Part I • Planning

1 • Introduction to planning

1.1 THE PURPOSE OF SURVEYING AND MONITORING

The development of a successful programme is dependent upon being clear about what you want to do and why, i.e. your objectives. It is therefore important to define what monitoring is and how surveys relate to monitoring. Survey and monitoring is undertaken for a wide range of objectives: for example, to measure a site's quality, or a species' abundance, to assess species and habitat trends, for Environmental Impact Assessment (EIA) studies, for corporate reporting, or to assess compliance with international conservation agreements. These operate at many different spatial scales and therefore necessitate targeted methods for different applications, objectives and deliverables. The significance and global importance of monitoring nature conservation is aptly summarised in Appendix 1, which describes the monitoring and reporting obligations under international conservation agreements as an example of the far-reaching implications of the need to use adequate methods.

1.1.1 General objectives of surveying and monitoring

For the purposes of Environmental Impact Assessment (EIA) studies, the term 'survey' defines the collection of spatial and/or temporal data about a species, a community or a habitat. The information provides a snapshot of presence, absence and, dependent on its design and sophistication, abundance and spatial distribution. In EIA studies the survey data are used to evaluate the ecological resource on a site, which is then assessed or evaluated against set agreed criteria. Impacts are considered in respect of this resource and assessed for significance. Parts II and III of this *Handbook* describe specific survey methods for habitats and the full range of species from lower plants to mammals. However, for some studies, particularly in relation to testing the effects of macroenvironmental policy changes at a large spatial scale, actual monitoring is performed. The emphasis in Part I of this *Handbook* is the design of data collection and the analytical treatment of the data collected. Much of Part I therefore considers the planning, design and implementation of survey and monitoring, the latter often comprising a series of replicated surveys using standard methods.

Once the data have been collected they will need to be used for a specific purpose. One of the most important uses is to evaluate a site, species, community, habitat, region, etc. Part I therefore includes a section on generic approaches to evaluation of biodiversity data, with more specific treatment for habitats and species given in the relevant sections of Parts II and III.

As with monitoring, it is essential at the outset of a survey to define objectives. A project may not meet its full potential unless the aims are properly understood and researched before data collection begins. Before planning your survey methods, consider the variety of possible scenarios that could dictate your project's fieldwork techniques. Do the results need to apply to one site or to a wide geographical area? Are many species involved or just one? Are accurate counts needed (spatially referenced) or will relative counts or presence–absence data suffice? Answers to these questions will determine the time commitments required and hence cost. In general terms, surveys conducted for EIA studies should aim to provide information on the following.

- What species and habitats occur (= the resource)?
- Where do they occur?
- How many of them are there or how much of the habitat is there?
- How does this amount of the resource relate to that existing in the wider area/biogeographical region?
- What are the seasonal changes and when is the most susceptible or sensitive period for these species/habitats?

Monitoring is often loosely regarded as a programme of repeated surveys in which qualitative or quantitative observations are made, usually by means of a standardised procedure. However, by itself this is merely surveillance as there is no preconception of what the findings ought to be. Monitoring can be more rigorously defined as 'intermittent (regular or irregular) surveillance undertaken to determine the extent of compliance with a predetermined standard or the degree of deviation from an expected norm' (Hellawell, 1991) . In this context, a standard can be a baseline position (e.g. maintenance of the existing area of a particular habitat or population of a particular species) or a position set as an objective (e.g. maintenance of more than 200 ha of a desired habitat or more than 200 individuals of a desired species).

Thus, whereas surveys and surveillance are to a large extent open-ended, a monitoring programme has a specific purpose that requires the standard to be defined or formulated in advance. This requires the identification of interest *features* (e.g. various habitats and species), their *attributes* (e.g. area, numbers, structure and reproductive success) and their target state, i.e. the *standard* that is to be monitored (see Glossary for detailed definitions of monitoring terms). Monitoring for conservation purposes should be closely linked to site management and should test whether conservation and management objectives have been achieved, as outlined in Figure 1.1.

The monitoring programme and methods chosen must be *focused and fit for their purpose* and should not attempt to describe the general ecology of a site. Unfortunately, monitoring schemes often resort to measuring a wide variety of variables, which may or may not be related to the questions that need to be addressed. As a result, resources may be spent collecting unnecessary data. Even worse, it may be found that key questions cannot be answered with the information obtained. This is because monitoring is often planned backwards, on a 'collect-now (data), think-later (of a useful question)' basis (Roberts, 1991).

