SURVEY & MONITORING

15

15.1 INTRODUCTION

Monitoring can be defined as:

A programme of systematic observations to assess compliance with a predetermined level, standard or accepted norm.

Surveying can be defined as:

Taking a set of observations using a standardised procedure, within a set time period.

(Hellawell 1991).

Monitoring and surveying are often used interchangeably; however, they are quite distinct. Both surveying and monitoring require observations to be taken in a systematic, consistent and predetermined manner. The key difference is that monitoring requires assessment against a predetermined standard or objective.

15.2 WHY SURVEY OR MONITOR?

Both monitoring and surveying can be difficult, expensive, time-consuming and often require specialist skills. So why bother?

Monitoring can provide information on:

- the success of a restoration or creation scheme
- whether objectives have been met or surpassed
- whether money has been spent effectively and efficiently
- where things can or could have been improved
- changes with time including the effects of management, surrounding land use or even climate change

A well designed monitoring programme may provide information, for instance, about causes of population or habitat changes. Evidence can then be used to drive changes in field management and sometimes used to change policy and funding decisions.

Monitoring and surveying can be statutory responsibilities and are mentioned in a range of legislation including the following:

- Recent European legislation such as the "Water Framework Directive[1]", which requires member states to monitor the status of all surface waters above a certain size. The site status is assessed against a "reference state". The exact methods used to monitor the status will be decided when the regulations are translated into UK law.
- The Countryside and Rights of Way Act 2000 (CRoW Act 2000) which requires the Secretary of State and Welsh Assembly to make and review lists of species and habitats essential for the conservation of biodiversity. The methods of determining these lists are not given in the Act. However, lists can only be compiled if there is knowledge of species status and changes in distribution, which in turn requires monitoring.
- The UK Biodiversity Action Plans (BAP) contain targets for habitat and species recovery and enhancement. Monitoring is required to assess progress towards these BAP goals and to highlight where more action is required. The UK BAP was given statutory underpinning by CRoW Act 2000. All government departments and National Assembly of Wales must have regard to the conservation of biodiversity when exercising their duties and functions. The Biodiversity Challenge Group[2] report (Avery *et al* 2001) highlights the need for monitoring of species and habitat status to identify population trends and assess progress towards BAP targets.
- Article 2 of the Habitats Directive[3] states that species listed in Annex II and habitats listed in Annex I of the directive, shall be maintained or restored to “favourable conservation status”. The UK statutory conservation agencies (CCW, EN, EHS, SNH) have undertaken to monitor statutory protected sites and species to assess their “conservation status”. For further information on monitoring using common standards adopted by the statutory conservation agencies and by the JNCC, see JNCC 1997.

[1]Directive of the European Parliament and of the Council establishing a framework for Community action in the field of water policy.

[2]The Biodiversity Challenge Group is a group of non-government organisations including The Wildlife Trusts which have been involved in the progression of the BAP process since its inception.

[3]The Council Directive 92/43/EEC on The Conservation of Natural Habitats and of Wild Fauna and Flora is known as the Habitats Directive. This has been implemented in UK law as The Conservation (Natural Habitats & C.) Regulations 1994, which are referred to as the Habitat

15.3 DESIGNING A MONITORING PROGRAMME

15.3.1 Setting Monitoring Objectives

Setting the objectives for monitoring is the first step in designing a monitoring programme but is frequently given the least consideration. For wetland restoration and creation, three phases of monitoring or surveying will be needed. The initial phase will be required to monitor the site prior to the restoration/creation; the second phase will monitor the success of the scheme post-restoration; and the third will be required to establish the effectiveness of long-term site management. The restoration or creation objectives (described in chapter 2) can give the basis for setting monitoring objectives.

As with restoration objectives, monitoring objectives should be:

- simple/specific
- measurable
- achievable
- repeatable

Monitoring should ask specific questions. Too often a wide range of variables are picked, seemingly at random, or for arbitrary reasons, resulting in wasted resources. Monitoring objectives should aim to assess the relative merits of any new or innovative restoration techniques and what improvements can be made for future projects.

15.3.2 What to Measure?

When choosing what to measure and how to measure it, there are three principal concerns:

- Subjects (the habitats, species, water quality, water quantity).
- Variables (depth, size, length, number, area, population size, reproductive success).
- Targets (something with which the variable can be compared, limits of acceptable change).

Figure 15.1 gives some examples of the types of subjects and variables that can be measured to assess the status of wetland habitats or species. Subjects and variables can be put into three main categories:

- Habitat (described in section 15.5).
- Physico-chemical (described in section 15.6).
- Species (described in section 15.7).

Although these three variable types are described separately, it is important to remember that species, habitats and the physical environment all interact and influence each other. The pH of raised bogs, for instance, can influence the chemical processes of a bog, the vegetation growing upon it, and the resulting herbivore community. The bog vegetation in turn can influence the pH; Sphagnum species, for instance, reduce the pH of water in which they grow. This interaction between physical and biological factors can cause difficulty when choosing subjects to measure within a wetland. To clearly answer monitoring objectives, it is often necessary to monitor physico-chemical, habitat and species variables in a coordinated programme.

For sites with a statutory designation the "subjects" will be identified by the special interests for which the site was designated. This is not always a simple option. Many SSSIs are designated for their "species assemblages", measuring the variables for species assemblages. Estimating the population trends for a range of invertebrates, for instance, would be enormously resource intensive. Even if the practical/resource problems could be solved, assessing when a species assemblage has been adversely affected can be problematic. What are the "limits of acceptable" change for a species assemblage? Choosing standards is one of the most difficult parts of monitoring as it requires an in depth knowledge of the species or habitats involved.

Figure 15.1

Types of Variables for Monitoring Wetlands

Variable type	Variable	Examples
Physico-chemical		
Physico-chemical Habitat variables	On site water (quantity and quality)	Presence/absence of open water Total area open water Surface water depths Water table depths Water flow rates Water chemistry (pH, nutrient values, N:P ratios etc…)
	Geology	Presence/absence peat Depth of peat
Habitat		
Quantity	Wetland habitat	Total habitat area
Habitat Composition	Communities	Presence/absence Area occupied by NVC communities
	Richness/diversity	Total species richness Diversity indices
	Definitive, keystone, dominant, characteristic and indicator species	Presence/absence Frequency/occurrence Number/density Total cover/percentage cover Total biomass/percentage biomass
Habitat Dynamics	Succession/ Cyclical change	Total area of scrub. Rate of silt accumulation. Litter depth. Percentage cover of key successional stages (also indicated by water depth and area variables).
Species		
Quantity	Species	Presence/absence Range Number/density Population size Frequency/occurrence Total cover /percentage cover
Population dynamics	Recruitment	Mean/total number of eggs/births Mean/total number surviving to sexual maturity
	Mortality	Total deaths, Percentage of deaths to named causes Number dying before breeding age
	Immigration/ Emigration	Mean/total numbers immigrating and emigrating
Population structure	Age and sex ratio	Mean age of population, modal age of population. Mean age of breeding males etc…
	Fragmentation/isolation Genetic diversity	Distance to nearest population Rate of colonisation Genetic diversity indices

15.3.3 How to Measure

Once the objectives of the project have been decided then the programme can be designed. For all surveys and monitoring schemes, landowner permission (preferably in writing) should be obtained prior to commencing the scheme. Some of the key tips and considerations when designing a monitoring programme are listed below:

- Choose the method likely to be least damaging to the habitat and least disturbing to those species present.
- Research to find any recent or historical records for the sites.
- Where possible and appropriate use standard methodologies.
- Ensure methods are recorded and repeatable.
- Design survey forms; these can help standardise the reporting and aid data entry.
- Photocopy maps onto acetate sheets for annotation and mark observations on this base map.
- Monitoring descriptions should list the timing, frequency and duration of methods.
- Convert all sightings into records with an OS grid reference, date, name of recorder and sampling procedure.
- Decide how the data will be stored and analysed prior to collection.
- Feed the results back to the surveyors and site managers.

Some wetland habitats are very sensitive to trampling, for example sphagnum communities. The act of kneeling next to monitoring plots in the Cors Fochno raised mire, in South Wales, caused changes in the vegetation structure. The conservation staff overcame this problem by lying across inflatable airbeds while recording. This distributed their weight and reduced the trampling pressure on the habitat (Hurford *et al* 2001).

Trampling can also be reduced by using remote methods or by sampling only part of a site. As highlighted in case study 15.1, large amounts of background information may be acquired from desk-based searches of historical and recent surveys. Desk studies can produce baseline information to help inform the monitoring programme design.

Standard methodologies are repeatable and have a lot of supporting research to inform the setting of targets and statistical analysis. Standard methodologies, however, are not always flexible enough to be applied to every site. Data storage and analysis are essential parts of the interpretation of monitoring data and must be planned prior to data collection.

15.3.4 To Sample or Not to Sample?

It is sometimes possible to measure or count all of a variable, for example the total area of scrub within a reserve can be measured from aerial photographs. It may also be possible to quantify the whole population of some species, for instance black poplar trees. Objectives will vary between national, regional and site monitoring programmes. For very rare or locally distributed species, such as the bittern, it may be possible to survey all sites where they occur. When surveying many sites, counting the entire population may be impossible. For instance, counting every single population of a widespread species, like the great crested newt, for a national survey would not be practicable. For these widespread species a sub-set of individuals or populations must be chosen. This sub-set is called a sample.

Sampling must be statistically valid and should be designed to reflect the analysis of the data. Most statistical procedures require a degree of randomisation in the sampling procedure and need to be free from sampling bias. One approach would be to draw a grid over the site or sites to be surveyed and assign numbers to each grid square. Random numbers could be used to select grid squares and the species could be monitored within these squares. The major problem with this approach is that species and individuals within a site are rarely, if ever, distributed completely at random. Plants are often clustered in an area with the right soil and micro-climatic conditions; animals are often associated with specific plant communities. For this reason, an approach known as stratified random sampling has often been used. Using this approach, only areas of suitable habitat can be put in the numbered grid and the random number samples can be chosen from within these grid squares. Fuller explanations of sampling procedures are given in Southwood (1978) and the practical aspects of statistical analysis are explained in Fowler & Cohen (1990). Applying sampling to monitoring for conservation management is discussed in Brown (2001) and in Hurford, Jones & Brown (2001).

15.4 ASSESSMENT OF RESTORATION/CREATION SUCCESS

The pre-restoration monitoring should consist of site appraisal as a minimum (described in chapter 2). For creation projects and some restoration projects, sites will not have existing conservation designations. Thus the subjects to be measured will be chosen only from the restoration or creation objectives.

In case study 15.1, the extensive monitoring programme had a total budget in excess of the restoration project. For sites where one of the primary aims is research (as in this case study) such a high expenditure on monitoring and assessment is acceptable. However 20 per cent of the total budget on pre and post site appraisal and long-term monitoring is a reasonable figure.

In Gwen Finch Nature Reserve (case study 5.1) one of the subjects monitored was the percentage survival of the planted common reeds, as this gives an indication of the vegetation establishment success. The water table at this site is also monitored. Water tables have risen on site post-restoration, a measure of the success of the Gwen Finch scheme. The overall objective of this scheme was to provide habitat for breeding otters. Therefore, the ultimate target for this project can be the successful breeding of otters at the site in at least two consecutive years in the next 20. This is a simple, measurable, achievable target. Once this target is met, new ongoing site management objectives will require a readjustment of the monitoring priorities.

In addition to the key features of a monitoring scheme mentioned in section 15.3, a restoration or creation monitoring programme should include the following points:

- Clear objectives.
- Outline of the phases of monitoring (eg pre-restoration site assessment, post restoration site assessment, long-term monitoring).
- Key subjects to be measured based on the site objectives.
- The variables to be measured for each subject including the frequency, duration and timing of measurements.
- The limits of acceptable change for these variables.
- Repeatable or standard methodology (see Section 15.3).
- A standard way of recording methods and results.
- A mechanism for feeding data into national, regional or area monitoring programmes wherever possible.
- A process for feeding data back to site management, and take remedial action if variables move outside the limits of acceptable change.
- Adaptions to the monitoring programme if site conditions or management objectives change.

Photo: © Dr Nick Giles

Monitoring is important to assess the effectiveness of restoration techniques. The regrowth of bank vegetation after fencing, can be effectively monitored by fixed point photography, like here on the River Piddle.

15.5 HABITAT SURVEYING AND MONITORING

15.5.1 Habitat Classification and Identification

The simplest habitat variable to measure is quantity, which can be measured in terms of area or percentage area. Measuring the area of a habitat type relies on an accurate definition of that habitat. Methods have been developed to help in habitat classification in order to measure extent and type of habitat, mostly based on classification of vegetation communities. These methods include:

- CORINE (Waterton *et al* 1995).
- National Vegetation Classification (Rodwell 1991, 1992, 1995)
- classifications from remote sensing and aerial photography including Land Cover Project, Countryside Survey 2000 and Northern Ireland Countryside Survey 2000).
- vegetation communities of British rivers (Holmes *et al* 1999)
- river habitat quality classification (Raven *et al* 1998).
- pond habitat quality classification (EA 2000).

