.,	Sweeping (spring + summer)	
	Dip., Hym.	Spot-sweeping (spring + summer)	
F112	Col., Het.	Ground searching (Apr. / May)	Pitfall traps
	Dip.	Sweeping (spring + summer)	
	Dip., Lep.	Spot-sweeping (spring + summer)	
F113	Col., Het.	Ground searching (Apr. / May)	Pitfall traps
	Lep., Hym.	Spot-sweeping (spring + summer)	
F211	Col., Het., Dip.	Sweeping (spring + summer)	Suction-sampling
F212	Dip., Col.	Sweeping & beating (spring + summer)	Suction-sampling
	Dip., Hym., Lep.	Spot-sweeping (spring + summer)	
F221	Col., Ar., Dip.	Ground searching	Pitfall traps
		Sweeping (spring + summer)	Suction-sampling

Table continued…

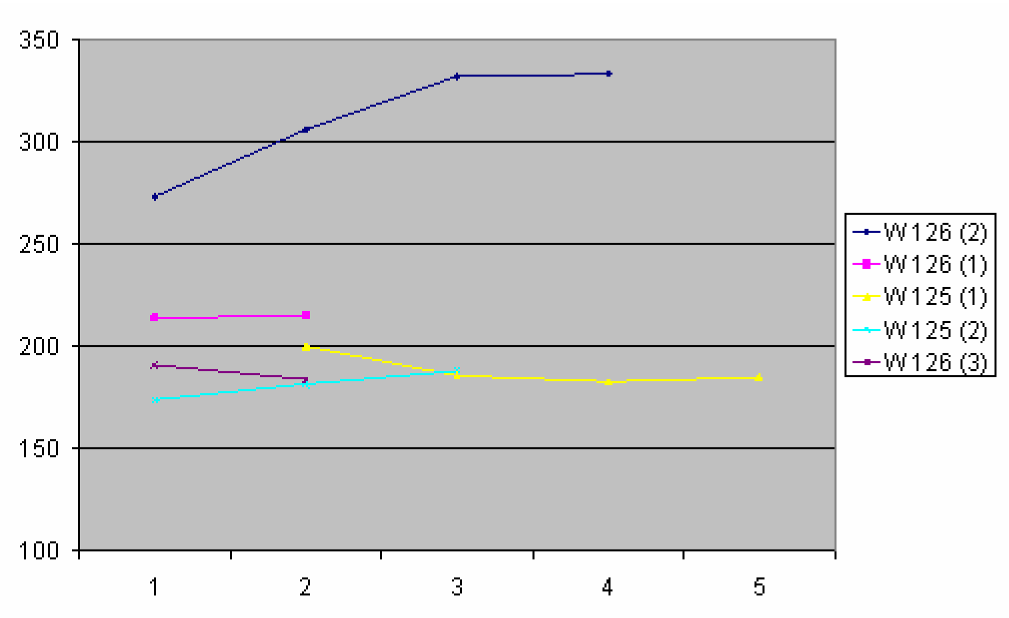
SAT	Target groups	Fieldwork methods	Alternative methods
F222	Ar., Dip., Col.,	Sweeping & beating (spring + summer)	Suction-sampling
	Dip., Hym.	Spot-sweeping (spring + summer)	
W111	Col.	Ground searching (May / June)	
W112	Dip.	Sweeping (spring + summer)	
W113	Dip.	Sweeping (spring + summer)	
	Col.	Ground searching (sieving moss)	
W121	Dip.	Sweeping (spring + summer)	
W122	Col.	Ground searching (May / June)	
W124	Col.	Ground searching (May / June)	
W125	Aquatic macroinverts	Pond-netting	
	Dip.	Sweeping (spring + summer)	
W126	Dip.	Sweeping (spring + summer)	
	Tric.	Pond-netting	
W211	Aquatic macroinverts	Pond-netting	
W212	Aquatic macroinverts	Pond-netting	
W221	Col.	Ground searching (Apr. / May)	Pitfall traps
W311	Aquatic macroinverts	Pond-netting	
W312	Col., Het.	Pond-netting	
	Col., Ar., Het.	Ground searching	
	Dip.	Sweeping (spring + summer)	
W313	Col., Het.	Pond-netting	
	Col.	Ground searching	
	Dip.	Sweeping (spring + summer)	
W314	Col., Het.	Pond-netting	
	Col.	Ground searching	
	Dip.	Sweeping (spring + summer)	
W521	Col.	Ground searching	
W531	Col., Het.	Pond-netting	
	Col.	Ground searching	
	Dip.	Sweeping (spring + summer)	

Target groups: Col. – Coleoptera, Lep. – Lepidoptera, Het. – Heteroptera, Dip. – Diptera, Hym. – Hymenoptera, Ar. – Araneae, Tric. – Trichoptera.

Broad Assemblage Type (BAT) assessments for CSM

4.7 All default BAT targets and thresholds for CSM have been set using data that covers a wide range of taxonomic groups, but excluding Auchenorrhyncha. BAT ‘rarity scores’ have been found to be influenced by taxonomic bias in the species list being analysed. For example, a list composed largely of Diptera will usually have a markedly higher rarity score than a list covering a wider range of taxa from the same habitat. The inclusion of Auchenorrhyncha in the list would tend to depress the SQI, because of the way that Auchenorrhyncha species have been allocated to the national conservation categories (the rarity scores used to calculate SQI are based on these categories). Consequently, the CSM thresholds should only be applied to lists covering a wide range of taxonomic groups, but excluding Auchenorrhyncha.

4.8 The need to cover a wide range of groups means that a large number of different fieldwork methods have to be used, often repeatedly, to cover seasonal variations. This makes the use of BATs for CSM comparatively expensive. The BAT rarity score is largely independent of sampling effort, so it is not necessary to prescribe the number of spatially separated samples that need to be taken. Occasionally, there is a positive relationship between the rarity score and number of samples (Figure 6). This situation arises in assemblages where nationally rare species also have relatively restricted distributions on site. However, this occurs only in a minority of cases and an asymptote is usually approached after about four samples. Three or four samples are also needed in most habitats to record enough BAT-specific species to generate a robust rarity score. In species-poor habitats, such as acid mires and uplands, a higher number of samples may be needed in order to find a sufficient number of species.



One assemblage (W126-2) shows an asymptotic curve.

Figure 5 Variations in average BAT 'rarity score' against number of samples for different W12 type assemblages (identified by target SAT)

Ground searching

4.9 This protocol is designed primarily to collect small ground-dwelling beetles, but it works as well for other active invertebrates (bugs, myriapods, snails).

4.10 Each sample consists of the combined catches of six separate 5-minute searches. The six sampling points (separated by, on average, 5 m) are chosen to maximise local environmental variability within the habitat stratum used to select the sampling area. The following factors should be considered in order of priority:

- substrate particle size;
- percentage of bare substrate;
- vegetation type;
- depth of litter; and

- shade.

4.11 Invertebrates may be collected using a pooter or taken directly by hand, if large enough.

Wetlands

4.12 The following techniques are used to find animals in wetlands:

- Soft sediments are trampled or patted, and surface-active insects pooted up directly from the ground.
- Next to water margins, bare ground is splashed with water. This works best on steeper banks, where a plastic kitchen sieve can be used to scoop up insects that are washed into the water.
- The basal parts of plants are examined or pulled apart; tussocks can be dissected over a sheet or tray using a small hand-saw.
- Litter and dense mats of fallen vegetation are sieved over a plastic sheet or tray, using a sieve with a mesh of 4 to 8 mm.
- Emergent vegetation, from monocots to sphagnum, is submerged and the insects that float to the surface are scooped up with a plastic kitchen sieve.

4.13 The five minutes covers the time to search and collect invertebrates on the plastic sheet, and excludes the time taken to sieve vegetable matter and pull apart plants. When searching litter, two lots of sieving, at different points, can normally be completed in five minutes. In upland areas and some acid mires, target insects may be very sparsely distributed. If fewer than 15 specimens are recorded in a full 30 minute sample, it may be necessary to take a repeat 30 minute sample that can be pooled, if necessary, with the first.

4.14 The composition of finds will vary with weather conditions: many beetles and bugs are more active in warm sunshine, whereas molluscs are more active under warm and humid, but not sunny, conditions. If the surveyor needs a thick woolly or a jacket to keep warm, conditions are probably too cold for this method to work well for active insects.

River shingle

4.15 The technique, known as excavation, is described by Sadler & Petts (2000). At a distance of 1 to 2 m from the river's edge, a garden trowel is used to dig out an area of approximately 1 m2 down to the water table. The sides of the excavation are collapsed down into the water so that animals trapped in the sediment float to the surface where they are scooped up with a tea-strainer. The process is continued until the water drains into the sediment. The time allotted for the excavation of shingle should be 15 to 20 minutes. One such excavation can count as one of six sub-samples using the protocol described above. Turning over stones and splashing are other techniques that work well on shingle banks. The six sub-samples should include habitat at the back of the shingle bank, as well as habitat at the river's edge. Remnant pools and secondary channels on the sedimentary deposit should also be investigated if they are present.

Dry habitats

4.16 The protocol is loosely followed over half an hour around each sampling point. Techniques to use include:

- dissecting grass tussocks over a sheet or tray with a small hand-saw;
- grubbing at the roots and rosettes of plants;
- sieving litter through a coarse (4 to 8 mm mesh) sieve;
- turning over stones and logs etc; and
- direct searching of bare ground.

Beating

4.17 Invertebrates living on the foliage and branches (saproxylic and epiphyte assemblages) of trees, bushes and tall herbage are collected by jarring the branches with a stick so the animals fall onto a sheet, tray or net held beneath. The technique appears rather primitive and of limited application, but its simplicity lends itself to ready inclusion in surveys for phytophagous, deadwood and epiphyte invertebrates, and where an inventory is more important than comparative data. Beating is useful mainly for beetles, bugs, caterpillars, barkflies (Psocoptera), lacewings and spiders.

4.18 A suggested (but untested) protocol is beating-and-searching for 5 minutes at each sampling point, and taking a total of six sub-samples from the area chosen as the sampling unit. This sampling effort is similar to that spent in ground searching. No constraints are suggested, as foliage and branches are so variable (eg heather to oaks) and – for saproxylic and epiphyte species – the number of suitable branches and conditions (state of decay and extent of epiphyte cover) may vary considerably from tree to tree.

Limitations

4.19 Many adult insects will be lost from the sample by flying or running away before they can be caught, so beating is best used as an adjunct to other methods. Rainfall and wet foliage generally render the method unusable because the collecting sheet becomes saturated and the specimens too wet to handle.

Sweep-netting

4.20 Insect nets are a basic tool of entomologists because of their versatility and ability to catch many insects from a wide range of groups in a short time. However, they will collect a biased group of species that fly or occupy aerial vegetation. Sweep nets can be used on most vegetation but become ineffective in areas of tall, dense reeds, and where plants are very prickly. Because sweep nets are so easy to use while walking about a large area of ground can be sampled, including casual collecting, whilst walking between sampling points.

4.21 Nets come in lightweight and heavy-duty designs. Lightweight mesh nets catch a different fraction of the fauna to that caught by heavy-duty canvass nets, so the net used in a survey must suite the target groups. Heavy-duty nets are better for spiders and most beetles; lightweight nets are better for most other groups. The principle underlying the standardisation of samples is the same for both types of net, but is described below for just the lightweight net.

Suggested protocol

4.22 The sample is based on a timed search spaced over several patches of ground, rather than a set number of sweeps. Fixing the time taken rather than the mechanical effort is the most effective way of sampling the micro-habitats that the surveyor considers most important. The light net has a frame 40 cm in diameter and is 50 cm deep. It is mounted on a pole at least 1 m long.

4.23 Each sample consists of sweeping for 10 minutes, during which time invertebrates are removed frequently from the net. Back-and-forth sweeps are taken while walking at a moderate pace, and keeping the net as low as practical in the vegetation for the whole length of the sweep. About 15 to 20 sweeps can be made before it is necessary to inspect the catch. Any more than this number of sweeps results in damage to captured insects and a high risk of escape by large powerful insects.

4.24 To prevent the surveyor spending too long on ‘hot-spots’, the 10-minute period is divided into five approximately equal periods, and each is spent on a different part of the area selected for sampling. It is not sensible to be more prescriptive than this since sites and terrain vary hugely. It is important to distribute effort over the sampling area in order to overcome patchiness in invertebrate populations.

4.25 Ten minutes’ search in most moderately productive conditions should result in several tens of species. Longer searching is therefore considered unnecessary; it is far better to spend time taking additional samples than spend the same time on fewer searches. The removal of captured invertebrates will take up most time, since it takes little time to net many specimens. Typically, a 50 m walk while netting will take less than two minutes. Attempting to separate the time spent sweeping from time spent collecting netted insects is not recommended as this introduces unnecessary complexity to an essentially rapid series of sweep-collect operations.

4.26 It is easy to be inaccurate with timing. A mechanical kitchen timer set for 10 minutes has been found to be more reliable than the surveyor checking their watch. The search may legitimately be extended slightly if sweeping has been conspicuously hindered, for example, by having to avoid brambles or walking over difficult or dangerous terrain.

4.27 To remove insects from a lightweight net, the net is put over the surveyor's head, and the end of the net held up towards the brightest patch of sky. Most insects will be attracted to the light and these are then collected using a pooter. Small insects are best sucked-up indiscriminately since it is impractical to attempt to identify target taxa in the net given that the sample is time-limited. The unwanted contents of the net are emptied between bouts of sweeping. Bees and wasps will escape very quickly from a net so, unless they are wanted, they can be released with little danger of loosing most flies and beetles. To do this, let the bees and wasps fly upwards, then quickly open the net to the sky.

4.28 The principle of standardising the sample time is the same when using a heavy-duty net. Invertebrates are removed from the bottom of a heavy-duty net using either an entomologist's or arachnologist's pooter, or a tube. Most actively flying insects will escape, so the heavy net should not be used to survey flies or aculeates.

Limitations

4.29 Netting can be frustratingly ineffective in strong winds, and fails on wet vegetation which makes the net and catch soggy. Snails and spiders are a nuisance if they are not the target taxa. Succineid snails in wetlands emit much mucus, and small helicids (and grass seeds) in dry grasslands and dunes can grind the catch. Unwanted spiders, especially in late summer, bind the catch in silk. The only way to reduce the damage caused is to take few sweeps between inspecting the catch. Large predators (eg sawflies, cantharids) damage or eat other invertebrates in the pooter and should be collected separately.

Spot-sweeping

4.30 The term spot-sweeping encompasses what entomologists have been doing for centuries – hunting with a net. It is the most effective way of catching or recording large, conspicuous and often fast-moving insects. It is less amenable to standardisation and relies more strongly on field-craft than other methods discussed here, but it can be time-limited. A period of 30 minutes is recommended, during which time the surveyor must have moved at least 50 m, covering a range of suitable collecting points (eg clumps of flowers or patches of bare ground).

4.31 The method is particularly useful for species using different resources over a wide area, but relies on the surveyor recognising and targeting likely resources.

Suction sampling

4.32 Petrol-engine suction samplers have advanced in user-friendliness since the early D-Vac sampler. Relatively inexpensive machines are sold for collecting or blowing away leaves and these can easily be modified to collect insects by securing a fine mesh net inside the collecting tube. Such DIY versions weigh about 4 to 5 kg. Custom-made commercial insect samplers are available, of which the Vortis sampler may be the most effective (Southwood & Henderson, 2000). The Vortis' collecting method is similar to that used by bag-less domestic vacuum cleaners. As there is no collecting bag in the air-stream, the sampler continues to collect with equal effectiveness instead of slowly blocking up as the catch increases.

4.33 Suction samplers may be used quantitatively, for example by collecting within a quadrate or, most loosely, during walk-through type surveys to accumulate as wide a variety of species as possible. The latter is more likely to be useful in site evaluation and is the basis of the protocol suggested here.

Suggested protocol

4.34 This protocol was developed using modified garden blowers, devices that are unlikely to be as effective as the Vortis sampler. The sampler is used as a qualitative device for a fixed time of two minutes. Walking slowly, the sampler is swept across the vegetation and pushed vigorously into tussocks and clumps. In two minutes, the surveyor will have completed a ‘random walk’ about 50 m long in an area about 20 to 30 m across.

4.35 The catch is caught in a collecting bag placed in the main tube. As soon as the motor is stopped, the machine is upturned and the bag removed as quickly as possible. The neck of the bag must be constricted to prevent the escape of flying insects. There are three ways of retrieving the invertebrates: the whole catch may be kept together with the plant litter (eg by tipping it into a polythene bag, or a series of collecting bags) for sorting later; the catch may be emptied into a sweep-net and treated like a sweep-net sample (see above); or it may be tipped into a tray to provide a stable surface on which crawling insects will become active and readily be seen (the latter is important for those invertebrates that remain quiescent for minutes before resuming activity). Inactive invertebrates, such as small beetles and snails, will be under-collected if the second method is used, but the second and third methods result in ‘clean’ catches that do not require lengthy processing in the laboratory.

4.36 The time is noted using the second hand of a wrist watch, or an electronic timer. Mechanical kitchen timers may not be suitable, as their alarm often cannot be heard over the noise of the machine.

4.37 The catch needs to be killed shortly after collection, otherwise predators will eat the lesser individuals. The unsorted sample is kept in a cool box and then transferred to a freezer as soon as possible. Killing the catch using ethyl acetate is not advised as a large amount will be needed to treat the large volume occupied by plant material. A carbon dioxide dispenser may be an alternative, but these appear to be difficult to obtain at present from high street retailers.

4.38 Spare fuel should be carried. Ear protectors are highly advisable. A shoulder strap helps when carrying the sampler.

Limitations

4.39 The major unstandardised variable with this method is the speed at which the blower’s motor runs. This is recognised as a major drawback to defining a protocol. After about 2 litres of material have been collected, the collecting bag is usually full and the efficiency of the sampler is reduced. In many grasslands and wetlands, 1 to 2 litres can be collected in 2 minutes at about half throttle using a modified garden blower.

4.40 The equipment is heavy and cumbersome, and the noise and fumes that blowers generate may make them unsuitable or unsafe in certain situations. The engine requires maintenance at least annually.

4.41 There are few habitats where suction sampling fails to provide a useful sample when used as described above. It can be particularly valuable in tall herb or reed beds and prickly vegetation where sweep-netting and direct searching fail, and in close-cropped grasslands where delving into the dense vegetation structure is difficult. Sand does not seem to cause problems. Water is sucked up effectively so care is needed in wetlands and at water margins (a wet catch is difficult to process). Suction sampling is unsuitable in places with much loose leaf litter, for example, woodland floors and under deciduous scrub, as it quickly collects lots of leaves but rather few animals.

Pitfall traps

4.42 These are steep-sided containers sunk to their brim in the soil. Active ground-dwelling invertebrates fall into them and may be collected alive or killed by a preserving fluid. They are most commonly used to sample beetles and spiders, but they are equally effective at sampling other ground-dwelling arthropods.

Suggested protocol

4.43 The protocol recommended here was established by Luff (1996) and is quoted almost verbatim with some additional suggestions. It has been used extensively in north-east England and so is here called the 'NE' recommended method. This method minimises small scale variations in trap efficiency by using pseudo-replicated traps, which are pooled to give a single sample per site. If true replication is needed, then more than one set of traps should be installed per locality, in an apparently identical biotope. The protocol has also been adopted by the UK Environmental Change Network (Sykes & Lane, 1996).

4.44 The Natural England traps are polypropylene pots (diameter 7.5 cm, depth 10 cm). At each chosen sampling site, 5 (minimum) to 9 (the recommended NE norm) or 10 (maximum), traps are installed in a straight line, if possible, at 2 m spacings. If the site is small and not linear, a 3 x 3 grid of 9 traps is an alternative, but traps in a grid can be harder to find again than those in a straight line. If possible, at least one end of the line should be marked with a post or a stone. In woodland, coloured tape can be tied to a tree or branch near to one or both ends of the line of traps. Careful notes should be made of where the traps are placed – it is very easy to lose them!

4.45 Each trap is sunk into the ground, using an auger, gardener's bulb-planter or trowel to dig out a hole. In loose substrates such as sand, a pit has to be dug, the trap inserted, and the soil then back-filled around it. It is important that the trap's lip is slightly below, rather than above, the soil surface. If necessary, dense vegetation and litter can be cleared away from the immediate vicinity of the trap. The dug-out soil should not be left immediately adjacent to the traps, as they may attract the attention of vandals. In saturated soil, the tub will need pegging in place to prevent it floating out of its hole, or it can be placed in tussocks above the water table. If two tubs are put in together, the upper one can be replaced repeatedly without having to clean out material that inevitably falls into the hole as the container is withdrawn.

4.46 Preservative is poured into the bottom of each trap to a depth of l to 2 cm. Neat commercial blue anti-freeze (neat ethylene glycol and colorant), pure ethylene glycol or propylene glycol are most often used. Other types of anti-freeze may contain alcohol, and act as fermenting agents rather than preservatives. A few drops of detergent should be added; this is especially important for trapping spiders effectively.

4.47 Each trap can be covered with a piece of 30 mm mesh chicken wire, pegged down with wire u-staples or held down by stones. This will prevent small vertebrates falling into the traps; farm stock drinking the anti-freeze; and stop birds, foxes and badgers interfering. A lid (eg of hardboard or a flat stone) propped up about 10 mm above the lid will reduce dilution by rainwater so the catch will remain in good condition for a long time.

4.48 At 2 week intervals (the minimum, unless vandalism is severe) to 4 week intervals (the maximum), the traps are emptied and replenished with fresh preservative. Normally the contents of all 5 to 9 traps can be pooled at each collection date.

4.49 The collected contents can be stored at room temperature, if covered in anti-freeze within their bottles or bags, but cold storage or freezing will produce less smelly material.

Limitations:

- New plastic traps catch more than re-used ones, as the latter become sufficiently scratched to provide footholds that allow beetles and spiders to escape. This effect may be overcome by using Teflon or a silicone-polish spray coating, or by using vending machine cups which are cheap enough to use only once (but are easily damaged and dislodged). Glass jars are least susceptible to scratching but are potentially hazardous and are not recommended.
- Where the water table is close to the ground surface (eg bog, fens, strandlines, river shingle), the traps float out or flood.
- It can be time-consuming or almost impossible to set traps in some stony soils.

- The results do not reflect relative abundance but relative activity in relation to vegetation structure and susceptibility to trapping – some species are able to avoid falling in or can climb out.
- Decaying carcasses, especially of small mammals, act as bait so carrion beetles will be over-represented. Formalin attracts carabid beetles and some other insects, but not spiders.
- Pitfall traps are inefficient at catching insects adapted to waterlogged habitats because they can generally skate over liquid surfaces and climb the sides of the trap. The problem can be reduced by using a surfactant (ie washing up liquid), but this makes the sample non-comparable with samples where this treatment has not been used.

Water traps

4.50 These are containers partly filled with water into which animals leap or fly, then drown. They are most effective for flower-visiting insects. As they are essentially attractant traps, the area of the container has only a small influence on the number of insects caught. The container should be about 7 to 10cm deep so that, when half-filled with water, there is enough liquid to counter evaporation in hot weather, and enough free-board to prevent overflowing in wet weather. An overflow hole covered with coarse gauze near the rim will stop rain from splashing any floating specimens over the top of the bowl.

4.51 The trap's colour affects the size and composition of the catch. The responses of different groups and species differ widely (see Kirk, 1984 for a summary). Yellow bowls catch flies and aculeates well, but white bowls are less effective for aculeates. Other colours are not recommended for conservation evaluation since they attract a small range of species. If the results of the trapping are to be used to compare different sites, it is important that all the traps have the same surface properties and colour. The latter is particularly important, because colours that appear the same to us can appear to be highly varied to insects that are strongly attracted to ultra-violet light. Day-glow yellow paint with a high UV reflectance is more attractive than 'ordinary' yellow, but does not stick well to polythene containers.

4.52 The preservative used (see 'Suggested protocol' below) is poisonous, so livestock should not be allowed access to it. Larger birds and smaller mammals may be deterred by a domed covering of coarse wire netting (20 to 30 mm mesh) but the traps rarely escape the attention of livestock so they are best placed out of reach of large animals.

4.53 Water traps are prone to vandalism and theft but small disposable containers resembling litter may be used in areas where constructed traps would be vandalised. Thus they have a role in urban survey. One solution to deterring people is an explanatory note written on clear plastic film placed in the bottom of the trap.

Suggested protocol

4.54 At each sampling point two traps are set on the ground at least 2 m apart. If more are wanted, they should be set in pairs and each pair treated as a single sampling unit. Each trap is white plastic and has an area of 200 to 900 cm2 (round bowls at least 15 cm in diameter, or deep 35 x 25 cm trays are suitable). Each trap is half-filled with either 3% formalin or 33% ethylene glycol or propylene glycol. Coloured antifreeze is not recommended in this method as it is likely to reduce the catch, although insects will still be caught. Detergent (about 0.5 ml per litre of water) is added so that captured animals wet quickly and sink. The traps are covered with netting, for example, fine flexible netting or chicken wire with 20 to 30mm meshes, and then pegged in place. In tall vegetation (>30 cm high) which may obscure a view of the trap, it should be placed either in the most prominent position or raised to the top of the vegetation on a tray mounted on a post. The traps are run for one week. The catches of the traps are combined to form a single sample.

4.55 A similar protocol was established by the RSPB for surveys of its reserves.

Malaise traps

4.56 Malaise's (1937) invention is a tent-like flight-interception trap of fine netting with a central screen suspended below a sloping ridge-roof that leads to a preservative-filled collecting chamber at its upper end. Flying insects that hit the screen then fly, or walk, upwards and along the roof to the chamber. Walls at either end of the screen reduce the number of insects escaping sideways. The screen is usually about 2 x 2 m. Alcohol (70% ethanol or propyl alcohol) is the most commonly used preservative. The trap must be erected so that the central baffle intercepts insects' flight-line, alongside hedges, for example.

4.57 The use of Malaise traps in conservation evaluation is limited by the huge size of their catch, which generally makes processing replicated samples unaffordable. However, as Malaise traps catch more species and a wider range of species than other methods, a well-sited trap usefully supplements structured sampling when the aim of the survey is to record the presence of species of conservation concern, notably in Environmental Impact Assessment surveys.

4.58 The cost in fieldwork time is low: about ½ to 1 hour to erect the trap, and negligible time to service the collecting head. As the collecting chamber is almost enclosed, the catch often remains in good condition for many weeks, so servicing can be at monthly intervals with little deterioration. Problems arise when so many insects are caught that the alcohol becomes diluted with body fluids; more frequent servicing is therefore advisable in June to August. To avoid public scrutiny the trap might have to be placed further away from a site's access points than would otherwise be necessary. The main cost in time is in sorting and identifying the catch.

4.59 The amount of preservative may need to be increased in midsummer, when most insects are collected, since they can completely fill the liquid in the collecting chamber, start accumulating above it, and then decay. In spring and autumn, a depth of 5 cm is usually enough, but 8 to 10 cm is recommended for midsummer.

Flight-interception traps

4.60 The size of the catch is directly proportional to the surface area of the barrier (Hammond, 1990). Design variations include a sheet of glass, transparent plastic or fine black netting fixed vertically over a collecting vessel. Commercially available traps have black terylene windows 2.4 x 1.1 m (or half these dimensions) in size. As level ground can rarely be guaranteed, the catch is collected into series of trays (aluminium baking trays or plastic seed trays are convenient) which are easy to empty and carry. The orientation of the window should be across any obvious flight lines, for example, at right angles to hedgerows or woodland rides.