Strictly speaking, the minimum requirement of monitoring is an assessment of adherence to, or deviation from, formulated standards. However, it is clearly desirable to collect data in such a way that gradual change can be detected to assist management decision-making. Management adjustments (at both field and policy level) require knowledge of the dynamic situation, i.e. whether the feature is moving towards or away from the standard, from which direction, and whether the change is expected, acceptable or otherwise (Rowell, 1993).

Monitoring should not be confused with research aimed at investigating ecological processes. Nevertheless, data collected for monitoring purposes can sometimes also be used to examine possible causes of change and to investigate the relationship between features of interest and environmental variables and pressures. Such information can then be used to formulate appropriate responses. For example, comparison of sward composition with stocking density may predict optimal management regimes. Further monitoring of the vegetation and stocking rates can then confirm whether management and habitat objectives are being met.

Thus, in summary, monitoring can:

- establish whether standards are being met;
- detect change and trigger responses if any of the changes are undesirable;
- contribute to the diagnosis of the causes of change; and
- assess the success of actions taken to maintain standards or to reverse undesirable changes, and, where necessary, contribute to their improvement.

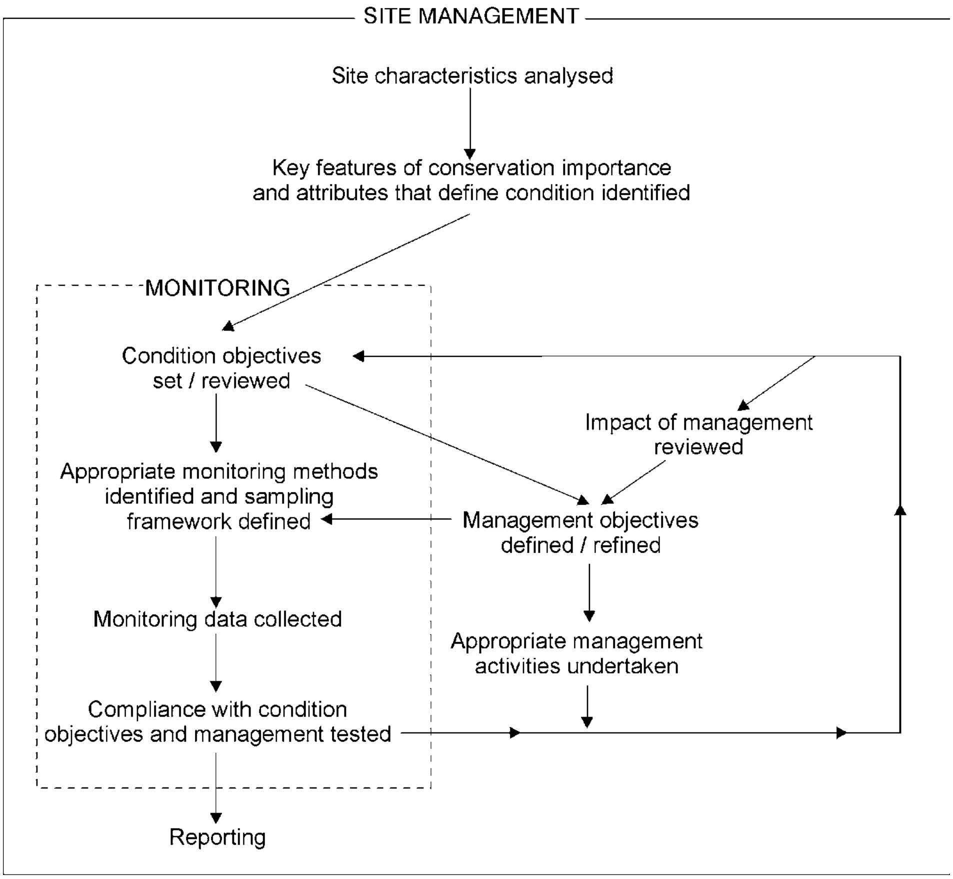

Figure 1.1. A schematic representation of the relationship between site management and monitoring.

Monitoring should therefore be an integral part of all conservation programmes.

1.1.2 Common Standards Monitoring in the UK

The UK statutory conservation agencies (the Countryside Council for Wales, English Nature, the Environment and Heritage Service in Northern Ireland, and Scottish Natural Heritage) have undertaken to monitor statutory protected sites to determine whether the features of interest for which each site has been designated are being maintained in a *favourable condition*. To provide a basic framework that will ensure consistent monitoring throughout the UK, a *Statement of Common Standards for Monitoring Designated Sites* (JNCC, 1997) has been adopted by the agencies and the Joint Nature Conservation Committee (JNCC). This formalises the monitoring principles outlined above and provides standards for the setting of objectives, judging the condition of site features, recording activities and management measures, and monitoring and reporting within an agreed time-frame.