CORINE

CORINE is an acronym for the EC programme "Co-ordination of Information on the Environment". The CORINE programme was a pilot project to study the possibilities of the coordination of European environmental information. At the same time the programme developed a habitat classification which was applicable across the European Union. The classification categories, known as biotopes, were chosen to describe habitats of major importance for nature conservation in the European community. The CORINE biotopes information has been used to classify habitats in the Natura 2000[4] network of European protected sites. CORINE was used as the basic description for "ecological unit" designations in the Habitats Directive. The CORINE classification gives a method of classifying habitats that is accepted throughout the community. However, the system is not backed up by systematic data such as species distributions and therefore identifying some habitats within the system can be difficult. For instance, separating "fens with *Cladium mariscus* and *Carex davalliana*" from "Alkaline fens" is difficult without comprehensive additional information. As a classification system for habitats on a European scale it appears to work reasonably well. Of the 169 biotopes listed in Annex I only 82 are found in the UK, of these only approximately 21 are water and wetland habitats.

National Vegetation Classification (NVC)

The NVC is a phyto-sociological classification, aimed at providing a framework for the classification of the natural and semi-natural, terrestrial and freshwater habitats of the UK. This classification was based on extensive field surveys throughout the UK, followed by comprehensive data analysis. The NVC provides an invaluable tool for vegetation community classification and the standardised reference to plant communities within the UK. In addition, NVC established a set of standard monitoring techniques for different habitat types.

NVC surveys can provide a good baseline set of data which is ideal for providing an inventory of plant communities at a new site, for example. NVC survey data can also provide information for site notification and may form a useful pre-restoration survey. Use of NVC in long-term wetland monitoring programmes may be difficult. Communities, undergoing, change can be the most difficult to assign to a category. In addition, the dynamic communities within open waters and rivers in particular, are not well categorised by this approach, leading to misclassification and interpretation. NVC surveys require specialist identification skills and are reasonably resource intensive. The use of resources is more justifiable for long-term vegetation assessment (once every 10 years for instance). Though NVC surveys pre and post wetland restoration will demonstrate differences in vegetation communities, these changes may be difficult to interpret. In long-term monitoring programmes, subtle changes in vegetation will also be difficult to interpret and without additional information will not demonstrate the cause of the changes. Setting the limits for acceptable change for NVC categories can also be difficult, making the assessment of whether changes require remedial action problematic. The NVC communities are described in detail in Rodwell (1991, 1995).

[4]The Habitats Directive and earlier legislation known as the Birds Directive require the establishment of protected areas known as Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) respectively. Together, the SACs and SPAs throughout Europe make up the Natura 2000 series.

River Habitat Survey (RHS)

RHS is a method, developed by The Environment Agency, to allow the assessment of physical habitat quality in watercourses, based upon 500m study sections. RHS was developed to provide a standard method for assessment of habitat quality in UK rivers and provide a tool to assist in the conservation of rivers and floodplains. The Environment Agency runs an accreditation scheme to ensure that practitioners follow a consistent interpretation of defined features. This is important if the results of the survey are to be comparable between sites. RHS surveyors must use the agreed standardised protocol and set of abbreviations provided with the survey pack/manual.

The RHS form is relatively simple and does not involve detailed geomorphological or botanical knowledge. The RHS can only be conducted when flows are medium-low; the river should not be in spate as many of the channel features will be missed. Data recorded include:

- valley form (gorge, vee, bowl, etc)
- numbers of riffles
- pools
- vegetated and unvegetated point bars
- land-use features
- bank profiles
- extent of channel features - waterfalls, cascades, rapids, riffles, runs, boils, glides and pools

Channel dimensions are also recorded at one representative location which ideally has straight banks and a riffle (gravel shallow), if available. In addition, typically, 10 spot checks are made at 50m intervals along the study section. The spot checks involve the recording of the following features:

- Flow types
- Physical features (from a 1m-wide transect of the channel)
- Vegetation structure
- Land-use and vegetation types (the last three relate to a 10m-wide transect around the spot check site)

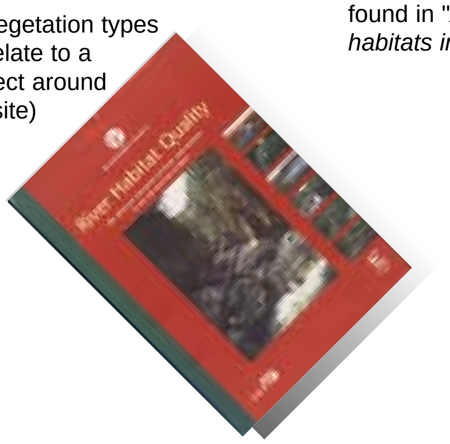
Within the channel the following groups of features are noted:

- Substrates (bedrock, boulder, cobble, gravel/pebble, sand, silt/mud, clay, peat, artificial)
- Bank materials (bedrock, boulder, cobble, gravel/sand, earth, peat, sticky clay, concrete, sheet piling, wood piling, gabion, brick/laid stone, rip-rap, builders' waste)
- Bank modifications (resectioned, reinforced, poached, berm, embanked)
- Flows (freefall, chute, broken standing, waves, unbroken standing wave, chaotic flow, rippled, upwelling, smooth boundary turbulent, no perceptible flow, dry)
- Channel modifications (culverted, resectioned, reinforced, dam/weir, ford)
- Channel features (exposed bedrock/boulders, mid-channel bars, island, trash)

For completion, a sweep-up check after the spot checks will ensure that important features have not been missed. The RHS manual (EA, 1996) and subsequent editions provide examples of the above features, or contact the Environment Agency for further information.

Countryside Survey

Over a period of 20 years the Department of Environment, Transport and the Regions (DETR) has worked in partnership, to support a programme of monitoring of Great Britain known as Countryside Survey. The most recent report presents the results of ground and remote sensing surveys and is known as the Countryside Survey 2000. This survey methodology uses broad "quality of life" indicators, and is not suitable for a restoration monitoring programme. The information available does provide indications of broad habitat area change, which can be used to set large-scale conservation objectives. The survey databases may also provide some background information for a pre-restoration site appraisal. More information on the techniques used and the data obtained, are found in "*Accounting for nature: assessing habitats in the UK countryside*" (DETR 2000).



One of the many published summaries of the River Habitat Survey and results.

System for Evaluating Rivers for Conservation (SERCON)

SERCON is a system for measuring the conservation value of rivers using measures including diversity of physical structure, naturalness and species richness.

SERCON follows three phases:

1: An extended River Habitat Survey (RHS) to provide physical habitat data.
2: Data on physical, chemical, biological features of the study river are collated from all available sources.
3: All these data are converted into a set of weighted scores for physical diversity, naturalness, representativeness, rarity, species richness and special features.

Some of the criteria used in these groupings are:

- physical diversity
- substrates, fluvial features.
- naturalness
- channel features, bank features, plant assemblages, riparian zone, aquatic and marginal macrophytes, aquatic invertebrates, fish, breeding birds.
- representativeness
- rarity
- EC Habitats Directive/Bern Convention (+ rare in UK), Scheduled species, EC Habitats Directive Species (but not rare in UK), Red Data Book/nationally scarce macrophyte and invertebrate species.
- species richness
- special features
- influence of natural on-line lakes, extent and character of riparian zone, floodplain: recreatable water-dependent habitats, floodplain: non-recreatable water-dependent habitats, birds wintering on floodplain, mammals
- impacts

Rivers are evaluated along 10-30km sections ('Evaluated Catchment Sections') with various quality indices banded A-E, with A representing the highest conservation quality band. More information on SERCON can be found in Boon *et al* (1996). This system is still under development and its long-term usefulness as a conservation aid has yet to be established.

River Corridor Survey

River corridor survey (RCS) was the forerunner to the RHS, and was developed by the NRA to allow the recording of the major habitats, vegetation and physical features of the river corridor. The RCS splits river valleys into four main habitats: Aquatic zone, Marginal Zone, Bank Zone and the Adjacent Land Zone. The RCS is based on 500m length sections of river corridor (similar to RHS). Both banks of the rivers should be surveyed simultaneously, ideally in late April-early May unless the river is in spate.

Surveyors record the visually dominant species in each of the four vegetation zones. Notes are recorded directly onto a base map. A phase I, NVC habitat survey is usually conducted on the Adjacent Land Zone communities. RCS requires records of nationally rare or endangered species, critical or easily damaged areas as well as all species in areas "hydrologically linked to the river". Within the 500m length at least one cross-section of the channel should be drawn identifying:

- the Width of the water-filled channel
- depth of water
- bank height, slope and width
- flood bank height and width where appropriate
- water-level relative to the top of the bank
- land use to a minimum of 50m either side of the river

In addition to the vegetation zones and the channel cross-section, summary descriptions of each 500m sections are also included within the RCS. The RCS survey provides valuable information on distribution of rare endangered species and riparian communities. The survey technique requires good identification skills of both aquatic and riparian plant communities. In addition, surveyors must be able to ascertain hydrological links and make subjective judgements about critical areas. The elements of subjectivity reduce the standardisation of RCS below that of RHS. The RCS survey methods are described in NRA (1992) and information on RCS can be obtained from the Environment Agency.

15.5.2 Models and Habitat Classification Programmes

In the past decade there has been a move towards the production of computerbased models and habitat classifications. Some of these classification programmes and models include the following:

- Physical Habitat Simulation Model (PHABSIM) is a computer model which incorporates a database of information on key characteristics of rivers such as flow velocity, depth, habitat types. These are related to the numbers of indicator invertebrate species using different micro habitat conditions. The impact of proposed river modifications (such as changes in channel form or flow) can be predicted by this model. This is principally a tool for water resource managers to assess the impacts of proposed abstractions. For more information on PHABSIM contact the Environment Agency.
- River Invertebrate Prediction and Classification System, (RIVPACS) was developed by the Institute of Freshwater Ecology in association with SEPA and the Environment Agency. This predicts the macro-invertebrate fauna expected at running water sites with no environmental stress. The system can compare the fauna observed at a site with predicted values and thus provide information on the biological quality of the river.
- LIFE: Another method using aquatic invertebrates as indicators, is called the Lotic-invertebrate Index for Flow Evaluation (LIFE). Currently under development by the Environment Agency, LIFE assesses the impact of river flows, on benthic macroinvertebrates. The system aims to provide a method of measuring the effects of low flows both current and historic (Armitage *et al* 1997).
- Predictive System for Multimetrics (PSYM). Developed by Pond Action (address in Appendix 4) in conjunction with the Environment Agency, this model uses a database of un-impacted reference sites to assess the level of "impact" upon aquatic systems. The initial system has been developed for ponds but is currently being adapted for larger waterbodies, for canals and for ephemeral waterbodies. Metrics are used to evaluate new sites which are compared to the predicted scores for un-impacted sites - obtained from the database.

  The metrics chosen for ponds are:
  - number of submerged and marginal plant species,
  - trophic ranking score for aquatic and marginal plants (an assessment of eutrophication based on macrophyte assemblages)
  - number of uncommon plant species
  - average score per taxon (ASPT - recorded as standard by the Agency; this is a measure of the invertebrate taxonomic diversity)
  - number of dragonfly and alderfly families
  - number of beetle families

  More information on the PSYM can be found in Environment Agency R & D report E110 (EA 2000).

These systems provide tools to assess various impacts upon freshwater ecosystems. All require detailed surveys of aquatic macro-invertebrates or/and macrophytes, requiring specialist survey skills and substantial time commitment. The advantage of such systems is the standardised methods of recording and surveying, that allow inter-site comparisons to be made. Some of these methods could be used to compare individual sites pre and post restoration. The efficacy of the systems is still being debated in scientific communities (eg Armitage *et al* 1997).

15.5.3 Remote Sensing

Remote sensing can be defined as

"any technique or method that determines the characteristics of an object, organism or community from afar. "

(Bureau of Reclamation Glossary website: www:usbr.gov/cdams/glossary.html)

The potential advantages and disadvantages of remote sensing techniques compared with more traditional vegetation and species surveying and monitoring are shown in figure 15.2.

Figure 15.2

Pros and Cons of Remote Sensing

ADVANTAGES	DISADVANTAGES
• Cover large areas. • Give quick response. • Can produce cost savings if large areas are monitored for long periods.	• Expensive initial start up/capital costs. • Expensive ongoing monitoring costs (not always the case). • Requires specialist skills and/or equipment for data analysis. • Resolution is comparatively low.