4.61 Flight-interception traps catch lots of beetles and a reasonable range of species of other groups. They are recommended in particular for studies of woodland beetles where direct collecting may damage dead wood habitat. Small versions are used to trap insects emerging from rot-holes and fungi on dead wood (eg Kaila, 1993). A compact design with vanes fitting over a washing-up bowl is effective in canopies where hoisting a Malaise trap would be more awkward. Muirhead-Thomson (1991) describes variations.

4.62 The main disadvantage of interception traps is that their visibility makes them prone to vandalism and interference from livestock and deer. For this reason they are not included in the suite of standardised methods, although they are excellent in some circumstances.

Pond-netting

4.63 The pond net is the most convenient and versatile tool for surveying shallow water bodies such as ponds, streams and river margins. Pond-netting is not suitable for sampling the fauna of soft sediments, and cannot be used safely or effectively in flowing water deeper than about 80 cm.

Suggested protocol for shallow water

4.64 This protocol works well for still-water faunas which are usually dominated by adult beetles, bugs and molluscs, but is less efficient when collecting running-water faunas where the larvae of mayflies, stoneflies and caddis flies dominate. The protocol is based on Drake (2005).

4.65 The effort of this sampling method is standardised by bank-sorting three qualitative hauls for 10 minute each, giving 30 minutes of sorting. The emphasis is on the free-style netting of features (microhabitats) that are likely to be most productive. Effort is deliberately not divided in proportion to the extent of features, since species are not distributed in this fashion. For example, large stands of submerged plants might be present but these will support fewer species than small stands of marginal vegetation, and it is here where sampling should be concentrated.

4.66 The recommended net is the Freshwater Biological Association design with a rectangular frame that is 20 to 25 cm along the bottom edge and 19 to 22 cm tall, the net being at least 30 cm deep and with a 1 mm mesh. Longer nets (50 cm) are recommended by the Environment Agency for their standards kick-sampling in flowing water, but these are cumbersome for netting in still water.

4.67 While standing at the water margin, the surveyor nets the vegetation by making short jabbing thrusts into dense emergent and raft-forming plants, and making using occasional longer strokes into submerged plants and over bare substrate in deeper water. The surveyor moves along the bank as the netting proceeds, selecting patches of vegetation that exhibit the greatest small-scale mosaic structure, since these patches yield more specimens. Netting stops after 1 to 3 minutes when the net begins to fill to the point where it becomes difficult to push and is usually a quarter to a third full of plant material (about 2 to 3 litres by volume). When duckweed or similar small plants are abundant, the net will fill within seconds, so some careful manipulation is needed to slow the rate that it is caught while probing more productive structures. Bottom sediment should be avoided since it clogs the net and contains almost no species that contribute to the analysis.

4.68 After sampling, a timer is set for 10 minutes (a mechanical kitchen timer works well) and the sample is tipped onto a white polythene sheet and spread out into a thin layer within about half a minute. The more thinly spread the material is, the greater the chances of seeing animals. Fast-crawling beetles, bugs and dragonfly larvae are collected or identified (if recognisable) before they escape during the spreading-out process. The sheet is then scanned for other animals. This cannot be hurried since it relies on the animals recovering from their shock and they can often remain still for some time. After a few minutes, the debris can be turned over and poked about, when more animals will be found. The pool of water that forms in the centre of the sheet allows weakly swimming animals to escape and be seen. Most people find fine flexible forceps the easiest tool for picking up animals; a tea strainer helps to 'net' animals in the pool in the middle of the sheet.

4.69 The last two minutes of the search are spent on two operations to find weak animals and small molluscs. Part of the debris is put into a white tray with 1 to 2 cm depth of water so that feeble animals can swim free, and are collected. Then all plant material is tipped into a bucket of water, larger pieces are removed, most of the water is decanted, and the heavy residue is tipped into the white tray with around 1 cm of water. By tipping the contents to one end of the tray, then slowly tipping the tray back again, the molluscs are left stranded in a pile which can be scooped up for preservation or sorted quickly for tiny species.

4.70 This operation is repeated at bank sections about 25 m in length. The mollusc-sorting exercise may be done as a single operation at the end rather than treating each haul separately.

4.71 The protocol results in one tube of animals per sample. There is no lengthy laboratory sorting, which can take a day for large samples if the weed or bottom sediments are brought back with the animals. The extra time spent on bank sorting, compared to preserving the whole sample in the field, is more than offset by the saving in laboratory time.

4.72 The preservative used in the field can be 70% alcohol or formalin. However, in alcohol or dilute formalin large beetles continue thrashing around for many minutes and damage frail animals. They die much more quickly in undiluted formaldehyde; five to ten drops at the bottom of a collecting tube is sufficient to kill them without being submersed but does result in very stiff specimens that can be more time-consuming to dissect if the genitalia need examination.

Variations on the protocol

4.73 Very shallow water (eg seepages) is often more easily sampled using a kitchen sieve. Since the amount of material collected is often much smaller, more than three separate samples will have to be taken. Saturated loose vegetation needs to be pushed down gently to create a small pool from which beetles (rarely much else) can be netted. The total sampling and search time remains 30 minutes.

4.74 Oligotrophic water bodies, for example in seepages and ponds in poor fen, will be species-poor so more netting sessions will be needed and less time spent on each, but still totalling 30 minutes.

4.75 Running water. Streams and shallow rivers are sampled by ‘kick-netting’ rather than ‘pond-netting’. The surveyor stands in the water (waders rather than wellingtons are advisable) facing downstream. The surveyor holds the net upright in the water in front of them, then disturbs the sediment immediately upstream of the net, upturning stones and displacing gravel with their feet. The surveyor moves backwards, upstream, all the while, and from one side of the stream to the other so that the banks are sampled as well as midstream. Pools and shallower riffle are included in the same sample. Sampling is timed for 1 minute (a kitchen timer is useful). The catch is treated as described above, and the operation repeated twice. This 3-minute sample has the same duration as the standard Environment Agency sample (Murray-Bligh, 1999) although, as bank-sorting is far less effective than sorting in the laboratory, the resulting species list will be smaller than in samples processed to Environment Agency standards.

Hints on servicing traps

4.76 Dealing with catches in liquid is the same for most types of terrestrial traps (after Luff, 1996):

- If ethylene glycol is used in pitfall traps, it remains as a separate dense layer below any rainwater which can be decanted from the top of each trap.
- Either: the contents of the traps are emptied into a plastic screw-topped bottle, and a label is placed in the bottle;
- Or: the trap contents are poured through a 1 mm mesh plastic kitchen sieve held over a large funnel that drains into in a plastic bottle. The material retained in the sieve is tipped into a polythene bag (45 x 30 cm is the recommended size). The final residues from the sieve are tapped out within the bag (the sieve can be washed through with neat anti-freeze if necessary) and sufficient preservative is added to the bag to keep the contents just moistened. A label is put in the bag before it is sealed. The sealed bag(s) are then put into a sealed outer bag to reduce the danger of seepage. This method produces a lighter, more easily portable set of catches (care is needed not to squash the bags) but, unless the preservative is re-used, the catches still need to be brought back to the laboratory for safe disposal.
- A suitably porous material, such as a disposable household cloth, placed in the sieve saves the bother of picking off any tiny specimens that get caught in the mesh.

Labelling samples

4.77 The following essential data should be included on the label: the collection date; locality; and compartment number or name.

4.78 For samples of dry insects (eg collected using a pooter from a net), pencil notes on thin card (eg 160g/m2) are adequate. Ink (other than Indian) notes on ordinary paper rarely survive intact; labels stuck on the outside of bottles are liable to come off, or have the writing washed off them.

4.79 There are alternative methods for creating labels that will be immersed in preservative or are likely to get damp:

- Pencil on grease-proof paper or plastic water-proof paper – which is more expensive, but indestructible and can be written on when wet.
- Pencil on any type of paper which is put into a dry 50 x 12 mm plastic-topped specimen tube within the larger container (particularly necessary if live molluscs are collected, as they eat paper).
- Spirit markers (sold for marking bags in deep freezers) can be used on polythene bags and polythene tubs for quick identification. However, since these inks can be rubbed off and are soluble in alcohol and ethylene glycol, they should always be supplemented by another label inside the container.
- Tubes and tubs can be given a permanently marked identity (number, letter, etc.) which is cross-referenced to information in a note-book. Although quick, it relies on the note-book not becoming separated from the container, and that another set of tubes with the same numbering is not used. This is recommended only if the material will be dealt with straight away.

Field equipment checklist

4.80 The following checklist includes field equipment for many eventualities. Most items are self-explanatory, but there are additional notes for those with suffixed numbers.

4.81 A shortened version tailored to the work of the surveyor is worth pinning to the equipment store where it can be consulted before setting off. This list (with minor additions) is used by one of the authors and everything has been used by at least one of the authors.

Field clothing

- cagoule;
- over-trousers;
- sun hat;
- hard hat[1];
- woolly hat;
- waders;
- walking boots;
- wellington boots;
- steeltoe-capped shoes[1];
- gloves;
- fluorescent jacket[1];
- wet suite;
- life jacket[2]; and
- safari or fisherman's vest with pockets.

Office

- OS maps;
- road atlas;
- site maps;
- site descriptions, aerial photos;
- plastic wallet for maps;
- card for creating labels;
- scissors;
- pencils;

- pencil sharpener;
- penknife;
- biro;
- magic marker;
- coloured markers;
- scrap paper;
- diary;
- address book;
- addresses of landowners;
- WCA licences[3];
- letters of authority[4];
- B&B addresses;
- laptop; and
- mobile phone and charger.

General

- shoulder equipment bag;
- haversack;
- notebook and spare[5];
- forms[5];
- labels;
- clipboard;
- waterproof clipboard[5];
- cool box[6];
- compass;
- camera;
- film;
- binoculars;
- GPS;
- cassette recorder and tapes[7];
- stakes for marking traps;
- tape measure[8];
- kitchen timer[9];
- needle and thread[10];
- string[10];
- thin galvanised wire[10];
- first aid kit;
- sun cream; and
- a toilet roll.

Sweeping and searching

- sweep net;
- spare nets;
- spare handles;
- beating tray;
- sieve and tray or sieve bag;

- hand saw[11];
- sheath knife;
- garden trowel;
- tea strainer[12];
- pooters[13];
- spare pooter;
- large glass tubes;
- small glass tubes;
- hand lens[14];
- ethyl acetate; and
- alcohol.

Aquatic sampling

- pond net;
- spare pond net;
- white polythene sheet;
- white tray;
- flour sieve[12];
- tea strainer[12];
- forceps on string[15];
- large plastic tubes;
- tubs;
- polythene bags;
- bucket;
- big plastic box for samples;
- pH meter;
- formalin;
- alcohol;
- waterproof gloves;
- barrier hand cream; and
- insect repellent.

Pitfall trapping

- traps;
- trowel;
- auger;
- hammer and chisel[16];
- bulb planter;
- water carriers;
- ethylene glycol;
- detergent;
- lids and sticks;
- wire pegs;
- J-cloths®;
- funnel, large; and
- rat-tooth forceps[17].

Water trapping

- traps;
- water carriers;
- formalin;
- detergent; and
- wire mesh to cover traps.

Suction sampling

- sampler and detachable tube;
- shoulder strap;
- ear protectors;
- collecting bags;
- extra two-stroke engine fuel; and
- polythene bags (self-seal or large enough to tie a knot).

Notes

1) Some clients insist on safety clothing being worn, for example when working in quarries or beside roads.

2) A risk assessment for work in big rivers and lakes would include a life jacket.

3) Wildlife & Countryside Act license when protected species may be present.

4) A letter from the client or related organisation saying, in brief, that they give permission for, or approve, the survey, and hope that the land owner will be helpful to the surveyor. It should include a point of contact if there is a problem.

5) Note books and forms. Custom-made forms are used in surveys when the same environmental variables are recorded at many sites, or when the same small suite of taxa can be identified or their abundance estimated (eg in butterfly or dragonfly surveys). Water-proof paper notebooks and weather-proof clip-boards with transparent covers (WeatherWriter®) can be useful in the rain and on aquatic surveys.

6) A cool box helps to keep dry-collected samples from 'sweating' in a hot vehicle. Blankets or spare sleeping bags do the same job.

7) Cassette recorder. Making audible notes allows much more information to be recorded quickly in the field than by writing it down. The disadvantage is having to transcribe it later.

8) Tape measure. Inexpensive tapes (20 m or more long) can be bought from a builder's merchant. Locating pitfall traps is easier when specific distances, rather than paced measurements, are used. A 3 m dress-making tape (available from haberdashery departments) is useful for recording tree dimensions (trunk or branch girth) when surveying saproxylic species.

9) Kitchen timer. These are useful for most timed samplings, but are unsuitable for use with noisy equipment since their alarm 'ping' cannot be heard.

10) String, thin wire and thread are useful for making emergency repairs.

11) Small handsaw, tiling axe and stout knife. These are used for digging out or cutting off tussocks, and dismembering dead wood when searching for saproxylic insects. A gent or dovetail saw (with a rectangular reinforced blade) is conveniently small and effective. However, although these tools are effective, they are also destructive, so should be used with restraint, especially on dead wood.

12) Kitchen sieves, tea strainers and nets sold for aquarium fish are useful for collecting water beetles from shallow water margins, and for emptying the catch from some types of trap (eg water traps).

13) Pooters. These miniature suction samplers come in three basic designs:

- Entomologist's pooter. These are used to collect and hold specimens. They also act as killing jars when tissues soaked with ethyl acetate are placed in the glass collecting chamber (ethyl acetate dissolves many plastics). One design uses a cylinder that has a suction tube (with gauze) at one end, and an inlet tube at the other. The other design has both tubes set in a bung that fits into the mouth of a collecting jar. The cylinder design is slightly easier to use in the confines of a net, but the second design allows bungs with different sizes of collecting tubes (eg 120 x 25 mm) to be exchanged rapidly. Polypropylene soft drinks bottles are not attacked by ethyl acetate and make good pooters for large catches or for large insects.
- Arachnologist's pooter. These are used to pick up animals that will eat others, and for delicate specimens, such as mosquitoes, that need to be kept separate. The chamber is a short (5 to10 cm) glass or clear plastic cylinder (5 to 12 mm diameter) separated from the flexible suction tube by gauze. The animal is held in the tube using gentle suction until it is blown into a collecting chamber.
- Blow-pooter. These are used when there is a risk of contracting disease, for example when collecting from dung, carcasses, bat roosts and the nests of birds and mammals. Safe designs include those that feature a battery-operated suction motor, or where suction is produced by blowing through a Pitot tube (BM(NH), 1974; Southwood & Henderson, 2000). These are unlikely to replace the conventional pooter for most survey work.

Further considerations:

- A long suction tube (c. 60 cm) allows greater manoeuvrability than a short one.
- Animals may escape the way they entered unless the entry tube is blocked between jobs (eg with a twig or stem) or a flap is constructed over the inlet tube.
- A piece of absorbent tissue (eg toilet paper) will provide sanctuary for small species. It will also absorb the condensation that would otherwise damage some specimens.
- Some invertebrates can damage fellow captives in the confines of the pooter. For example, spiders, when abundant in late summer, can quickly wrap much of the catch in web, and large sawflies and soldier beetles will chomp at anything. This damage can be avoided by not mixing these groups in the first place (ie using more than one pooter), tubing the errant specimens, or by using a large pooter with plenty of crumpled tissue inside to help animals avoid one another.

14) Hand lens. A x10 lens is usually adequate for identifying specimens in the field. If identification requires a higher magnification, then returning the specimens to the laboratory is more sensible. A hard-pressed surveyor should not spend valuable field time squinting through a lens of high magnification.

15) Forceps. Flexible stainless steel forceps are useful for picking up some specimens, for example, aquatic species on a wet polythene sheet where a pooter does not work. Attaching a length of brightly coloured ribbon or string to a pair of forceps will help the surveyor find them again when they are put down in the field (blue is the most noticeable colour).

16) A hammer and chisel is needed when setting pitfall traps in rocky ground, such as quarries.

17) Stout forceps (rat-toothed forceps with a tiny 'claw' at the tip are best) are used for removing small vertebrates from pitfall traps before the catch is emptied; otherwise laboratory sorting becomes more unpleasant than normal.

Killing agents and preservatives

Ethyl acetate

4.82 This is a highly volatile liquid which anaesthetises most insects within seconds and kills them within a few minutes. Beetles, spiders and aculeates, particularly bees, require up to an hour's exposure otherwise they may recover; bumble bees can survive many hours in the killing bottle. A small piece of tissue paper is twisted up, soaked with ethyl acetate and put in the collecting bottle. About three drops of ethyl acetate are required to quickly dispatch the contents of a 50 cm3 pooter. A wide-mouthed container (eg a plastic film canister) can be filled with twisted tissue and wetted with ethyl acetate; this avoids carrying the liquid about in the field. Alternatively, the bottles used for the thinners of typewriter correcting fluid make safe dispensers for field use. Some insects (beetles and bugs, but not flies) will remain relaxed and will not decay in an airtight container with ethyl acetate.

4.83 Ethyl acetate is cheap but not necessarily easy to buy (some high-street chemists are unwilling to supply it). It dissolves most plastics but not polythene, polypropylene or nylon.

Hot water

4.84 This instantly kills large beetles which often take some time to die using chemicals. The water must be nearly boiling, not just cup-of-tea temperature, so water in a thermos flask is usually too cool to kill quickly.

Laurel

4.85 Crushed, young laurel leaves (Prunus laurocerasus) release hydrogen cyanide which kills insects quickly in the confined space of a jar. Laurel is free and very effective.

Alcohol

4.86 Ethanol (ethyl alcohol), industrial methylated spirits (IMS, also called denatured alcohol) and isopropanol are the alcohols most frequently used. A license from Custom & Excise is needed to buy IMS, but there is no problem in obtaining this for legitimate survey. The purple domestic form should not be used because it forms a white flocculent precipitate when added to water. Isopropanol requires no license. It works just as well as ethanol, evaporates slightly less rapidly than ethanol and is reported to be more effective at lower concentrations.

4.87 Alcohol is diluted to 70%; stronger solutions result in very hard specimens. As ethanol cannot be made 100% (it always contains 6% water), a 70% solution will be made with 75 ml of alcohol plus 25 ml distilled water. Fluids from specimens will dilute the alcohol, so it is advisable to replenish or replace it after a few days if there is likely to be significant dilution.

4.88 When alcohol is used for the long-term storage of specimens in the laboratory, a small amount (5%) of glycerol may be added to prevent complete desiccation if the container dries out. Glycerol leaves a sticky film on specimens as they dry out, so if pinned voucher specimens are retrieved from alcohol, the glycerol must first be washed off with more alcohol.

Ethylene glycol (antifreeze) and propylene glycol

4.89 These weak preservatives are used in traps in place of formalin or ethanol. Their advantages are that they evaporate only slowly and are cheap and can be bought readily. They are slightly attractive to some invertebrates and some vertebrates may be tempted to drink them. When used in traps that are serviced infrequently (at four week intervals), the preservative should be used undiluted, since specimens will deteriorate in dilute ethylene glycol after several weeks. For shorter periods, diluting to half strength is acceptable (this saves money and reduces the risk of pollution if it is spilt). Be warned that some antifreeze solutions are based on alcohols that act as fermentation mediums rather than as preservatives.

4.90 It is unclear how much the colour of antifreeze affects the catch in water traps. Yellow antifreeze, sold for diesel engines, will least obscure the underlying colour of the trap but large catches of some groups (especially crane flies which probably do not respond to colour) have been obtained using blue antifreeze.

4.91 Both glycols are poisonous if drunk, but propylene glycol is less toxic. Pitfall traps in grazed pasture or where people might walk their dogs need to be well covered with wire mesh. Water traps, which are more vulnerable to disturbance, should not be used in these situations. A saturated salt solution is a rather unsatisfactory alternative preservative for water traps in vulnerable situations (see below).

Formalin

4.92 This is a 40% solution of formaldehyde in water. It is a useful reagent to kill and preserve aquatic animals in the field, and is suitable for traps because it evaporates only slowly. It is effective at about 5 to 10% so only small quantities need be carried in the field. Full-strength formalin kills large specimens rapidly and is preferable for use with larger beetles and bugs that take a long time to die in alcohol (during which time their activity can damage other specimens); for this purpose a small amount of full-strength formalin can be placed in a collecting bottle, then diluted at the end of the sampling session for use with smaller animals. Formalin hardens most specimens so they cannot be easily manipulated, but this effect is less in a weak solution (c. 5%).

4.93 Formalin is not recommended for long-term storage as it breaks down to produce an acidic solution that dissolves snail shells and insect cuticle. It can be neutralised using borax, hexamine or powdered chalk (5 gl-1, shaken then filtered) but this treatment is only temporary because the formaldehyde will continue to dissociate.

4.94 Formalin is carcinogenic but its use as a preservative is still allowed by the Health & Safety Executive in Britain.

Propylene phenoxytol (1-phenoxy-propan-2-ol)

4.95 This embalming fluid is used as a medical bactericide. It is an odourless, non-volatile, non-flammable alternative storage medium to ethanol and formalin. Its advantage over alcohol is that it does not evaporate and does not smell, so is more pleasant to work with. It does not fix the material (that is, it does not stop decay caused by autolysis) so specimens must first be immersed in formalin or alcohol for at least an hour, or longer if the sample contains large specimens. This also makes it unsuitable for use in traps unless formalin is added too. The storage solution is made up of:

- propylene phenoxytol 1 ml;
- propylene glycol (propane-1,2-diol) 10 ml; and
- distilled water 89 ml.

4.96 The propylene glycol stabilizes the propylene phenoxytol and increases its solubility in water. Propylene phenoxytol is liquid at room temperature and solidifies to a wax when colder. The drawback to this chemical is its high cost. It also dissolves very slowly and this can lead to poor preservation.

Salt

4.97 Saturated table salt (sodium chloride) will act as a preservative in traps for a few days but will cause shrinkage. It is adequate for the short-term exposure of traps but useless for normal weekly or fortnightly periods. A dilute solution (c. 5%) in traps will maintain the osmotic pressure of the preservative and prevent specimens from swelling up and becoming distorted; this is especially important in spiders whose palps are crucial for identification but distort easily.

Temporary storage

4.98 Between collection and identification, specimens can be stored in liquid preservative, dry, frozen, in a 'laurel' bottle or in ethyl acetate vapour.

4.99 Specimens belonging to most taxonomic groups can be identified when wet, so wet preservation is the recommended method of storage for large samples. Specimens trapped directly into liquids can be stored in alcohol or propylene phenoxytol. Wet preservation is not recommended for moths, because the scales fall off, making them difficult to identify.

4.100 Adult insects collected in a dry state can be stored using any method. If thoroughly dried, they can be stored in flat cardboard boxed between layers of tissue, or in Petri dishes. The advantage of dry over wet specimens is that many species are more recognisable and quicker to handle in this form. Dry specimens can be softened by putting them in a sealed container with damp paper for a few hours (less for tiny flies, more for large aculeates and beetles). Some groups distort badly when dry (eg mayflies, stoneflies, some caddis flies, lacewings) so drying is not advisable. Some surveyors pin part of their catch at the end of the day. This can be valuable for retaining important voucher specimens in a better condition than those retrieved from wet storage; genitalia can also be exserted, thus making later identification quicker. A convenient method for mass micro-pinning is to use clear plastic boxes (120 x 80 x 20 mm) with Plastozoate® foam.

4.101 If home or the laboratory is reached at the end of the day's survey, specimens can be frozen. Frozen insects slowly release water that condenses inside the container. When this thaws, the specimens get wet, thus defeating the object of preserving fresh, dry specimens. It can be overcome by wrapping the catch in soft toilet-paper that will absorb the condensation. After several months, small specimens in some groups will dry out completely and become brittle, so the advantage of freezing is lost if the catch is stored for too long. However, beetles appear to remain fresh for years if kept in tightly capped containers.

4.102 Tough-bodied insects such as beetles, aculeates and some bugs can be stored in a relaxed state for a long time in air-tight containers with ethyl acetate or crushed laurel leaves (which produce hydrogen cyanide). This is the old-fashioned killing bottle. Picric acid is an alternative.

Recording environmental features

4.103 Putting invertebrate data into an environmental context is nearly always helpful, yet some invertebrate surveys contain little site information. Site descriptions do not need to be detailed but should allow the reader to visualise the sampling points. A paragraph indicating features such as the gross vegetation or topographic structure, dominant plants and wetness will suffice for most surveys. Falk (1998) suggested a format for formalising the description so that it focuses on the key requirements of scarce invertebrates when undertaking environmental assessment for planning purposes.

4.104 Land managers are often far more interested in understanding the features of a site they can control than in the species. They need to be told the basics – which features are of most value and what condition is wanted. Descriptions and photos of good and poor examples on the site will be a great help to the resident land manager.

4.105 Photographs can:

- Remind the surveyor of conditions and features when writing up results.
- Provide pictures for a report, for example, to show habitat structure, the setting, and features that are not easily described in words. They may complement a description or a diagram but are rarely a complete substitute. Panoramic shots are usually less useful than closer pictures of features.
- Show features that can be measured or categorised easily in the laboratory.

4.106 With digital cameras, there is no need to be frugal. The date and time imprint function will allow cross referring to a notebook and help avoid the muddles that sometimes occur with traditional film cameras.

4.107 Surveys designed to discover relationships between environmental factors and assemblage composition usually demand quantified descriptors. Much useful information can be collected by using presence/absence categories (eg grazed or not grazed) or semi-quantitative categories, such as on a 0 to 3 scale and the botanists' DAFOR (Dominant-Abundant-Frequent-Occasional-Rare) scale of plant cover. Compared to taking real measurements, collecting such nominal data is quick and keeps the mind focused on what is being estimated (rather than blindly recording a number from an instrument). Because they represent the surveyor's assessment of conditions, they are often more realistic than a single precise quantitative measurement that implies high accuracy but which takes no account of temporal variation. The limits of each category need to be clear and workable, so short scales (eg 0 to 3) are likely to be more reliable than long or fiddly ones (eg DAFOR, which looks good on paper but whose estimation by different surveyors in the field is notoriously variable). Nominal data can be handled by ordination programs such as CANOCO and by non-parametric statistical methods.

5 Target taxa and methods for assemblages

5.1 Taxonomic groups differ in their contribution to the fauna of each assemblage type. Taxa also vary in the contribution they can make to site evaluation; those whose ecology, distribution and rarity status are better understood are more useful in making an assessment. In most surveys, it therefore pays to select ecologically appropriate and well-studied taxa. If the aim of the survey is an inventory, there are no constraints to what may be collected, but most commissioned surveys will have a limited budgets and more specific aims. This chapter suggests taxa and methods that will help maximise the return for effort in various circumstances.

5.2 The recommendations are based on assemblage types rather than conventionally understood habitats, since there is greater ecological similarity in the species comprising a particular assemblage type than in species associated with a particular habitat. However, the described habitats in which the assemblage types are most often found are used as labels in the below as this allows easy cross-reference between the two systems. ISIS has been used to generate diagrams showing the dominant taxa, to make it visually obvious where the sampling effort needs to be directed. The diagrams need some interpretation since the four large insect groups of flies, beetles, aculeates and moths will inevitably out-number smaller orders in most assemblage types. A second diagram ranks taxa by the proportion of their species associated with that assemblage type.

