19.5 Investigating populations

Learning objectives

- → Name the factors to be considered when using a quadrat.
- → Explain how a transect is used to obtain quantitative data about changes in communities along a line.
- → Describe how the abundance of different species is measured.
- → Explain how the mark-release-recapture method can be used to measure the abundance of motile species.

Specification reference: 3.7.4

To study a **habitat**, it is often necessary to count the number of individuals of a species in a given space. This is known as **abundance**. It is virtually impossible to identify and count every organism. To do so would be time-consuming and would almost certainly cause damage to the habitat being studied. For this reason only small samples of the habitat are usually studied in detail. As long as these samples are representative of the habitat as a whole, any conclusion drawn from the findings will be reliable. There are a number of sampling techniques used in the study of habitats. These include:

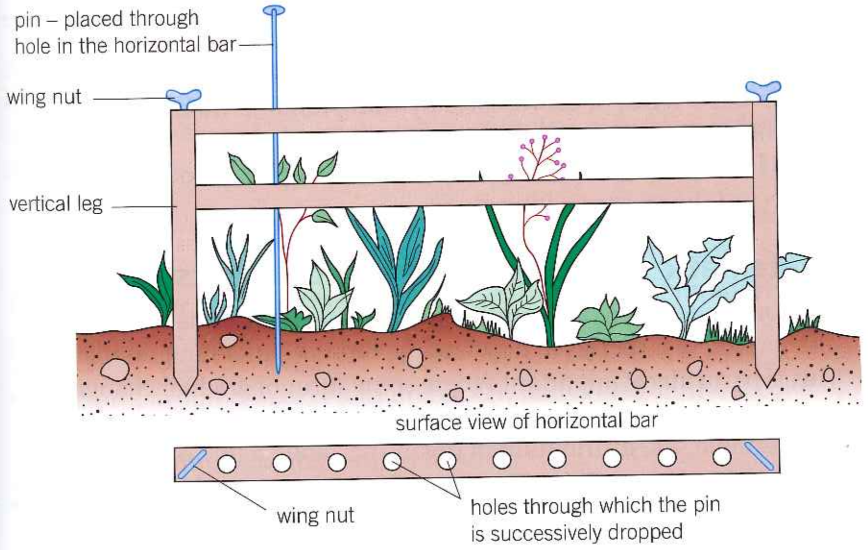
- random sampling using frame quadrats or point quadrats
- systematic sampling along a belt transect.

Quadrats

Two types of quadrat frequently used are:

A point quadrat which consists of a horizontal bar supported by two legs. At set intervals along the horizontal bar are ten holes, through each of which a long pin may be dropped (Figure 1). Each species that the pin touches is then recorded.

A frame quadrat which is a square frame divided by string or wire into equally sized subdivisions (Figure 2). It is often designed so that it can be folded to make it more compact for storage and transport. The quadrat is placed in different locations within the area being studied. The abundance of each species within the quadrat is then recorded.



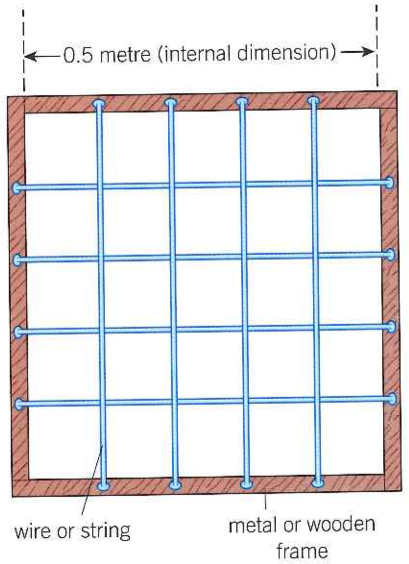
▲ **Figure 1** *A point quadrat*

There are three factors to consider when using quadrats:

- **The size of quadrat to use**. This will depend on the size of the plants or animals being counted and how they are distributed within the area. Larger species require larger quadrats. Where a population of species is not evenly distributed throughout the area, a large number of small quadrats will give more representative results than a small number of large ones.

Synoptic link

Random sampling was considered in Topic 10.5, Quantitative investigations of variation, and provides further information on the subject.



▲ **Figure 2** *A frame quadrat*

▲ **Figure 3** *Students carrying out fieldwork*

- **The number of sample quadrats to record within the study area**. The larger the number of sample quadrats the more reliable the results will be. As the recording of species within a quadrat is a time-consuming task a balance needs to be struck between the reliability of the results and the time available. The greater the number of different species present in the area being studied, the greater the number of quadrats required to produce reliable results for a valid conclusion.
- **The position of each quadrat within the study area**. To produce statistically significant results a technique known as random sampling must be used.