Satellite Remote Sensing

Weather and other satellites cover the whole of the earth's surface at least once every day. This kind of global, long-term coverage presents exciting possibilities for monitoring global processes, such as climate change. Since vegetation reflects light, and different vegetation reflects different parts of the visible and UV spectrum, vegetation types can be identified from satellite images. Some of the higher resolution satellites provide information on vegetation types at the field-scale. Potentially, this data could provide information on the changes in land-use in recent years. Use of satellite remote sensing is ideal for broadscale habitat monitoring and surveying projects, for instance the Countryside Survey (section 15.5.1).

Aerial Photography

Aerial photography can be a very useful tool in pre- and post-restoration assessment. Photographs from the 1940s and 1950s can provide a visual record of former land use. Former land use can be compared with current land use to assess change and/or deterioration. The former extent of habitats may also be used to help set restoration objectives. For example, the Broads Authority used aerial photographs to assess scrub invasion of Norfolk fens in the latter half of the 20th century. Photographs from the 1940s were compared with current photographs and the recent scrub growth was identified. Scrub and woodland extant in the 1940s was left intact, as valuable wet woodland habitat. A large portion of the remaining scrub growth was deemed recent and was removed as part of the fen restoration project (Tolhurst 1997).

An aerial photograph pre- and post-restoration, particularly of river valley restorations, can provide a record of broadscale habitat change. Aerial photographs can be digitised to produce base maps for recording other biological data or may be included in geographical information systems (GIS).

The rental of the light aircraft usually forms a substantial part of the cost of aerial photography. A cheaper alternative to light aircraft, is remote control model aircraft with remote control cameras. This technique has been investigated by RSPB and the Environment Agency as part of an Environmental Impact Assessment of an upstream sewage treatment works on the Stour and Orwell estuaries. Algae (*Enteromorpha* species) bloom in response to increased nutrient inputs but monitoring this algae on foot was hazardous as the area was large with extremely soft mud. A camera was mounted on a remote-controlled helicopter, which was able to hover while the operator "framed" the picture. An anti-vibration mount and a calibration disc allowed the production of clear photographs of known scale. Therefore, the area of algal growth can be estimated directly from the pictures. This method was rapid and produced an on-site time saving of 75 per cent, with associated cost savings.

Fixed Point Photography

Fixed point photography covers a spectrum of monitoring. At its simplest, a point is marked using a cane or other position marker and a tripod photo is taken at this point. A photograph is then taken at the same point repeatedly at standard time intervals, usually six months. This can provide a very simple, visual record of vegetation change which can be invaluable in explaining and demonstrating the progress and success of restoration programmes.

As a tool for monitoring biodiversity change, it is somewhat limited as species identification from photographs can be limited. More intensive monitoring, for a research programme for instance, may use still or video cameras fixed in position which take photographs at fixed intervals. This may be used to map the progression of a flood for instance. Alternatively, cameras can be triggered by movement; these have been used, for instance, by the Environment Agency and The Wildlife Trusts in Winchester to record the movements of otters.

15.6 PHYSICO-CHEMICAL SURVEYING AND MONITORING

15.6.1 Why Monitor Physico-Chemical Processes?

The following section provides brief notes on measurements of the physico-chemical aspects of wetland sites and in particular using physico-chemical techniques to monitor wetland creation and restorations. Wetlands have two key physico-chemical components - the water and the soil or substrate. As described in chapter 3, wetlands can be supplied by groundwater, surface water and/or by precipitation. Both depth and chemistry of water and substrate have influences on the flora and fauna of wetlands.

The relationship between the animals, plants and the abiotic component (substrate, water, temperature etc) is very complex. In rivers, the flow rate of water can be affected by vegetation growing within the channel, and the plant communities present are adapted to grow at certain water flow rates and water depths. The water-crowfoots are a good example; they are strong plants, well able to withstand buffeting flows and adapted to growing quickly in fast, cool, clear springtime currents. As the beds of crowfoot grow, they start to trap silt around their bases, uncut crowfoot beds flower and then gradually slow their annual growth cycle. By now, other plants have taken root in the silty areas between the crowfoot beds - starworts are a good example.

On many rivers differing species of water-crowfoot represent so-called 'keystone' species - vital to the maintenance of high quality characteristic habitats in rivers as diverse as chalk winterbournes, chalk streams, clay vale rivers and upland spate systems. The interaction between these physico-chemical components and the biotic component (flora and fauna) is clearly a twoway process.

The pre-restoration site assessment requires assessment of many of the physico-chemical processes, including the hydrology, topography and substrate. Some of the key physico-chemical surveying and monitoring techniques for pre-restoration site evaluation, including water-level gauging and topographical surveying, are described in chapter 3. Physico-chemical parameters can give an indication of habitat suitability for species and can indicate breaches in environmental legislation or licences such as through pollution or over-abstraction. For this reason, physico-chemical monitoring is routinely undertaken on main rivers by statutory environmental protection bodies (EA, SEPA, EHS). Figure 15.3 lists some examples of physico-chemical monitoring methods and potential reasons for monitoring.

Estimating the limits of acceptable change for physico-chemical variables of a wetland is, at best, complex and sometimes impossible. The tolerances of individual species to changes in nutrients, pH and even water-levels are only well recorded for some species. The water-level requirements for individual wetland plants, for example, are described in Newbold and Mountford (1997).

How changes in water-levels will affect communities or ecosystems is difficult to predict and further research is required in this area. However, monitoring of surface and groundwater movements will contribute to the knowledge base of community and physical interactions. Such monitoring will provide essential information on limits of acceptable change and also on best practice of water-level management for site managers. Simple methods of monitoring water-levels and flows at wetland sites are described in (EA *et al* 2000).

Photo: © Dr Nick Giles

Water-crowfoots are keystone species in chalk streams. Monitoring their health can indicate the overall state of river health. In addition, some chalk streams and rivers with stands of water-crowfoots are protected as SACs. There is a legal requirement to monitor the health of these rivers under the Habitats Directive.

Figure 15.3

Examples Of Physico-Chemical Monitoring For Wetlands

Example Subjects & Variables	Example Methods	Example Reasons for Monitoring
Water Quality Total phosphorous Total available nitrate	Quarterly water samples (upstream) at multiple control and downstream sites followed by flame photometric analysis.	Assessing impacts of an upstream sewage treatment plant. Monitoring diffuse pollution from farm fertilisers.
Water Quality pH	Continuous pH data loggers at selected main run-off points. Data downloaded to laptop in the field.	Assessing impacts of high pH run-off from industrial development on water quality of downstream wetland.
Water Quantity Range of surface water-level	Use surface water-level range gauge (WaLRaG) and record max - min monthly.	Monitoring the impact of land drainage activity on the water-levels of a designated wetland.
Water Flow	Cumecs of water flow through a gauging weir with data logger.	Enforcing low flow abstraction licencing conditions.
Substrate Depth of peat	Fixed-point marker, embedded within peat with depth markings. Record markings as they become visible above the peat surface.	Monitoring peat shrinkage due to drying caused by adjacent land pumping.

15.6.2 Advantages and Disadvantages

Physical and chemical processes sometimes change in predictable cycles, but often in a more unpredictable way. Measuring physico-chemical processes across a site will only tell you what is happening at the moment of measurement. Even with repeat or automated constant measurements the data only provide information on the point where the measurement was taken. This is known as point sampling. A well-designed sampling strategy is essential if physico-chemical monitoring is to provide useful information about the functioning or status of a site.

The potential advantages and disadvantages of physico-chemical monitoring techniques compared with flora or fauna surveying and monitoring are shown in figure 15.4.

The efficacy of a physico-chemical monitoring strategy will be dependent upon careful design. Some of the main points to consider are:

- where to sample; target run-off points to assess the maximum concentration of pollutants
- to sample both upstream/gradient and downstream/gradient of the potential threat. This may allow the upstream data to act as a control
- to assess whether existing monitoring can be used to provide some or all of your data needs
- to use standard, repeatable techniques
- to seek advice on interpretation of data and sampling strategies prior to beginning the sampling programme

Figure 15.4

Pros and Cons of Physico-Chemical Monitoring

ADVANTAGES	DISADVANTAGES
• Methods often precise and repeatable • Can provide precise information and may be necessary to identify the cause of changes in communities • May also give an indication of when things are going to change prior to that change happening which will allow remedial action to be taken	• May require expensive equipment, difficult to analyse and interpret • Long-term monitoring requires mechanisation which is expensive • May require specialist knowledge

15.7 TAXA MONITORING

15.7.1 Introduction

Species are the units of biodiversity, and are long-term indicators of water quality and habitat status since their presence, population size and behaviour can be affected by habitat quality and quantity. Since species are present either year round or for prolonged periods at a site they overcome the problems of point sampling discussed in section 15.2.

Habitats are often described in terms of the species or communities of species found there. Therefore, changes in wetlands can be assessed by monitoring the species status that inhabit them. Species that can be used to monitor the status of a waterway or wetland are:

- **Definitive species**. These are species used to define the habitat, for example the size, shape, density and length of common reeds can be used to describe a reedbed.
- **Integral or "keystone" species.** These are species that contribute to the form and physical nature of the habitat, for example sphagnum mosses build the structure and form the peat associated with bog habitats.
- **Dominant species.** These are species which dominate communities and may be used to define habitats. For example perennial rye-grass and crested dog's-tail in dairy and fatting pastures defined as MG6 grassland communities by the NVC (Rodwell1992).
- **Characteristic species.** These are species consistently found within a habitat such as red fescue or crested dog's-tail in flood meadows defined as MG4 by the NVC (Rodwell 1992).
- **Indicator species.** These are species that react to particular aspects of habitat quality, for example certain aquatic invertebrates are very sensitive to water pollution and are therefore indicators of water quality. Blooms of algae can be caused by nutrient enrichment and can therefore be used as an indicator of nutrient status.

There are three key kinds of survey:

- Presence or absence survey.
- Detailed survey (Relative abundance within a site and possibly population structure etc).
- Changes in population size or structure (monitoring).

Presence or absence surveys simply identify whether a species or group of species are present at a site. Presence or absence surveys are appropriate for national surveys or prior to development of a currently unmonitored site to identify if a protected species is present. Since this type of survey can be used to provide a species list of a site; this is sometimes referred to as inventory surveying. Detailed surveys are required to identify the relative abundance, population structure, mean size or distribution of a species at or between sites.

At least two detailed surveys are required to assess apparent changes in population features. A clear assessment will only be possible if the survey methods used pre- and post- restoration are the same, as they were in the monitoring of the River Cole (case Study 15.1). However, a single population census prior to restoration is unlikely to reveal very much about species with fluctuating populations (such as amphibians). For these species, long-term trends are usually only discernible with many years data, and collection of this kind of data will not usually be possible prior to a restoration project. Not all species can be monitored at the same time, as their life cycles, activity and therefore visibility differ. Frogs and toads for example, are best surveyed in spring, whereas flowering plants are easier to find or identify later in the year. Species can be surveyed and monitored to:

- identify population trends in response to management and conservation work
- identify population trends in response to pollution, climate change and development etc
- be used as indicators of habitat status
- be used as flagships to raise awareness of threats
- identify key populations of rare or declining species for statutory designation

Though species give indications of problems with management or pollution, physico-chemical monitoring may be necessary, to confirm the source of a pollution incident for example.

15.8 PLANTS

15.8.1 Emergent and Bank Side Plants - Introduction

Monitoring vegetation along water edge habitats and bank sides involves essentially similar techniques to surveying higher plants in terrestrial habitats. The National Vegetation Classification (NVC), described in section 15.5.1, can be used for surveying and mapping riparian and emergent vegetation. Phase 1 habitat survey can provide an initial "environmental audit"; this method is useful for broadscale habitat mapping, leading to NVC-level analysis of high conservation value sites.

As with terrestrial plants, quadrats, suitably chosen for the species and habitats concerned - (ie of the correct size) are the usual route to quantitative plant monitoring. Quadrats are usually dropped randomly, so as not to bias sample data. As with surveys of terrestrial plants, identification skills are of primary importance, if uncommon species are not to be overlooked. Recognising species from vegetative growth alone (no flowers) is crucial, if good estimates of plant population density are required. Similarly, the timing of surveying is important as differing species grow, flower and die back at differing times of the year.

Photo: © Dr Nick Giles

Arrowhead, an attractive emergent plant.

A single plant survey series or full monitoring programme must, therefore, have a well determined strategy if it is to provide a comprehensive description of the botanical community.

Wetland habitats can present particular difficulties for the botanical surveyor due to:

- their inaccessibility
- plant species richness which can be high (many diverse families)
- common occurrence of difficult taxonomic groups such as mosses, sedges, grasses
- variety of communities. Succession, for instance, from open water to reedy shoreline to willow/alder carr to dry woodland can occur quite rapidly in the same place. The botanical community changes rapidly and fundamentally in a short space
- habitat management which can halt seral succession and cause major changes in plant abundance and distribution

Any wetland plant monitoring programme must be fully integrated with an agreed long-term management plan so that it is possible to determine whether management objectives are being achieved. Some plant communities require frequent monitoring (several times a year or annually). These might include those with small numbers of rare species or important short-lived species. Other communities, such as large reedbeds, fringing willow, alder woodland or large areas of wet grassland may only require monitoring every five years in order to maintain an adequate view of their conservation status.