5.3 Assemblage types are treated in three broad groups: wetland, field-layer and arboreal. Each section has separate tables of target taxa and their value in assessment, methods for different survey aims, and a graphical representation of the contribution of major taxa. Table 14 gives the seasonality of major taxa and is applicable to all assemblage types; again, any particular variations are mentioned in the text.

Wetland assemblages

Running water assemblages (W11 and W12)

Taxa

5.4 Running water assemblages include several clearly different assemblage types but the dominant taxa are similar in most of them. Flies and beetles dominate the ‘terrestrial’ component of this assemblage, while the ‘aquatic’ component is dominated by several groups, including caddis flies, stoneflies and mayflies. There is not necessarily a good correlation between an assessment based on either of these components at any one site, since the ‘terrestrial’ assemblage is affected more by fluvial processes and bank management, and the ‘aquatic’ assemblages more by water quality. Both components need sampling to evaluate the water course.

5.5 The soft rock seepage assemblage type (W124) is mainly characterized by beetles that exploit damp, sparsely vegetated sand and clay. Suitable target taxa and sampling methods are similar to those of riparian assemblages associated with running water. The seepage assemblage type (W126) is dominated by flies. Calcareous seepages support greater numbers of uncommon species than neutral examples, among which Stratiomyidae and caddis flies should be targeted. A small number of snail species are also characteristic of this assemblage. Shaded seepages are a special case, where flies are particularly important (notably Tipuloidea) but rather few other groups make a significant contribution, so there is little advantage in including more than flies when evaluating shaded seepages.

Methods

5.6 The aquatic component is sampled using pond-netting, or other methods in deeper water (eg dredging, grabs on soft bottoms). Pond-netting the margins of rivers that are too deep to wade into can give biased catches that underestimate dominant taxa. Ground searching and sweeping are used for 'terrestrial' groups. The sampling of shingle bank assemblages should include excavation as part of the ground searching. Pitfall traps are particularly vulnerable to flooding on Exposed Riverine Sediments. If pitfall traps are set high on the bank, the catch may not reflect the specialised assemblage found at the water margin. Pitfall-trapping adds useful data to a full site quality evaluation, but is not needed for Common Standards Monitoring (CSM). Ground searching should not take place immediately after major flooding episodes, or the sample will be dominated by species displaced from other habitats.

5.7 Open water in seepages may be very shallow, so a flour sieve is often more effective than a full-size pond net. If any characteristic snail species are already known from a site, they should be targeted by ground searching. As in acid mire, species richness and the abundance of individuals may be low, so timed searches may need to be extended to obtain a useful catch.

Timing

5.8 Riparian beetles should be sampled between mid May and late June; this covers the breeding season of most species, especially ground beetles, when the adults are easiest to find.

5.9 Aquatic macroinvertebrates should be sampled between April and early June. This is when the late instar larvae of many stoneflies, mayflies and caddis flies and the adults of aquatic bugs are most abundant.

5.10 The end of April to the end of June is the productive period for open seepages, and shaded seepages may be productive well into July. As Tipuloidea are important, the autumn-emerging species can be targeted in October. Dry summers lead to poor catches.

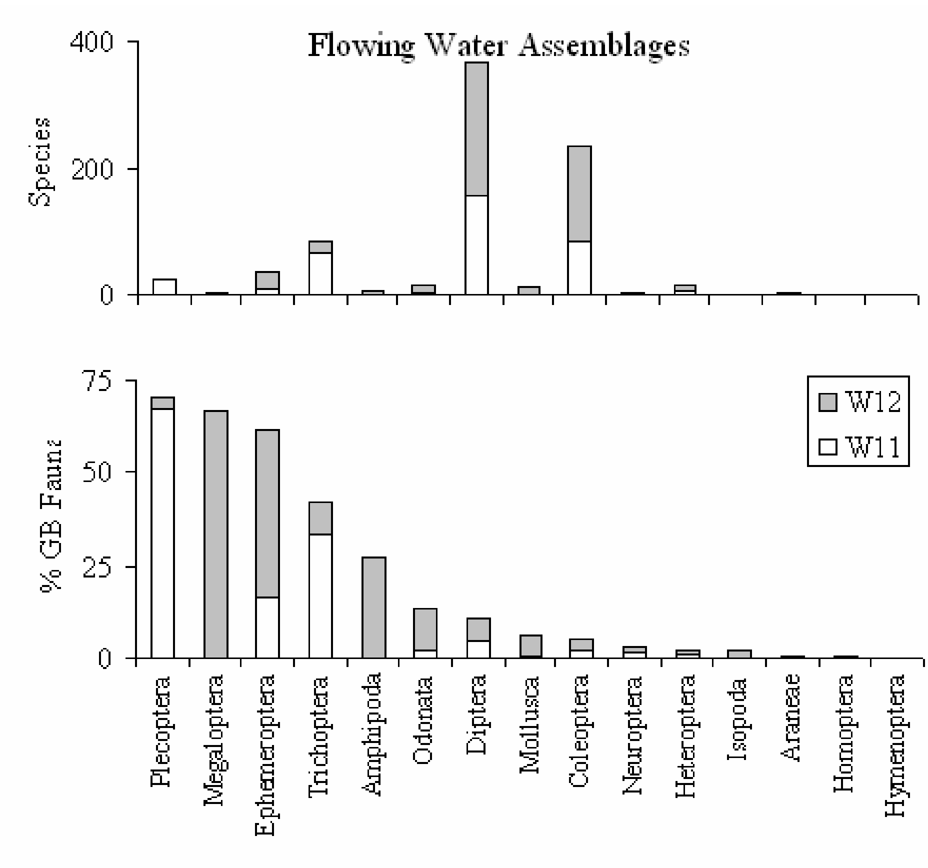


Figure 6 Running water assemblages (W11 and W12)

Mineral marsh and open water assemblages (W21)

Taxa

5.11 This assemblage type is associated with still open water bodies, such as ponds, lakes, reservoirs, canals and the banks of slow-flowing rivers. It includes completely aquatic groups (eg caddis flies, stoneflies, mayflies) and is therefore diverse at a high taxonomic level. The littoral component is dominated by beetles.

Methods

5.12 Only pond-netting needs to be used for assessing the aquatic assemblage types, W211 and W212. Ground searching and sweeping should be used for assessing W21 assemblages as a whole.

Timing

5.13 Littoral beetles, water bugs and, to a lesser extent, water beetles are best sampled in the spring when the adults are most easily found.

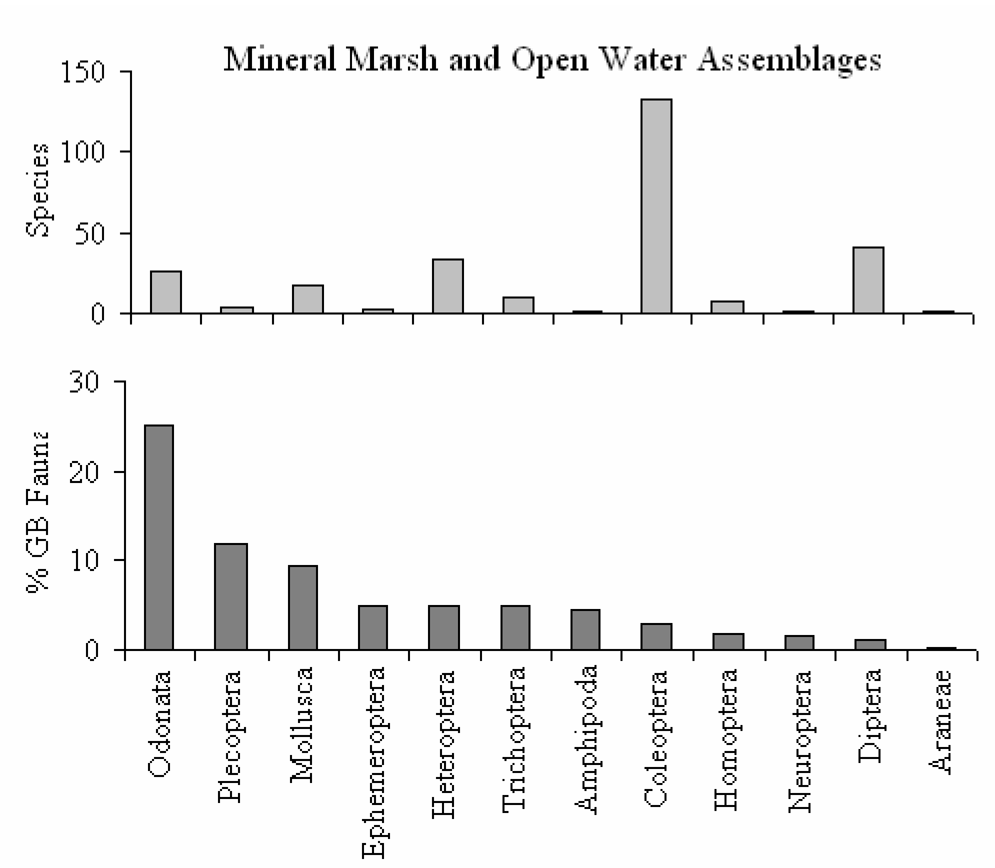


Figure 7 Mineral marsh and open water assemblages (W21)

Litter-rich fluctuating wetlands assemblages (W22)

Taxa

5.14 This assemblage is dominant in wetlands where disturbance is more or less limited to fluctuations in water levels. Between flooding, the surface remains humid rather than saturated. The assemblage is found in floodplains, fluctuating meres, dune slacks reservoir margins, wet woodland and the edges of fens. It is largely dominated by beetles. Flies and bugs are less important. An evaluation requires that beetles are surveyed well; no great improvement on the assessment would result by including other groups.

Methods

5.15 Only ground searching need be used.

Timing

5.16 Late April to May is the optimum season to sample this assemblage type. After this, herbs such as stinging nettles often become too tall to permit comfortable and efficient sampling. Also, the adults of several species, especially ground beetles, become scarcer as the season progresses. After dry winters, vernal pools may have to be sampled particularly early before they dry out completely.

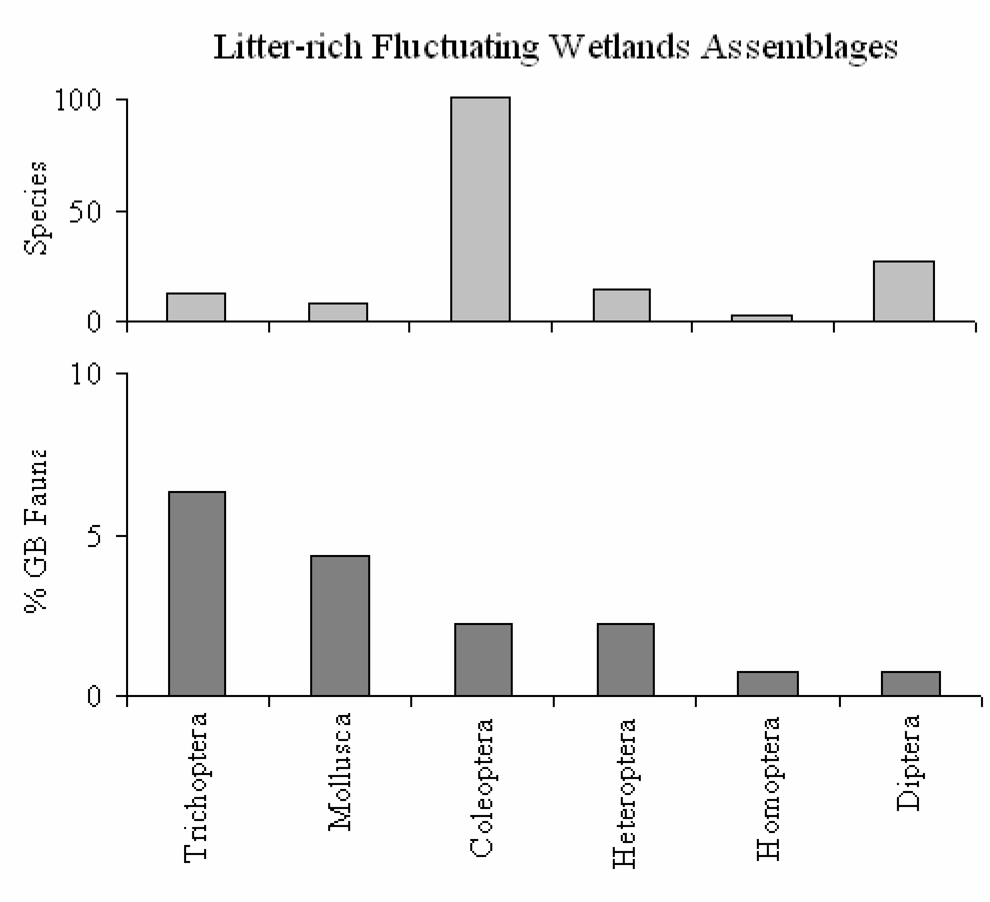


Figure 8 Litter-rich fluctuating wetlands assemblages (W22)

Mire assemblages (W31)

Taxa

5.17 While different assemblage types can be distinguished in acid, mesotrophic and rich fen, many wetland species occur widely in mires. A broad range of major groups are well represented in mesotrophic and rich fen, although flies in many families usually dominate. The choice of suitable taxa is therefore wide, and should include some families of both flies and beetles. Spiders and leaf hoppers are well represented. Water beetle species are key indicators of high quality mesotrophic fen. In both lowland and upland soligenous and ombrotrophic acid mires, there is a smaller range of well-represented groups; beetles (notably water beetles, Carabidae and Staphylinidae) and flies (notably Tipuloidea and Dolichopodidae) dominate, but smaller taxa for which the habitats are important are dragonflies, caddis flies, leaf hoppers and spiders.

Methods

5.18 The same principal methods apply to all types of mire: pond-netting, ground searching and sweeping, but only pond-netting is needed for open water in acid mire assemblages (W311). Ground searching is usually productive for beetles and preferable to the use of pitfall traps, which are vulnerable to flooding and require surfactants to catch a representative sample. However, in acid mire, the number of species, and their abundance, is usually low. In this case a longer sampling time than that suggested for time-standardised methods may be necessary to collect sufficient species to generate usable results. If not sampling for CSM, trapping methods can be useful if time is limited. Water or Malaise traps and suction sampling are also useful in surveys other than CSM for sampling reed-beds which are difficult to sweep.

Timing

5.19 There are no special considerations for timing a survey of lowland mires and wetlands that do not dry out. They remain productive throughout summer months. For upland mires, weather conditions are more critical than seasonality for most groups. Flies are probably most sensitive to both factors, because the adults have a shorter emergence period and windy conditions can affect their sampling.

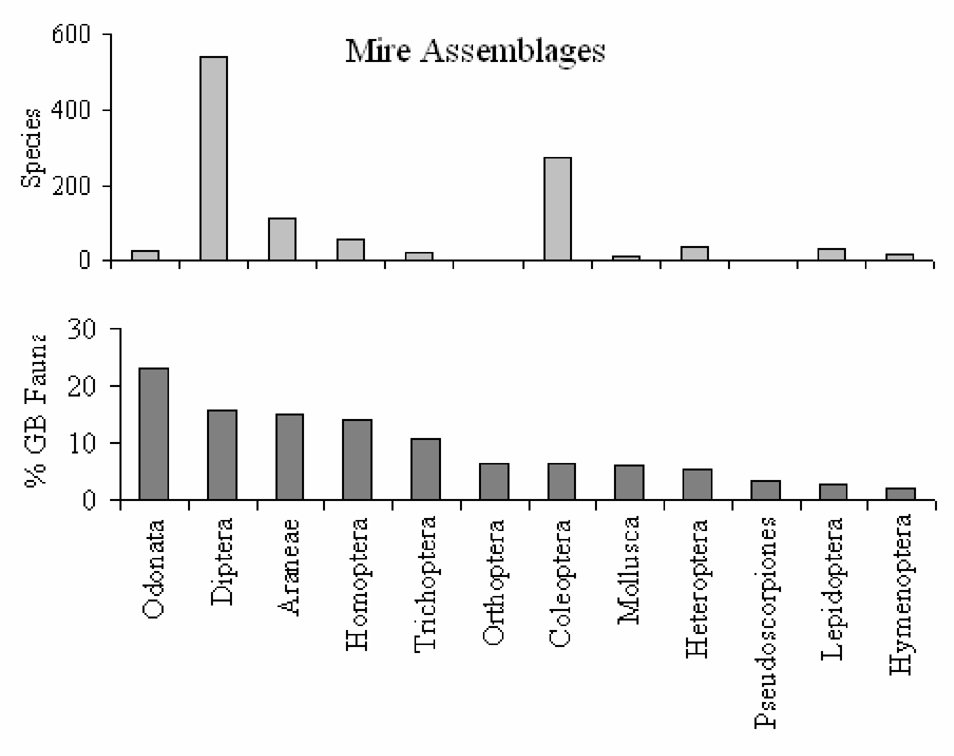


Figure 9 Mire assemblages (W31)

Sea shore assemblages (W51, W52 and W53)

Taxa

5.20 These assemblage types occupy intertidal and supralittoral habitats including saltmarsh, sandy and rocky shore, and brackish pools and ditches. The target groups should include beetles and flies as the minimum, but there are also relatively large numbers of spiders, crustaceans and bugs which could be usefully added.

Methods

5.21 Pond-netting, ground searching and sweeping are required for W53 assemblage types. Only ground searching is needed for sandy shore (W521), unless it is necessary to target the small number of hybotid flies characteristic of this assemblage type. Most species are found on or around the strand line. Special techniques are needed to sample rocky shore assemblages (W51), because of the highly specialized microhabitats of some species, which include intertidal rock crevices and supra-littoral rock pools in the splash zone. Traps are susceptible to tidal inundation, but can be placed at the tidal limit and operated between spring tides (ie those occurring shortly after the full and new moon – check using tide tables). Ground searching should include sieving of tidal debris.

Timing

5.22 There seems to be a long season, from mid April to August. The monthly tidal cycle may influence the catch size and profile, but this aspect has received insufficient attention to permit any advice on the timing of sampling visits. Sampling should avoid high tide since water may cover some useful habitat.

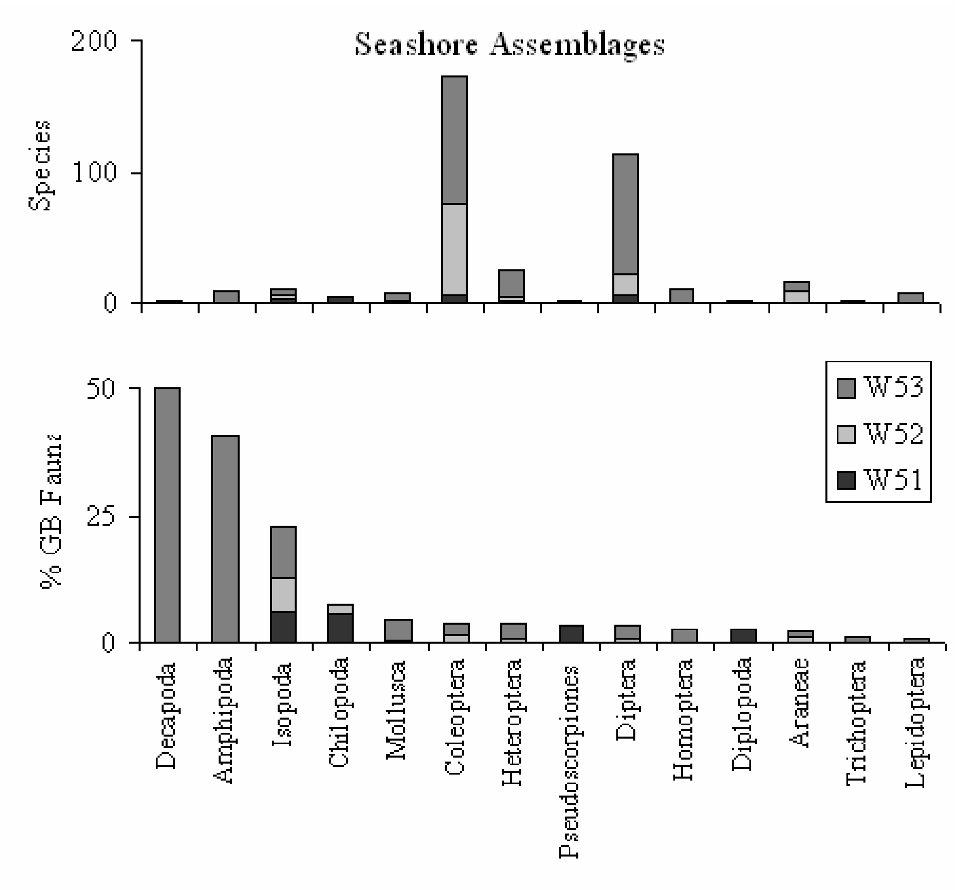


Figure 10 Sea shore assemblages (W51, W52 and W53)

Table 10 Target taxa in wetland assemblages, and their value in assessment

Taxa	**Ease of identification**	**Assemblage types**							
		acid/neutral mire	**fen, water margin**	**open seepage**	**shaded seepage**	**fluctuating wetland**	**open water, min. margin**	**flowing water**	**sea shore**
		W311 W312	**W313 W314**	**W126**	**W126**	**W22**	**W21**	**W11 W12**	**W51 W52 W53**
Mollusca (snail, bivalves)	1-3(4)								
Hirudinea (leeches)	1								
Coleoptera									
Anthicidae	1-3								
Cantharidae (soldier beetles)	1-2								
Carabidae (ground beetles)	1-3								

Table continued…

Taxa	Ease of identification	Assemblage types
Chrysomelidae (leaf beetles)	1-4	
Coccinellidae (ladybird beetles)	1	
Curculionoidea (weevils)	1-3	
Elateridae (click beetles)	1-3	
Staphylinidae (rove beetles)	2-4	
Water beetles (several families)	1-3	
Other families		
Diptera		
Athericidae, Rhagionidae, Stratiomyidae, Tabanidae ('larger Brachycera')	1(-3)	
Chaoboridae (phantom midges)	1-3	
Chloropidae	2-4	
Culicidae (mosquitoes)	2-3	
Diastatidae	2	
Dixidae (meniscus midges)	1-3	
Dolichopodidae	1-3	
Empididae, Hybotidae (empids)	1-3	
Ephydridae (shore flies)	3-4	
Lauxaniidae	2	
Lonchopteridae	2	
Micropezidae	2	
Muscidae	2-3	
Scathophagidae ('dung' flies)	2	
Sciomyzidae (snail-killing flies)	1-2	
Sepsidae (lesser dung flies)	2	
Syrphidae (hoverflies)	1-3	
Tephritidae (picture-wing flies)	1-2	

Table continued…

Taxa	Ease of identification	Assemblage types [1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Tethinidae	3-4								Dark
Thaumaleidae (trickle midges)	2			Mid	Light			Mid	Light
Tipuloidea, Ptychopteridae (crane flies)	1-2 (3)	Dark	Dark	Dark	Dark		Mid	Mid	Mid
Ulidiidae (picture-wing flies)	1-2		Mid	Mid	Light	Light	Light	Light	Light
Ephemeroptera (mayflies)	1-2	Light	Mid	Light			Light	Dark	
Hemiptera (Bugs)									
Auchenorrhyncha (hoppers)	2-4								Mid
Heteroptera ('terrestrial' families)	1-4		Light						Mid
Water bugs (several families)	1-2	Dark	Mid	Light			Mid	Light	
Hymenoptera, Aculeata	1-3(4)	Light	Mid					Light	Light
Lepidoptera		Mid							Mid
Megaloptera (alderflies)	1		Light					Light	Light
Neuroptera (lacewings)	1-2		Light				Light	Light	
Odonata (dragonflies)	1-2	Mid	Dark	Mid			Dark	Mid	Light
Orthoptera (grasshoppers)	1	Light	Light						
Plecoptera (stoneflies)	1-2	Light	Light	Mid	Light		Light	Dark	Light
Trichoptera (caddis flies)	1-3	Light	Mid	Mid	Light		Mid	Dark	
Crustacea	1-2		Light	Light			Light	Mid	Mid
Araneae (spiders)	1-3	Dark	Dark	Mid			Light		Mid
Opiliones (harvestmen)	1-2		Light						

Excludes small families even if individual species are rare, large, easy to identify and likely to be collected.

Ease of identification: 1 (easy) to 4 (requires experience, keys not necessarily easily available).

The relative values of the taxa in conservation evaluation for each assemblage are:

- Dark: Essential for a realistic evaluation.
- Mid: Taxa will add noticeably to the evaluation, but not all need be included in the survey.
- Light: Includes species characteristic of the assemblage but whose addition will make marginal difference to the conclusions.
- White: Not worth including if their identification involves marked extra effort (or species are absent from that assemblage).

Table 11 Methods for different types of wetlands survey

	acid/neutral mire, fen, water margin	open seepage	shaded seepage	fluctuating wetland	open water, mineral margin	flowing water and soft rock seepage	sea shore
ground search	C E L	E L		C E L	C E L	C E L	C E L
spot-sweeping	E L	E L		E L	E L		e l
excavation						C E L	
sweeping	C E L	C E L	C E L	C E L	C E L	C E L	C E L
beating	E L	e l	e l	e l		e l	
suction sample	EL	EL		e l	e l		
water trap	E L	E L	E L	E L	E L	E L	E L
pitfall trap	E L	E L		E L	e l	E L	e l
Malaise	E	E	E	E			
flight-interception trap	E L	E L	E L	E L			
pond-netting	C E L	C E L	C E L	C E L	C E L	C E L	C E L

C = Common Standard Monitoring; E = Environmental Impact Assessment / site selection; L = landscape and regional surveys. Lower case indicates that the method is less useful.

Field layer assemblage types

Early successional mosaic assemblages (F11)

Taxa

5.23 The assemblage type is found in lowland habitats where disturbance removes vegetation to create areas of bare or sparsely vegetated ground. Semi-natural habitats include sea cliffs, dunes, heathland and chalk downland; anthropogenic habitats include arable land, quarries and post-industrial sites. The large groups, beetles, aculeates and flies dominate the fauna but this assemblage type is particularly important for aculeates, grasshoppers, heteropteran bugs and spiders. All these orders should be covered in a detailed regional survey but acceptable evaluation is possible by omitting spiders and perhaps the bulk of flies, although some large species, such as 'larger Brachycera', should be included while recording aculeates.

Methods

5.24 Ground searching, spot-sweeping and, for F112 assemblage types, sweeping are used. Spot-sweeping is essential for recording aculeates and some of the more specialised larger flies. Separate sweep samples are needed for flies on the one hand (using the lightweight net) and bugs, beetles and spiders on the other (preferably using the heavy-duty net), although ground searching is often much more effective than sweeping for the latter groups. Pitfall trapping is a highly effective alternative to ground searching.

Timing

5.25 Ground searching is best carried out in late April or May. These habitats tend to become unproductive for beetles and flies (although less so for aculeates and grasshoppers) by midsummer, so surveys should take place before August if only one or two visits can be made.