For further information on the Common Standards approach see Rowell (1993, 1997) and Brown (1994). See Shaw & Wind (1997) for a discussion of monitoring European conservation sites. Detailed guidance on the interpretation and application of Common Standards Monitoring has been prepared by the statutory agencies and is available from them.

2 • Planning a programme

The major steps involved in planning and executing a monitoring programme are illustrated in Figure 2.1. Many of the aspects are relevant to planning and executing a survey. A list of key considerations that must be addressed when planning a monitoring programme is given in Box 2.1 with the relevant section numbers. All of these issues should be carefully considered in a step-by-step process before any fieldwork is started.

2.1 SETTING THE OBJECTIVES FOR THE MONITORING PROGRAMME

Clearly and explicitly defining your objectives is probably the most important single step of any monitoring programme. Failure to do so may render any results gained inappropriate to the question you wished to address, and therefore useless. Carefully defining your objectives will also allow you to select the most appropriate methodology. In particular it is essential that you ask yourself: What do I really need to know? The process of defining objectives underpins good site management principles and the development of management plans (see, for example, CCW, 1996) of which monitoring should be an integral part (Figure 1.1). Guidance on establishing clearly defined objectives is provided below.

2.1.1 What features of conservation interest are to be monitored?

The first step in defining the objectives of any ecological monitoring programme must be the identification of features of interest on the site. Biological features may be habitats, species or species assemblages.

As there is clearly a link between habitat and species features, there is often likely to be some overlap between their monitoring requirements. Species, particularly plants, are often essential components that define a habitat (e.g. ericoid shrubs on heathlands). Individual species or species assemblages may therefore often be monitored as attributes of a habitat feature.

In addition to monitoring species for which sites have been designated, it is important to monitor the area and quality of suitable habitat for such species. There may also be other species that, although not necessarily of conservation concern in themselves, may require monitoring by virtue of association with a species that is a feature of interest (for example, the food plant of a particular animal species). Monitoring such habitats and associated species can give extra information about the condition of species features that may prove useful for formulating management options for the site.

Some sites may be important for the presence of a species assemblage (e.g. a diverse community of insects or a good example of a particular vegetation community). For these assemblages, it may be possible to monitor one or more indicator species, which can be used to infer the presence or status of other associated species, rather than monitoring each individual species. However, the use of indicator species should be approached with care, and in particular should only be relied on when the relationship between the condition of the indicator and that of the interest feature has been proven and quantified. If this is not the case, then all relevant species will need to be monitored. See Rowell (1994) for further guidance on the use of indicators.