15.8.2 Emergent and Bank Side Plants - Methods

Walk-over Surveys

Presence or absence of many species and rough abundance estimates can often be determined from a series of transect walk-over surveys, noting on a base map where species occur. Walk-over surveys usually involve a degree of close-range observation, usually requiring stopping and kneeling to observe the ground flora. Note that seasonal growth and flowering patterns, degrees of grazing by wild herbivores (deer, rabbits, hares) and domestic livestock will have important effects upon apparent dominance of species. When heavily grazed, many plants develop a low-growing shape; this makes them much more difficult to spot during a walk-over survey. Also, some plants can lie dormant for a year or more under unfavourable weather conditions. Drought can reduce flowering times considerably while warm, wet weather can advance growth and maturation. Notwithstanding these limitations, expert surveyors can often conduct rapid, cost-effective plant surveys, adequate for many monitoring objectives.

Photography

Plant communities, their species composition and extent of habitat distribution can be surprisingly well recorded through regular standardised photographic surveys. While an accurate estimate of species abundance or mix will seldom be possible, these surveys are rapid, repeatable and inexpensive. Photographs may now be in digital format and so readily stored and analysed on computer. At the very least, many botanical surveys can be supported with a good photographic record of the site. The success of management regimes can also, often, be established through an analysis of a time series of pictures. As described in section 15.5.3, aerial photographs are excellent for documenting large-scale habitat restoration projects.

Total Population Counts

One approach of botanical survey is to count the total population, at a site or within an area. These can be easy and very precise, for large plants that grow singly, for example the number of mature black poplar trees on a given stretch of river. These surveys can also work well for small sites or species that grow in clumps, for example the number of water-lily beds in a small lake. Where population sizes are small and species readily identified, this is a good approach, yielding excellent data.

Quadrats

Quadrats can be frames (covering an area) or points (pins lowered through vegetation). Frame quadrats must be large enough to be likely to encompass a reasonable number of species but not so large that identification and recording take too long. Quadrat size varies from 10cm squared for identifying small vegetation and mosses, to 25m squared or more for trees. Frame quadrats can be used to record cover, density and/or frequency of occurrence of species. NVC surveys rely on quadrat sampling of vegetation stands.

Point quadrats involve the use of single needles or groups of needles on a frame which are lowered vertically down onto a short sward and each species touched is recorded. This is very time-consuming but excellent for accurately determining the cover of species within a community and the vertical structuring of a plant community.

Frame and point quadrat surveying is a lengthy process and therefore costs for such detailed botanical surveys can be prohibitive. However, such surveys could be built into a long-term monitoring scheme, say once every 10 years, with key indicator species monitored annually.

Population Density Estimation

When sampling plant communities to estimate the population size or density of single species or the species composition of the overall community, it is necessary to do the following:

1. Define the objectives of the programme.
2. Choose an appropriate sampling method (say random quadrats).
3. Calculate the best size of (eg) quadrat and the number of samples required to provide population estimates of a given degree of precision. This will probably require an initial survey to gain an understanding of the distribution and abundance of the species concerned, followed by some standard statistical calculations to determine the number of samples required.

All species are amenable to this approach but the exercise will probably be time-consuming. This is particularly laborious if the plants are widely-dispersed, small and difficult to identify. The estimation of percentage cover of species within a quadrat is highly subjective and recorder biased. It is very easy to underestimate the importance of finely-divided, low-growing plants such as grasses and sedges.

Transects

These provide similar data to a quadrat approach but are very useful where vegetation is either too tall for easy quadrat use or where clumps of plants are sparse. In the latter case transects are deliberately chosen to include vegetated areas. A logical extension of this approach is to set up plots and to monitor these.

Plots

These are defined areas, which are sampled regularly to monitor changes in populations. Useful for trees, shrubs and colonies/clumps of uncommon rushes, sedges or reeds, etc. Data can be collected on the growth of individual trees or on the extent of clumps and can thus be very precise. Where good data sets on large numbers of individual plants are developed then demographic analyses are possible. These can yield very useful information on, for example, plant lifespans, regularity of seed production, woodland productivity or the growth rates and survival of colonies of rare species. These tend to be more of a research tool for gathering ecological data. However, some restoration schemes may be monitored by comparing the changes in vegetation in plots within restored parts and unrestored (control) plots.

15.8.3 Submerged Plants - Introduction

Introduction

Growth of aquatic plants, like their terrestrial counterparts, is dependent upon climate (macro and micro), nutrient status and management (boating, fisheries stocking, cutting etc). In addition, the flow rate and oxygenation of water influence the plant communities.

Still Waters

Still waters are defined by their nutrient status and each of the three main nutrient categories (eutrophic, oligotrophic and mesotrophic) all have associated plant communities.

High nutrient (eutrophic) still waters tend to display two relatively steady ecosystem states:

1. Clear watered with abundant submerged macrophytes (large plants).
2. Turbid with few submerged macrophytes and periodic algal blooms.

State 2 can often be initiated through the stocking of high densities of bottom-feeding cyprinid fish such as common carp or bream. State 1 can sometimes be re-established via large-scale fish removals, reducing nutrient cycling, lake bed turnover and the grazing of seedlings (eg Giles, 1992).

Eutrophic waters can often be relatively species-poor in terms of aquatic weeds but have very high production, sometimes with submerged weed beds (eg pondweeds, milfoils or hornworts) filling the body of the pond or lake during high summer. Naturally, mesotrophic (medium-nutrient status) and oligotrophic (low nutrient status) still waters often have high species diversity of submerged aquatic macrophytes but may have relatively low overall productivity (annual growth).

The nutrient status and bed type can affect the ease of monitoring of still waters. Shallow firm-bedded lakes with clear water can be readily waded and submerged plants sampled by various means or their percentage cover estimated by eye. Deeper, more turbid waters, particularly those with silty or muddy beds, are difficult to see into and difficult to sample effectively.

Running Waters

The aquatic flora of differing river types tends to be dictated by the surrounding geology (and hence water chemistry) and, to a lesser degree, topography (river elevation and slope). A recent analysis (Holmes 1999) has sub-divided UK rivers on the basis of macrophyte community types.

Aquatic plants can be indicators of habitat quality, in particular nutrient status. Because of the relatively predictable response of many commoner river macrophytes to polluting inputs, it is possible to calculate “Trophic Ranks” for plant communities present in a given river. Such analyses provide useful indirect monitoring methods for assessing the ecological quality of running waters.

It must be remembered that differing species peak in their growth cycles at differing times of year, for instance, in a typical chalk stream water-crowfoot species thrive in the fast, cool, clear flows of springtime while starwort beds flourish later in the summer under lower-flow conditions. In lakes, milfoil and fennel pondweed thrive in the spring in many waters while Canadian pondweed and hornworts peak in abundance in the early autumn.

Marginal aquatic plants such as rushes, sedges, reeds and other grasses are routinely sampled using standard techniques for terrestrial plant species (Section 15.8.2). Submerged aquatic plants require a different strategy.

CAUTION

Wading should be undertaken with care - it is easy to get stuck in muddy substrates, sometimes with fatal consequences. Always wear a life jacket (preferably of the slimline automatically-inflating type) if you intend working in depths greater than thigh-deep in ponds/lakes or in rivers/streams with a swift current and unstable or slippery bed. Also, working in pairs is a sensible precaution. It is important for water-related ecologists to be aware of the influenza-like symptoms of Weil's disease, a potentially fatal bacterial infection transmitted in rat urine which can enter the body via cuts, abrasions and mucous membranes. Never eat food while at the waterside without washing your hands in clean water. If you develop a bad headache or flu-like symptoms soon after sampling, see your doctor telling her/him that you could have been in contact with **Weil's disease** (Leptospirosis). Another far less serious but very irritating risk lies in contacting Ichthyophthirius multifilis ('swimmer's itch'), a protozoan fish parasite which burrows under your skin and dies, causing very itchy allergic red bumps which can take several days to disappear. More information on working safely with water can be found in Appendix 6.

15.8.4 Submerged Plants - Methods

Observations

Skilled observers can identify many aquatic macrophyte species from above the water (plus taking the odd cutting to examine minor features). Presence or absence of expected species in suitable habitats can thus be easily and rapidly established in many clear-watered streams, rivers and pools. Lake margins are also amenable to such observational studies. Percentage cover can be estimated or the well-known DAFOR scale (Dominant, Abundant, Frequent, Occasional, Rare) can be used to record those species which form the bulk of the floral community. Rare or small species are easily missed by this method and estimates of cover, as with terrestrial plants, are subjective and recorder biased.

Weed Drags

A simple, effective and inexpensive weed drag can be made by lashing two steel rake heads back-to-back and securing them to a long length of rope. This can then be thrown and retrieved from either shore or boat to obtain qualitative weed samples. Deep, turbid waters with soft silty beds are accessible by this useful method. This method can be used for presence/absence surveys or for confirming the identification of plants whose cover has been estimated by eye from the bank. The method does not, however, provide quantitative information unless combined with an additional sampling procedure. Small amounts of habitat will be temporarily damaged by weed drags.

Quadrat Sampling

For truly quantitative work, simple quadrat sampling (30-50cm sides) can be used where plants are accessible. Divers using SCUBA can use quadrats at greater-than wadable depths. Quadrats are randomly dropped onto the lake or river bed and the plants contained within the perimeter are harvested and bagged for further identification and, if required, drying and weighing.

Sampling sites can be relocated with reference to fixed bearings on bankside features, stake or buoy marker systems or, when accurate enough, modern Geographical Positioning Systems (GPS) receivers. This method is extremely time-consuming and expensive.

Transects

Transects can be sampled across streams at predetermined intervals or across lake beds to record aquatic plant species, numbers, weights, community dominance, etc. Submersible Remotely Operated Vehicles (ROVs) have been used to collect submerged aquatic plant data (Boon *et al*); however, these are likely to be too expensive for non-specialist monitoring programmes.

Cylinder Sampling

A 50-100cm deep steel or hard plastic cylinder of around 30-40cm diameter is a very useful standard sampler for rooted aquatic plants. The cylinder can be pushed into a lake bed and the plants contained within removed by hand and/or ladle, sieved, and retained for identification and drying prior to weighing. Macroinvertebrate samples can be collected at the same time provided that the sieve is of appropriate mesh size and that the substrate is excavated to a depth sufficient to catch deeply-burrowing animals such as mussels or chironomid larvae. Once the area of the base of the cylinder is known, it is easy to multiply up dry weights to obtain standing crop per square metre data for key macrophyte species. Such data can then be compared year to year to obtain trends in productivity and species composition. This is a destructive method and should be used with caution if rare or vulnerable species may be present.

15.9 INVERTEBRATES

15.9.1 Introduction

Freshwater invertebrates are essential links in aquatic ecosystems. Invertebrate communities of rivers and streams are determined primarily by water chemistry and are very useful for determining degrees of pollution. The animals have to survive all through the year and therefore overcome the problems of point sampling described in section 15.6.2. Some pollutants, such as synthetic pyrethroid sheep-dips, are so toxic that virtually all invertebrates are killed. The first signs of this are often a prolific growth of algae on the river bed - no longer cropped by a grazing invertebrate community. Figure 15.5 gives a brief overview of pollution tolerant (low score) to sensitive (high score) aquatic invertebrate groups.

As with rivers, still waters, particularly long-established ones, with good water quality, are also likely to harbour diverse invertebrate species assemblages. Fish-free ponds may be richer than those stocked for angling - fish are expert invertebrate predators, driving down numbers, average size and species diversity.

The differing groups of invertebrates can be quite easily identified with a hand lens and appropriate field guide; pond-dipping is, therefore, an excellent opportunity to introduce people to freshwater ecology. If you have access to a boat, a fine-meshed plankton net trawled slowly through the depths (many zooplankton migrate down to the safety of the bottom during the day) may reveal water fleas, copepods and (under the microscope) rotifers and protozoans. If you do not have a boat, a plankton net held under water at a lake outlet will catch many of the species present. The following methods are split up into those most usually used on flowing and still waters. Of course, many methods can be used in both situations.