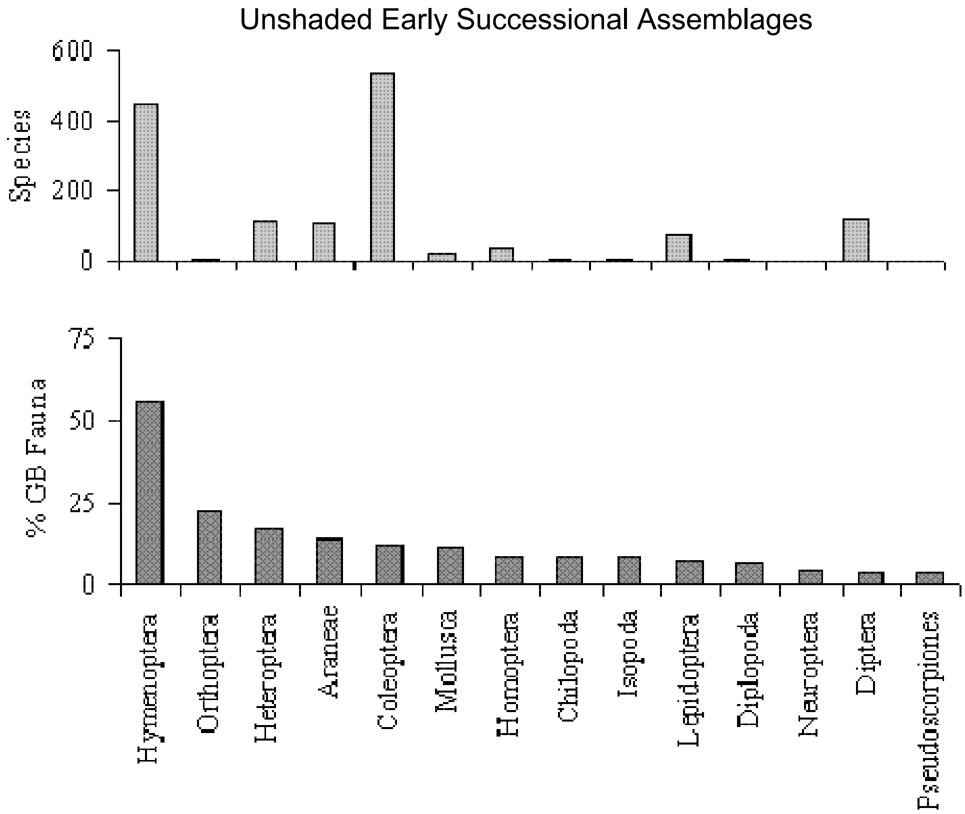


Figure 11 Early successional mosaic assemblages (F11)

Grassland and scrub matrix assemblages (F21)

5.26 Different invertebrate assemblages are found in grasslands that vary in moisture content and base-richness, but the overall composition of major taxa and the methods most appropriate for their survey are similar for all types of grasslands, scattered scrub and woodland edge.

Taxa

5.27 The five big groups (beetles, flies, bugs, aculeates, butterflies and moths) dominate grasslands but beetles, bugs (Heteroptera and Auchenorrhyncha) and aculeates are the most important for survey. Spiders, although species-rich, are relatively less important in making an evaluation. It is not practical to expect all these major groups to be surveyed, but a robust evaluation will be possible using any two of the beetles, flies, bugs and aculeates. The last order will be less useful in herb-poor grasslands.

Methods

5.28 Sweeping, spot sweeping and beating are used. Only sweeping is necessary for assessing F211. Separate sweep samples are needed for flies on the one hand (using the lightweight net) and bugs, beetles and spiders on the other hand (preferably using the heavy-duty net). Suction sampling can be a highly effective alternative to sweeping. Grasslands are one of the easiest habitats to survey. Livestock reduce the usefulness of large traps (water, Malaise, flight-interception) if these cannot be placed out of reach. More species will be recorded at the margins where grassland meets other habitats, rather than in the centre of relatively uniform swards. Some of this effect is due to species congregating in sheltered areas, such as at scrub margins, and the sampling effort should be focused here. Margins with other habitats with their own distinctive fauna, such as woodland edge or water margins, will contain a mixture of assemblages, and these may need to be treated separately when describing the results. Assessment of dung assemblages and similar microhabitat-based assemblages will require specialised hand-collecting techniques.

Timing

5.29 The useful season extends from May to September. The presence of breeding birds on damp meadows may reduce the window of opportunity in spring (see 'Making the best of a bad job').

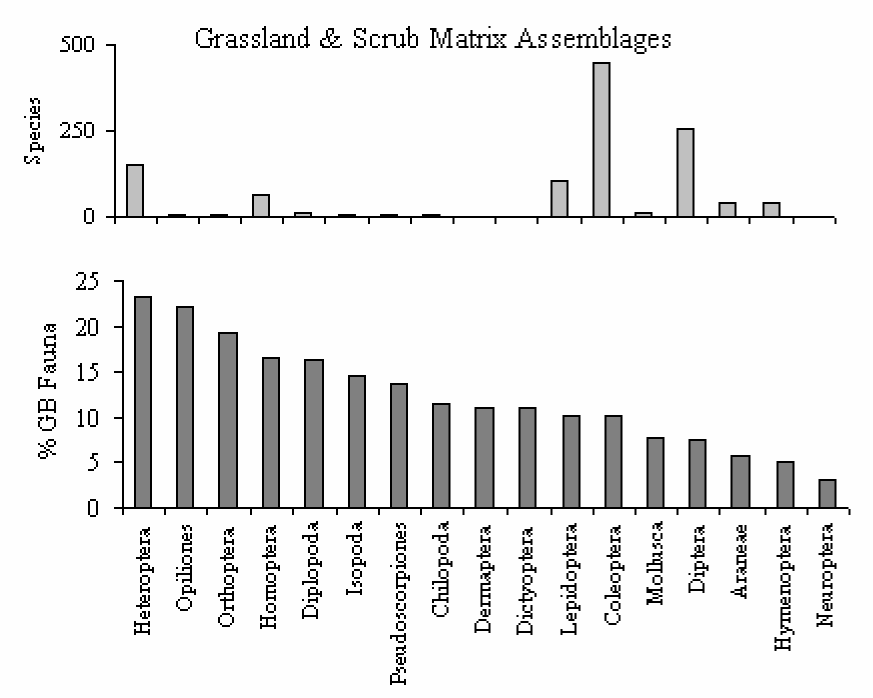


Figure 12 Grassland and scrub matrix assemblages (F21)

Scrub-heath and moorland assemblages (F22)

5.30 The assemblage is dominant on nutrient-poor, acid soils where exposure, grazing or mowing limits the development of trees. Herbaceous or dwarf shrub vegetation is dominant but trees and shrubs can be an important component of the overall habitat. Lowland heaths, moorland, montane biotopes and upland pastures support the assemblage.

Taxa

5.31 The habitats are naturally species-poor and no major taxon is particularly well represented in comparison with grassland habitats. Spiders, homopteran bugs and moths are relatively more important, although beetles and flies will dominate the catches. The recommended minimum groups for most survey aims are beetles, spiders and homopteran bugs.

Methods

5.32 Sweeping, spot sweeping and beating for lowland sites; sweeping and ground searching for upland sites. Suction sampling can be an effective alternative to sweeping, while pitfall-trapping can be a highly effective alternative to ground searching. The unpredictable weather of upland areas makes trapping a more reliable option than active methods. These habitats are intrinsically species-poor, so a greater sampling effort is needed to make a robust evalutation than in more base-rich habitats, especially in upland habitats. Repete sampling on one day will often reveal the same rather limited fauna over a wide area, so for a given budget, a better evaluation will be made by making several visits, rather than spending the same time taking more samples during one or two visits.

Timing

5.33 Seasonality is more marked than in many other habitats, so the target groups may need to be changed through the summer. For example, lowland heath can become very unproductive for flies by midsummer, when aculeates are a better group to concentrate on. Uplands have a short season, starting later and ending sooner (May to September) than in the lowlands.

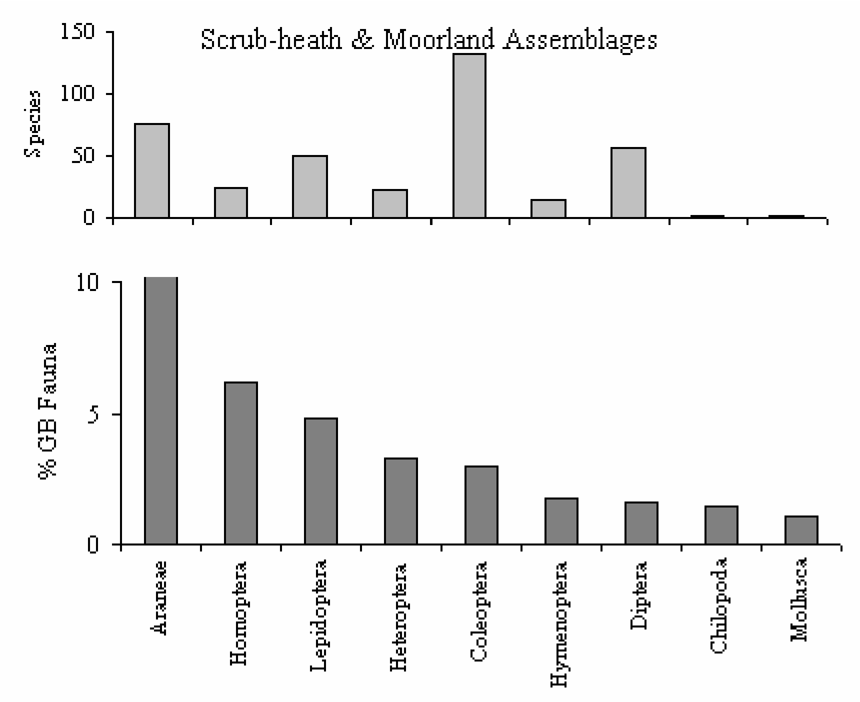


Figure 13 Scrub-heath and moorland assemblages (F22)

Shaded field layer assemblages (F31)

Taxa

5.34 The shaded field layer assemblage is relatively small and dominated by flies and beetles, although the habitat is important for several non-insect groups (millipedes, centipedes, woodlice, harvestmen, molluscs). Bugs, aculeates and moths are very poorly represented in the field layer assemblage. The target taxa are therefore flies, beetles and, if regarded as important to the survey aims, the non-insects listed above.

Methods

5.35 Sweeping and ground searching are used. Ground searching mainly consists of sieving leaf litter. Some leaf litter species are difficult to see in the field and are best extracted back in the lab. Suction sampling works poorly owing to the number of dead leaves that are sucked up.

Timing

5.36 Although May to October encompasses the main useful period, both beetles and flies show a dip in interest in August and September. Nematoceran flies (especially Tipuloidea) can be productive in October.

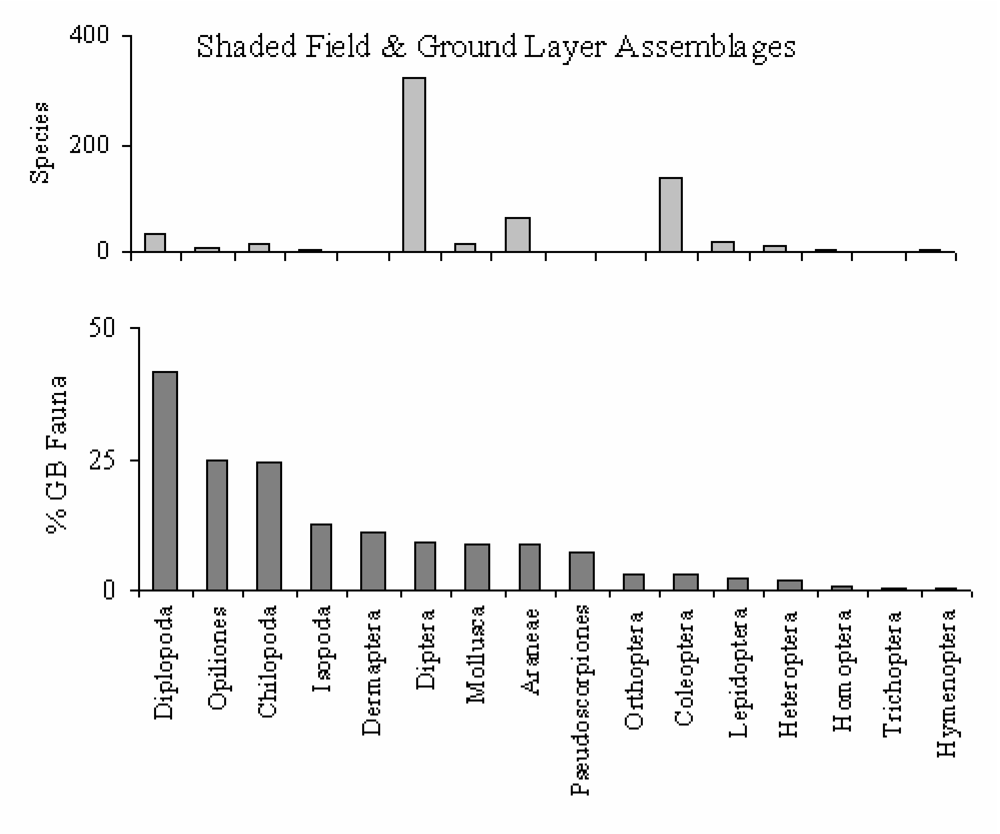


Figure 14 Shaded field layer assemblages (F31)

Arboreal assemblage types

5.37 Trees and shrubs create complex habitats supporting several very distinct invertebrate assemblages associated with the canopy foliage, decaying wood or bark and wood surfaces. It is likely that all these assemblages would be targeted in surveys of 'woodland', although special consideration will need to be given to open wood-pasture and individual trees in a variety of other situations.

Arboreal canopy assemblages (A11)

Taxa

5.38 Phytophagous species dominate the assemblage, although it also includes their predators and parasites. Tree blossom and fruit associates are included, as are species that feed on the surfaces of the leaves, such as certain mildew-feeding ladybirds and specialist barkflies (Psocoptera). Moths are the dominant group and the tree canopy is the habitat that supports the greatest numbers of species. Beetles and bugs are also species-rich. Recommended target taxa are moths, bugs (Heteroptera and Auchenorrhyncha) and, if necessary, beetles.

Methods

5.39 Light-trapping is the only practical and rapid option for moths, since few surveyors can identify caterpillars. Malaise, flight-interception and water traps (in declining order of usefulness) will produce catches that include canopy-dwelling insects. Beating and sweeping are restricted to what can be reached from ground level and are likely to produce limited catches. The standard protocols are not likely to work effectively.

Timing

5.40 Many phytophagous beetles are adult early in the year so should be targeted in April and May.

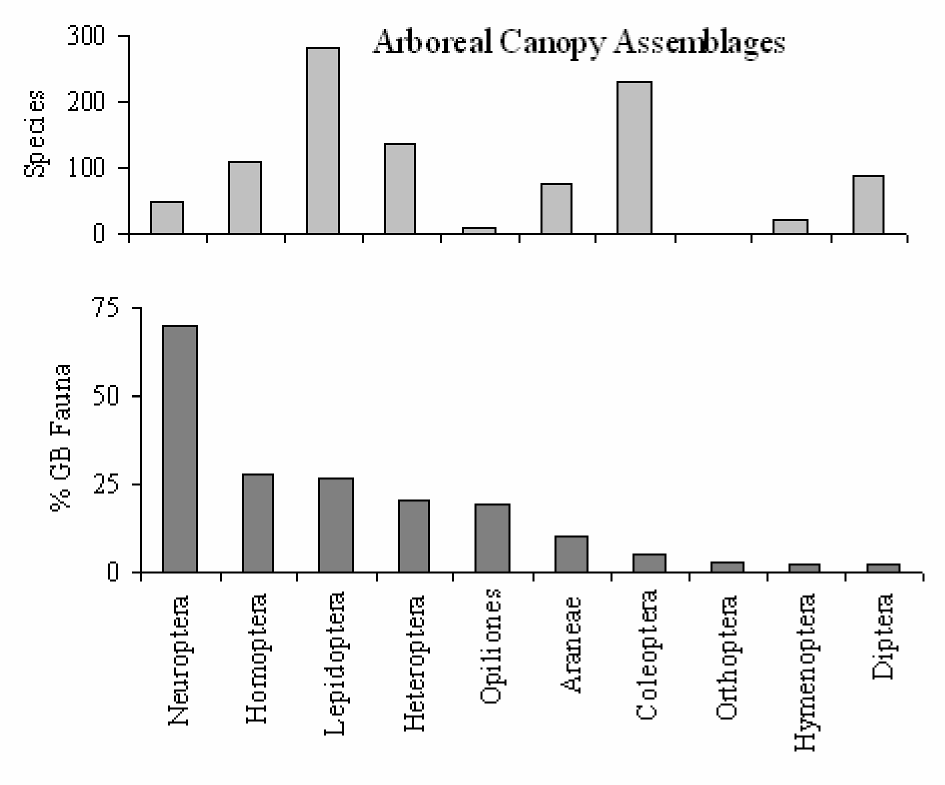


Figure 15 Arboreal canopy assemblages (A11)

Wood decay assemblages (A21)

5.41 Species of wood decay and wood surface assemblages are found wherever trees and shrubs grow, and are not confined to 'woodland' – indeed the most species-rich examples occur with large, old and open-grown trees. The majority of species are associated with wood decay and the fungi causing decay (the saproxylic species), but there is a significant number of species grazing on algae, lichens and mosses on the surface of trunks and branches. Predators and parasites may use both saproxylic and epiphyte invertebrates indiscriminately although many appear to have a particular emphasis on one or the other. Most of the rare species are found on ancient and veteran trees, but common saproxylic species live on small pieces of dead wood and its associated fungi, derived from trees and shrubs of all ages.

5.42 Dead wood and allied microhabitats are given a far more detailed treatment than other habitats as they are one of the most demanding types to survey. The recommended standard approach is to use a series of visits across the field season. During this time as wide a variety of available niches as possible should be investigated using the standard hand techniques of beating, sweeping and panning, supplemented by direct observation. These methods will catch different elements of the assemblage so all are needed to collect an adequate range of beetles, flies and aculeates that are the key groups in this habitat.

5.43 The tree and shrub component of sites will vary considerably in total abundance (from one tree or bush to an entire forest), density (from open-grown trees and shrubs to dense closed-canopy situations) and age structure (from young through to veteran or even ancient trees or shrubs), and these aspects may also vary across the site. The invertebrate fauna varies in composition, abundance and conservation quality accordingly. Small numbers of open-grown trees and shrubs are generally of greater conservation interest for invertebrates than larger expanses of dense closed canopy woodland. This is especially the case with saproxylic and epiphyte assemblages.

5.44 Wood surface species have tended to be overlooked in nature conservation and indeed by most recorders. Key groups are barkflies (Psocoptera) and Microlepidoptera, but there are also a wide range of other groups involved including molluscs, millipedes, harvestmen, predatory bugs and spiders. The spiders are particularly difficult to allocate to assemblages as many are using wood surface structures only to set their webs in crevices, etc, or as hunting arenas. However, many are specialists of tree trunks and they most logically fit ecologically within this wood surface assemblage.

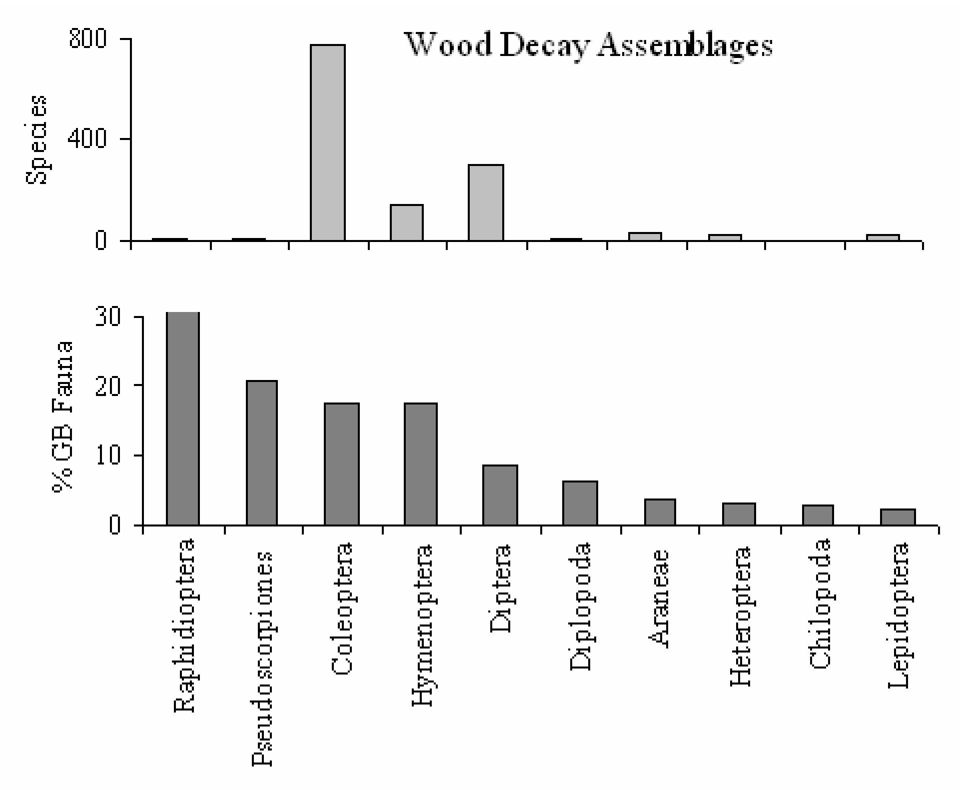


Figure 16 Wood decay assemblages (A21)

Taxa

5.45 The saproxylic fauna is dominated by beetles and flies. Many aculeates feed on other saproxylic invertebrates and use dead timber as nesting sites – particularly large dead timbers in open sunny situations – but this niche is much less prominent amongst beetles and flies. Decaying timber and its fungi are important for other groups, such as snake flies and pseudoscorpions, but the number of species is small, and their exclusion from a survey will make little difference to an evaluation. Therefore, beetles and flies form the core taxa to be surveyed, but aculeates should be included in situations where timber is exposed to the sun. On coniferous dead-wood, beetles are more important than flies but both should be included in an evaluation.

5.46 For CSM, beetles, bugs (Heteroptera) and moths need to be sampled using beating and targeted search.

Method

5.47 A good survey strategy will necessarily depend on what the surveyor encounters when they arrive on-site and may be modified by what they find after exploring the site – determining a detailed strategy in advance is not sensible. The basic features that need to be investigated are:

- Large old trunks of living trees, especially those with well-lit sunny areas, and both rough-barked and smooth-barked examples. The latter are better for adult flies in the families, Dolichopodidae and Hybotidae, but the former are better for barkflies (Psocoptera):

    Inspection for active invertebrates, eg resting flies or hunting spiders, which may be captured directly into a tube, pooted, or netted.

    Inspection of any sap-runs or other wet fluxes for visible insects, collection of any larvae for rearing.

Inspection of any exit holes that may gives clues to the identity of the inhabitants, including hole shape and size. Watch for secondary occupation by aculeates.

Bark cavities:

Older trees may develop large cavities within the bark and beneath it, and these may be detected by knocking for hollow sounds or judged by eye. If cavities are found, bark sections need to be pulled off to see if any cobweb beetle larvae are present and to record spiders, etc.

Trunk cavities – rot-holes:

These are best investigated using emergence traps set across the opening or by rearing larvae taken from samples of wet debris – most of the contents will be in the larval stage (flies predominantly).

Trunk cavities – hollowing:

Direct investigation of white-rotten or red-rotten decayed wood.

Examination of accumulations of wood mould using panning (as in gold-panning, with material sorted by size category in a tray through agitation and tossing) or sieving techniques; Tullgren funnels or Winkler extractors could also be used.

Accessing pockets of decay debris within the interior of hollow trunks by placing a net in the base of the hollow and probing the interior above with a beating stick or net pole.

- Aerial dead branches on living trees:

  Beating or tapping over a net, etc; high summer and autumn are important times for specialist beetles of this habitat; epiphyte-associated invertebrates are recorded in the same way.

  Sections of branch, with or without fruiting fungi, can be taken away for rearing purposes.

- Aerial live branches:

  Beating over a net, etc, to capture resting adults after emergence from saproxylic habitats or in cop.

- Standing dead trunks (snags and monoliths):

  Much as for live trunks (above), but often with better access to decay and cavities; aculeates are most likely to be found on dead trunks as they will be less shaded in general and there will be a greater range of cavities available for nesting; warmth-loving species also favour dead trunks.

- Fallen trunks and boughs:

  General investigation, breaking into loose and soft material.

  Turning over to inspect the moister undersides (always placing back as found!).

- Fruiting fungi:

  Inspection for active insects and netting any that are disturbed by the surveyor.

  Tapping over net, etc.

  Inspection for insect exit holes.

Breaking a representative sample open and checking for larvae that might be taken for rearing.

- Targeted beating of blossom on flowering trees and shrubs, especially hawthorn, elder, holly, etc:
- Field layer beneath or close to trees and shrubs:

Sweep-netting low over the field layer and beneath the aerial foliage.

Inspection of any flowers, eg hogweed, bramble, etc.

5.48 A survey should aim to cover all or most of the above. Supplementary work, with a variety of trapping devices, may also be feasible although is not part of the recommended CSM methodology for these assemblages. Potential traps include Owen extractors, window and flight interception traps, Malaise traps, baited traps (such as bones wrapped in grass cuttings, that can be left in tree cavities to attract carrion species), pitfall traps set within hollow trees, and artificial habitats such as sawdust-filled boxes placed in the canopy or hollow trunks. Canopy fogging is a more demanding technique that has been used mostly in tropical work, and is not considered appropriate for the type of surveys covered in this book.

Timing

5.49 For CSM, three visits should focus on:

- the late spring optimum in adult abundance (May-June);
- high summer species (July-August); and
- autumnal species (September-October).

5.50 One day should be spent on four sampling areas that have been chosen to represent a range of suitable habitat across the site. Around one and a half hours should be spent in each sampling area. For small sites, it may only be possible to fit in three sampling areas. For more intensive surveys aimed at site quality evaluation, monthly visits may be necessary. For each visit, one full day should be spent on a site of 60 to 70 hectares, with shorter periods on smaller sites and longer on larger sites. Where possible, visits should take place during extended periods of high atmospheric pressure so that weather conditions are most likely to be optimal.

5.51 The requirements for blossom mean that a late spring visit is needed to coincide with the peak in hawthorn flowering, and hopefully a high summer visit will coincide with elder blossom. The high summer visit will also enable work with fruiting Laetiporus sulphureus and other earlier bracket fungi, while an autumn visit will hopefully coincide with the fruiting of Fistulina hepatica and other later fungi.

5.52 The hierarchy of survey intensity is as follows:

- Exploratory visit – one day or part of a day at any time of year.
- Baseline seasonal survey (recommended for CSM) of three visits across field season.
- Intensive survey of at least monthly visits across the field season, from April into October and possibly November, in any one year.
- Full survey, combining the last with a variety of trapping techniques.

5.53 Recording should always include good details of the tree or wood on/in which species were found in order to help to build up the knowledge of habitat use and hence its conservation needs. Tree and branch girth is very important to record, together with branch length if practical. Tree form is also important – open grown or high forest. Fungal associations should also be recorded and contact with a local mycologist is recommended to ensure reliable identification.

