Practical Methods in Ecology

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This book is intended for use by undergraduate biologists and their lecturers. My aim has been to introduce a wide variety of ecological methods and analytical techniques that are appropriate for studies in open grassland, woodland, small freshwater habitats such as ponds and streams, and the seashore. These habitats are probably those that are most accessible to students and most likely to be studied on field courses. I hope the book will be a source of ideas and advice for students who undertake an ecological project as part of their coursework. There are parts of the book that I hope will be useful for sixth form and high school students.

Ecology is a fascinating subject that uses the ancient skills of tracking, trapping, and fishing, the eighteenth- and nineteenth-century skills of classification and identification, and more recent computer-aided approaches of multivariate analysis and computer simulation. While each of us will develop skills in only some of these areas there are certain core ideas and skills that all ecologists require, and this book is aimed at these areas.

Practical Methods in Ecology is closely linked to Ecological Methods, the standard text written by Professor Sir Richard Southwood with whom I had the privilege and pleasure of working on the 3rd edition. Ecological Methods is probably too advanced for undergraduate teaching, although it is an invaluable reference. Both books have the same general organization of the subject, which was thought out by Dick Southwood while teaching ecology at Imperial College. Dick Southwood taught me as an undergraduate and the knowledge gained was a fine foundation from which to build a career as a professional ecologist. I hope, by using his insight into how to structure the subject, a little bit of his magic as a teacher will also be transmitted. Many of the subjects just touched upon in this book are covered in far more detail in Ecological Methods, which I hope will be made more accessible by the present work.

I would like to thank Dr Richard Seaby and Mr Robin Somes of Pisces Conservation Ltd for their help, particularly with the scientific computing, and my wife Claire who proofread the manuscript.

Peter Henderson
Planning and preliminary considerations

If you do not carefully plan ecological fieldwork your effort will be wasted. However, some unfocused preliminary work can be useful to help to form your ideas. It is impossible to plan a study without background information on the natural history of the organism and the nature of the habitat. While much can be gained from reading, undertaking computer searches, and talking to others with experience, it is often essential to do some preliminary sampling and try out alternative techniques to assess their relative merits. During a pilot study a record should be kept of the cost of each part of the sampling routine, normally expressed in man-hours. If you have a clear appreciation of the cost, you will not attempt a study that is beyond your resources. Having completed preliminary studies, the objectives of your study should be clearly stated and a sampling program designed. Your objectives should be written down and you should be able to describe them verbally in clear and simple terms. If you are unable to do this, you probably have confused and muddled objectives and you certainly will not be able to convey your ideas to others.

Armed with the information obtained during the preliminary investigations and a clear objective, the full sampling plan can be created. It is important to remember that ecological studies rarely go according to plan as the natural world is variable and the weather will frequently disrupt sampling. Further, all sampling methods have a certain range of population density over which they are appropriate and may become unsuitable if the population should greatly decline or rise. Therefore build contingencies into the plan. While some studies focus on the ecology of a single species or even race (autecology), others investigate whole communities or some part of them (synecology). Both types of study require the collection of data about populations and require consideration of the same general principles described below.

The need for sampling

As it is rarely possible to count or collect all the individuals in a population, the size of the population and its attributes such as mean size and age must be estimated by sampling. Much of the planning of an ecological study is
concerned with ensuring that the samples accurately reflect the population or community as a whole.

The scale of the study

The size of the area to be studied needs to be determined. This area must be of sufficient size to adequately reflect the true nature of the target population or community. However, if it is too large you will waste resources and may not be able to complete the study.

Whether the area of study should be a single habitat (e.g. field, pond, woodland, or particular rock pool) or selected representatives of the habitat type from a wider geographic area will depend on whether an intensive or an extensive study is planned. Extensive studies have a low intensity of sampling per unit area or through time. They are frequently used to provide information on distribution and abundance for conservation or management programs. Intensive studies involve the repeated observation of the population of an organism with the intention of producing accurate estimates of population parameters. An intensive study would be needed, for example, to produce a life-table (see page 108).

Safety

During the planning stage you should identify potential hazards and plan how to work safely. You will find it useful to refer to Nichols (1983). When working on or close to water, or in remote localities, it is important not to work alone. Pay particular attention to risks associated with adverse weather and exposure, becoming lost, and the effects of heat and excess sun. You may also need to take preservatives such as formalin or other chemicals into the field. If so, consider carefully how they will be transported and how harmful exposure such as splashing formalin into your eyes will be avoided and dealt with. If you plan to handle wild animals ensure you have the correct protective equipment to avoid bites and scratches. Finally, get acquainted with the features and risks of the study area. Are there biting insects that will make concentration and careful measurement at certain times of day impossible? Are there parasitic mites in the vegetation just waiting for a soft-skinned mammal to pass? If these aggravations and dangers are recognized you will be able to dress defensively, use repellents and work at the best times of day so that field work is a pleasure rather than an ordeal.

Care for the environment

As your plans are developed always consider the potential harm caused to the habitat and its inhabitants by your study and minimize general disturbance.
Keep the number of organisms handled, removed and killed to a minimum, and take care not to trample on plants that are easily damaged. If animals are to be returned, ensure that they are released close to their point of capture and in a manner that will give them a good chance of survival. Consider carefully if any of the proposed methods are cruel and likely to cause unnecessary distress. In particular, if animals are to be killed, plan carefully how this will be done. Finally, ensure that you know the local regulations concerning the protection of habitats and endangered species and always obtain the consent of licensing authorities, landowners, etc.