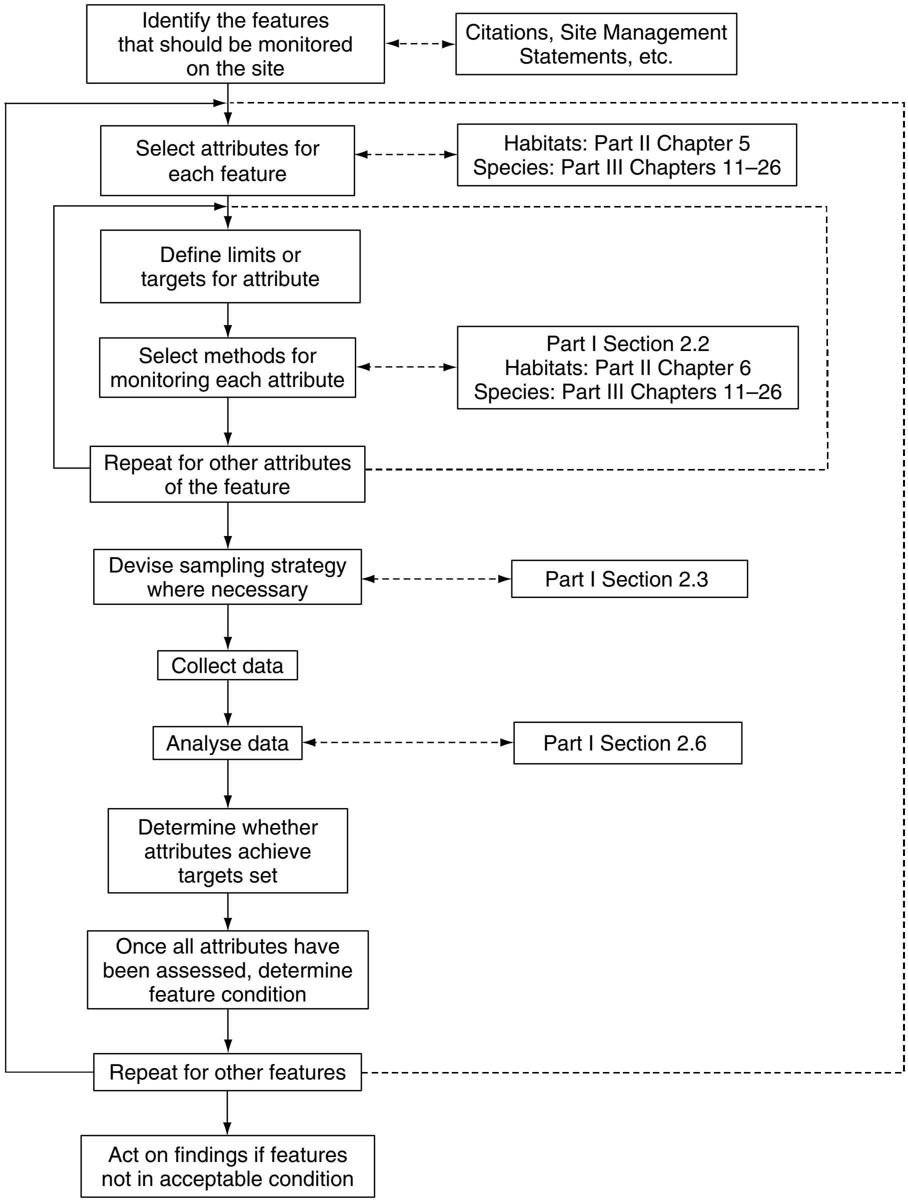

Figure 2.1. A schematic diagram of the steps involved in a monitoring programme.

The monitoring of assemblages presents some problems. On a site important for its diverse beetle community, for example, does the loss of one species constitute serious damage, or do several species need to decline before the assemblage is considered to be in an unacceptable condition? Assemblages can be assessed by using species richness or diversity indices; judgement will be required to decide how to set limits for these.

In general, an essential part of monitoring a species of conservation concern will be to monitor the area of suitable habitat, and an essential part of

Box 2.1 A checklist of considerations during the preparation of a monitoring programme

SETTING OBJECTIVES FOR THE MONITORING PROGRAMME (2.1)

What features of conservation interest are to be monitored? (2.1.1)
What is the objective for each feature? (2.1.2)
What attributes define condition in these features and what are likely to be their acceptable limits? (2.1.2)
How often should monitoring be carried out? (2.1.3)
What are the operational and/or management objectives for the site? (2.1.4)
Are there external factors that may have significant impacts on the site? (2.1.5)
What monitoring has been undertaken, and are baseline surveys required? (2.1.6)
Should the site be subdivided into monitoring units? (2.1.7)

SELECTION OF METHODS FOR MONITORING EACH ATTRIBUTE (2.2)

Is the method likely to damage the environment? (2.2.1)
Are samples required? (2.2.2)
Will the method provide the appropriate type of measurement? (2.2.3)
Can the method measure the attribute across an appropriate range of conditions? (2.2.4)
Is the method prone to substantial measurement error? (2.2.5)

DESIGNING A SAMPLING STRATEGY (2.3)

Has the method been thoroughly tested and are preliminary field trials necessary? (2.3.1)
Is the method sufficiently precise? (2.3.2)
Should sample locations be permanent or not? (2.3.3)
When should the data be collected? (2.3.6)
How will consistency be assured? (2.3.7)

REVIEWING THE MONITORING PROGRAMME (2.4)

Are there sufficient long-term resources available? (2.4.1)
Are personnel sufficiently trained and experienced? (2.4.2)
Are licences required? (2.4.3)
Is specialist equipment required and available? (2.4.4)
Are there health and safety issues to consider? (2.4.5)

DATA RECORDING AND STORAGE (2.5)

How will data be recorded in the field? (2.5.1)
How will the data be stored? (2.5.2)
Who will hold and manage the data? (2.5.3)

DATA ANALYSIS, INTERPRETATION AND REVIEW (2.6)

Who will carry out the analysis and when? (2.6.1)
How will the data be analysed? (2.6.2)
What statistical tests are appropriate to analyse the data? (2.6.4)
Is transformation of the data necessary before statistical analysis? (2.6.4)
What statistical packages are available for the analysis of data? (2.6.6)

monitoring a habitat will involve the monitoring of its constituent species.