5.54 The equipment carried on the survey will largely depend on the amount of damage the surveyor intends to cause in the pursuit of saproxylic invertebrates. Basics are a sweep net (which can also be used as a beating tray), a beating stick, a tape measure, a sharp knife and/or folding hand-saw, and a variety of containers for specimens and samples – a large supply of plastic bags is useful for taking samples of wood and fungi for rearing purposes. A ladder is useful for improving access to aerial cavities but should always be used in compliance with health and safety policies.

5.55 The assemblage type classification has been designed to separate sites important for veteran and ancient tree specialists (A211) from those that are important for sapwood and sap specialists (A212), the latter having the potential to be more widespread in the absence of older generations of trees and shrubs. The fungal fruiting assemblage (A213) enables the specialist survey of this more easily accessible resource (that is, relatively easy compared with the difficulties of getting access to heartwood decay).

Table 12 Target taxa in field layer and arboreal assemblages, and their value in assessment

Taxa	Ease of identification	Assemblages						
		early successional mosaic	grassland and scrub matrix	mature heath and dry scrub mosaic	montane & upland	shaded field layer	arboreal canopy	wood decay
		F11	F21	F222	F221	F31	A11	A21
Mollusca (snails)	1-3(4)							
Coleoptera								
Cantharidae (soldier beetles)	1-3							
Carabidae (ground beetles)	1-3							
Chrysomelidae (leaf beetles)	1-4							
Coccinellidae (ladybirds)	1-3							
Curculionoidea (weevils)	1-4							
Elateridae (click beetles)	1-4							
Staphylinidae (rove beetles)	2-4							
Other families	1-4							
Diptera								
Asilidae, Acroceridae, Bombyliidae	1-2							
Chloropidae	2-4							
Clusiidae	2							
Conopidae	1							
Dolichopodidae	1-3							
Empididae, Hybotidae (empids)	1-3							
Ephydridae (shore flies)	3-4							

Table continued…

Taxa	Ease of identification	Assemblages
Fanniidae	2-3	
Lonchaeidae	3-4	
Lauxaniidae	2	
Muscidae	2-3	
Mycetophilidae and related families	3-4	
Opomyzidae	1-3	
Rhagionidae, Tabanidae	1-3	
Platypezidae	2-3	
Psilidae	2	
Sarcophagidae	2-3	
Scathophagidae ('dung' flies)	2-3	
Sciomyzidae (snail-killing flies)	2	
Sepsidae (lesser dung flies)	1-2	
Syrphidae (hoverflies)	2	
Tachinidae	1-4	
Tephritidae (picture-wing flies)	1-3	
Tipuloidea, Ptychopteridae (crane flies)	1-2 (3)	
Ulidiidae (picture-wing flies)	1-2	
Xylomyidae, Xylophagidae	1	
Hemiptera (Bugs)		
Auchenorrhyncha (hoppers)	2-4	
Heteroptera	1-4	
Hymenoptera, Aculeata	1-3(4)	
Lepidoptera		
Neuroptera (lacewings)	1-2	
Orthoptera (grasshoppers)	1	
Araneae (spiders)	1-3	
Opiliones (harvestmen)	1-2	
Hymenoptera, Aculeata	1-3(4)	

See Table 10 for interpretation.

Table 13 Methods for different types of survey of field layer and arboreal assemblages

	early successional mosaic	grassland	mature heath and dry scrub mosaic	montane & upland	shaded field layer	arboreal canopy	wood decay
hand search	C E L	E L	E L	C E L	C E L	e l	E L
dead wood methods							C E L
spot-sweeping	C E L	E L	C E L		el	E L	E L
sweeping	C E L	C E L	C E L	C E L	C E L	C E L	E L
beating			C E L		E L	CE L	E L
suction sample	E L	E L	E L	E L			
water trap	E L	E L	E L	E L	E L	E L	
pitfall trap	E L	E L	E L	E L	e l		
Malaise trap	E	E	E	e	E	E	E
flight-interception trap	E L	E L	E L	e l	E L	E L	E L

C = Common Standard Monitoring; E = Environmental Impact Assessment / site selection; G = landscape and regional surveys. Lower case indicates that the method is less useful.

Table 14 Seasonality of major taxa

Taxa	Month									
	J	F	M	A	M	J	J	A	S	O	N
Mollusca											
Coleoptera											
Carabidae											
Staphylinidae											
Scarabaeoidea											
Elateridae (adults)											
Cantharidae											
Coccinellidae											
Cerambycidae (adults)											
Chrysomelidae											
Curculionoidea											
dead wood species											
water beetles											
Diptera - all groups											
Tipuloidea											

Table continued…

Taxa	Month
all ‘larger Brachycera’	
Empididae/Hybotidae	
Dolichopodidae	
Syrphidae	
Tephritidae, Ulidiidae	
Sciomyzidae	
Acalyptrates	
Calyptrates	
Hemiptera	
Heteroptera	
Hymenoptera	
solitary bees	
bumble bees	
Pompilidae	
Sphecidae, Eumenidae	
Formicidae	
Symphyta	
Lepidoptera (adults)	
butterflies	
macro-moths	
micro-moths	
Odonata (adults)	
Orthoptera	
Trichoptera (adults)	
Spiders (all species)	

See Table 10 for interpretation.

6 Laboratory methods

6.1 The processing and identification of samples are unavoidable aspects of invertebrate surveys. These activities can be very time consuming, so it is sensible to develop procedures that keep them as short as possible. All surveys involve identification, so this is dealt with first. Hints on extracting animals from debris and sorting them into convenient taxonomic fractions are given later. Once identification is complete, consideration needs to be given to storing both specimens and data.

Identification

6.2 Inaccurate identification is one of the biggest problems in evaluating sites for invertebrates, and is the surest way of getting a report discredited. If there is any uncertainty about the identity of a specimen, the safest course is to leave it out of the list altogether, or leave it at genus level (question marks next to names soon get lost during data inputting!). Recording a specimen's sex is sometimes helpful because, in some groups, one sex is easier to identify than the other.

6.3 When the fauna is relatively small, for example in many aquatic habitats, the use of a check list can save time in both identification and data inputting. This list is used as a form in the data inputting routine (for example in Recorder). This method does not work for many terrestrial surveys where the numbers of species are large and cannot be predicted (and listed) in advance. When the rate of identification is slow relative to the data inputting effort, more time can be saved by inputting as one identifies. The disadvantage in this is that there is no means of checking a record if inputting mistakes are discovered later on.

6.4 Less experienced surveyors make faster progress when all the individuals in a manageable taxonomic group (eg a family) are identified in one go, but even experienced surveyors will save time if specimens of infrequent species that cannot be identified on sight are put to one side while going through the sample. This is particularly relevant with large samples of beetles and flies; for instance, 10-minute sweep-net samples frequently contain 50 species and several hundred individuals of flies, and which ones have been already noted has to be remembered for the time it takes for that sample (perhaps 2 to 4 hours).

6.5 Some suggestions for estimating abundance are given in 'Analysis – Population size and individuals' abundance'.

Identification guides

6.6 There are keys to nearly all British invertebrates but only a small proportion are in readily available handbooks, the rest being scattered in journals. Barnard (1999) gives a bibliography of key work for the British fauna. Other European series (notably Fauna Entomologica Scandinavica) cover the British fauna well, and are important given the rate at which new species are added to British fauna.

6.7 Identification keys are very useful aids but they can be difficult to interpret by inexperienced workers. Comparison with a reliably named reference collection is the most foolproof way to make identifications.

6.8 It is standard editorial practice in refereed publications to give the binomial authority either when the species is first mentioned, or in tables. This practice is more relaxed in unpublished reports but, if the authority is not given, then the check list or other source that is used should be quoted. As well as paper check lists and biological recording packages, several check lists are available on the web, although superseded web pages cannot be viewed.

Microscopes and a few hints

6.9 An adequate microscope is essential to undertake accurate identifications and prevent eye-strain. Suitable models need not be expensive and are available for about £1,200 (2006 prices). Cheaper models are inadequate for long periods of work. The following should be considered when selecting a microscope:

- Magnification of at least X10 to X40, and preferably both higher and lower (for sorting).
- Working distance between the objective and the stage of at least 70 mm.
- Field of view at low power preferably greater than 30 mm (for sorting).
- A good light source is more important than the quality of the optics at the magnifications used for most insect identification.

6.10 The incandescent light sources fitted to many microscopes can become uncomfortably hot to work under and cause alcohol to evaporate quickly. They can also create annoying convection currents that move small specimens around. Energy-efficient bulbs provide a cool light source but may not be sufficiently bright if the bulb cannot be placed within a few centimetres of the specimen; commercial small fluorescent sources are available. Commercial cold light sources – where the light is delivered through optical fibres – provide a stronger light but are expensive. If these are used, point sources are preferable to ring lamps which produce a glittering effect on specimens (like that produced by sunlight) and, when working in liquids, form an irritating bright circle on any meniscus, such as that around the tips of forceps. A diffuser of grease-proof paper will help reduce these effects. Sub-stage lighting is rarely used but can help to view veins in insect wings (notably caddis flies) in alcohol.

6.11 For most microscope work, a white background is best, but some nearly transparent features on specimens in liquids can be seen far better against a black background. A good dark background is best produced using a glass Petri dish or watch-glass; plastic containers are usually too scratched for this purpose. For sorting material from traps or suction samples, a Petri dish marked with a grid allows a more systematic search.

6.12 When identifying specimens in liquid, they can be difficult to hold in the required orientation. A useful aid is a bed of fine glass beads sold for gas chromatography or cell-disruption in grinding mills. An appropriate size of bead is 0.25-0.5 mm. They work well in alcohol whose low surface tension causes them to sink, but in water a layer of floating beads usually obscures the specimen. A cheaper alternative is clean fine pale sand.

6.13 Identification keys that use surface dusting, sculpturing and structural colours on dried specimens may not work well for specimens in liquid. These features will become visible if the specimen is allowed to dry out temporarily.

Processing samples

Sieving

6.14 Dry samples containing litter, for example suction samples, can be sieved into increasingly fine fractions which are far easier to search for animals than the unsorted sample. A series of four sieves with meshes of c. 10 to12 mm, 4 to 5 mm, 2 mm, and 1 mm result in the most easily looked-through fractions. The sieving action should be a gentle and up-and-down motion, not side-to-side which will break up the animals. The largest mesh lets through nearly all invertebrates but retains large bits of vegetation that can be very quickly checked in a white tray. The fractions retained by the 4 mm and 2 mm sieves can also be sorted in a white tray, either by spreading the material over a white grid-marked tray (c. 5 cm squares), or by sifting through a pile of debris a bit at a time. Material passing through the 2 mm sieve is most reliably searched a bit at a time using a microscope at low power. Very few insects pass through a 1 mm mesh but using this sieve gets rid of fine dusty material and makes searching the 2 mm fraction easier and quicker.

6.15 The two larger sieve sizes can be home-made using galvanised wire mesh from hardware shops. Smaller sizes are not so easily made, and expensive test sieves may need to be bought. A 20 cm diameter sieve is preferable to cheaper 15 cm diameter sieve as the former has nearly twice the area of the latter and will enable the same job to be done much faster.

6.16 Particularly messy wet samples, for example from pitfall traps into which leaves have fallen, can also be passed through sieves to hasten searching and removal of the animals, but this is not often necessary. Pitfall samples are usually dealt with effectively by putting the catch into a fine sieve (preferably 0.5 mm mesh, and certainly not more than 1 mm) over a sink and rinsing off the preservative. The catch is then placed in a white grid-marked tray (c. 5 cm squares) with about 6 to 8mm of water, and searched for animals.

Field-preserved aquatic samples

6.17 There are no short-cuts to extracting animals from field-preserved pond-net samples. These will contain large amounts of vegetation, stones and silt. The following method is adapted from that used by the Environment Agency for its biological monitoring (Murray-Bligh, 1999).

6.18 The preservative is first removed by putting the sample in a bucket of water and gently swirling it around, decanting the water through a 0.5 mm mesh sieve, and refilling the bucket until the water clears. Plant material and larger stones (in kick-net samples) are taken out and searched in a white tray in shallow (6 to 8 mm) water. When the vegetation and larger stones are removed, a small amount of the sample is gently tipped into the largest sieve (8 mm mesh) and this is very gently shaken up-and-down in a bucket of water until the smaller material has gone through. The retained fraction is put into a tray for sorting. This continues until all the coarsest material has been sieved and sorted. The process is repeated with the next sieve (4 mm), and so on to the finest (0.5 mm).

6.19 Only a small amount of material is put into the white tray for sorting any one time, and it is spread out so that there is much more tray visible than debris. Each fraction will take several trays to sort; there is no point in trying to put a lot of material in each tray since too many individuals will be obscured by the debris. Trays about 35 x 25 cm are most convenient to use.

6.20 Samples sorted and counted to Environment Agency standard take about 4 hours on average to process; large ones can take 8 hours. As counts are not usually needed for conservation evaluation, and a greater error in species-detection is allowable, less time will be needed, although it is still considerable. This is the reason why this handbook recommends the bank-sorting of life samples for many conservation evaluation aims.

Sorting into taxonomic groups

6.21 Mass collections of invertebrates in terrestrial surveys are identified faster if first sorted into taxonomic groups (often orders). This reduces the number of identification guides needed at any one time and places less demand on the sorter’s memory.

6.22 Fewest errors are made if the catch is sorted under a low power binocular microscope; sorting without a microscope can lead to tiny specimens getting lost within the convolutions of larger ones. Most of the time is spent handling specimens and this can be reduced by using a small brush or forceps to shunt specimens into separate piles in a Petri dish rather than removing them individually. If only one or two groups need to be extracted from a mass of specimens, for example, from a Malaise trap, a grid placed under a clear glass dish – or one marked on the bottom of the dish – will allow the sample to be methodically scanned.

6.23 Large catches may comprise mostly one order (flies in Malaise traps, for example) and sorting such samples is best done by removing the infrequent orders and leaving the abundant order in the dish. Such samples need to be sorted a fraction at a time. Sub-sampling may be appropriate for some surveys (for methods, see Southwood & Henderson, 2000).

6.24 The level of expertise needed to sort to Order-level is relatively low compared to species-level identification and can be acquired quickly, so this task is suitable for contracting out to non-specialists. Nevertheless, sorting requires patience and stamina as it is tedious, and some overseeing will be needed to ensure that tiny species are not being routinely overlooked. Sorting flies and beetles to family-level requires considerably greater knowledge and this job should not be expected of inexperienced personnel.

Storing specimens and data

Voucher specimens and archiving

6.25 At least one voucher specimens of all uncommon and rare species should be kept in case their identities are queried. The survey report should state where the vouchers are stored so they can be examined at a later date.

6.26 Vouchers may be stored in alcohol. Alternatively, many adult insects can be pinned. Specimens of many groups usually shrink badly when dried after storing in alcohol, so specimens collected into a fluid are best stored wet. This is not true of strongly chitinised animals such as beetles and many bugs which can be dried without ill effects.

6.27 Specimens such as flies and soft bugs can be retrieved from liquid preservative using the methods outlined by McGavin (1997). The specimens are transferred to 2-ethoxy-ethanol for 12 to 24 hours, then to ethyl acetate for 1.5 to 3 hours (the longer time for larger specimens), then placed on paper to dry, or on glass so that the wings can be flattened out. Bees are pinned after 24 hours in 2-ethoxy-ethanol, soaked in ethyl acetate for 24 hours, then blow-dried using a hair-drier.

6.28 Ideally, all specimens, whether identified or not, should be kept but this can result in vast quantities of material that are never looked at again. Unwanted specimens can be offered to other depositories such as museums or individual taxonomists who may welcome more specimens for their research.

6.29 Experts who will check vouchers include most national and regional organisers of recording schemes. It is polite to request their help before sending specimens and there can be no expectation that they will respond to commercial deadlines.

6.30 Dry-collected specimens can be completely dried after identification and stored ‘en masse’ in pest-tight containers. Should specimens need to be retrieved, the material can be relaxed by leaving the opened container in a plastic box together with water-soaked tissue for 24 hours. This will reduce damage when sorting through the jumble of specimens.

6.31 Material in alcohol becomes vulnerable as it slowly dries out. Adding glycerol or ethylene glycol to make a c. 5% solution with the alcohol will prevent the specimens from desiccating completely.

6.32 There are several good texts on specimen mounting and curation, eg Martin (1977), Walker & Crosby (1988), and Cooter & Barclay (2006).

Data entry, storage and transfer

6.33 Results should be entered onto a database; there is little excuse these days for working exclusively with paper. The two most commonly used methods of entering and storing data are spreadsheets and biological recording packages.

6.34 Large data sets containing over 10,000 records accumulated from several surveys are best kept in a database. However, using spreadsheets to manipulate data from individual surveys can save vast amounts of time. Records are best kept in a list with one line per record and the first line of the spreadsheet used as a header containing field names. Such lists can be easily sorted on any field or a combination of fields to facilitate safe global updates. Functions can be selected and formulae composed to carry out a large range of quantitative analyses of data very quickly. In Excel, pivot tables are particularly useful for producing the following:

- species lists defined by field values, for example for pasting into ISIS (the resulting lists are free of duplicate names);
- summary statistics and charts; and
- site/species matrices for report appendices and multivariate analysis programmes.

6.35 Species lists to be used for ISIS must conform to certain standards. ISIS only accepts scientific binomial names without authorities. ISIS can recognise commonly used synonyms, but unrecognised synonyms and mistyped names must be corrected. Errant empty spaces at the end of specific names are a common cause of problems. Errors can be identified using the ISIS spreadsheet data entry screen. Species in groups not included in the ISIS species index are also returned as errors.

6.36 Data collected in a survey can be put to wider uses. Other people and organisations will welcome the data and they should be sent a copy of the report (preferably) or the species lists or tables. After the customer who commissioned the survey, the most important recipients of records and recommendations are the country conservation agencies, biological records centres and national recorders, and some land owners (eg Wildlife Trusts, National Trust, RSPB, Forestry Comission).

6.37 Landowners or customers may request confidentiality on data and localities. While this needs to be respected, it is worth trying to negotiate a time limit after which the data may be sent to recording schemes, used in publications or sent to other interested parties.

7 Setting up a survey

7.1 Some aspects of survey planning, such as what to include in a project brief and report, and what responsibilities lie with whom, will be familiar to managers in all fields of conservation, and so are covered only briefly. The rest of this chapter discusses aspects that are specific to invertebrate surveys, and the issues that project managers should be aware of when writing their brief. Topics covered include: the extraordinary time invertebrate surveys takes and the frenetic nature of cramming field work into a short season; the degree of expertise needed to undertake the work; ways to avoid wasting an experienced surveyor's time on trivial tasks; legal constraints; and the use of existing data whose nature may modify the aims of new survey. These issues need to be addressed while the survey is being designed, or at least before field work starts.

Timetabling

7.2 The elements to consider are:

- project planning and management
- field work
- identification and processing samples
- analysis and writing the report
- making corrections requested by the client.

Project planning and management

7.3 Even on small to medium surveys at least one day should be allowed to cover discussions with the client and land owners, to check that field equipment is serviceable, to sort out maps, and work out the best approach (even after a tender has been accepted). Gaining access permissions may take additional time (see below).

7.4 A preliminary visit with the client, or someone who knows the site and its problems, is sometimes useful; it gives an opportunity to refine the scope and methods of the survey, and can save the surveyor's time by helping with the selection of promising sampling locations.

Identification and sample processing

7.5 Most non-entomologists have little idea just how long laboratory sorting and identification can take. 'Sorting' covers picking out animals from debris (for example in pitfall traps, suction samples and field-preserved aquatic samples) and separating the catch into large taxonomic groups for later identification. The following are approximate times for sorting animals from debris:

- 3-minute kick-net or pond-net samples: 3 to 8 hours per sample
- 2-minute suction samples: 1 to 4 hours
- lumped catches from 9 pitfall traps: 2 to 4 hours.

7.6 These timescales cannot be more specific as, whereas animals always have to be sorted from debris in these types of samples, sorting catches into taxonomic groups may not always be necessary. Be aware that the catch of a single Malaise trap in high summer can take a day to sort through, and that even water trap catches can take up to an hour. By comparison, sorting is reduced or completely avoided when using methods in which animals are selectively removed in the field, for example, in sweep-netting and direct searching.

7.7 The time spent on identification clearly depends on the thoroughness of the work. As a very rough guide, a day's field work represents 2 to 3 days' identification.

7.8 Ways to reduce identification time:

- Focusing on groups that the surveyor is familiar with, so reducing the time spent referring to identification guides.
- Doing all the identification from similar sites at one sitting, since the fauna becomes familiar and key identification characters can be remembered over a short time. Conversely, switching between habitats and sites, and leaving gaps between identification sessions puts greater strain on the memory.
- Doing one taxonomic group at a time, for the reasons given above.
- Using other experts to identify 'their' groups.
- Ignoring groups where there is little information on their conservation status or distribution, since they represent redundant information in site evaluation.

7.9 The field season is short and busy. Spending the summer months identifying and writing is not efficient; these tasks can be done in the cold months with no detriment to the client.

Analysis and writing the report

7.10 Between two to five days is the minimum time needed to write a report for a small to medium-sized site (10 to 50 ha). The shortest report that just lists species, describes the methods and sites, draws some basic conclusions and includes a map, will take two days. Most surveys that record a few hundred species from a medium-sized site will take about five days. No guide can be given to larger surveys, but a very rough rule of thumb is that a page of results or discussion can take half a day to write; if the analysis is more complex (eg includes ordinations and other tests that may need running several times) this time can easily be doubled.

Access permission

7.11 Permission to work on private land is essential. Gaining access permission to sites with multiple ownership can take longer than the fieldwork itself and the time for this task needs to be built into the work programme. Publicly funded organisations may have owners' and occupiers' contact details but may not be allowed to release these to private individuals (including contract surveyors) under the Data Protection Act. The Environment Agency may be able to help indirectly by providing contacts for river bailiffs and fishing syndicates.

7.12 Suggested procedures:

- The client has responsibility for making the initial contact if they hold the relevant details (eg for SSSI, nature reserves). Thereafter the contractor should make contact to arrange a time and date, details of physical access and confirm any restrictions on activities.
- If the owner is unknown (the most frequent case outside notified sites), the Land Registry may be able to supply information. There is a small charge per enquiry, but information will be available if the land has been registered – which happens only when it changes ownership.
- When all else fails, knock on doors. This can be a frustrating use of time, and a generous allowance should be made when estimating costs if many owners are involved. The client needs to understand that the survey might not be completed if access permissions cannot be obtained.

Expertise

7.13 Field entomologists are often self-taught and start as collectors. The experience, reference collections and specialised literature these researchers have gained enables them to make rapid, accurate identifications. There is no quick way of acquiring similar skills, but useful courses and workshops in identification are offered by the Natural History Museum, Field Studies Council, Freshwater Biological Association and amateur societies (eg British Entomological and Natural History Society, Dipterists Forum). However, there is little point in training in identification without the back-up of practical experience. Therefore, prospective surveyors need a proven record in survey work.

7.14 Occasionally methods need to be applied in a standard fashion, for example when two surveyors undertake the same survey. In this case, the surveyors need to agree on the procedure and see how the other works to ensure similar results are obtained. This applies mainly to active collecting methods such as sweep-netting and suction sampling, but also to how various types of traps are set. If they select specimens in the field, the surveyors also need to agree on the limits of each group collected, so, for example, when collecting aquatic invertebrates, they must decide whether to include aquatic weevils with water beetles. Training will reduce, but cannot eliminate, differences that are inevitable when using non-quantitative methods. However, discrepancies between trained personnel are likely to be small compared to differences in the quality of genuinely different sites.

7.15 If unskilled personnel are used to service traps or sort samples, some training is needed. Poorly set traps will spoil a survey and poorly sorted samples will waste time as some specimens may be sent to the wrong experts for identification.

Essential skills for using ISIS in CSM

7.16 There are a number of tasks critical to the CSM process (and often in other types of survey) that require considerable expertise:

- The surveyor sampling a target assemblage must have the ecological knowledge to recognise optimal habitats. Failure to select suitable habitats for sampling will depress scores in the results.
- Because of the vast numbers of invertebrate species, entomologists have always specialised in certain taxonomic groups. Even highly competent entomologists cannot be expected to efficiently sample groups with which they are not familiar. The surveyor must therefore be experienced in sampling the target groups, or the score may be depressed. More than one surveyor will often be necessary.
- The correct identification of species in the sample is critical and should be carried out by a specialist with the appropriate identification skills. Identification errors can seriously inflate the scores used in ISIS and lead to gross errors.

Splitting the work between operators

7.17 Invertebrate surveys often have clearly different elements requiring different skills, so there is scope for using different people to reduce costs, or to obtain the best results for each element.

- Field work. Although field craft is a skill, the routine emptying and resetting traps can be undertaken by non-specialists, if they receive appropriate training. Using people, such as site managers or botanical surveyors, who live or work close to sites can be cost-effective.
- As stated above, surveyors with expertise in different taxonomic groups may be needed to collect the range of groups demanded by the project brief.
- Sorting catches to higher taxa. This can be a tedious activity but requires knowledge of invertebrate groups. Biology students have been used successfully for this element, but it should be realised that it has almost no educational value. Sorting big orders into families needs considerably greater knowledge and experience.
- Identification. Surveyors may not be experts in all the groups they are asked to collect. Using experts for each order or even just several key families within major orders often gives the most reliable identifications. However, the minimum number of people should be involved as contacting and contracting these experts, and sending them the catch, can take a long time in itself.
- Analysis and evaluation. Non-professional surveyors can produce excellent and accurate species lists, but these people may not have the equipment or experience to analyse the

results, evaluate the site or make recommendations. In these cases, the later elements of the survey may be best left to the client or another experienced invertebrate specialist, as long as the sampling protocol has been designed to take account of the methods of analysis.

Using existing data

7.18 Examining existing data can be useful in identifying target taxa or habitat features to include in a new survey, and to help make comparisons over time. If someone is asked to prepare an Environmental Impact Assessments the first step should be a literature search. Such a search might make a survey unnecessary if sufficient evidence already exists. The Institute of Environmental Assessment (1995) provide detailed criteria that would trigger a further survey for EIA. They are reproduced here:

- For all sites where the development will have a direct or indirect impact on the water quality of rivers or still waters, a baseline survey of the aquatic invertebrate fauna should be undertaken unless adequate data already exist.
- When this initial water quality invertebrate survey sample achieves any of the following values equivalent to the top 10% of samples from the 1990 survey of the UK:
- 26 or more families of invertebrates.
- Biological Monitoring Working Party (BMWP) score of 150 or greater.
- Average [BMWP] Score Per Taxon (ASPT) score of 6.48 or greater.

7.19 The samples taken should then be analysed to species level wherever practical:

- Further survey is required when the desk study reveals that a Red Data Book invertebrate has previously been recorded from the site, and the extended Phase 1 survey indicates that suitable habitat for it still exists within the impact area. If the presence of the species is not detected on the site, the likelihood of its continued presence should be assessed in terms of the survey coverage and species ecology.
- Further survey is required when the desk study indicates that Nationally Scarce species of invertebrate are present on the site, or RDB or Nationally Scarce species of invertebrate occur near the site in habitats similar to those present within the study area. In the latter case the relevant on-site habitats may need to be surveyed to assess their value for invertebrates in comparison with the nearby areas of known invertebrate value.
- Further survey is required when the extended Phase 1 habitat survey identifies features or habitats of significant value to invertebrates (Kirby, 1992), for example, dying timber, ancient woodland or fens.
- Further survey is required when the desk study reveals that the site qualifies as a drag¬onfly key site (SSSI Citation), as this is a good indicator for quality habitat for invertebrates.