**Taxonomy**

Are there any taxonomic difficulties? It is essential that you ensure that you can identify the target species and maintain a consistent taxonomy. As a study progresses taxonomic ability frequently improves. It may be necessary to revisit early samples to reassess species identifications. When possible, you should retain samples. Studies have failed when it became apparent that two or more species had been confused during the early period of sampling. Problems can also occur if only some life stages can be identified.

In community studies, you may need to identify or discriminate between large numbers of forms. Will this be feasible? The appropriate degree of taxonomic discrimination must be decided upon. It may not be essential to identify to the species level. For example, a study of stream invertebrates for the effects of pollution can be based on the presence of families and the calculation of a quality index such as the BMWP score (see Chapter 10). In community studies it is common to identify different groups to different taxonomic levels. For example, in freshwater studies stoneflies and dragonflies may be identified to species level while the larvae of small flies are recorded at the family level. Such mixed taxonomic resolution is often appropriate and the only practical option. However, you may need to consider what effect this will have on the analysis of species richness or diversity.

Sample sorting and species identification are often the most labor-intensive parts of a study and it may be useful to process a trial sample during a pilot study to assess the effort required.

**Recording, labeling, and note taking**

It is essential that you keep good records of your observations while in the field. Observations may be entered onto a tape recorder, palm-sized computer, digital camera, or onto paper. The durability of pencil on paper is second to none and unlike all the other devices listed above, it will even survive total immersion in water and will not require batteries. Always use notebooks of good quality paper that are designed to withstand water. If you use any form of electronic device always extract the data immediately upon returning from
the field, ensure the data is not corrupted, and make backups and hard copy as appropriate. As a backup, notebooks should be photocopied, scanned or digitally photographed. To protect valuable data it may be useful to transmit it by e-mail to another locality. Data protection is not the only reason why information should be transcribed as soon as possible; field notes are often rather poorly written and will be better understood while events are still fresh in your memory. Never return to the field without having secured your data from the previous trip.

When taking notes remember to date the page, record who is present, and other general information such as the weather. When using photography, you will need to record the details of each photograph. Digital cameras are invaluable aids for ecologists. They allow you to instantly check that a good photograph has been taken and frequently allow details of the image to be entered as text or even a voice record.

Samples must be securely labeled. Usually you should place a pencil-and-paper label inside the sample and label the outside with a permanent marker. Paper of the correct quality must be used, as some papers will disintegrate when wet. Remember that a standard permanent marker is water insoluble, but the label might be lost if the sample is preserved in alcohol which leaks out. When labeling, use a numbering system that will not become ambiguous if part of the label is lost. For example, avoid roman numerals such as ii and iii. It is frequently advisable to check the labeling (and preservative) soon after returning from the field.

**Data security and processing**

A sampling plan needs to consider the processes involved in data acquisition, organization, analysis, and presentation. Smooth and rapid progress along this chain is aided by the use of computers, but only if the data can be easily transferred between software. If different software products are used, then compatibility must be considered. Both software and hardware capability need to be considered for each stage of the study. During data acquisition, it is important to assess the data storage and processing requirements. Automatic data collection devices, such as digital temperature recorders, can collect prodigious amounts of data if set to record at short intervals. Remember that data has only been acquired when it has been processed into a usable form. Data processing and input rates are often different. Data that takes many weeks to enter into a computer is often analyzed and plotted in a few seconds. Portable computers and palm-sized input devices allow field observations to be immediately stored in digital form and this may offer a way of streamlining the data-input process. Great care needs to be taken to ensure that data is not subsequently lost.

Ecological data is frequently arranged in spreadsheet software such as Excel. These programs are particularly appropriate for data that are naturally arranged in a grid, such as the species recorded from a number of samples. In
many cases, appropriate statistical tests and plots can be undertaken within the spreadsheet program. If the data will need to be exported to a more specialized program for statistical analysis, you should ensure during the planning stage that the spreadsheet program is able to export the data in a suitable form.

Effect of the time of year on sampling

You must ensure that your proposed study will be undertaken at a suitable time of year. It is often important to sample when numbers are high. For plants you may need to work when they are in flower so that they can be easily identified. For seasonal insects such as butterflies the adults may only be abundant for a relatively short period of time each year. For annual species the life stage or age group that is chosen for study will determine the sampling period. The life stage of choice may be chosen because it is particularly easy to sample or possibly because it has a particularly important ecological impact. For insect pests, the best stage for sampling may be that most closely correlated with the amount of damage. For aquatic organisms, timing is often determined by the reproductive cycle. For example, in temperate waters, benthic surveys (the study of organisms living on or in the seabed) carried out in autumn will show a population dominated by recent recruits. The same survey carried out in the spring or early summer will show the resident community that has survived both competition for space and the rigors of the winter. While the life history stage to be sampled will depend on the objectives, the stage must not be one whose numbers change greatly with time and it must be present for a period of sufficient extent to allow the survey to be completed. Finally, the easier the stage is to sample and count the better.

Extensive surveys can result in different areas holding populations that differ in their development. The timing of blooms and larval production in marine plankton, for example, can vary by 1 month over 1 degree of latitude. The timing of the flowering of plants also shows clear latitudinal and altitudinal gradients. These differences may be used to advantage by allowing the different habitats to be sampled in succession.

Effect of the time of day on sampling

When observing birds and mammals the time of day when observations are taken is clearly important. However, it is not always realized that this can also be the case for invertebrates. The diurnal rhythms of insects may cause them to move from one part of the habitat to another. Many grassland insects move up and down the vegetation at certain times of the day or night and aquatic insects may emerge at a particular time. During the day quite a proportion of active insects may be airborne. Similarly, plankton also show diurnal rhythms in their vertical distribution and may concentrate in surface waters at