Identifying notified features should be straightforward for Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), as a list of features is drawn up during the designation process. Identification of notified features may be more difficult on Sites of Special Scientific Interest (SSSIs) for which the citation may be imprecise or based on an early version of the selection guidelines. For clarification, refer to the guidelines for the selection of biological SSSIs (NCC, 1989; Hodgetts, 1992; JNCC, 1994) and contact the relevant country agency.

2.1.2 What is the objective for each feature?

For each interest feature to be monitored, an objective should be defined that identifies appropriate attributes of the feature and, where possible, sets a target for each one. Each target may include an upper and a lower limit, within which the feature is considered to be in acceptable condition.

Attributes of a habitat may reflect a number of properties of the feature, including aspects of quantity (e.g. size or number of individuals),

Box 2.2 Examples of attributes that may be used to define the condition of habitats and species

HABITAT ATTRIBUTES

Quantity
area

Quality: physical attributes
geological (e.g. presence of bare rock or deep peat)
water (e.g. presence of open water or depth of water table)

Quality: composition
communities
richness or diversity
typical, keystone or indicator species
presence–absence
frequency
number or density
cover
biomass

Quality: structure
inter-habitat (landscape) scale (e.g. fragmentation, habitat mosaics)
intra-habitat scale
macro-scale
  horizontal (e.g. plant community mosaics)
  vertical (e.g. ground-, shrub- and tree-layer topography)
micro-scale
  horizontal (e.g. patches of short and tall vegetation)
  vertical (e.g. within-layer topography)

Quality: dynamics
succession
reproduction or regeneration
cyclic change and patch dynamics

Quality: function
physical and biochemical (e.g. soil stabilisation, carbon sinks)
ecosystem (e.g. net producer)

SPECIES ATTRIBUTES

Quantity
presence/absence
range
population size
frequency
number/density
cover

Population dynamics
recruitment
mortality
emigration
immigration

Population structure
age
sex ratio
fragmentation or isolation
genetic diversity

Habitat requirements

composition (presence of particular species, overall diversity, etc.), structure, function or dynamics (Box 2.2). These principles are outlined below. There is further discussion of attributes that define the condition of specific habitat types in Chapter 5.

Species attributes for which targets may be set include range, abundance, population dynamics and habitat requirements. Part III describes methods for monitoring range (presence–absence across a site), abundance (population density) and dynamics (e.g. breeding success and population structure) (see Box 2.2). In most cases, direct monitoring of species will generally be targeted towards measuring range and abundance; more detailed studies may be constrained by a lack of resources or appropriate skills. The costs involved in monitoring population structure, for example, can be particularly high. It should be borne in mind that in some cases (for example, monitoring bryophytes in fragile habitats), quantitative monitoring may damage the habitat and hence the species, and is therefore not feasible.

The setting of targets and limits for attributes is outside the scope of this *Handbook* as these are dependent on local site conditions. The UK statutory agencies have produced guidance on this for the purposes of Common Standards Monitoring.

Habitat attributes

Quantity

Quantity may be the simplest attribute of a habitat in terms of indicating its condition. However, in many situations habitats and communities are not objectively or precisely definable and there is consequently some doubt about where boundaries lie. This can make habitat quantification and interpretation of change difficult. None the less, especially for EIA studies, this is important if habitat area is to be lost and needs to be replaced according to some criteria.

Quality: physical attributes

Certain physical attributes of a habitat can be considered to be essential or desirable in their own right. For example, the presence of peat is an essential attribute of blanket bog. Similarly, the presence of grikes is a characteristic attribute of limestone pavements.

It is often difficult to decide whether physical properties are direct attributes of a habitat or factors that may influence it. For example, are the chemical characteristics of river water (e.g. nutrient status and pH) attributes or factors that influence other aspects of the habitat such as macrophytic communities? In principle, in habitats in which such distinctions are difficult, key factors that may influence the habitat should be monitored.

Quantity: composition

The composition of a habitat in terms of its communities and species is a fundamental attribute of habitat condition. Many statutory sites are notified because of the presence of particular vegetation communities and therefore monitoring should ensure that targets for these are being met.

Monitoring all species is clearly not feasible in all but the simplest habitats. Therefore, the most commonly used species-based attributes of habitat composition are species richness and the presence or abundance of typical species or vegetation communities.