7.20 Information may be sought from the following sources (see Appendix 3):

- NBN Gateway.
- National recording schemes, via the scheme organiser or the Biological Records Centre (BRC) at the Institute of Terrestrial Ecology.
- Local record centres.
- County recorders for specialist interests. Local records centres and natural history societies will know who these are and where to contact them. There are good networks for most of the larger groups such as butterflies and moths (Butterfly Conservation), dragonflies (British Dragonfly Society), flies (Dipterists Forum) and aculeates (BWARS).
- Invertebrate Site Register (Ball, 1994) maintained by the country statutory nature conservation agencies. The database holds information on rare, nationally scarce and local species at sites in Britain. It can provide species lists for named sites, vague sites (eg the New Forest), counties, English Nature’s natural areas, and selected grid squares (down to 1 km).

- Site reports held by a wide range of statutory and non-statutory organisations, for example, the statutory conservation agencies (Natural England etc), the Environment Agency, the Scottish Environmental Protection Agency, Forestry Commission, county wildlife trusts, RSPB, National Trust, Wildfowl & Wetland Trust, Institute of Terrestrial Ecology, Institute of Freshwater Ecology, universities, polytechnics and museums.
- Private individuals (collectors, recorders). These people are the source of most records that may or may not have been passed to a recording scheme. Some may be able to provide insight to sites they have worked well or known for a long time.

Legal constraints

7.21 Entomologists in Britain have several legal constraints to their activities:

- Legally protected invertebrates (see the JNCC website). A license issued by the relevant statutory conservation agency is needed to collect species fully protected under the Wildlife & Countryside Act. This will also cover invertebrates listed in Annexed IV of the Habitats and Species Directive and for which a license is required under European regulations (large blue and large copper butterflies, violet click beetle). No license is needed to collect species listed in Annexed II of the Habitats and Species Directive. The purpose behind licensing is to monitor and, if necessary, control the taking of protected species; it is not a mechanism to prevent admissible collecting.
- Legally protected vertebrates. It is an offence to collect or disturb protected species even as an incidental part of a lawful operation, unless it can be shown that reasonable precautions were taken. The onus rests with the collector to prove that they took these precautions. Unfortunately for invertebrate surveyors, their methods also work for some small vertebrates that are protected under British or European legislation; these include shrews, natterjack toads, great crested newts and sand lizards, all of which can fall into pitfall traps. A license is therefore needed if there is any risk of capturing these species (almost a certainty with shrews in wetlands, and often with great crested newts in pond surveys). If it is found that a method kills fully-protected species, it would be prudent to change it to one less likely to cause death or injury. A wire mesh placed over pitfall and water traps will reduce or prevent many deaths, although it may also reduce the catch of large invertebrates.
- Bye-laws and rules. Capturing animals is prohibited by bye-laws and the rules of several organisations, including the Forestry Commission, Forest Enterprise, the National Trust, the National Trust for Scotland, the Environment Agency, the Scottish Environmental Agency, county wildlife trusts and local authorities (for local nature reserves). These organisations should be contacted for permission to collect on their property or land they control. The permit should be taken when surveying on their land.
- National Nature Reserves and Sites of Special Scientific Interest. Collecting on these sites is classed (in England) as an 'operation likely to damage (OLD)', and permission to collect must be obtained from the local office of the statutory conservation agency. Permission is unlikely to be refused for a 'bona fide' survey.
- Criminal damage. Under the Wildlife & Countryside Act, it is an offence to uproot a wild plant without the land-owner's permission. While it is acceptable to pick fruit, flowers, foliage and fungi, it is not acceptable to break branches. However, some invertebrates are best recorded by examining galls, cracking open branches, or digging up plants. If a surveyor anticipates doing any of these things, it is definitely worth talking with the land-owner to explain their necessity and purpose.

Table 15 Responsibilities of the client and surveyor

Client	Surveyor	Both or negotiable
Writing a project brief that is achievable within the budget.	Undertaking the work in accordance with the survey design and its aims. If it is obvious that the design will not fulfil the aims, the surveyor should suggest changes.	Arranging access permission to sites. In delicate cases, it is best for the client to undertake discussions.
Providing maps and suggesting appropriate entry points and parking sites.	Subcontracted elements should be agreed with the client.	Obtaining necessary permissions or permits for collecting (eg on SSSIs, nature reserves).
Providing habitat maps or aerial photographs.	Preparing species lists or tables.	Obtaining licences from the statutory conservation agency if legally protected species might be collected.
Providing background information such as citations for SSSIs, previous surveys, and species lists.	Providing interim, draft and final reports.	Liaison and time-tabling.
Reporting results or conclusions to land owners if requested.	Personal safety. Appropriate safeguards must be taken to fulfil all Health & Safety requirements associated with sites, equipment and techniques employed during any survey or other assessment being made. An appropriate lone working procedure must be followed.	Modifying the survey design if the unexpected happens.
	Remaining within the law.	

Table 16 Preparing a project brief

Section	Comment
Background	It must be clear why the survey is needed because this will determine the scope of the survey.
Aims of the survey	These must be stated so it is clear what information is required.
Methods (some of the detail may best be left to the contractor)	Timing and frequency of visits. Collecting methods to be used. Taxonomic groups to be collected, sorted and identified to species level. Other information to collect, eg description of sampling locations. How and where specimens and data are to be archived. Whether vouchers and their verification are needed.

Table continued…

Section	Comment
Data processing (details may be left to the contractor)	How raw data are to be presented. Types of analyses and level of detail required. Whether the results are needed in electronic format.
Report	Deadlines for interim, draft and final reports. Paper copies: how many, loose or bound. Format of the electronic copy. The principal points that the final report may cover (see table 17)
Liaison	Meetings, interim reports, how progress will be checked.
Timescales	
Health & Safety	
Contact officer	
Confidentiality	Clients and landowners may request that data or localities are kept confidential. Permission may be needed before results are published or records are submitted to recording schemes.
Copyright	Who owns copyright on the data and the report, and what can be published. Much useful information is held in reports that hardly anyone sees. Unless there are good reasons for maintaining confidentiality, publication and submission of records to recording schemes should be encouraged. Three years is suggested as the maximum embargo period. The Ordnance Survey requires that their permission is given for each reproduced map, which must bear their acknowledgement, copyright and the licence number issued to the user. Royalty payments may be due but waived if a publication is not money-making. These requirements do not apply to very small scale maps such as the outline of Britain.

Table 17 Suggested report format

Section	Aspects to cover
Circulation list	Many reports do not warrant an ISBN and are difficult to trace, so a circulation list can be helpful.
Summary	
Contents	
Introduction	Reasons for, and context of, the study; previous work. Objectives (client's remit).
Site description	Site name and other names that may be used for the area; county or vice-county. Grid references of sampling points or collecting areas. Descriptions adequate to the needs of the survey including gross and fine structure, dominant plants and management. Photographs, sketches.
Maps	Locations of sampling points and important habitat features. Include grid lines and 100 km grid square (eg in the map legend) so that others can locate the sites and sampling points. Ordnance Survey copyright
Methods	Collecting methods and how they were used. Times of visits and duration of trapping periods. Weather conditions if these influenced the effectiveness of the collecting methods. Taxonomic checklist used (important when binomial authorities are omitted). Specialists who have undertaken identification or vetting of identifications. Location of specimens and vouchers in case they need to be checked. Database where records may be retrieved. Analytical methods. Source of rarity statuses.
Results	Key findings in text as well as tables. Uncertainty in the data, especially species identifications still to be confirmed. Comparison with other relevant data. When discussing important species, it will help non-entomologists if the binomial is accompanied by the group name, eg "the ground beetle *Carabus monilis*", and add common names for popular groups. When evaluating the interest of particular species, the context should be made clear, for example, national or local rarity, assemblage type or habitat fidelity. Although this can lead to a slightly cumbersome text, it will help others to follow the reasoning.

Table continued…

Section	Aspects to cover
Discussion / Conclusions	This should include issues related to previous work, the context and objectives of the project mentioned in the introduction.
Recommendations	The opinion of the surveyor can be of great value to the client. Recommendations should not be tempered by what the surveyor thinks the client is likely to implement. The surveyor may not be an expert in site management, and should be honest about the limits of knowledge in this field. It is often easier to make recommendations about management objectives rather than specific management operations. Recommendations may encompass further survey work, especially the monitoring of any changes in site or landscape management.
Acknowledgments	
References	
Appendices	Full species lists often formatted as site x species tables and other primary data are best placed in appendices to keep the kernel of the report easy to navigate.

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Further reading

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Appendix 1 Invertebrate status categories – NCC/JNCC

Red Data Book category 1. RDB1 – Endangered

Definition

Taxa in danger of extinction in Great Britain and whose survival is unlikely if the causal factors continue operating.

Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so dramatically reduced that they are deemed to be in immediate danger of extinction. Also included are some taxa that may possibly be extinct.

Criteria

Species which are known or believed to occur as only a single population within one 10 km square of the National Grid.

Species which only occur in habitats known to be especially vulnerable.

Species which have shown a rapid and continuous decline over the last 20 years and are now estimated to exist in five or fewer 10 km squares.

Species which have been recorded this century, but which are possibly extinct and which if rediscovered would need protection.

Red Data Book category 2. RDB2 – Vulnerable

Definition

Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating.

Included are taxa of which most or all of the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range.

Criteria

Species declining throughout their range.

Species in vulnerable habitats.

Red Data Book category 3. RDB3 – Rare

Definition

Taxa with small populations in Great Britain that are not at present Endangered or Vulnerable, but are at risk.

These taxa are usually localised within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Criteria

Species which are estimated to exist in only fifteen or fewer 10 km squares. This criterion may be relaxed where populations are likely to exist in over fifteen 10 km squares but occupy small areas of especially vulnerable habitat.

Red Data Book category 4. RDB4 – Out of danger

Taxa formerly meeting the criteria of one of the above categories but which are now considered relatively secure because effective conservation measures have been taken or the previous threat to their survival in Great Britain has been removed.

Red Data Book category 5. RDB5 – Endemic

Definition

Taxa which are not known to occur naturally outside Great Britain. Taxa within this category may also be in any of the other RDB categories or not threatened at all.

There are few truly endemic species in Britain. Most that have been identified are in fairly obscure groups which are relatively poorly known and the species may well eventually be discovered elsewhere in Europe.

Red Data Book Appendix. RDBApp. Extinct

Definition

Taxa which formerly had breeding populations in Great Britain but which are now believed to have died out.

Red Data Book category I. RDBI – Indeterminate

Definition

Taxa considered to be Endangered, Vulnerable or Rare, but where there is not enough information to say which of the three categories (RDB1 to 3) is appropriate.

Red Data Book category K. RDBK – Insufficiently known

Definition

Taxa that are suspected, but not definitely known, to belong to any of the above categories, because of lack of information.

Criteria

Taxa recently discovered or recognised in Britain which may prove to be more widespread in the future (although some recent discoveries may be placed in other categories if the group to which they belong is thought not to be under-recorded).

Taxa with very few or perhaps only a single known locality but which belong to poorly recorded or taxonomically difficult or unstable groups.

Species with very few or perhaps only a single known locality, inhabiting inaccessible or infrequently sampled but widespread habitats. such as some northern moorland species, species associated with some agricultural situations and species which are adult only during the winter.

Species with very few or perhaps only a single known locality and of questionable native status, but not clearly falling into the category of recent colonist, vagrant or introduction.

Provisional Red Data Book pRDB(x)

The prefix ‘p’ before any Red Data Book category implies that the grading is provisional. In the majority of cases this means that the species' status has been reconsidered and changed in a Species Group Review produced subsequent to the publication of the relevant Red Data Book.

The statuses so given are described as provisional, pending the publication of a future edition of that Red Data Book. These statuses are however, based on a greater amount of evidence than was available for the original Red Data Book and therefore more likely to be a true representation of the species' actual status.

The prefix ‘p’ is also used for RDB status categories in groups where a Red Data Book has not yet been produced but is in preparation, or is used for species in groups covered by the original Red Data Book, where it is considered that there is evidence that the original grading was incorrect or that there has been a genuine change in status of the taxon.

Nationally Scarce (Notable) species

The term ‘Nationally Scarce’ was adopted and replaced the term ‘Notable’ during the compilation of the Guidelines for Selection of Biological SSSIs. The two terms are thus interchangeable but ‘Nationally Scarce’ is preferable.

The Invertebrate Site Register project includes the preparation of National Species Reviews which seek to identify and document uncommon species. The criteria used have been based directly on those evolved by botanists and two levels of ‘National Notability’ have been used. These are Notable A, for species known to occur in thirty or less 10 km squares of the National Grid and Notable B for those known from 100 or less squares.

This system can be used directly with well recorded groups like dragonflies, butterflies, and grasshoppers, but when dealing with many other groups of insects, the level of recording is not sufficient to apply the criteria rigorously. A combination of three alternative approaches has been employed:

- The approximate number of squares in which a species may occur can be estimated by looking at the number it has been recorded from as a proportion of the total in which the whole group (eg its family) has been recorded.
- Coarser measurements such as the number of vice-counties in which a species has occurred can be used (7 or less for Notable A, 20 or less for Notable B).
- Experts can be asked to use their field experience to judge the status of species in their particular specialist group against others with a better established status. By consulting as many people as possible and taking a consensus of their views, geographical and personal biases can be minimised.

In the Diptera (and also in some other groups) a group in which widespread interest and recording is a rather recent phenomenon, no attempt has yet been made to separate Notable A and Notable B species, and all Nationally Notable species are simply graded 'Notable'.

Nationally Scarce (Notable) category A – NA

Taxa which do not fall within RDB categories but which are none-the-less uncommon in Great Britain and thought to occur in 30 or fewer 10 km squares of the National Grid or, for less well recorded groups, within seven or fewer Vice Counties.

Nationally Scarce (Notable) category B – NB

Taxa which do not fall within RDB categories but which are none-the-less uncommon in Great Britain and thought to occur in between 31 and 100 10 km squares of the National Grid or, for less well recorded groups, within between eight and twenty Vice Counties.

Nationally Scarce (Notable)

Species which are estimated to occur in 16 to 100 10 km squares in Great Britain. The subdividing of this category into Nationally Scarce A and Nationally Scarce B has not been attempted for some species because of either the degree of recording that has been carried out in the group to which the species belongs, or because there is some other reason why it is not sensible to be so exact.

Regionally Scarce (Notable) Nr

Species which are considered to occur in 5 or less 10 km squares in an area equivalent in size to a region of the old Nature Conservancy Council or larger, approximately one eighth the total area of England.

Such statuses were worked out during the compilation of the Invertebrate Site Registers. They cover various groups in Scotland, in Northern England as a whole, in North East and North West England, in Vice County Yorkshire and in the east Midlands and East Anglia. They were worked out by local entomologists.

Other terms used by the Invertebrate Site Register

Local

The term local is not rigidly defined, but loosely means species confined to a particular habitat type (usually associated with better quality examples of that habitat), a particular geographic area, or species that are too widespread to warrant Nationally Scarce (Notable) status but are nevertheless infrequently encountered.

Common

Common or ubiquitous species, frequently recorded.

Synanthropic Species

Species dependent on man, his buildings or crops.

Unknown

Species where no status has been attributed. There may be confusion over the species' taxonomy, it may belong to a poorly recorded group or may occur in an infrequently sampled habitat. As a species is entered into the Invertebrate Site Register or JNCC Recorder, the status automatically defaults to ‘Unknown’. Certain common or local species may therefore occasionally appear in this category if there has been no necessity to use the species record.

Ireland Only

Species recorded from Ireland (Eire or Northern Ireland), but not recorded from Great Britain.

Appendix 2 IUCN invertebrate status categories

Extinct (EX)

A taxon is Extinct when there is no reasonable doubt that the last individual has died.

Extinct in the Wild (EW)

A taxon is Extinct in the Wild when it is known to survive only in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual) throughout its range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

Critically endangered (CR)

A taxon is Critically endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as detailed by any of the criteria A to E.

Endangered (EN)

A taxon is Endangered when it is not Critically endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria A to E.

Vulnerable (VU)

A taxon is Vulnerable when it is not Critically endangered or Endangered but is facing a high risk of extinction in the wild in the medium term future, as defined by any of the criteria A to D.

Lower Risk (LR)

A taxon is Lower Risk when it has been evaluated but does not satisfy the criteria for any of the categories Critically endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three sub-categories:

- Conservation Dependent (cd). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
- Near Threatened (nt). Taxa which do not qualify for Lower Risk (Conservation Dependent), but which are close to qualifying for Vulnerable.
- Least Concern (lc). Taxa which do not qualify for Lower Risk (Conservation Dependent) or Lower Risk (Near Threatened).

Data Deficient (DD)

A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that a threatened category is appropriate.

Not Evaluated (NE)

A taxon is Not Evaluated when it has not been assessed against the criteria.

Table A Summary of the thresholds for the IUCN Criteria

Criterion	Main thresholds		
	Critically Endangered	**Endangered**	**Vulnerable**
A. Rapid decline	>80% over 10 years or three generations in past or future	>50% over 10 years or three generations in past or future	>20% over 10 years or three generations in past or future
B. Small range – fragmented, declining or fluctuating	extent of occurrence <100 km2 or area of occupancy <10 km2 (<1 x 10 km2)	extent of occurrence <5000 km2 or area of occupancy <500 km2 (<5 x 10 km2)	extent of occurrence <20,000 km2 or area of occupancy <2000 km2 (<20 x 10 km2)
C. small population and declining	<250 mature individuals, population declining	<2500 mature individuals, population declining	<10,000 mature individuals, population declining
D1. Very small population	<50 mature individuals	<250 mature individuals	<1000 mature individuals
D2. Very small range			<100 km2 or <5 locations
E. Probability of extinction	>50% within 10 years	>20% within 20 years	>10% within 100 years

Appendix 3 Websites for information

URL://www.jncc.gov.uk Joint Nature Conservation Committee. A downloadable spreadsheet lists all designations for British species, including international and UK legal categories, rarity status, and Biodiversity Action Plan listing. Species reviews published since 1991 are listed but not earlier ones that are still invaluable. Explicit pages are also put aside for Common Standards Monitoring (URL://www.jncc.gov.uk/page-2217) where an overview of all the taxonomic groups and habitat types can be found.

URL://www.nbn.org.uk National Biodiversity Network. Web-links to many other natural history organisations and societies.

URL://www.searchnbn.net NBN Gateway. Uses data supplied by national recording schemes and other sources to provide downloadable 10 km distribution maps for individual species and species lists from defined areas that more or less coincide with SSSIs and other designated sites. Also maps boundaries of designated sites. Taxonomic coverage is not comprehensive, but is growing all the time. If desired, dodgy data sources can be filtered out from the results. Maps can be customised to show date categories.

URL://nbn.nhm.ac.uk/nhm NBN Species Dictionary. Searchable species checklists. All checklists are previously published, but on-line checklists are ignored, so this site does not necessarily provide current names. It can also be used to list species in different categories of protection and rarity but all lists are unhelpfully arranged in alphabetical order, often regardless of phylum, with no facility to select species quickly.

URL://www.nbn.org.uk/habitats NBN Habitat Dictionary. Lists habitats within sixteen classifications. Reviews the strengths and weaknesses of each classification and cross-links habitats between classifications.

URL://www.magic.gov.uk/website/magic A Defra website that provides downloadable maps showing boundaries of English sites with a bewildering variety of national designations including SSSIs, NNRs, SACs, countryside stewardship schemes etc, but not local designations such as wildlife sites. Select 'Rural designations – statutory' for most purposes related to biodiversity. In order to produce an intelligible map, it is essential to turn off designations of no interest, but this takes some time. It also returns names of designated sites. Useful for finding nationally designated sites within a certain area.

URL://www.english-nature.org.uk/special/sssi/search.cfm Natural England. Provides boundaries, citations and habitat condition assessments for English SSSIs. Useful for finding information on individually named SSSIs. Information can also be accessed through lists of SSSIs within each county.

URL://www.ordnancesurvey.co.uk/oswebsite/getamap Ordnance Survey. Provides free downloadable 2 km by 2 km map images at 1:25,000 scale. Also returns a six figure grid reference for cursor position. Particularly useful if the GPS has been lost or old field records are being interpreted.

URL://www.brc.ac.uk Biological Records Centre (ITE). List of published atlases (both available and out-of-date).

URL://thasos.users.btopenworld.com/ersqi.htm Species Quality Index for beetles of Exposed Riverine Sediment. Lists species with their current score.

URL://thasos.users.btopenworld.com/sqi.htm Species Quality Index and Index of Ecological Continuity for saproxylic beetles of wooded habitats in Britain. A table of scores for c.600 sites can be downloaded as a spreadsheet.

URL://www.coleopterist.org.uk The Coleopterist. Contains a frequently updated checklist of British beetles. The best place to find current names for Coleoptera. The checklist is easy to browse, but if you are searching for a particular species, you need to know its family.

URL://www.dipteristsforum.org.uk Dipterists' Forum. Contains a frequently updated checklist of British two-winged flies. The best place to find current names for Diptera. Browsing is a painful experience, crippled by an over-complicated hierarchical classification, but searching for a particular name is easy. It also gives a comprehensive list of identification works for each family.

URL://www.bwars.com Bees, Wasps and Ants Recording Scheme. Lists key identification works. An online checklist of British species is planned, but was not operational when this handbook went to press.

Other checklists published on the web can be found at the following sites:

URL://www.bmig.org.uk Myriapods and isopods.

URL://www.britishspiders.org.uk Spiders.

URL://www.ephemeroptera.pwp.blueyonder.co.uk/files/checklist.pdf Ephemeroptera.

URL://www.dragonflysoc.org.uk Odonata (also provides ecological information on selected species).

URL://www.benhs.org.uk/ British Entomological and Natural History Society. The events program includes a series of identification workshops.

URL://www.NFBR.org.uk National Federation for Biological Recording. Links to major local records centres. Lists biological recording packages.

URL://www.meto.gov.uk The Met Office. Weather forecasts.

URL://www.wildlifetrusts.org Links to all 47 county wildlife trusts for access contacts.

Appendix 4 ISIS Assemblage type descriptions

Broad assemblage types

Arboreal canopy (A11)

This assemblage type is characterised by a wide range of invertebrates, with butterflies and moths being the largest group in terms of numbers of species.

Habitat
The assemblage type is found in the canopy of trees and shrubs irrespective of their density and occupies space that overlaps with other arboreal assemblage types. It is found in situations that range from woodland and scrub through to isolated open-grown trees and shrubs. Open-grown trees and shrubs have full canopy development and therefore the greatest potential for full expression of the assemblage. Assemblages include phytophagous species that feed on leaves, flowers and fruits, and their predators and parasites. Many phytophagous species target new shoots for feeding, so, unlike saproxylic species, they are found as commonly, if not more commonly on young trees and shrubs as on mature trees. Some even specialise in young growth of trees and shrubs developing within an unshaded field layer matrix. The height in the canopy that particular species prefer for larval development is a poorly studied subject, and little more is known about the height preferences of the adults. There is some overlap with 'Wood decay' assemblages, particularly with regard to predatory species. Some species that live in the canopy as adults have larvae that develop on roots or in leaf litter, so there is also overlap with the 'Shaded field and ground layer' assemblage type.

Individual phytophagous species are often host-specific. Broad-leaved woodland and coniferous woodland have distinctive assemblages. There are also specialist predators including parasitoids and gall inquilines. Some of these are very rare and probably particularly sensitive to environmental change.

Table B Important land use factors

Factor	Effect on assemblages
Conversion of native broadleaved woodland to coniferous plantation	Reduction of species richness and changes in assemblage species composition
Introduction or cessation of coppicing	Not known at the assemblage level
Canopy closure	Decline in species-richness, especially at individual tree level, although edge situations may continue to maintain variety
Decreasing canopy density through thinning, etc	Increase in species-richness, provided appropriate species occur within dispersal range
Fragmentation of tree and shrub presence at landscape level	Decline in species-richness due to loss of population viability and other metapopulation factors

Wood decay (A21)

This is a species-rich assemblage type, characterised mainly by beetles, two-winged flies and wasps.

Habitat
This assemblage type is associated with trees and shrubs wherever they are growing – in woodland, wood-pasture, scrub and as isolated trees – and occupies space that overlaps with other arboreal

assemblage types. Wood-decay species are saproxylic, which means that they are associated with the decomposition of woody tissues and their agents, notably fungi. Many species develop in specific microhabitats, some of which are mostly or entirely restricted to mature trees. Many of the rarest species are dependent on the presence of ancient trees, whose age can be measured in centuries. For these species, the rarity and isolation of prime habitat in the modern landscape makes colonisation of new sites all but impossible. Consequently, internationally important examples of this assemblage type can be found in a handful of sites that have a history of continuity of ancient tree cover stretching back over a thousand years. The epiphyte fauna includes grazers of algae, lichens and mosses on the surface of trunks and branches, as well as their predators and parasites.

Many species benefit from insolation of their breeding habitat and prefer open-grown trees and shrubs to closed canopy woodland. Assemblages of national importance often occur in parkland, old orchards and other open landscapes with concentrations of old trees. Although dead trees may retain an interesting fauna for several years, living trees with plentiful wood decay provide much longer term continuity of habitat.

See also:

ALEXANDER, K.N.A. 1999. The invertebrates of Britain's wood pastures. *British Wildlife 11: 108-117*.

ALEXANDER, K.N.A. 2002. The invertebrates of living and decaying timber in Britain and Ireland - a provisional annotated checklist. *English Nature Research Reports, No. 467*.

Associated SATs
Heartwood decay (A211), Bark and sapwood decay (A212), Fungal fruiting bodies (A213), Epiphyte fauna (A215).

Table C Important land use factors

Factor	Effect on assemblages
Removal of old trees and deadwood	Net reduction of assemblage type.
Damage to trees (eg through over-grazing, ploughing, vehicle access beneath canopy)	
Lack of regeneration of trees and shrubs	Eventual loss of assemblage type
Cessation of grazing	Loss of species sensitive to canopy closure

Unshaded early successional mosaic (F11)

This assemblage type is characterised by a wide range of invertebrates, with beetles and aculeates being the largest groups in terms of the number of species.

Habitat
The assemblage type is dominant in lowland habitats where disturbance removes vegetation to create areas of bare or sparsely vegetated ground. Suitable sources of disturbance include landslips, wind and salt blast on sea cliffs, sand accretion on sand dunes and small-scale poaching by grazing animals. The juxtaposition of disturbed areas of bare ground with other structural types of vegetation is often important to insects with complex life cycles that require different microhabitats at different stages of development. This juxtaposition is associated with small-scale dynamic processes driven by cyclical disturbance patterns. Many species are efficient at dispersing and colonising newly formed habitats, but landscapes with some degree of continuity of habitat are more likely to hold assemblages of the highest conservation value. Habitat continuity is often associated with nutrient-deficient soils or exposure regimes that deflect ecological succession. Semi-natural biotopes supporting important examples of this assemblage type include sea cliffs, sand dunes, heathland and chalk downland. Arable land on nutrient-poor and freely-draining soils can also support interesting examples as can recently disused quarries and post-industrial and urban demolition sites. However, at these latter sites, the original source of disturbance is not

cyclical, so the assemblage cannot sustain itself without the imposition of a management regime that introduces a suitable disturbance pattern.