Sampling at random

In Topic 10.5 we introduced the idea that sampling at random is important to avoid any bias in collecting data. Avoiding bias ensures that the data obtained are reliable.

Suppose we wish to investigate the effects of grazing animals on the species of plants growing in a field. We begin by choosing two fields as close together as possible in order to minimise soil, climatic, and other abiotic differences. One field is regularly grazed by animals such as sheep, whereas the other has not been grazed for many years. We then take samples at many random sites in each field by placing the quadrat on the ground and recording the names and numbers of every species found within the area of the quadrat.

But how do we get a truly random sample? We could simply stand in one of the fields and throw the quadrat over our shoulder. A better method of sampling at random is to:

1. Lay out two long tape measures at right angles, along two sides of the study area.
2. Obtain a series of coordinates by using random numbers taken from a table or generated by a computer.
3. Place a quadrat at the intersection of each pair of coordinates and record the species within it.

Systematic sampling along belt transects

It is sometimes more informative to measure the abundance and distribution of a species in a systematic rather than a random manner. This is particularly important where some form of gradual change (transition) in the communities of plants and animals takes place. For example, the distribution of organisms along a line of succession, such as, through sand dunes by the edge of the sea and inland up into woodland. The stages of succession are especially well shown using transects. A belt transect can be made by stretching a string or tape across the ground in a straight line. A frame quadrat is laid down alongside the line and the species within it recorded. It is then moved its own length along the line and the process repeated. This gives a record of species in a continuous belt.

Measuring abundance

Random sampling with quadrats and counting along transects are used to obtain measures of **abundance**. Abundance is the number of individuals of a species within a given area. For species that don't move around, it can be measured in several ways, depending on the size of the species being counted and the habitat. Examples include:

- **frequency**, which is the likelihood of a particular species occurring in a quadrat. If, for example, a species occurs in 15 out of 30 quadrats, the frequency of its occurrence is 50%. This method is useful where a species, such as grass, is hard to count. It gives a quick idea of the species present and their general distribution within an area. However, it does not provide information on the density and detailed distribution of a species.
- **percentage cover**, which is an estimate of the area within a quadrat that a particular plant species covers. It is useful where a species is particularly abundant or is difficult to count. The advantages in these situations are that data can be collected rapidly and individual plants do not need to be counted. It is less useful where organisms occur in several overlapping layers (more probably plants).

To obtain reliable results, it is necessary to ensure that the sample size is large, that is, many quadrats are used and the mean of all the samples is obtained. The larger the number of samples, the more representative of the community as a whole will be the results.

Mark-release-recapture techniques

The methods of measuring abundance described above work well with plant species and non-motile (sessile) or very slow moving animal species that remain in one place but not with motile organisms. Motile animals move away when approached. They are often hidden and are therefore difficult to find and identify. To estimate the abundance of most animals requires an altogether different technique.

A known number of animals are caught, marked in some way, and then released back into the community. Some time later, a given number of individuals is collected randomly and the number of marked individuals is recorded. The size of the population is then calculated as follows:

$$\text{estimated population size} = \frac{\text{total number of individuals in the first sample} \times \text{total number of individuals in the second sample}}{\text{number of marked individuals recaptured}}$$

This technique relies on a number of assumptions:

- The proportion of marked to unmarked individuals in the second sample is the same as the proportion of marked to unmarked individuals in the population as a whole.
- The marked individuals released from the first sample distribute themselves evenly amongst the remainder of the population and have sufficient time to do so.
- The population has a definite boundary so that there is no immigration into or emigration out of the population.
- There are few, if any, deaths and births within the population.
- The method of marking is not toxic to the individual nor does it make the individual more conspicuous and therefore more liable to predation.
- The mark or label is not lost or rubbed off during the investigation.

Summary questions

1. An ecologist was estimating the population of sandhoppers on a beach. One hundred sandhoppers were collected, marked and released again. A week later 80 sandhoppers were collected, of which five were marked. Calculate the estimated size of the sandhopper population on the beach. Show your working.
2. When using the mark-release-recapture technique, explain how each of the following might affect the final estimate of a population.
   a. The marks put on the individuals captured in the first sample make them more easily seen by predators and so proportionately more are eaten than unmarked individuals.
   b. Between the release of marked individuals and the collection of a second sample an increased birth rate leads to a very large increase in the population.
   c. Between the release of marked individuals and the collection of a second sample, disease kills large numbers of all types of individual.
3. In a mark-release-recapture exercise, a sample of 120 woodlice were marked. After five days a second sample of 120 woodlice were collected. The population size was found to be 960. Calculate the number of marked woodlice that there were in the second sample.