Figure 15.5

Pollution Tolerant & Sensitive Invertebrate Groups

Group	Score
Small aquatic worms (eg*Tubifex*)	1
Chironomid midge larvae (eg bloodworms)	2
Asellus (water louse), most leeches and snails	3
Baetis (olive) mayflies, Alder flies (Sialis), fish leech	4
Water boatmen, most water beetles and bugs, flatworms	5
Shrimps (*Gammarus*), mussels, freshwater limpets	6
Caenis mayflies, *Rhyacophila* & *Limnephilus* net-spinning caddis, *Nemoura* stone flies	7
Native crayfish, most dragonflies	8
Ephemera, *Leptophlebia* & *Ephemerella* mayflies, *Perla*, *Chloroperla*, *Leuctra* stoneflies, *Phryganea*, *Molanna*, *Leptocerid*, *Sericostoma* cased caddis flies	10

15.9.2 Monitoring Aquatic Invertebrates in Streams

Stone-turning

Turning over stones on rocky stream-beds is a good method of locating crayfish, mayfly, stonefly, caddis fly larvae, snails, leeches, shrimps and flatworms. A good guide to stream quality can be gained from this simple, non-destructive approach. Indices of abundance can be generated, for example for native crayfish, by following a timed systematic transect picking up the stones along the way. Note that an EN/CCW licence is required to survey native crayfish, which are now a protected species.

Kick-sampling

By holding a pond net with its upper edge firmly on the river bed and vigorously stirring-up the bed immediately upstream with your feet, invertebrates are dislodged and carried by the current into the net. By choosing representative areas and sampling for a given period, standardised samples can be collected for analysis. These so-called “kick samples” are a widely used method for monitoring benthic macroinvertebrate species diversity and abundance. A net with a mesh of around 1mm will not get clogged too easily but will retain all the larger bottom-living invertebrate species ('benthic macroinvertebrates').

River Edge Samples

By probing under banks and through marginal vegetation, many additional invertebrate species will be captured, that are not readily caught by kick-sampling. In order to gain an accurate impression of the invertebrate diversity of a river or stream, it is important to sample all habitats and their characteristic communities listed in figure 15.6.

Figure 15.6 **Characteristic Communities of River and Stream Habitats**

Habitat	Community	Notes
Rock surfaces	Blackfly, stonefly, mayfly nymphs, snails, freshwater limpets, leeches, snails, flatworms. Crayfish under rocks.	Species which can grasp firmly or stick onto rocks: streamlined fast water species.
Gravel	Shrimps, mussels, caddis larvae, midge larvae.	Species which live in spaces between gravel.
Sand and Silt	Burrowing mayfly nymphs, worms, alder fly nymphs, snails, mussels, water lice, midge larvae.	Burrowers living in tunnels or searching through leaf-litter layer.
Marginal vegetation & tree roots	Some mayfly and stonefly nymphs, dragonflies, damselflies, snails, caddis flies, shrimps,	Surface crawlers unable to cope with strong currents.
Deadwood rafts/dams	Shrimps, caddis flies, stoneflies, crawling mayflies, snails.	Detritus (decaying organic matter) feeders able to shelter in-between twigs, etc.

15.9.3 Monitoring Aquatic Invertebrates in Still Waters

Grab Sampling

The Ekman grab is a jawed apparatus which is dropped down on a cable onto soft lake beds and triggered with a sliding weight so that a 'bite' is taken out of the sediments. The grab contents are then retrieved, emptied into a bucket and taken back to the shore for sieving and sorting. Quantitative samples of deep lake bed invertebrate communities such as worms, midge larvae, small mussels, etc are collected in this way. Identification of invertebrates from an ekman grab sample is likely to require microscopes and specialist identification skills. These samples are quick to take but require substantial analysis time.

Cylinder Sampling

Cores can be taken of deep lake beds or of shallow littoral zones by driving a steel cylinder into the substrate and then retrieving it or ladling it out with a scoop. In the shallows, the sample is washed through a sieve. The animals/plants retained can be counted to give an accurate measure of numbers per area. Deep water mud cores are usually used to sample diatom cell cases and/or pollen grains as indirect measures of past lake water chemistries - acidification processes, for instance. Like the Ekman grab, these samples are simple to take but require specialist knowledge and substantial time to analyse. The data provided by such a sample can provide information for "hind-casting”. That is, predicting the conditions in or around a lake before anthropogenic impacts affected the lake chemistry.

Emergence trapping

Insects groups which have aquatic larval phases and which swim up to emerge at the water surface, include non-biting midges (chironomids), biting midges (ceratopogonids), some caddis and mayflies. Emerging flies can be caught in floating mesh-boxes buoyed up by polystyrene floats and emptied of their contents daily. To catch the flies, they need to be sprayed with dilute alcohol and grasped with tweezers, which can prove extremely difficult. Placing the trap quickly in a large polythene bag increases the efficiency of the operation.

Plankton Netting

Fine-meshed plankton nets can reveal a high diversity and abundance of small, open water, largely transparent, crustacean species. These species range from tiny water fleas and copepods through to quite large predatory species such as *Leptodora* and *Bythotrephes*. An insect, the transparent 'phantom midge' larva also hunts this domain. Plankton communities are readily monitored by standardised plankton net trawls which reveal daily, seasonal and habitat-related cycles of productivity.

Readers who are keen to learn more about freshwater ecology are recommended to join the Freshwater Biological Association (Far Sawrey, Windermere) which publishes a series of excellent and inexpensive identification keys.

Pond Netting

The perimeter of small lakes and ponds can be walked and each homogenous stand of vegetation communities or emergent vegetation can be sampled with a pond net. Surveys of weed beds, muddy, sandy or gravel substrates, leaf litter and open water habitats can be made in this way, catching a wide variety of invertebrate groups. Success is heavily dependent upon the taxa being sampled, the substrate type and the technique of the sampler. Figure 15.7 (below) indicates what you may expect to catch in different parts of the waterbody.

Figure 15.7

Characteristic Communities of Still Water Habitats

Habitat	Community	Notes
Open water	Zooplankton, water beetles, midge pupae, back-swimmers, water boatmen, water striders.	Transparent or hard-bodied fast swimmers, able to avoid predators in open water.
Deep muds	Midge (chironomid) larvae, worms, mussels, silt-crawling mayfly nymphs (Caenis sp).	Burrowers or surface crawlers able to tolerate low dissolved oxygen conditions.
Shallow mud/sand/ gravel	Caddis larvae, mayfly nymphs, snails, alder fly larvae, shrimps, water lice.	Burrowers, cavity-dwellers, crawlers through surface layers.
Weed beds	Dragon and damsel flies, snails, caddis fly larvae, grazing mayfly nymphs, water measurers, water scorpions, other water bugs.	Cryptic plant surface grazers and stalkers.
Outflows	Blackfly larvae, hydras, net-spinning caddis larvae.	Filter feeders living in flowing current.
Reedbeds	Beetles, snails, shrimps, midge larvae, aquatic moth larvae, dragonflies, damselflies.	Dense cover stalkers and detritus-feeders.

15.10 REPTILES

15.10.1 Introduction

There are only six species of reptiles commonly accepted as native in the UK:

- Sand lizard
- Grass snake
- Smooth snake
- Adder
- Slow worm
- Viviparous lizard

This small group of species, represents an important part of the UK biodiversity and as an integral part of UK ecosystems. Adders and smooth snakes feed mainly on small mammals and other reptiles, whereas amphibians and fish form the most frequent prey of grass snakes. Viviparous lizards, sand lizards and slow worms feed mainly on invertebrates such as spiders, insects and earthworms. Reptiles are prey for birds and larger mammals, though they are not significant prey of many wetland bird species.

Reptiles are ectothermic (get their heat from outside their bodies). They have to overwinter in refuges, and may have to "bask" in the sun early in the morning to obtain the correct temperature for activity. Many reptiles are associated with heaths, including wet heaths. However sand lizards and smooth snake, in particular, are often associated with the drier, sandier soils. Reptiles tend to be found in open, undisturbed areas in a variety of habitats including heathland, chalk downland, sand-dunes, disused allotments and embankments or cuttings, rough grassland and golf courses. Reptiles are, however, found in wetlands and the grass snake in particular is associated with water, where it swims and hunts amphibian and fish prey. The life cycles, distribution and ecology of European reptiles and amphibians are described in "Mammals, reptiles & amphibians of Britain and Europe" (Morrison, 1994). Most of the UK's reptiles are declining and monitoring is essential to help identify key sites and areas of particular concern.

15.10.2 Methods

Direct Observation

Reptiles are usually found, in particular microhabitats, at a site termed "hotspots". By concentrating on these areas, surveys are most likely to record any reptiles at a site. This is suitable for a presence or absence study but will not produce an accurate density (number per unit area) or population estimate for a whole site. The following are potential reptile "hotspots":

- Gullies
- Slopes
- Log and rock piles
- Compost heaps
- Piles of grass cuttings
- Boardwalks
- Rides or paths through scrub
- Hedgerow bases
- Dry stone walls
- Fallen trees
- Fences or metal sheets

Grass snakes may be seen swimming in ponds and streams. The hotspots at a site should be searched during March-October; however, the best times for searching are April, May and September, during the morning (8:30am-11:00am) or late afternoon (4:00pm - 6:30pm). Timing depends on air temperature and, therefore, time of year. Reptiles are most easily found in hotspots when the air temperature is between 9-18°C. The best day to go out is a warm hazy day following a cold spell. To locate reptiles, walk slowly and quietly with the sun behind you, looking 3-4m ahead. To establish presence or absence with a combination of tinning (looking under iron sheets) and direct observation, seven visits in appropriate weather should suffice. For more detailed information on population size at least 20 visits per season is recommended by Froglife (1999). In general, the greater the number of visits the better the information.

Using Refuges (Tinning)

Since metals absorb heat, they provide an opportunity for reptiles to warm up while still under cover. Corrugated iron sheets ("tins") can be placed down in set patterns at sites. Checked regularly a pattern of the number of reptiles visiting a site can be identified. However, some animals may never visit refuges and reptile populations, particularly viviparous lizard and grass snake numbers, will be severely underestimated by this method. Combining a visual and tinning search is likely to provide the best estimate of animals at a site. Guidelines for where and how to place refuges are given by Froglife in Advice sheet 10 "Reptiles Survey" (Froglife 1999). For surveying with tins in areas where sand lizards or smooth snakes may be found, a licence must be obtained from the statutory conservation agency.

Legal Protection of Amphibians & Reptiles

In England, Scotland and Wales all amphibians and reptiles are protected by the Wildlife and Countryside Act 1981. It is an offence to deliberately sell, kill or injure any native species. Under the same Act it is also an offence to disturb or take smooth snakes, sand lizards, natterjacks or great crested newts without a licence. In Northern Ireland it is an offence to kill, injure or take viviparous lizards or smooth newt without a licence.

Additional protection is afforded to smooth snakes, sand lizards, natterjacks and great crested newts under the Habitat Regulations 1994. Additional care must be taken when surveying these species. Consult the local statutory conservation authority before surveying for protected species.

Reptile Skins

Reptiles shed their skin periodically, and these shed skins (sloughs) can usually be found by looking for rough vegetation, rocks or wood. Snakes sloughs can provide information on the species, sex size and therefore age. Sloughs of lizard species provide less information as they are easily damaged and break down rapidly. All reptiles shed the outer layer of their skin periodically.

Photo: © Dr Louise Bardsley

Amphibians are important parts of wetland ecosystems

15.11 AMPHIBIANS

15.11.1 Introduction

There are six amphibians commonly accepted as native to the UK:

- Great crested newt - BAP priority species
- Smooth newt
- Palmate newt
- Common frog
- Common toad
- Natterjack toad - BAP priority species

The pool frog, whose status as a native species is under review, is also a BAP priority species. All six of the amphibians listed above have an aquatic larval stage and the adults spend most of their lives on the land. Adult amphibians can be omnivorous but feed mainly on invertebrates such as slugs, flies and beetles. Amphibians are important prey species for many wetland birds, large fish and wetland mammals, including otters. Amphibian larvae also provide food for invertebrates such as dragonflies and beetle larvae. The varied requirements of amphibians needed to complete their life cycles and their central role as both predators and prey make amphibians good environmental indicators.

Natterjacks have the most restricted distribution of the UK amphibians, living mostly on coastal sand-dunes, heaths and grasslands with isolated relic heathland populations inland. Most natterjack sites are recorded in a site register held by the Herpetofauna Conservation Trust (Appendix 4). Other species are widespread and locally common and may be found in suitable habitat anywhere in the UK, except Northern Ireland which has fewer native species than England, Scotland and Wales. Toads tend to live in larger, deeper waterbodies than frogs or great crested newts, the latter preferring shallow, heavily vegetated ponds. These are, however, broad guidelines and amphibians can breed in practically any waterbody. Most amphibian species migrate to their natal pond (where they hatched), in spring to breed. Monitoring activity is, therefore, best focused around breeding ponds. The life cycles, distribution and ecology of UK amphibians are described in Ecology and conservation of amphibians (Beebee,1996). During the breeding season, most of the males and females of the same species develop secondary sexual characteristics which make the sexes easier to identify. This is particularly true for frogs and toads. Amphibian numbers are very prone to fluctuations and general trends are difficult to establish.