Many characteristic species develop in the soil and have thermophilic larvae that benefit from insolation of the breeding habitat. Bare ground on south-facing slopes is therefore a particularly valuable microhabitat for this assemblage type. Several species are seed eaters that profit from the high seed production of annual plants that share the same habitats.

See also:

KEY, R. 2000. Bare ground and the conservation of invertebrates. *British Wildlife. 11, 183-191*.

Associated SATs
Bare sand and chalk (F111), open short sward (F112) and exposed sea cliff (F113).

Table D Important land use factors

Factor	Effect on assemblages
Cessation of grazing and other sources of small-scale disturbance	Conversion to 'Grassland and scrub matrix' or 'Scrub-heath and moorland' assemblage type.
Fertilisation	
Coastal protection works	

Grassland and scrub matrix (F21)

This assemblage type is characterised by a wide range of invertebrates.

Habitat
The assemblage type is dominant in areas of dense herbage or partial shade where a humid microclimate is maintained at ground level. Dominance by woody plants is limited by exposure, grazing or cutting of vegetation, but they often form an important component of the habitat. Semi-natural systems supporting important examples of this assemblage type include hay meadows, scattered scrub and woodland edge. Sward height and density is often an important factor in species representation, as are the extent of flowering and seed-set. The juxtaposition of open grassland matrix with woody development is often important to insects with complex life cycles that require different microhabitats at different stages of development. The balance between woody growth and the factors which limit it is often a fine one and sites may undergo cycles of changing proportions of open grassland and woody growth as a result. This is especially the case where human intervention is required to maintain open conditions so that land use and its underlying economic factors have a pervading influence on this dynamic equilibrium.

Some species are efficient at dispersing and colonising newly formed habitats, but landscapes with some degree of continuity of habitat are more likely to hold assemblages of the highest conservation value.

This Broad Assemblage Type can form mixed assemblages with a wide range of other types, especially 'Unshaded early successional mosaic'.

See also:

KIRBY, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB/JNCC.

Associated SATs
Herb-rich dense sward (F211) and Scrub edge (F212).

Table E Important land use factors

Factor	Effect on assemblages
Cessation of grazing or cutting	Eventual conversion to arboreal assemblage types
Increase in grazing pressure	Gradual move towards 'Unshaded early successional mosaic'
Fertilisation	Decline in species richness
Scrub-clearance	Decline in specialist species which require broad habitat mosaics

Heath-scrub and moorland (F22)

This assemblage type is characterised by a wide range of invertebrates.

Habitat
The assemblage type is dominant on nutrient-poor, acid soils where herbaceous or dwarf shrub vegetation is dominant. Trees and taller shrubs can be an important component of the overall habitat in lowland areas. Semi-natural systems supporting important examples of this assemblage type include mature areas of lowland heath, moorland and montane biotopes. In dry lowland areas, the juxtaposition of dwarf shrub and scrub with disturbed areas of bare ground or woody development is often important to insects with complex life cycles that require different microhabitats at different stages of development. This juxtaposition is associated with small-scale dynamic processes driven by disturbance regimes of a wide variety of types. The balance between different vegetation types is often a fine one and sites may undergo cycles of changing proportions of bare ground, open grassland, dwarf shrubs, shrubs and trees as a result. This is especially the case where human intervention is required to maintain open conditions, and economic factors may control this dynamic equilibrium. When grazing and active management of lowland heaths is discontinued, this assemblage type becomes dominant at the expense of early successional assemblage types.

See also:

KIRBY, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB/JNCC. [only covers low altitude situations]

Associated SATs
Montane and upland (F221) and Mature heath and dry scrub mosaic (F222).

Table F Important land use factors

Factor	Effect on assemblages
Reduction or cessation of grazing	Eventual conversion to 'Arboreal' assemblage types at low altitudes in the south
Increased disturbance from intensive grazing / recreational activity	Localised conversion to 'Unshaded early successional mosaic' assemblage type
Nutrient enrichment through fertilisation / diffuse pollution	Conversion to 'Grassland and scrub matrix
Scrub-clearance	Decline in specialist species which require broad habitat mosaics

Shaded field and ground layer (F31)

This assemblage type is characterised by a wide range of groups, with two-winged flies being the largest group in terms of numbers of species.

Habitat
The assemblage type is dominant in closed canopy woodland and scrub, where it is separated vertically rather than horizontally from arboreal assemblage types. It is associated with low levels of disturbance. Plant cover at ground level is restricted by relatively low light levels and accumulations of leaf litter. Ground-living species tend to have hygrophilous larvae and some species can also occur in assemblages on damp open moorland mixed with the 'Scrub-heath and moorland' assemblage type. Many characteristic species occur in or under leaf litter and are either saprophagous or predaceous. Several of these are associated with fungal fruiting bodies, either fresh or decomposing, and in this area there is some overlap with species that are found on gill fungi fruiting from stumps and fallen branches, and that are associated with saproxylic assemblage types ('Wood decay'). A smaller number of species are phytophagous and develop on shade-loving plants. The presence or absence of grazing animals may not be of great significance as there is relatively little forage available, although trampling and poaching will alter the characteristics of both the soil surface and the soil structure below to some extent and this will have consequences on the invertebrate assemblage.

In Britain, assemblages seem to be able to survive clear-felling as long as the woodland canopy is allowed to regenerate and close over again naturally. Some species may be associated with ancient woodland and further work needs to be done in this area.

As well as the assemblage types mentioned above, this Broad Assemblage Type forms mixed assemblages with 'Grassland and scrub matrix' and 'Litter-rich fluctuating wetland' types.

Table G Important land use factors

Factor	Effect on assemblages
Conversion of broad-leaved woodland to conifer plantation	Net reduction of assemblages
Introduction of coppicing	Conversion to 'Grassland and scrub matrix' assemblage type
Introduction or removal of grazing regime	Loss or gain of species associated with bare ground or friable soil structure

Fast-flowing water (W11)

This assemblage type is characterised mainly by two winged flies, beetles and aquatic macro invertebrate groups, especially caddis-flies.

Habitat
This assemblage type is dominant along stretches of rivers and streams where the velocity of flow during spates disturbs sediment to reveal bedrock or boulders or to deposit fresh shingle. The timing of these events is essentially unpredictable, but they exhibit a strong seasonal pattern peaking in the winter. Assemblages are sensitive to changes in river flow patterns of frequency and severity of flood pulses. As well as rivers and streams, suitable habitat also occurs in association with coastal and lacustrine shingle, waterfalls and trickles on hard-rock cliffs, and artificially disturbed sites containing water such as quarries and gravel pits.

This Broad Assemblage Type is often interspersed with 'Slow-flowing water and seepage' assemblages and grades into 'Unshaded early successional' mosaic assemblages.

Associated SATs
Shingle bank (W111), stony river margin (W112), fast flowing streams and waterfalls (W113).

Table H Important land use factors

Factor	Effect on assemblages
Water abstraction Drainage associated with agriculture or development	Conversion to 'Mineral marsh and open water' or 'Unshaded early successional mosaic' assemblage types
Impoundment of water for reservoirs or hydro-electric schemes	Conversion to 'Mineral marsh and open water' assemblage type
Eutrophication due to diffuse pollution	Loss of sensitive species
Changes in physico-chemical qualities (eg oxygenation, nutrients and poisonous chemicals) due to pollution	Loss of sensitive species

Slow-flowing water and seepage (W12)

This assemblage type is characterised mainly by two winged flies and beetles.

Habitat
This assemblage type is dominant along stretches of rivers, streams and spring-fed seepages where water action removes or retards vegetation, disturbs sediment and deposits fresh sand and silt. Assemblages are sensitive to changes in flow patterns that change the frequency and severity of flood pulses. Assemblages in small-scale seepages may be especially sensitive to hydrological and habitat change. Suitable habitat also occurs in association with large lakes, whose marginal areas are disturbed by wave action, seepages on soft-rock cliffs, which are disturbed by landslip, and artificially disturbed sites such as sand pits and gravel pits in early stages of ecological succession.

This Broad Assemblage Type is intermediate between 'Mineral marsh and open water' and 'Fast-flowing water' assemblages. It often forms mixed assemblages with either of those two types and elements of 'Unshaded early successional mosaic'. In young dune slacks, there can be some overlap with 'Sandy shore' assemblages.

Associated SATs
Sandy river margin (W121), riparian sand (W122), soft rock seepage (W124), slow-flowing river (W125), seepage (W126).

Table I Important land use factors

Factor	Effect on assemblages
Water abstraction Drainage associated with agriculture or development	Conversion to 'Mineral marsh and open water' or 'Unshaded early successional mosaic' assemblage types
Increase in severity of flood pulses due to stream channel straightening	Conversion to poor quality 'Fast-flowing water' assemblage type
Impoundment of water for fishing, navigation or reservoirs	Conversion to 'Mineral marsh and open water' and eventually 'Permanent wet mire' assemblage types
Eutrophication due to diffuse pollution	Loss of sensitive species
Changes in physico-chemical qualities (eg oxygenation, nutrients and poisonous chemicals) due to pollution	Loss of sensitive species

Mineral marsh and open water (W21)

This assemblage type is characterised by a wide range of groups, with beetles being the largest group in terms of numbers of species.

Habitat
The assemblage type is associated with still open water bodies. In marginal areas, it occurs on mineral substrates that are subject to repeated disturbance, for example by flooding or wave action. Typical habitat is sparsely vegetated, though often subject to rapid colonisation by vegetation between disturbance events. In naturally disturbed habitats, it is rarely dominant away from coastal areas, large rivers and lakes. However, several characteristic species are good dispersers and will readily colonise artificially disturbed habitat such as clay pits, amenity lakes and heavily grazed marsh. Suitable habitat is found in lakes and reservoirs, canals, silt ponds and the banks of slow-flowing rivers.

This Broad Assemblage Type is intermediate between 'Litter-rich fluctuating wetland' assemblages and 'Slow-flowing water and seepage' assemblages. It often forms mixed assemblages with either of those two types and elements of 'Saltmarsh, estuary and mudflats' type.

Associated SATs
Open water on disturbed sediments (W211), northern lakes and lochs (W212).

Table J Important land use factors

Factor	Effect on assemblages
Hydrological disconnection due to flood control	Conversion to 'Litter-rich fluctuating wetland' or 'Grassland and scrub matrix' assemblage types
Eutrophication due to diffuse pollution	Loss of sensitive species
Changes in physico-chemical qualities (eg oxygenation, nutrients and poisonous chemicals) due to pollution	Loss of sensitive species

Litter-rich fluctuating wetland (W22)

This habitat is mainly characterised by terrestrial beetles.

Habitat
The assemblage type is dominant in wetlands where disturbance is more or less limited to fluctuations in water levels. Sites are flooded for varying periods either by surface run-off or by rising groundwater, but between floods, they lose surface water to reveal a substrate that is humid rather than saturated. Flooding events are essentially unpredictable, but exhibit a strong seasonal pattern. Typically, they occur several times each winter, but rarely (less than once a year) in the summer. Removal of vegetation and disturbance of the substrate is limited and mostly restricted to accretion of litter and silt during flooding episodes, but vegetational succession may be retarded by prolonged inundations. Assemblages intermediate with 'Permanent mire' assemblages can occur on peat, but purer assemblages are usually found on mineral soils incorporating large amounts of coarse litter. Species with terrestrial larvae probably exploit litter and soil exposed by falling water levels for breeding. Assemblages are sensitive to changes in hydrology and levels of disturbance, and especially to disturbance arising from factors other than flooding, eg grazing and mechanical excavation. Suitable habitat is found in floodplains, fluctuating meres, dune slacks, reservoir margins, carr, wet woodland and the edges of fens.

This is a closely defined assemblage type intermediate between 'Permanent mire' assemblages and 'Mineral marsh and open water' assemblages. It often forms mixed assemblages with either of those two types and elements of 'Grassland and scrub matrix', or 'Shaded field and ground layer' types.

Associated SATs
Undisturbed fluctuating marsh (W221)

Table K Important land use factors

Factor	Effect on assemblages
Water abstraction Drainage associated with agriculture or development Hydrological disconnection due to flood control	Conversion to ‘Grassland and scrub matrix’ and ‘Shaded field and ground layer’ assemblage types
Increase in flood pulses Disturbance due to recreation or agriculture	Conversion to ‘Mineral marsh and open water’ assemblage type
Impoundment of water for fishing, navigation or reservoirs	Conversion to ‘Permanent wet mire’ assemblage type at margins
Eutrophication due to diffuse pollution	Not known
Changes in physico-chemical qualities (eg oxygenation, nutrients and poisonous chemicals) due to pollution	Not known

Permanent wet mire (W31)

This assemblage type is characterised mainly by two-winged flies and beetles.

Habitat
This assemblage type is dominant in wetlands where disturbance is limited, although levels of environmental stress may be high as in some upland examples. In large open-water bodies, it is confined to well-vegetated margins, but it is particularly characteristic of mires which may have little open water, but which remain permanently wet. Water level fluctuations are not usually significant or at least, when they do occur, the substrate rarely dries out completely. Consequently this assemblage type is dominant on wet peat. Disturbance regimes leading to small-scale, periodic removal of vegetation can play an important role in the creation of suitable habitat or in the prevention of ecological succession. Such disturbance patterns may be associated with traditional peat cutting, fire, mowing or non-intensive grazing. Species with aquatic or semi-aquatic larvae predominate, but there are also many terrestrial species associated with emergent vegetation.

Assemblages are sensitive to large-scale disturbance and changes in hydrology, especially those caused by water abstraction. Suitable habitat is found in mires, lakeside and floodplain fen and well-vegetated spring-fed flushes. This assemblage type grades into ‘Litter-rich fluctuating wetland’, ‘Scrub-heath and moorland’ and ‘Grassland and scrub matrix’ types.

Associated SATs
Open water in acid mire (W311), acid mire (W312), mesotrophic fen (W313), rich fen (W314).

Table L Important land use factors

Factor	Effect on assemblages
Water abstraction Drainage associated with agriculture or development Hydrological disconnection due to flood control	Conversion to ‘Litter-rich fluctuating wetland’, ‘Scrub-heath and moorland’ and ‘Grassland and scrub matrix’ assemblage types

Table continued…

Factor	Effect on assemblages
Large scale disturbance due to recreation, agriculture or peat extraction	Conversion to 'Mineral marsh and open water' assemblage type
Forestry plantation	Conversion to 'Scrub-heath and moorland'
Eutrophication due to diffuse pollution	Loss of sensitive species
Changes in physico-chemical qualities (eg oxygenation, nutrients and poisonous chemicals) due to pollution	Loss of sensitive species

Rocky shore (W51)

This assemblage type is characterised by marine and terrestrial invertebrates from several different groups. It has relatively few characteristic species, but because of the specialised nature of the habitat, most of the species from terrestrial groups are highly specific to this assemblage type. In the main, they are widely distributed. The small number of characteristic species leads to problems in deriving robust measures of assemblage quality. In fact, the habitat of this assemblage is widespread in Britain with a relatively high proportion of suitable habitat being occupied. The habitat is not normally considered to be under threat, except perhaps from oil-spills. However, the assemblage does represent a conservation priority in that some of its characteristic species have European distributions which are restricted to the Atlantic sea-board and Britain may hold a high proportion of their global populations.

Habitat
The assemblage type is restricted to the intertidal and supralittoral areas of coastline subject to severe weathering by the sea. Several species exploit narrow intertidal crevices in hard rock. Each species occupies different but overlapping tidal zones. Ochthebius lejolisii is an aquatic beetle that lives in rock pools in the splash zone above the tidal limit. Larvae of the two-winged fly, Aphrosylus, feed within barnacles. This is a very distinctive Broad Assemblage Type that normally occurs on its own, although on a large scale it may be interspersed with 'Sandy shore' assemblages along the coastline.

Important land use factors
None identified

Sandy shore (W52)

This assemblage is characterised mainly by terrestrial beetles.

Habitat
The assemblage type is found along the drift line and immediate upper intertidal and supralittoral zones of seashore dominated by sand and, to a lesser extent, shingle. The habitat is saline and subject to tidal disturbance, augmented by storm surges at irregular intervals. Wrack beds deposited on the drift line often support rich assemblages, although they are often dominated by widespread species. It is unclear which factors favour the development of assemblages of importance for conservation. This is a distinctive Broad Assemblage Type that can grade into 'Unshaded early successional mosaic' assemblages in the supralittoral zone.

Associated SATs
Sandy beach (W521).

Table M Important land use factors

Factor	Effect on assemblages
Sea wall construction	Complete loss or reduction of assemblage
Sea level rise	Net reduction of assemblages and changes in SAT distribution

Saltmarsh, estuary and mud flat (W53)

This assemblage type is characterised mainly by beetles and two-winged flies.

Habitat
The assemblage type is restricted to less exposed shorelines, characterised by net deposition of fine sediment. However, habitats are still defined by levels of salinity and tidal disturbance. Suitable habitats occur in saltmarsh, tidal creeks, estuarine shores and brackish water marshes that grade into freshwater marsh. Several intertidal species exhibit behavioural and physiological adaptations to tidal rhythms or high levels of salinity. Other species occur in habitats inundated only by spring tides or even brackish water habitats where tidal influence is much reduced.

This Broad Assemblage Type that can form mixed assemblages with elements of 'Unshaded early successional mosaic', 'Mineral marsh and open water' and 'Permanent wet mire assemblages'.

Associated SATs
Saltmarsh and transitional brackish marsh (W531).

Table N Important land use factors

Factor	Effect on assemblages
Sea wall construction	Complete loss or reduction of assemblage
Sea level rise	Net reduction of assemblages and changes in SAT distribution
Managed retreat	Net gain of assemblages and changes in SAT distribution
Eutrophication due to diffuse pollution	Not known

Specific assemblage types

Heartwood decay (A211)

8.1 This assemblage type is mainly characterised by beetles and two-winged flies.

Habitat
The assemblage type is found in and around mature and ancient trees and shrubs. Many of the two-winged flies are associated with smaller pockets of wet heartwood decay within, for example, cavities resulting from ripped out branches, and a proportion have aquatic or semi-aquatic larvae within waterlogged decayed woody tissues (rot-hole species). In contrast, the rarer and more threatened beetles tend to develop in the main column of decaying heartwood within the trunk, where drainage is free but the atmosphere humid. Some species developing in debris within tree cavities are also encountered amongst debris accumulations under loose bark. Heartwood species are dependent on the state of decay rather than the tree species and so exotic tree species can be as important as native ones. Sites with the fullest expression of the assemblage are however historic sites with concentrations of mature and ancient trees, and so ancient wood pasture situations are the most important. This assemblage is Britain's key 'old growth' assemblage.

Open-grown conditions are important for a variety of reasons. Space is needed to enable sunlight to reach the trunk and main boughs, to help raise the temperatures for larval development within and adult flight activity. Trees past full canopy development are vulnerable to canopy competition from younger growth and cannot survive under close-grown conditions. The juxtaposition of mature and aging trees with open areas containing flowering shrubs is a key factor since the adult stages of many of the insect species have a requirement for pollen and nectar. Large herbivores are essential to maintain suitable open conditions.

Potentially important environmental impacts:

- Overgrazing leading to reduced regeneration and removal of nectar-providing plants, etc.
- Loss of grazing leading to the smothering of older trees by secondary growth.
- Removal of old trees for health and safety reasons or 'tidiness'.
- Intensification of land-use leading to root damage etc.
- Cutting up of dead limbs and fallen trunks leading to changes in microclimate of heartwood decay environment.

See also:

ALEXANDER, K.N.A. 1999. The invertebrates of Britain's wood pastures. *British Wildlife, 11, 108-117*.

ALEXANDER, K.N.A. 2002. The invertebrates of living and decaying timber in Britain and Ireland – a provisional annotated checklist. *English Nature Research Reports, No. 467*.

ALEXANDER, K.N.A. 2004. Revision of the Index of Ecological Continuity as used for saproxylic beetles. *English Nature Research Reports, 574*.

READ, H. 2000. Veteran trees: A guide to good management. Peterborough: English Nature.

Bark and sapwood decay (A212)

This assemblage type is mainly characterised by beetles.

Habitat
The assemblage type is found in and around trees and shrubs generally, but especially in older specimens. The assemblage is primarily associated with death and decay of the outer woody tissues of the trees or shrubs – the sapwood and bark. Some species are associated with fluxes of sap (sap-runs). The composition of the assemblage varies with tree species far more than the heartwood assemblage does, since the tissue structure and chemical composition is more species-related. The assemblage is also less affected by the density of tree cover than the heartwood assemblage, although there is a suite of species that is restricted to the larger lower canopy boughs of open-grown trees. Other species are said to develop in dead boughs high in the canopy.

This assemblage is particularly found in dead limbs that are either still attached to living trees or recently fallen. In smaller branches, this assemblage starts to be replaced by a more generalist late-successional assemblage within a year of hitting the ground, although it may persist for several years in larger limbs and stumps. As with the heartwood assemblage, sites with the fullest expression of the assemblage are historic sites with concentrations of mature and older trees, and so ancient wood pasture – and ancient woodland situations generally – are the most important.

The juxtaposition of mature and aging trees with open areas containing flowering shrubs is a key factor since the adult stages of many of the included insects have a requirement for pollen and nectar.

Potentially important environmental impacts:

- Lopping of dead limbs;
- removal of fallen wood;
- cutting up and stacking of wood (damaging to species which require larger amounts of habitat); and
- removal of trees with sap fluxes for 'forest hygiene' reasons.

See also:

ALEXANDER, K.N.A. 1999. The invertebrates of Britain's wood pastures. *British Wildlife, 11, 108-117*.

ALEXANDER, K.N.A. 2002. The invertebrates of living and decaying timber in Britain and Ireland - a provisional annotated checklist. *English Nature Research Reports, No. 467*.

ALEXANDER, K.N.A. 2004. Revision of the Index of Ecological Continuity as used for saproxylic beetles. *English Nature Research Reports, No. 574*.

READ, H. 2000. Veteran trees: A guide to good management. Peterborough: English Nature.

Fungal fruiting bodies (A213)

This assemblage type is mainly characterised by beetles.

Habitat
The assemblage type is found in and around trees and shrubs generally, but especially in older specimens. A large variety of wood-decay fungi are active in all types of woody tissues from heartwood through to twigs and roots. All produce fruiting bodies on the outside of the decaying wood and above ground, which are exploited by this assemblage type. Many species feed primarily on the fungal spores while others burrow into the fruit body itself. Some species specialise in the fruit bodies of particular fungal taxa, but the majority are generalists. The soft gill fungi in particular support a wide variety of invertebrates, while the tougher and woodier fruit bodies host a more specialist fauna.

Living trees and shrubs are important for this assemblage type, as they have the potential to continually produce fresh dead wood for fungi to break down, whereas dead trees provide more finite fungal habitat. Wood-decay fungi and their invertebrates are generally not host-specific, so exotic tree species can be as important as native ones. Sites with the fullest expression of the assemblage are however historic sites with concentrations of mature and older trees and so ancient wood pasture – and ancient woodland situations generally – are the most important. Many species of fungi fruit most prolifically in open sunny conditions, although others fruit in shade. Canopy density can therefore be an important factor.

Potentially important environmental impacts:

- Removal of old trees and deadwood for health and safety, 'tidiness' and 'forest hygiene'.
- Loss of grazing leading to the smothering of older trees by secondary growth.

See also:

ALEXANDER, K.N.A. 1999. The invertebrates of Britain's wood pastures. *British Wildlife, 11, 108-117*.

ALEXANDER, K.N.A. 2002. The invertebrates of living and decaying timber in Britain and Ireland - a provisional annotated checklist. *English Nature Research Reports, No. 467*.

ALEXANDER, K.N.A. 2004. Revision of the Index of Ecological Continuity as used for saproxylic beetles. *English Nature Research Reports, No. 574*.

READ, H. 2000. Veteran trees: A guide to good management. Peterborough: English Nature.

Epiphyte fauna (A215)

This assemblage type is characterised mainly by bugs and moths.

Habitat
This assemblage type is found on the surface of trunks and branches of trees and shrubs. It includes grazers of epiphytes such as algae, lichens and mosses, as well as their predators and parasites. Some species are also found on epiphytes growing on rocks and boulders.

Potentially important environmental impacts:

- The effects of nutrient enrichment by aerial pollution and of the cessation or introduction of coppicing are unknown.

Bare sand and chalk (F111)

This assemblage type is characterised by a wide range of invertebrates.

Habitat
The assemblage type is most frequently found in lowland areas on freely draining soils where repeated disturbance removes vegetation to create areas of bare and sparsely vegetated ground. Good examples of the assemblage type can be found in sand dunes, grazed heathland, chalk pits and sand pits. The juxtaposition of disturbed areas of bare ground with other structural types of vegetation is often important to insects with complex life cycles that require different microhabitats at different stages of development. This juxtaposition is associated with small-scale dynamic processes traditionally driven by poaching from grazing animals, but also by small-scale extraction of sand or chalk and along trackways by recreational activities such as walking and horse riding. Away from sand dunes where wind erosion is an important source of disturbance, habitat quality is therefore largely related to land use and the economic factors which underlie them.

Suitable habitat can also be found in recently disused quarries (especially limestone), post-industrial sites and urban demolition sites, but here the original source of disturbance is not cyclical, so the assemblage cannot sustain itself without the imposition of a management regime that introduces a suitable disturbance pattern.

Many characteristic species develop in freely draining soil and have thermophilic larvae that benefit from insolation of the breeding habitat. Bare ground on south-facing slopes is therefore a particularly valuable microhabitat for this assemblage type. A proportion of species are efficient at dispersing and colonising newly formed habitats, but landscapes with some degree of continuity of habitat are more likely to hold assemblages of the highest conservation value. Habitat continuity is associated with nutrient-deficient soils or exposure regimes that deflect ecological succession. Many species are seed eaters that profit from the high seed production of annual plants that share the same habitats, while others depend on an abundance of flowers to provide pollen or nectar.

Potentially important environmental impacts:

- Cessation of grazing and small-scale sand and chalk extraction.
- Control measures against erosion, eg dune stabilisation, restricted human access.
- Coastal protection works.
- Large scale coastal erosion due to climate change.

See also:

KEY, R. 2000. Bare ground and the conservation of invertebrates. *British Wildlife, 11, 183-191*.

Open short sward (F112)

This assemblage type is characterised by a wide range of invertebrates, but especially beetles.

Habitat
The assemblage type is found most frequently in lowland habitats where grazing or cutting of vegetation over calcareous soils limits the development of taller vegetation. Soils are also generally nutrient poor, which limits the dominance of grasses and thereby encourages widespread development of broad-leaved herbs. Exposure may also be a key factor in limiting taller growth on coastal sites. Taller vegetation and even woody plants are nonetheless often an important component of the overall habitat. The balance between taller and coarser vegetation and the factors which limit it is often a fine one and sites may undergo cycles of changing proportions of open short sward grassland and taller growth as a result. This is especially the case where human intervention is required to maintain open short sward conditions. Consequently, land use and its underlying economic factors have a pervading influence on

this dynamic equilibrium. Chalk downland and limestone grasslands are the predominant semi-natural systems supporting this assemblage type, although elements may also occur on short acid turf, sea cliffs and sand dune systems where shelly wind-blown sand produces similar conditions.