Typical species are hard to define, but Shaw & Wind (1997) suggest the following:

- species on which the identification of the habitat is founded;
- species that are inseparable from the habitat;
- characteristic species;
- species that are consistently present but not restricted;
- species that are an integral part of the habitat; and
- keystone species (Jermy *et al.*, 1996), which significantly influence the habitat's structure and function. (Note: such species may include animals as well as plants.)

Diversity indices (Magurran, 1983) are not normally recommended for habitat condition monitoring as the setting of targets and interpretation of changes in these indices is difficult.

In some cases it may be appropriate to monitor 'indicator species'. The presence and/or abundance of such species may be used to indicate favourable or unfavourable ecological conditions that may be difficult or costly to detect by other means. For example, aquatic plants can be used as indicators of overall water quality (Palmer *et al.*, 1992). Care should be taken with the use of indicator species, however, as they may not always be reliable (Rowell, 1994).

There are a number of parameters that may be appropriate for target setting and measurement when monitoring the abundance of typical (or other) species. These are described below.

Presence or absence

The simplest target for a species is that its presence at the site, or at a defined location within it, is maintained. This is normally straightforward to monitor, but there are occasions when difficulties may arise: for example, for species that are inconspicuous, difficult to identify or rare, or those that inhabit inaccessible areas.

The distribution (range) of a species across a site can be monitored by assessing presence–absence across a number of locations (e.g. grid squares), and distribution maps can be drawn up for such surveys. Repeat presence–absence surveys can indicate expansions or contractions in range.

Frequency

Frequency is the proportion of quadrats (or other sample units) examined in which the species is present. Frequency is a simple, quantitative measure, and has been widely used to describe relative abundance. With a large number of sampling units of sufficiently small size, frequency estimates of plant species can approximate to cover (see below). For plants, there are two measures of frequency: shoot frequency (the presence of any foliage within the quadrat) and root frequency (the presence of rooted individuals only). Frequency estimates depend on the size of the quadrats and of individual plant species (large plants may be over-represented compared with small plants) and the spatial distribution of individuals of a species (clustered species may be under-represented compared with more widely spaced ones). Frequency measures may also exaggerate the apparent biomass of small species and hence overestimate their functional significance.

Changes in frequency are relatively insensitive to seasonal or management changes, and therefore a large sample size is required to be effective for monitoring change in the short term. However, frequency estimates are relatively free of observer error and hence are particularly useful for general habitat condition monitoring purposes.

A useful extension of the simple frequency measure is to record presence–absence within subdivisions of each plot. For example, a plot may be divided into a 5×5 grid giving 25 subdivisions. The measure recorded is the proportion of subdivisions containing the species of interest. This will be more sensitive to change than simple frequency and is often quicker to record than cover. Within this *Handbook*, this measure is referred to as *sub-plot frequency*.

Density

Density is the number of individuals per unit area (e.g. plants within the habitat). Counts of numbers of individuals in quadrats have been widely used for demographic studies, but less so for vegetation monitoring because of the difficulties of defining individuals of clonal or rhizomatous plants (White, 1979) and the amount of time required to count numbers accurately in large sample sizes. However, sub-plot frequency is often used as a quicker alternative. Densities depend on reproduction, dispersal, population ages, etc., which may vary from year to year. These annual variations in population sizes mean that samples have to be recorded regularly to separate normal fluctuations from directional change.

Density estimates can be converted to total population size estimates by multiplying the density by the area of similar habitat. Alternatively, total population counts over an area may be used to derive density. Extrapolating density estimates from a smaller area to a larger one is only meaningful if the larger area has the same characteristics as the area from which the density was originally estimated. When making such extrapolations you need to be sure that all individuals are detected or that a detectability function can be estimated: see Section 10.6 for more details.

Cover

Cover is a measure of the area covered by the aboveground stems and foliage of a plant species when viewed from above. Greig-Smith (1983) defined cover as 'the proportion of ground occupied by a perpendicular projection onto it of the aerial parts of individuals of the species'. The sum of cover values from all species in layered vegetation often totals more than 100%. Cover is usually described as a percentage, or by using one of the numerous categorical indices available (see Shimwell, 1971). The most widely used of these is the Domin scale as used in the National Vegetation Classification (NVC) methodology (Rodwell, 1991 *et seq.*). (Box 2.3) Cover estimates provide a good description of the contributions of each species to the vegetation; as long as measurements are accurate, they are sensitive to short-term fluctuations in season or management. However, cover estimates, whether percentages or scales, are prone to bias and considerable care is required to ensure accuracy and consistency.