Most surveys for amphibians are conducted during the breeding season at the breeding pond. The time of year will be site- and area-specific. In general, the further north-east and the higher in altitude in the UK the later the breeding season of all species. So, breeding seasons for frogs start as early as January in Cornwall but as late as April or even May in Scotland and uplands.

15.11.2 Methods

Direct Counts of Adults

Calls or vocalisations of some toad and frog species can be heard but the numbers calling can be hard to quantify and therefore unlikely to be useful except where access for other survey methods is limited or where only "presence" data is required. Frogs and toads can float on the water surface, sit just at the waters' edge or just below the surface, making them relatively easy to see. All the visible adults can be counted if the surveyor makes a slow circuit of the breeding site with a torch. Direct counts of adult toads or frogs can produce a proportional estimate of the numbers of adults present at a breeding site.

All three newt species show various levels of courtship behaviour; their bright breeding colours making the males in particular relatively easy to spot in the water by torchlight. A circuit of the pond with a torch can be used to detect the presence or absence of newts. Newts can be difficult to see in muddy water and ponds with large amounts of vegetation. Repeated visits and a combination with other methods is often necessary to assess absence with any degree of certainty. The activity of amphibians and therefore their visibility is weather-dependent; visual counts will therefore also be highly weather dependent. An experienced surveyor may be able to make rough estimates of population size from torch counts. However, accurate population estimates require more detailed surveys and a combination of methods.

Spawn or Egg Counts

Common frog spawn is laid in clumps and all the common frogs within a waterbody usually spawn in one small area and within a few days of one another, if not interrupted by inclement weather. Each female common frog lays a single discrete spawn clump. In the first few days after spawning, the clumps are distinguishable and counting the total number of clumps can give an estimate of population size. Natterjack toads lay long strings of eggs in shallow water, which can be counted to give numbers of breeding females and a basic population estimate. Common toads spawn in deeper water, wrapping spawn around vegetation, often several females spawning in the same area. Common toad spawn is therefore often difficult to find and almost impossible to count with any accuracy.

Newt eggs are laid individually and wrapped in vegetation. Counts of newt eggs are hard, but may provide an order of magnitude of the breeding population size. Laying artificial egg strips may provide a simple way of detecting presence or absence which is particularly useful in ponds where visibility is reduced by turbidity or vegetation.

Netting

Using a sweep net in a standard way in heavily vegetated ponds may help detect the presence of newts. This method is disrupted and less reliable than torching or bottle trapping. An additional worry is the risk of spreading invasive plant species on nets. This method may allow tadpoles of frogs and toads to be detected after the adults have left the pond. However, it should not be used alone as a method of detecting presence of a species.

Bottle Trapping

Soft drinks bottles can be turned into traps. Adult newts, larval newts, toads and frogs can be caught by this method. Traps must be checked every day and must be set carefully to avoid the risk of adult newts drowning or adults eating the larvae! If great crested newts may be caught, a licence must be obtained from the relevant statutory conservation organisation (CCW, EN, EA).

More Detailed Studies

Information on ecology, movements, population structure and size can be determined by detailed studies, often involving mark, release and recapture. These usually require marking of individuals by any one of a range of methods, including:

- dye marking (Pan-jets)
- toe clipping
- passive Integrated Transponder tags (PIT)
- radio transmitters
- natural marking such as newt belly patterns

It is very difficult to establish age from size after sexual maturity so measurements of population age structure are difficult.

15.12 Freshwater Fish

15.12.1 Introduction

Freshwater fish are important components of wetland communities. Rarer species such as shads, whitefish, charr and lampreys have high conservation value. Common species (such as eels, roach, common bream, minnows) are often important food items for aquatic birds and mammals. An indication of a self-sustaining population is given by the occurrence of fish over long periods without artificial stocking. Self-sustaining fish stocks rely on good habitat quality including water quality, water quantity and appropriate physical habitats. Clear-watered weedy lakes can support thriving rudd, perch or trout stocks and such waters are often much more valuable in conservation terms than turbid waters devoid of submerged weed beds. This latter category of still water has often been intensively stocked with common carp or bream.

Fish are not easily monitored as they are usually out of sight underwater and may be difficult to catch with nets or other equipment. Whether a river or still water has a high, medium or low fish stock abundance is often difficult to assess. Indirect indicators can also be used to give broadscale indications of fish population size. Weed growth, typical water clarity and benthic macroinvertebrate abundance can all provide important clues on still waters.

Where it is essential to establish what order of fish abundance is present, only a specialised fishery survey will do and this is generally a job for experts. Since fish can have a high conservation and/or commercial value, some species are regularly surveyed by for instance, Environment Agency staff.

Fisheries surveys can be important on a number of fronts, for instance:

- monitoring populations of rare and endangered species to aid conservation
- assessing stock abundance of exploited species to facilitate fisheries management
- use as indicators of habitat health or habitat change
- use to establish balances between commercial and wildlife interests

Any single 'snapshot' of fish community structure and species abundance is, of course, of limited value as stocks fluctuate in abundance. Though these snapshots can give you an idea of the fish numbers and population distribution, they reveal little about the long-term trends in population size. Ideally, long-term catch data should be analysed wherever possible to give insights into probable trends in fish numbers on a given waterway or waterbody. Many fish species school to form shoals, leading to very variable catch statistics, dependent upon catching the whole shoal, part or none of it. Interpretation of catch statistics of shoaling fish can, therefore, be difficult. Some species tend to cruise in open water and are readily netted (roach, bream) while others lurk singly or in small shoals around sunken branches and weed beds (perch, pike, carp, tench) and can be very difficult to capture quantitatively.

A great deal of fish monitoring work is carried out each year, to check the abundance of both salmonid and coarse fish stocks. Common techniques include netting of still waters and the electric fishing of flowing waters. Most of the work is carried out by the Environment Agency in England and Wales, private fishery managers, Scottish River Boards, biologists from River Trusts and by consultants. The following monitoring techniques are tried and tested; many require specialist equipment and operator skills if they are to produce reliable results.

Photo: © Dr Nick Giles

Monitoring brown trout is important for conservation and commercial reasons.

15.12.2 Methods - Still waters

Seine Netting

A seine net is a vertical wall of netting with a top float line, a bottom lead line and a rope at either end. Some large seines have a bag in the centre to collect the catch. The net is usually set from a rowing boat (a 'coble') in a 'U' shape and then pulled slowly back to the shore, ideally with the lead line just brushing the bottom and with the floats on the surface. The ideal net for a given lake needs to be around 1.5 times the deepest water to maximise the chances of catching the fish.

Species such as carp and tench are very good at burrowing under the lead line on soft-bedded lakes and escaping. Trout, carp and pike often leap over the float line to evade capture. Eels simply dive into the mud and are uncatchable! Sunken trees and other obstacles can make seine netting very inefficient and it pays to have a SCUBA diver on hand to untangle the net in unfamiliar waters.

The overall populations of various fish species can be roughly estimated from the decline in a series of successive catches. Sub-sampling (species, lengths, weights, scales for ageing) provides very useful data for analysis of age structure, breeding success and growth. If done carefully, seine netting and electric fishing cause fish little damage - an important consideration.

Gill Netting

Gill nets are made of fine transparent nylon monofilament meshes which fish swim into and get tangled in by their heads/gill covers. Gill nets have a top float line and a bottom lead line and are usually fished in 'gangs' - series of varying mesh size to catch differing sizes and species of fish. Most fish are caught in gill nets set on lake or river beds overnight.

Gill netting can be very efficient in terms of manpower (just one person can set many nets). Gill netting is, however, very destructive of fish stocks because many fish suffocate in the net and even those caught alive are difficult to disentangle without causing them terminal damage (split fins, scales rubbed off, cuts and abrasions). Salmon and sea trout are often poached from rivers with gill nets - the effects can be devastating if a large run of fish is intercepted on its way upstream to spawn.

Where a brief initial fisheries survey of a large lake is required, small-scale gill netting operations may well be a good way of obtaining some quick data. Fish caught can be used for analysis of diet, growth, age, condition factor (weight for length) and other characteristics. Sometimes the catch is good to eat and is not wasted.

Trawling

Small trawls can be towed behind slowly moving motor vessels on large lakes and slow-flowing rivers. Trawling can catch a variety of species, including eels, and is of value for surveys of clean-bedded waters where appropriate boats are available.

Eels and Elver Fishing

Fyke nets have vertical mesh walls which lead fish into a series of mesh cones down into a final chamber from which they are unlikely to escape. Fyke nets are generally used along lake shores or river banks, usually to catch yellow (maturing) or silver (mature, down stream-migrating) eels which are then sold for consumption. Dip nets are simply long-handled, large fine-meshed 'pond nets', used in estuaries and lower river stretches to dip out elvers (young eels migrating in from the sea) on their springtime upstream migration. Fyke nets should be fitted with otter guards which reduce the risk of otters accidentally being trapped within nets.

SONAR Techniques

Sophisticated echo-sounding equipment is now available for the cost-effective monitoring of fish stocks in very large lakes and rivers where methods to actually catch fish are very inefficient. Difficulties of interpretation (which fish species the echoes are coming from) can cause problems but, on the positive side, miles of water can be rapidly scanned and the results analysed directly by computer and shown on a screen or printed out without the need to actually catch a single fish.

Trapping

Mesh fish traps with cone-shaped or slit entrances are occasionally used to catch freshwater fish such as perch, pike or eels. Their use is generally for research purposes as they are inefficient and expensive.

Analysis of Angling Catch Data

Where anglers record their catches from fishing matches (competitions) and have done so on a given fishery for a number of years, the data can be analysed to look for trends in fish abundance. It is usual to relate catches to the numbers of people fishing (fishing effort) to calculate 'Catch Per Unit Effort' or CPUE which is a useful index of actual fish abundance.

Where records of commercial fish netting (eg for salmon, sea trout or eels) are available, these can be analysed to produce valuable CPUE data and long-term trends in indices of fish abundance. When carefully corrected for errors, such analyses may often give a correct impression of actual fluctuations in fish abundance. Mark-Release-Recapture experiments, when carefully carried out; can allow population estimates for still waters, including very large lakes.

Figure 15.8

Relative Merits of Fish Trapping Methods

	Gill-netting	Trapping	Seine-netting	Sonar
Capital costs	LOW	MEDIUM	HIGH	VERY HIGH
Running costs	LOW	LOW	LOW	HIGH
Expertise needed	LOW	MEDIUM	MEDIUM	HIGH
Usefulness for assessing fish community structure	HIGH	LOW	MEDIUM	MEDIUM
Accuracy for assessing fish stock abundance	LOW	LOW	MEDIUM	MEDIUM

15.12.3 Methods - Running waters

Visual Observations

In small streams many fish are quite visible (minnows, trout, grayling, pike) or can be revealed by the careful turning over of stones (bullheads, stone loach, crayfish) and such observations can be sufficient to derive maps of species distribution and broad indications of abundance (frequent, occasional, rare).

Hand Netting

Pond nets pushed through marginal silt beds can be used to catch eels and lamprey larvae (ammocoetes), giving, at least, presence or absence data. Nets pushed quickly through weed beds can catch large numbers of smaller species such as minnows, sticklebacks and the fry of roach, perch, bream, rudd, etc.

Electric Fishing

On most flowing waters and on some shallow lakes, electric fishing is accepted as the standard method to catch fish. A generator is used to produce Alternating Current (AC) which is then rectified to Direct Current (DC) and pulsed through the water at carefully defined frequencies between hand-held anodes and a static cathode. Fish are attracted towards the anode (so-called 'galvanotaxis') and are then stunned and can be netted out.

As long as the current strength is kept low and the fish are not subjected to repeated shocks, recovery in a tub of water is rapid, survival is good and damage is minimal. Beware, however, as operators of old-fashioned equipment or people who do not understand what they are doing can end up killing or injuring many fish and/or themselves.

Electric fishing surveys, when carried out properly, can provide very accurate estimates of the abundance of most species of freshwater fish. Small streams are most readily sampled between stop nets to contain a given stretch of water. On larger or weedy rivers, the efficiency of electric fishing rapidly drops away. In shallow lakes, areas can be sequentially netted off and electric-fished to provide reasonable indications of the abundance of fish present, although seine-netting is usually the preferred approach.

Note

In England and Wales, written permission must be obtained from the Environment Agency before any electric-fishing or netting operations are carried out. In Scotland, contact the local District Salmon Fisheries Board; in Northern Ireland, the Rivers Agency will be able to provide advice.