Several characteristic species develop in the soil and have thermophilic larvae that benefit from insolation of the breeding habitat. South-facing slopes may therefore be a particularly valuable microhabitat for this assemblage type, but in these cases a short sward is adequate and the presence of bare ground not important. Several characteristic species are phytophagous and floristic diversity is often a feature of habitats supporting good examples of this habitat. A proportion of species are efficient at dispersing and colonising newly formed habitats, but landscapes with some degree of continuity of habitat are more likely to hold assemblages of the highest conservation value.

Potentially important environmental impacts:

- Reduction in grazing levels;
- nutrient enrichment eg by fertilisation; and
- scrub clearance.

See also:

ALEXANDER, K.N.A. 2003. A review of the invertebrates associated with lowland calcareous grassland. *English Nature Research Reports No. 512*.

KIRBY, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB/JNCC.

Exposed sea cliff (F113)

This distinctive assemblage type is characterised by a wide range of invertebrates but especially beetles and moths.

Habitat
The assemblage type is a feature of coastal situations where wind and salt blast on rocky coastal cliffs combine with shallow freely-draining and drought prone soils to restrict establishment of plants along the more exposed cliff edges, ledges and crevices. Similar habitat may occur around rocky exposures somewhat father inland, and cliff grazing schemes may also expand the habitat type farther inland.

Many of the characteristic species are phytophagous and host-specific to the specialist plants of this extreme environment.

Potentially important environmental impacts:

- Cessation of grazing.

See also:

KEY, R. 2000. Bare ground and the conservation of invertebrates. *British Wildlife. 11, 183-191*.

Herb-rich dense sward (F211)

This assemblage type is characterised by a wide range of invertebrates, but especially beetles and bugs.

Habitat
The assemblage type is found mainly in lowland areas where grazing or cutting of vegetation limits the development of woody plants, but allows the development of a dense sward supporting a humid microclimate at ground level. Exposure may also be a key factor in limiting woody plants on coastal sites. Soils are generally nutrient poor, which limits the dominance of grasses and thereby encourages widespread development of broad-leaved herbs. Biotopes supporting important examples of this assemblage type include traditionally managed hay meadows, pastures on limestone, Fuller’s earth and alluvial soils, sea cliffs, river banks and fixed sand dunes. Many characteristic species are phytophagous and floristic diversity is often a feature of habitats supporting good examples of this assemblage type.

The extent of available habitat and the extent of flowering and seed-set are important factors determining species representation.

A proportion of species are efficient at dispersing and colonising newly formed habitats, but in many landscapes, habitats have become fragmented and isolated. Sites with continuity of habitat are more likely to hold assemblages of the highest conservation value.

Potentially important environmental impacts:

- Changes in grazing levels;
- nutrient enrichment eg by fertilisation; and
- land drainage.

See also:

ALEXANDER, K.N.A. 2003. A review of the invertebrates associated with lowland calcareous grassland. *English Nature Research Reports, No. 512*.

KIRBY, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB/JNCC.

Scrub edge (F212)

This assemblage type is characterised by a wide range of invertebrates but especially beetles and two-winged flies.

Habitat
The assemblage type is dominant in situations where unshaded field layer matrices are able to grow tall and vigorously under conditions of relative shelter and humidity, with a relatively mild microclimate, and with limited development of coarse grasses and/or woody plants. The most widespread situations are open areas in and around ungrazed and dense stands of trees and shrubs, eg hedgerows, rides, glades and margins of woods and scrub, which are usually maintained by annual or subannual cutting regimes, or coppices and clear-fells where the cutting cycle is much longer. In all cases, human intervention is required to maintain open conditions, which are therefore vulnerable to changes in economic forces. Soils are generally nutrient poor, which helps to limit the dominance of grasses and other coarse vegetation such as nettles.

Potentially important environmental impacts:

- Cessation of ride maintenance;
- cessation of coppice management; and
- scrub clearance.

See also:

KIRBY, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB/JNCC.

Montane and upland (F221)

This assemblage type is characterised by a wide range of invertebrates, but especially beetles, spiders and two-winged flies.

Habitat
The assemblage type is most frequently found above the natural tree line, ie wherever exposure limits the growth of trees and tall shrubs and allows the development of dwarf shrubs and other forms of stress-tolerant vegetation. Suitable conditions can occur at sea level in the north. Transitional assemblages can also occur on nutrient-poor soils in less exposed areas kept open by livestock grazing and/or burning. However, the most distinctive assemblages are associated with the highest altitudes and large expanses of high level land, especially mountain summits with low outcrops and loose frost-shattered rocks, Rhacomitrium moss mats, etc.

Land management can have dramatic impacts on the assemblage composition, through livestock grazing practices and cutting and/or burning practices, resulting in changes in distribution of grass species and dwarf shrubs, and hence of associated invertebrates.

The assemblage type occurs in habitats with a cool, damp microhabitat at ground level, even on exposed mountain tops, where rock crevices and scree slopes can provide suitable conditions. There is some overlap of species composition with woodland assemblages that occupy habitats with a similar microclimate.

Potentially important environmental impacts:

- Climate change;
- land drainage;
- changes in grazing levels; and
- nutrient enrichment eg by fertilisation.

Mature heath and dry scrub mosaic (F222)

This assemblage type is characterised by a wide range of invertebrates, but especially spiders.

Habitat
The assemblage type is dominant over freely-draining acid soils, which limit the dominance of grasses and encourage the development of dwarf shrubs. Shrubs and young trees are often an important component of the overall habitat. Ground cover is extensive limiting insolation of the ground and litter layer, but the microclimate is nevertheless dry. The assemblage type often occurs together with assemblages associated with bare ground on freely draining soils, when human activity creates patches of bare or sparsely vegetated ground.

Potentially important environmental impacts:

- Changes in grazing levels; and
- scrub clearance.

See also:

KIRBY, P. 1992. Habitat management for invertebrates: a practical handbook. RSPB/JNCC.

Shingle bank (W111)

This assemblage type is mainly characterised by ground-living beetles.

Habitat
The assemblage type is found on exposed coarse-grained riverine sediments ranging from gravel to cobbles and small boulders. In their natural habitat, assemblages depend on the resorting of sediment during periods of high flow, whose frequency and severity usually peak in the winter away from montane areas. Sparsely vegetated, freshly deposited sediment is exploited for breeding as water levels fall in the spring. Some species can also occur on exposed coastal or lacustrine shingle or in artificially disturbed sites such as gravel pits, but only in the early stages of vegetational succession.

Assemblages on large sedimentary bars in the piedmont zone tend to have a higher species richness than smaller bars on streams in the upper catchment. Some species such as Lionychus quadrillum and Coccinella quinquepunctata are often found higher up on the bank and tend to persist into later stages of ecological succession than those species restricted to freshly worked sediment.

Adults of larger species are active above ground, but spend resting periods within the sediment. Several species have flattened body forms to facilitate access underneath the surface. Smaller species can move through interstitial spaces in gravel. Larvae are presumed to be terrestrial and probably benefit from insolation of their habitat to aid development. The larva of the diving beetle, Bidessus minutissimus, is aquatic. It is possible that its preference for remnant pools high up on shingle banks reflects a preference for warm water to facilitate development.

Potentially important environmental impacts:

- Reduction in frequency and severity of spates responsible for production of fresh habitat and removal of pioneer vegetation.
- Heavy trampling of breeding habitat by grazing stock.
- Siltation caused by changes in sediment load of river.

The effects of nutrient enrichment are not known.

See also:

EYRE, M.D. 2000. Preliminary assessment of the invertebrate fauna of exposed riverine sediments in Scotland. *SNH report no. F97AC306*.

EYRE, M.D. & LOTT, D.A. 1997. Invertebrates of exposed riverine sediments. *EA R&D Technical Report W11*.

SADLER, J. & BELL, D. 2002. Invertebrates of exposed riverine sediments – phase 3. *EA R&D Technical Report W1-034/TR.*

SADLER, J.P. & PETTS, G.E. 2000. Invertebrates of exposed riverine sediments – phase 2. *EA R&D Technical Report W196.*

Stony river margin (W112)

This assemblage type is characterised by flies in a number of families, and to a lesser extent by water beetles. While assemblages of this type can coexist with beetle-dominated 'Shingle bank' assemblages, examples of high quality can also occur on quite separate stretches of river where there is little interest in the terrestrial beetle fauna.

Habitat
The assemblage occurs widely in western and northern Britain along the margins of streams and rivers where pebble or cobble sediments are dominant on shorelines exposed in lower flows of the summer months. There may be sand mixed with the large particles, and where this is locally extensive then the 'Sandy margin' assemblage will be found as well. As the assemblage is found on the shores, the sediments are usually a mixture of sizes with few obvious interstices, and consequently they remain wet or damp below the surface layer of stones. The shoreline may be shaded, often by alders, or unshaded, and it is possible that this assemblage could be split into shaded and unshaded varieties. Adults of many of the empids are found on stones, which may be moss-covered, protruding from the river as well as at the water margin of the shore. The sediments are usually sparsely vegetated owing to annual flooding, but the adults of many species shelter in taller herbs and tree foliage and on the bank.

The species may be grouped into those whose larvae are true aquatics, amphibious species with spiracles that must remain in contact with air, and 'soil-dwelling' species in saturated sediments. Thus although the adults occur together, the larvae are likely to respond differently to changes in flow regime or shoreline management. The larvae of the empids Chelifera, Heleodromia, Hemerodromia and Wiedemannia, and the rhagionid Chrysopilus erythrophthalmus are completely aquatic, living on the river bed or perhaps in wet moss, and their adults remain at or close to the river margin. Amphibious species clearly associated with wet or damp stony margins include Lonchoptera nigrociliata, Oxycera terminata and Dixa maculata. The larval habitats of most of the remaining flies are poorly understood but are likely to be saturated soils or wet surfaces at the water margin. At least one species, Melanostolus melancholichus, also occurs in 'Soft-rock seepage' assemblages.

Potentially important environmental impacts:

- Reduced annual fluctuations in water level, leading to little stony shoreline being exposed in summer.

- Increased nutrient loading which may directly affect larvae living in contact with the water.
- Siltation caused by changes in sediment load of the river.

Fast-flowing streams and waterfalls (W113)

This assemblage type is characterised by both aquatic and terrestrial insects.

Habitat
The assemblage type is found within and on the margins of fast-flowing streams, especially in moss on bedrock and boulders often in the splash zone of waterfalls and torrents. Typically, this assemblage type occupies ravines rather than river stretches with milder gradients undergoing net deposition. Suitable habitat can also be found in trickles on hard rock coastal cliffs. Most species that are characteristic of this assemblage type seem to be restricted to natural habitats, but some more widespread species can be found on weirs.

Potentially important environmental impacts:

- Reduction of flow.

Sandy river margin (W121)

This assemblage type is characterised almost exclusively by crane flies. It is closely allied to 'Riparian sand' (W122) but the habitat requirements of the beetles that dominate that assemblage type appear to differ from those of the two-winged flies in this assemblage type.

Habitat
The assemblage is found along rivers and streams passing though floodplains with sand as a major component, and appears to be restricted to the west and north of Britain. Such floodplains may also receive additional sand from riverine deposits although where the underlying soils are not sandy these are insufficiently well developed to support the assemblage. There may be coarser particles (pebbles, cobbles) in the same river corridor, so this assemblage merges or overlaps with the 'Stony river margin' (W422) assemblage. The soils are often shaded by willows or tall herbs, and this humid shade appears to be an essential part of the habitat for Tipula and Nephrotoma species, although perhaps less so for many of the smaller crane flies. The soils are damp or saturated and may be vegetated or bare. It is unclear whether closely vegetated areas are unsuitable as larval habitat, but tall sparse herbs, such as Himalayan balsam or nettles, do not appear to be disadvantageous.

The larvae of most of the crane flies are either semi-aquatic or live within the saturated to damp soil. The larvae of the shore flies Hecamedoides unispinosus and Polytrichophora duplosetosa are likely to be semi-aquatic at the water margin. Most of the characteristic species appear to be restricted to this assemblage and several can occur together, but Arctoconopa melampodia also occurs in 'Soft-rock seepage' assemblages, and the aquatic larvae of the horsefly Tabanus cordiger may occur in more stony rivers too.

Potentially important environmental impacts:

- Reduction in spates required to maintain moderately vegetation-free habitat.
- Removal of fine-grained sediment caused by for example an increase in water velocity.
- Removal of riverside copses.

Riparian sand (W122)

This assemblage type is almost exclusively characterised by ground-living beetles.

Habitat
The assemblage type is found on soft, bare or sparsely vegetated exposed riverine sediments ranging from fine sand mixed with silt to coarse sand mixed with cobbles. Elements of this assemblage type also occur on eroded sections of bank, especially in areas of slumped sand and clay. In their natural habitat,

assemblages depend on erosion and deposition of sediment by annual periods of high flow. Elements of this assemblage type also occur on the sandy edges of large lakes which are disturbed by wave action and in artificially disturbed sites such as sand pits and gravel pits, but only in their early stages of vegetational succession. Some species such as Omophron limbatum have recently increased their distributional ranges and appear to have benefited from an increase in gravel extraction coupled with warmer summer temperatures, which have aided their dispersal to newly created artificial habitats.

The distribution of several species including Bracteon litorale and Tachyusa constricta is concentrated in the north and west, where they can occupy the less disturbed areas of sedimentary structures otherwise used by riverine shingle species. Neobisnius villosulus is more prevalent by slow-flowing rivers in the east of the country. Quedius plancus is characteristic of open woodland streams, where coarse woody debris are incorporated into the sediment, while Bembidion lunatum is characteristic of larger rivers often close to the sea. Bembidion fluviatile occupies slumping clay banks frequently in association with the more widespread Asaphidion flavipes.

Adults exhibit a variety of morphological adaptations related to living on or in bare substrates. Several species of Stenus and Ischnopoda have long legs for running quickly over the surface in pursuit of prey. Species of Dyschirius, Bledius and Augyles have short but powerful legs for moving through burrows constructed in the ground. Omophron limbatum is shaped like a water beetle for 'swimming' through loose sand. Larvae are presumed to be terrestrial and to require insolation of their habitat to aid development.

Potentially important environmental impacts:

- Reduction of spates required to produce fresh habitat.
- Removal of fine-grained sediment caused by eg an increase in water velocity.
- Heavy trampling of malleable sediments eg by grazing stock. (Because of the localisation of habitat to a narrow marginal zone, even low stocking levels can cause serious damage to habitat.)

Soft rock seepage (W124)

This assemblage type is mainly characterised by ground-living beetles and two-winged flies.

Habitat
The assemblage type is found on damp, sparsely vegetated clay or sand exposed by landslip associated with springs or seepages of water. It is predominantly coastal or at least estuarine and associated with slumping cliffs or tall vertical banks. It occurs not only on soft rocks, but also on slumped areas of what might otherwise be regarded as hard rock (eg old red sandstone). On the continent, some of the characteristic species are more widespread and found by silty and sandy banks of streams, but in Britain, they are on the northern edge of their distributional range and they appear to benefit from the warming effect associated with the south-facing aspect of many sea cliffs. Many species also benefit from the large scale disturbance provided by landslips, which create extensive areas of bare ground for breeding habitat. Consequently, elements of this assemblage type can also be found inland in sites subject to severe artificial disturbance, such as quarry pools at an early stage of vegetational succession.

Several species are restricted to slumping Jurassic limestone cliffs on Lyme Bay and the Isle of Wight. Other areas with species more or less restricted to them include the old red sandstone cliffs of south Devon and Pembrokeshire, Castle Eden Dene in County Durham and the east coast between Norfolk and Yorkshire.

Larval habitats include bare damp sand and clay. On the whole they seem to be closer to the habitats of riparian species than to the habitats of true seepage species, which are probably associated with thin films of oxygenated water. True 'seepage' assemblages can also occur on soft rock cliffs.

Potentially important environmental impacts:

- Cliff stabilisation schemes which prevent the natural processes required to generate early successional habitats for breeding.
- Interruption of ground water source.
- Coastal erosion associated with climate change.

See also:

BOYCE, D.C. 2002. A review of seepage invertebrates in England. *English Nature Research Reports, No. 452.*

HOWE, M.A. (2002. A review of the coastal soft cliff resource in Wales with particular reference to its importance for invertebrates. *CCW Natural Science Report no. 02/5/1.*

HOWE, M. 2003. Coastal soft cliffs and their importance for invertebrates. *British Wildlife, 14, 323-331.*

Slow-flowing river (W125)

This assemblage type is characterised by aquatic species.

Habitat
The assemblage type is found in slow-flowing rivers on silty substrates, generally in lower and middle catchments. Elements of this assemblage type can also occur in lakes and impounded sections of faster-flowing streams as well as a wide range of artificial water courses including canals, fenland drains and ditches.

Potentially important environmental impacts:

- Reduction in water quality.

Seepage (W126)

Habitat
The assemblage type is found widely in Britain in association with groundwater sources. Assemblages in shaded seepages are dominated by crane flies and are especially species-rich in wet woodlands, especially in seepages under alder or willow (sallow) woodland in valley bottoms, and under birch or sometimes alder-ash woodland on hillsides. The soil is constantly saturated and usually contains a large proportion of organic matter giving rise to deep ooze. Vegetation is often limited, although Carex paniculata may be well developed in some places. Dead wood is an important component of these seepages, as this is the medium for some crane fly larvae.

Assemblages in more open seepages are confined to limestone districts and to a lesser extent chalk. Sometimes they can be found in base-rich seepages and springs arising from glacial clays and sands which are rich in calcium carbonate. Most calcareous seepages are small and very localised features, although large expanses are present in some upland areas such as the Pennines. As well as a high base status that gives rise to travertine deposits, the issuing water is also characterised by small temperature fluctuations and relatively low trophic status. Patches of short or open vegetation are maintained by grazing or, in the uplands, by exposure.

The fly larvae are aquatic or semi-aquatic and often found in the thin water film or within mosses. Most crane fly larvae are either predators or detritivores living submerged within the surface layer of shaded, saturated soil. The snails are found above the water but in damp tussocks. As seepages merge into runnels and small streams, elements of this assemblage type, for example Oxycera analis, occur in conjunction with flowing water assemblages. Some species, such as Eubria palustris and Oxycera pardalina occur on base-rich seepages on coastal cliffs mixed with 'Soft-rock seepage' assemblages. The snails, Vertigo genesii and V. geyeri, are listed on the EU Habitats Directive.

Potentially important environmental impacts:

- Cessation of mild grazing and trampling in open seepages, leading to closing-over of vegetation.
- Opening-up of the canopy in shaded seepages, leading to less humid conditions or growth of rank vegetation.
- Reduction in water supply through natural processes (especially in south-east England) or water abstraction from aquifers.

See also:

BOYCE, D. 2002. A review of seepage invertebrates in England. English Nature Research Reports, No. 452.

Open water on disturbed sediments (W211)

This assemblage type is characterised by aquatic species.

Habitat
The assemblage type is found in open water bodies on mineral sediments, especially those containing clay. It is dependent on substrate disturbance and is characteristic of silt ponds, but can also be found in larger water bodies such as lakes and canals. Naturally disturbed sites are often coastal or associated with floodplains. Several species are good dispersers and can be found in newly created water bodies in borrow pits and gravel pits as well as recently cleaned out ponds and ditches. Some species such as Hygrotus nigrolineatus have recently increased their distributional ranges and appear to have benefited from an increase in gravel extraction coupled with warmer summer temperatures, which have aided their dispersal to newly created artificial habitats.

Potentially important environmental impacts:

- Cessation of management activities connected with ditch and pond maintenance leading to encroachment by vegetation.
- Invasion by alien plants such as *Crassula helmsii*.

Northern lakes and lochs (W212)

This assemblage type is characterised by aquatic species.

Habitat
The assemblage type is found in sheltered bays of natural lakes and lochs mainly on mineral substrata. Some species can also be found associated with artificial water bodies on post-industrial sites. The assemblage type has a mainly northern distribution.

Potentially important environmental impacts:

- Nutrient enrichment.

Undisturbed fluctuating marsh (W221)

This assemblage type is mainly characterised by ground-living beetles.

Habitat
The assemblage type is restricted to localised areas which flood in the winter, but dry out in the summer to expose coarse litter of sufficient quantity to maintain a highly humid environment. The litter may sometimes be partially subterranean in layers between deposits of silt imported by winter floods. Larvae are presumed to develop in or underneath the litter and are probably hygrophilous rather than aquatic. The main breeding season for many species is in spring, when the larval habitat is exposed by falling water levels.

Typically, this assemblage type is found in lowland floodplain wetlands, reservoir draw-down zones, wet woodland and mature dune slacks and hollows. It also occurs in disused gravel pits, but only after vegetational succession to sallow scrub. Several species of the rove beetle genus, Calodera, are early spring breeders and may be particularly associated with vernal pools and hollows in river floodplains. In floodplains the level of hydrological connectivity to the main channel is critical. Secondary channels and ditches are occupied, if they are remote enough to prevent scouring of litter by fast-flowing water, but close enough to be flooded annually. Occupied reservoir margins are often adjacent to fen or woodland which produce large amounts of litter.

Potentially important environmental impacts:

- Mechanical disturbance that removes litter from the substrate and leaves a bare, compacted mineral surface.
- Removal of litter and heavy trampling by grazing stock etc. (Because of the localisation of habitat to water margins and small, isolated water bodies, even low stocking levels can cause serious damage to habitat.)
- Change in frequency of flooding and in the severity of disturbance caused by flooding.
- Reduction in water level fluctuations by impoundment of water.

Open water in acid mire (W311)

This assemblage type is characterised by aquatic invertebrates.

Habitat
The assemblage type is found in lochans and temporary peat pools mainly in upland areas, but also at lower altitudes in northern districts.

Potentially important environmental impacts:

- Siltation;
- nutrient enrichment; and
- climate change.

Acid mire (W312)

This assemblage type is characterised by a large number of species from a variety of taxonomic groups.

Habitat
The assemblage type is more or less restricted to soligenous and ombrotrophic mires. Species richness is very low in ombrotrophic mires unless there is some disturbance of the substrate, for example small-scale peat cutting. Water chemistry is often acidic, but not exclusively so. Low productivity appears to be more important than base status. Some species, such as Elaphrus lapponicus, have a predominantly upland distribution, while others, such as Acylophorus glaberrimus, are restricted to the New Forest and southern heathland.

Potentially important environmental impacts:

- Large scale disturbance eg peat extraction, afforestation, wind farm infrastructure construction.
- Siltation from surface run-off.
- Nutrient enrichment.
- Interruption in ground-water supply.

Responses to changes associated with intensive grazing and peat erosion are varied and poorly understood. Some associated species have been recorded in large numbers on bare peat associated with localised disturbance.

See also:

BOYCE, D.C. 2004. A review of the invertebrate assemblage of acid mires. English Nature Research Reports, No. 592.

Mesotrophic fen (W313)

This assemblage type is mainly characterised by water beetles, but also by terrestrial beetles and two-winged flies.

Habitat
In rich fen areas such as the Broads, this assemblage type is found in the middle of fen compartments, where the habitat is buffered against nutrient enrichment by river water. The habitat is often somewhat neglected with incipient shrubs, though not usually completely shaded out. Sphagnum is invariably present often with tussocks of Carex species. Water quality is clearly a critical factor and the assemblage type is also found in spring-fed fens as well as in a variety of sites in the north and west where it can occur independently of rich fen. It has a discontinuous distribution and the best examples occur in sites with a long history of ecological continuity such as pingo systems.

Many of the water beetles are found in saturated moss and tussocks with little free water above the surface. Schistoglossa species are often associated with emergent tussocks.

Potentially important environmental impacts:

- Siltation and nutrient enrichment by surface run-off or inundation from polluted streams and rivers.
- Succession to carr and terrestrialisation.
- Interruption of ground water source.

Rich fen (W314)

This assemblage type is characterised by a number of groups, but especially two-winged flies and also beetles.

Habitat
The assemblage type is mainly restricted to topogenous mires and fens. Many sites are in floodplains or at lake margins and subject to water level fluctuations. Nevertheless, the substratum rarely dries out completely. The best examples of this assemblage type are found on peat in stands of Phragmites or Cladium or the wetter areas of fen meadow. Elements of this assemblage type can also occur widely at the margins of ponds and ditches in beds of tall monocots on a wider range of substrate types.

The larvae of Donacia, Notiphila and Erioptera squalida are closely associated with emergent wetland plants, and have adaptations to obtain oxygen by plugging their spiracles into the plant stems, although only Donacia larvae are actually herbivorous. Many of the sciomyzid parasitoids and predators of wetland snails require shallow water or fluctuating water levels that bring potential prey within reach of ovipositing females. Shallow water either over the bottom sediments or over dense submerged plants is also essential for most of the fly larvae which respire through ‘rat-tails’ (Ptychoptera) or floating posterior spiracles (Odontomyia, Oplodontha).

Potentially important environmental impacts:

- Change in frequency and severity of flooding.
- Change in management by grazing, cutting or burning leading to ecological succession to carr, or conversely to a sustained reduction in vegetation.

See also:

DRAKE, C. M. 2004. Grazing marsh assemblages and site classification using invertebrates. *English Nature Research Reports, No. 579.*

Sandy beach (W521)

This assemblage type is characterised mainly by terrestrial beetles.

Habitat
The assemblage type is found on sandy shores subject to tidal disturbance, but only Actocharis readingii appears to be truly intertidal. Many species are mainly found in areas only affected by spring tides. Several species such as Omalium rugulipenne and Teropalpus unicolor are restricted to wrack beds at the upper margins of the strand line. Other species such as Anotylus maritimus occur in association with other types of detritus such as carrion and dung. Some species such as Nebria complanata and Cicindela maritima also occur well into the supra-littoral zone, which could also serve as a refuge for other species during storm surges. The tiny predatory two-winged flies Chersodromia speculifera and Crossopalpus setigera are found on exposed sand at the top of the shore.

Potentially important environmental impacts:

- Trampling of breeding habitat eg as a result of recreational use of beaches by holiday makers.
- Removal of wrack beds and other detritus-related habitat.
- Increased coastal erosion associated with climate change.

Saltmarsh and transitional brackish marsh (W531)

This assemblage type is characterised by species in several different taxonomic groups, but mainly beetles and two-winged flies.

Habitat
The assemblage type is mainly found in areas that are inundated by spring tides or storm surges. Here, reduced levels of severity of tidal disturbance result in mainly silt and clay substrata. This is a wide-ranging assemblage type and several constituent sub-assemblage types can be recognised with more specific habitats, which vary in terms of tidal influence, conductivity in aquatic environments and vegetation cover in terrestrial environments. Species such as Bembidion ephippium, and Pogonus littoralis occupy patches of low vegetation dominated by Salicornia, Limonium and Aster etc containing temporary saline pools. Species such as Brachygluta helferi and Melieria picta occupy higher areas of coarse grass and accumulations of tidal litter at the high water mark. Aquatic species may be associated with freshwater springs, brackish ditches or hypersaline lagoons, whose conductivity may be higher than sea water because of evaporation. Several aquatic species, such as Enochrus halophilus are confined to brackish marshes above the saltmarsh proper, where they are found in assemblages dominated by freshwater species.

Potentially important environmental impacts:

- Hydrological disconnection with the sea eg as a result of coastal protection.
- Increased coastal erosion associated with climate change.

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