Figure 15.9
Relative Merits of Methods to Catch Fish in Running Waters

	Electric fishing	Hand netting	Bank side observations	Analysis of catch statistics	Electronic counters	Traps
Capital costs	MEDIUM	LOW	LOW	LOW	VERY HIGH	MEDIUM
Running costs	LOW	LOW	LOW	MEDIUM (including collecting data)	HIGH	MEDIUM
Expertise needed	HIGH	LOW	MEDIUM	MEDIUM	HIGH	MEDIUM
Usefulness for assessing fish community structure	HIGH	LOW	LOW	MEDIUM	LOW	LOW
Accuracy for assessing fish stock abundance	HIGH	LOW	LOW	MEDIUM	HIGH mobile species	LOW

Fish Counters and Traps

A few salmon rivers are equipped with electronic counters which sense fish movements as they pass over electrodes embedded in a weir structure. Some counters also video passing fish allowing species (salmon/sea trout) to be identified and sizes of fish to be assessed.

A very few rivers systems have trapping stations built into them for research or commercial exploitation reasons. Traps are, however, relatively inefficient and so are little used for routine fish monitoring. Examples of commerical traps include eel screens which catch downstream-migrating silver eels in autumn or ranks of static cone-shaped 'putchers' which catch salmon and other species in estuaries such as that of the River Severn. Research fish traps include salmon and sea trout funnel cages or grids which allow upstream-migrating adults to be caught for egg and milt-stripping procedures. The fertilised eggs are reared in hatcheries/fish farms. Smolt traps which catch downstream-migrating smolts on their way to sea are set up for research purposes on a few rivers.

Photo: © Dr Nick Giles

Electic fishing can provide useful point estimates of fish populations.

15.13 BIRDS

15.13.1 Introduction

Birds are an important part of all wetland ecosystems in the United Kingdom and are conserved via both domestic (eg Wildlife & Countryside Act) and European legislation (Birds Directive). UK wetland birds of high conservation value include the species listed in figure 15.11. Birds are often used as biological indicators of environmental quality because:

- many species are readily seen and identified
- some species are top of food-chains, acting as bioaccumulators of persistent pollutants (PCBs, etc)
- all species are important contributors to ecosystem functioning and some are very sensitive to pollution and disturbance

Birds are among the most well recorded species in this country, most species are simple to identify by volunteers, appealing and with lots of interest, having major charities devoted to their conservation (RSPB, BTO, WWT).

For more than 50 years the Wetland Birds Survey (WeBS) has used a nationally coordinated synchronised system of volunteer-based monthly winter counts. In 2000, 3,000 volunteers contributed to the effort of counting all UK sites. The total numbers of water birds wintering on a standard series of estuaries, reservoirs, gravel-pits and large natural lakes are estimated from these counts and the long run of data now available means that quite subtle trends in abundance can be established. The WeBS data-set is, therefore, increasingly valuable for the detection of changes in waterfowl conservation status.

Common Bird Census (CBC) is another long-running volunteer-based survey of birds, in this case breeding birds of woodland and open countryside (farmland) habitats, carried out by BTO members. Breeding adult birds tend to be faithful to sites year-on-year and so the monitoring of a given area builds up a picture of the pattern of abundance and habitat use of a localised bird community. The CBC usually includes 200-300, 40-60ha sites each year and a total of around 40,000 bird territories. All bird territories are mapped and the BTO has selected the 75 commonest species for the calculation of year-to-year population indices. Almost always, however, only an unknown proportion of the overall population can be counted or heard at any one time and so only fragmentary data are collected. Some birds are more easily seen or heard than others and the ensuing data should not be taken simply at face value - they need inspection and interpretation plus the application of appropriate statistical techniques. CBC data are thus carefully analysed and co-ordinated by the British Trust for Ornithology (BTO) and WeBS winter wildfowl counts by the Wildfowl & Wetlands Trust (WWT), BTO, RSPB, and Joint Nature Conservation Committee (JNCC).

These surveys are useful as they can be extremely valuable, both at a local level, for instance for the designation of SSSIs, and at National level for assessment of population trends in British birds.

15.13.2 Methods

Common Bird Census (CBC)

A skilled field ornithologist familiar with bird songs visits a given site around 10 times each year, listening and noting on a large-scale map the locations of singing males of a given species. Each species has its own map. Gradually, a pattern of territories emerges and an estimate of the breeding pairs of birds present is obtained. The data can be used as total counts or densities, and/or can be related to habitat differences to help understand the preferred breeding areas for given species. When this is understood, active habitat management can be undertaken to try and improve conditions for the target species on wildlife reserves.

Despite the immense value of CBC data and the vital insights which the Survey has given us on breeding bird abundance, the system is now considered rather cumbersome and out-dated. The complexities of the CBC are to be superceded by a line transect approach currently under development by BTO. The new survey is known as the UK Breeding Bird Survey (BBS).

Figure 15.10

Statutory Protection for Birds in the UK

COMMON NAME	LATIN NAME	CONSERVATION STATUS
Red-throated Diver Black-throated Diver Great Northern Diver Bittern Slavonian grebe Little Bittern Bewick's Swan Marsh Harrier Osprey Spotted crake Crane Avocet Wood Sandpiper Red-necked Phalarope	*Gavia stellata* *Gavia arctica* *Gavia immer* *Botaurus stellaris* *Podiceps auritus* *Ixobrychus minutus* *Cygnus columbianus bewickii* *Circus aeruginosus* *Pandion haliaetus* *Porzana porzana* *Grus grus* *Recurvirostra avosetta* *Tringa glareola* *Phalaropus lobatus*	Schedule 1 WACA 1981 Annex 1 EC Birds Directive
Red-necked grebe Black-necked grebe Greenshank Cetti's Warbler Savi's Warbler Marsh Warbler Bearded Tit	*Podiceps grisegena* *Podiceps nigricollis* *Tringa nebularia* *Cettia cetti* *Locustella luscinioides* *Acrocephalus palustris* *Panurus biarmicus*	Schedule 1 WACA 1981 EC Birds Directive
Bean Goose	*Anser fabilis*	Schedule 1 WACA 1981 Annex II/1 EC Birds Directive
Black-tailed Godwit Redshank	*Limosa limosa* *Tringa totanus*	Schedule 1 WACA 1981 Annex II/2 EC Birds Directive
Pink-footed Goose	*Anser brachyrhynchos*	Schedule 2 WACA 1981 Annex 1 EC Birds Directive
Barnacle Goose	*Branta leucopsis*	Protected under WACA 1981 Annex 1 EC Birds Directive

After Batten *et al* 1990

Mist-netting

Birds can be caught early in the morning in spring and summer in fine-meshed 'mist' nets and, when the effort is standardised, 'constant effort sites' can be established. Several (12, or more) visits are needed to establish the local song bird population in a given area and standard samples are obtained year-on-year by using similar sized and located nets, set at well defined periods.

Data on sex, age, body condition (weight) and young-to-old ratios as well as overall abundance of the various species can be obtained and birds ringed. Ringing returns are, of course, very useful ultimately for estimates of longevity, survival rates and migratory routes. Only workers holding a valid BTO ringing licence can legally ring birds in the UK.

Transects

Rather than searching a given area for singing males, transects of habitat can be walked and all birds seen using the habitat or heard can be recorded. Such data can yield density estimates when corrected for distances from the transect line at which birds can be identified. Double counting should, if at all possible, be avoided. This technique is very useful for monitoring both open and linear habitats using, for instance, wet grassland, willow carr or lake shoreline reedbeds for feeding or nesting.

Rarer Species

Figure 15.12 summarises data typically collected to monitor wetland bird populations of high conservation interest.

Figure 15.11

Survey Methods for Selected Groups of Birds

Species Group	Data Typically Collected
Grebes, Divers	Sightings of number of breeding pairs, numbers of non-breeding adults, fledged young per pair.
Geese, Swans	Total birds in winter flocks, young-to-old ratios.
Marsh Harrier	Probable and actual number of breeding pairs, number of fledged young seen.
Bittern	Number of booming male bitterns heard.
Kingfisher	Number of occupied territories.
Ruddy duck (for control purposes)	Number of breeding pairs and fledged young seen.
Herons	Numbers of nests in heronry, numbers of fledged young.
Wading birds	Numbers of nests, numbers of fledged young seen.
Warblers, Bearded tits and other small reedbed birds	Numbers of territorial males singing - CBC approach. Visibility of small birds in reedbeds is rather low!

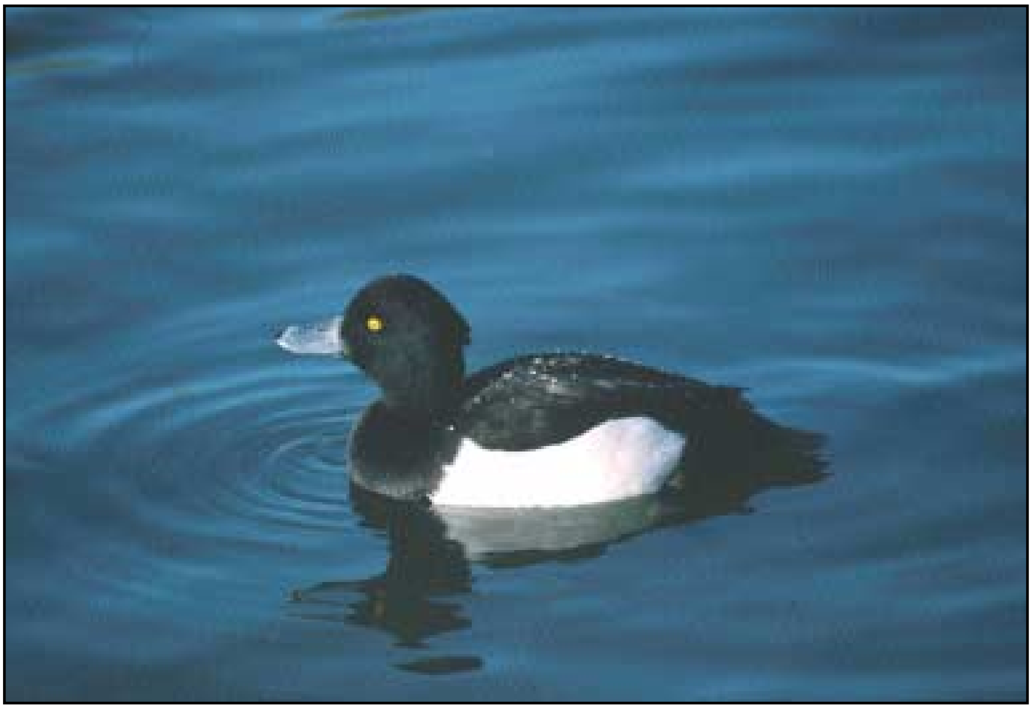


Photo: © Derek Moore OBE

Huge flocks of waterfowl can provide spectacular sights on water and wetlands.

15.14 MAMMAL MONITORING

15.14.1 Semi-aquatic Mammals - Introduction

There are three semi-aquatic mammals native to the UK. These are, in descending order of size, the:

- otter
- water vole
- water shrew

All three have adaptations to allow them to survive in water, as well as on land.

The otter is a mustelid and at just over a metre from nose to tail when adult is a similar size to a badger, although the latter is shorter and slightly heavier. Otters inhabit a variety of wetlands, rivers, small streams, canals, lakes, and coastal wetlands. They can also travel large distances across land between watersheds (one documented report followed an otter across land for six miles) (Woodroffe, 1994).

Otter diets are variable but usually consist mainly of fish (75-85 per cent). Otters also feed on amphibians, small mammals and birds, the relative proportions depending on the time of year and availability of prey (Woodroffe, 1994). Otters can be active during the day, but are mainly active at night especially around dawn and dusk. An anal scent gland allows otters to communicate their presence to other otters through their droppings (spraints).

Otter populations suffered a serious decline in numbers during the middle of the last century. Conservation projects throughout the UK have contributed to the return of otters in recent decades across much of the UK. Ireland, Scotland, Wales and south-west England are strongholds, with the Midlands and the central south of England being the last areas to have otters return to in numbers.

One key project aimed at otter conservation was The Wildlife Trusts' Otters and Rivers Project, which began in 1989 as a continuation of the work of the Vincent Wildlife Trust. The first three national otter surveys were carried out by the Vincent Wildlife Trust. The Wildlife Trusts' Otters and Rivers Project Officers have undertaken the fourth in conjunction with the Environment Agency. The results are due to be published 2001.

Until the end of the last century, the water vole was common throughout most of the UK, but was absent from Ireland and north-west Scotland. Two surveys in 1989-1990 and 1996-1998 have shown that this species has undergone a catastrophic population crash, with reductions in both range and population size (Strachan *et al*, 2000). The slow decline attributable to habitat destruction during the greater part of the 20th century has been greatly accelerated by the establishment of the American mink on many river catchments. Mink are able to predate water voles, causing local extinction along river stretches, especially with little cover.

Water voles are active both day and night, all year long; however, above ground activity is greatly restricted in the winter months. Water voles breed from April to October. During the breeding season, females become very territorial and mark their territory with scented latrines along the banks where they live. During winter, most time is spent below ground in burrows, sometimes communally.

Water voles are predominantly vegetarians, preferring the lusher grasses such as reed canary-grass, common reed and reed sweet-grass during summer and roots and rhizomes during winter. On the Continent, water voles sometimes live completely underground in a similar way to moles. Water voles are mainly associated with waterways in the UK, including slow flowing rivers, canals, lakes, ponds and wetlands. They are sometimes mistaken for the similar sized brown rats, but the water vole has a rounder snout and less conspicuous ears.

Water shrews are the smallest and least studied of the three UK semi-aquatic mammals. They weigh up to 18g and are common throughout most of mainland UK, but are not present in Ireland. As they are small and live in burrows, sightings of these creatures are rare, although the black back and pale underbelly, coupled with their greater size compared to other shrews, makes them very distinctive. They do have home ranges, but tend to be nomadic by shifting these ranges every few months (Corbet & Harris, 1991).

As insectivores they have similar diets to other shrews, but specialise in aquatic prey, such as freshwater hog louse, freshwater shrimp and cased caddis larvae, which makes up half of their diet. They breed from April until September. Shrews may be active during the day but are most active at night.

15.14.2 Methods of Surveying Semi-aquatic Mammals

These survey techniques can positively prove that the animals are present at a site, but cannot prove that they are not using the site.

Otters

As sightings of these wide-ranging animals are rare, field signs are the best way of establishing the presence of otters. The main field signs used for identifying their presence are:

- feeding remains
- footprints
- spraints (faeces)
- anal gel (the secretion from the anal scent gland)

Extensive field experience is required to accurately identify feeding remains. Field signs of otters are described in Chanin, 1993. Surveys for otters can be undertaken throughout the year. The five toed, semi-webbed, rounded feet of otters are easily distinguished from dogs, badgers and mink. However, spraints, and to a lesser degree anal gel, are the most reliable field-sign of an otter.

As spraints are used as a means of communication between otters they are put in obvious places or on distinctive features, such as the saddle of a tree, on logs, rocks or ledges under bridges. Where such obvious features do not exist, the otter piles up material into sign-piles, and spraints upon these.

The National Otter Survey (NOS) methodology uses a 600m sample of single bank to find signs, examining all the appropriate features. The stretch is marked onto a map with grid reference, scale and the bank that was surveyed indicated to allow future workers to identify the exact stretch surveyed. Spraint sites are noted on this or a detailed map of part of the site, but habitat features are covered in note form (Strachan & Jeffries, 1996).

These surveys are conducted at 5km intervals along each waterway, making approximately six sites per 10km square. The NOS methodology is appropriate for a county or regional surveys, but for development surveys it is best to survey at least a kilometre up and downstream of the development site. It is most important to check the area for holt sites (breeding dens). These are difficult to identify, so contacting. A local Wildlife Trust is recommended. Otter surveys can be conducted at any time of the year but high river flows can mask signs, making surveying less reliable.

Water Shrew

Water shrews exhibit some territoriality, marking ranges with scent (males only) and droppings. However, as they frequently shift their home ranges it makes population estimation difficult. The small size of the droppings, at 4-5 mm, adds to the difficulty. Next to water courses the scats (droppings) can easily be identified from other shrews by the presence of aquatic invertebrate remains in them.

An accepted method of surveying is using baited tubes to identify the presence of shrews (Churchfield, 1985). Plastic tubes of 40mm diameter cut into 20cm lengths with one end covered by muslin are used. The open end should be flush to the ground and the tube should be baited with casters (maggot crysalises available from fishing shops as bait). This is left on site for at least a week and then examined for scats at the end. Since the animals are not captured or handled, this is a none invasive form of survey (Sarah Churchfield, *Pers comm*).

Other field signs include the burrow entrance, usually 2cm across with no disturbance to the surrounding vegetation, and feeding remains. Water shrews eat their aquatic prey on the river bank, often leaving distinct piles of caddisfly larvae cases and mollusc shells (Corbet & Harris, 1991).

Water Voles

Surveying for water voles involves more work than otter surveys. Water voles produce distinctive feeding remains, footprints and droppings, but unlike otters, these tend to be found beneath vegetation within a few centimetres of the water line and so can be harder to locate. Water vole burrows are 4-8cm in diameter and have no spoil piles, as they are usually excavated from the waterside. Rat burrows have spoil outside the entrance, usually covered by tapered droppings.

Surveys should be conducted during the breeding season (April to October), at which time there tends to be plenty of emergent vegetation. The feeding remains from these are distinctive, with leftover stems in neat piles, all of similar lengths with an oblique cut across them. This is similar to other vole signs, but substantially larger, tending to be from thicker vegetation and 8-10cm in length (small voles leave stems only 3-6cm long) (Strachan, 1997).

The footprints are difficult to distinguish from a brown rat's, but the droppings are easily identified. These are about 10mm long, cylindrical with rounded ends. As the scent gland is located on the flank of the animal, when scent marking they beat their feet on the ground, usually over old droppings, before depositing more droppings there. These piles of flattened droppings are known as latrines and act as territory markers. Breeding females have on average six latrines each, so an intensive survey of a stretch of waterway can produce a rough estimate of population based on the number of breeding females present.

Detailed surveys should be plotted onto a map for each 600m section of watercourse surveyed, which should also give some idea of vegetation coverage. A separate sheet on the physical make-up of the watercourse, land use and other wildlife is usually taken to provide additional information (Strachan & Jeffries, 1993). From this mapping procedure, it is possible to identify individual colonies, or even individual territories.

More detailed surveys can be carried out using mark and release methods, or radio tracking individuals using radio collars. The marking would range from simple dye marking and fur clipping up to the more complex tattooing or transponder tags to identify individuals.

The survey is simple along river and canal banks where the habitat is linear, but becomes more complex in wetlands, such as reedbeds. In these situations water voles may leave signs on floating rafts of vegetation. In partially dry reedbeds territories are difficult to determine, as signs are on top of vegetation, linked by small pathways where droppings can be found. A further complication is on winterbournes where, as the water-levels drop, the water voles tend to leave signs on top of the lush vegetation in the centre of the channel rather than along the banks (Satinet, 1998).

Photo: © Lyndon Hill

The water vole is rapidly declining. Monitoring of the remaining populations can help conserve this once common mammal.

15.4.3 Bats - Introduction

These fascinating and little known mammals are important components of a variety of wetland systems. Various bat species roost and or feed around rivers, streams, marshes and still waters. Often, aquatic insects hatching as adults (caddisflies, chironomid midges, mayflies, etc) provide an evening feast for these sophisticated nocturnal predators. All British bats are a protected species (WACA 1981, EU 'Habitats Directive', Schedule 2) and knowledge of their distribution and abundance is, therefore, crucial to their successful conservation.

Unfortunately, bats tend to hide away in dark daytime roosts and winter hibernating places and only venture out at dusk when they fly fast and erratically and so are difficult to identify to species by eye. Fortunately, 'bat detectors' (ultra-sonic receivers) can pick up their high-pitched sonar squeaks allowing identification of species by expert listeners. Enthusiastic amateurs can make valuable contributions by watching bat roosts and feeding areas - The Bat Conservation Trust (Phone: 0171 627 2629) provides useful information.

15.4.4 Bats - Methods

General Observations

Most bat species need further basic research work and so all projects, if well designed, are likely to yield worthwhile information. Most studies are based around estimates of numbers of bats leaving colonies around dusk and, with suitable licences, counts of roosting bats in colonies (bridge, culvert, cave or mine sites or lofts of old buildings are often used). Note that any disturbance or handling/catching of bats requires licencing from EN/CCW/SNH. Bats form nursery colonies where females brood offspring - colonies of a given species may move around an area from time to time and this makes the estimation of local population sizes very difficult.

Males tend to roost separately, visiting female roosts in autumn for mating purposes. Females store the sperm over-winter, allowing eggs to be fertilised early the following spring. Bats usually have only one offspring per year and can live for 20 years or more - these vulnerable animals therefore have limited ability to build up numbers quickly and are liable to population declines under adverse conditions. Bats tend to use traditional roosts and so are also vulnerable to changes in local conditions - for instance, the sealing of openings, demolition of old structures or felling of rotten trees. Bat roosts are legally protected and this helps their conservation. The relatively warm southern English counties have 15 bat species while only three or four are able to brave northern mainland Scotland. Ireland currently has eight or nine species of bat.

Roost Exit Counts

By watching a roost site regularly (usually in June with three or four weekly counts) it is sometimes possible to count bats emerging to feed at dusk. Standardised counting procedures allow the estimation of an index of population size and such measures can be compared year-on-year to gauge trends in abundance. Remember, of course, that bats will come and go, so gaining an accurate count really requires subtracting returning numbers from those seen leaving. Also, many roosts have more than one entrance/exit! A further key problem is that thriving bat colonies give rise to emigrations of small groups which found new colonies. Clearly, to gain a real insight into the population dynamics of a species, it will be necessary to find and monitor new colonies as well as watching existing ones. This is a tall order and, save for the well studied rarer species, it is probable that little is really known about the ways in which bat populations fluctuate in response to environmental change. This is an important new area for research.

Winter Hibernation Site Counts

During hibernation, bats live on their fat stores, allowing their body temperature to drop close to that of the environment, slowing their metabolism and making their food reserves last as long as possible. Disturbing hibernating bats may force them into activity during adverse weather, weakening them in the process. Licensed workers can, however, visit hibernation sites (usually three or four times each winter) to assess numbers of bats. Great care is needed not to disturb hibernating animals. It is often the case that more than one species will be present and so correct identification is crucial if good data are to be collected. Warm weather will mean that many bats may have woken up to go foraging while hard frosts can give rise to sudden influxes of animals seeking shelter. Clearly, the accurate interpretation of counts is fraught with difficulties.

'Bat Detectors'

Bat detectors allow us to hear the species-specific clicks and squeaks which bats use to echo-locate flying insect prey. By setting up a regular transect in good feeding habitat it is possible to collect data on foraging times and numbers/species of bats frequenting a given area. Enthusiastic beginners can obtain information on bat calls and reception equipment from The Bat Conservation Trust.

Figure 15.12
Key Bat Species : Where and When You Can Expect to Find Them

NAME (Common) Size and Wingspan	WHERE (Usual) & Key Food	HABITAT NOTES
Greater horseshoe Length 5.6-6.8cm Wingspan 33-39cm	South-west/southern England & Wales. Food - beetles, moths & tipulids .	Steep south-facing coasts, mixed deciduous woodland, permanent pasture.
Lesser horseshoe Length 3.5-3.9cm Wingspan 22-25cm	South-west England, Wales, west of Ireland. Food - moths, caddisflies, lacewings, beetles.	Sheltered valleys with mixed deciduous woodland.
Barbastelle Length 4-5.2cm Wingspan 24.5-28cm	Central/southern England. Food - flies and other insects.	Wooded river valleys.
Brown long-eared bat Length 3.7-4.8cm Wingspan 23-28cm	Whole British Isles Food - moths, beetles, caddisflies & other flies.	Lightly-wooded sheltered valleys.
Grey long-eared bat Length 4-5.2 cm Wingspan 25-30 cm	Central southern England Food - moths, beetles, flies.	Cultivated lowland areas, roosting in house lofts.
Pipistrelle Length Length 3.5-4.5cm Wingspan 19-25cm	Whole British Isles Food - mayflies, caddisflies & other insects.	Many habitats including marshes and lakes.
Leisler's bat Length 5.4-6.4cm Wingspan 28-34cm	Central England and all Ireland Food - large flies & moths.	Hole-roosting forest bat.
Noctule Length 7-8.2cm Wingspan 33-45cm	Whole of England Food - crickets, large beetles and flies.	A tree bat roosting in holes, and in woodland.
Serotine Length 6-8cm Wingspan 32-38cm	Southern England Food - large beetles, moths, & flies.	Open, flat pasture and parkland.
Mouse-eared bat Length 6.5-8cm Wingspan 36-45cm	Sussex only - probably now extinct in UK. Food - larger moths & beetles.	Open, lightly- wooded country.
Bechstein's bat Length 4.3-5cm Wingspan 25-30cm	Central southern England Food - moths, flies.	Forest habitats.
Natterer's bat Length 4-5cm Wingspan 25-30cm	All British Isles except Hebrides. Food - moths, caddis flies & beetles.	Woodlands, parkland, river valleys, lake sides.
Daubenton's bat	Whole of British Isles Food - caddis flies, midges.	Wooded areas close to water.
Whiskered bat Length 3.5-4.8cm Wingspan 21-24cm	Whole of England, Wales & Ireland Food - small insects & spiders	Wooded areas and open country often near water.
Brandt's bat Length 3.7-4.8cm Wingspan 21-25cm	England Food - insufficient data	Wooded country roosting in caves.