Core practical 15: Investigate the effect of different sampling methods on estimates of the size of a population

Objectives

- To investigate the effect of using different quadrat types on estimates of the size of a population
- To understand how to use a quadrat to estimate density and percentage cover

Safety

- Do not throw quadrats.
- There is low risk of infection from plants or soil, which may be contaminated by animal faeces. Cover any cuts with a plaster and do not eat while working outdoors. Wash your hands using soap after fieldwork.
- There is a possibility of allergic reactions to substances such as pollen, plant sap, or insect stings. Ensure students inform you immediately if they feel unwell.
- Dress appropriately for wet and cold weather. Wear sunscreen in summer months.

Specification links

- Practical techniques 1, 5, 11, 12
- CPAC 1a, 2a–2d, 4a, 4b, 5a

Procedure

The size of a plant population can be estimated using a number of different methods for taking small samples within a larger area. In this investigation you will compare population estimates made with different sizes and types of quadrats.

A frame quadrat is a simple frame of a known area. This can be used to make estimates of population density (number of individuals per unit area) or to estimate percentage cover (the proportion of the ground area covered by a species).

A point quadrat usually consists of a frame with holes through which long needles are lowered onto the ground below. Percentage cover can be estimated from the proportion of the points that touch the species of concern. Traditional point quadrats are not always available in schools, so in this practical the intersections of a grid within a frame quadrat will be used in the same way. Each intersection of the grid (where two wires cross) will be a 'point'.

1. In this investigation you will consider the population of a single species within a grassland area such as a school field or parkland. Decide which species you will use in your population estimates. It must be possible to distinguish the individual plants and they should be relatively abundant. Make sure that you can identify your chosen species confidently.
2. Draw a suitable table to record your results.
3. Choose a 10 m by 10 m area of grassland to study. Mark this out using two tape measures as shown in fig A, with the tapes laid at right angles from A to B and from B to C.
4. Use random numbers to determine the coordinates for a quadrat sample within the grid. Place one corner of the 0.25 m^2 quadrat at this point.
5. Estimate the percentage cover of your chosen species within the quadrat. If your quadrat is divided up into 25 smaller squares, each small square will represent 4%. Use this to help you make your estimate.
6. Without moving the quadrat, use it again as a point quadrat, recording the number of grid intersections under which your chosen plant is found. If you are using a 0.25 m^2 quadrat divided into 25 smaller squares there will be 16 intersecting points inside the quadrat.

7. Next measure plant density. Count the number of individuals of your chosen species that lie within the 0.25 m^2 quadrat and record your result. Try to trace each plant down to the base of the stem to make sure you are counting a single individual. To account for the 'edge effect', do not count plants that cross the right-hand and lower sides of the quadrat but do count all plants that cross the top and left-hand sides of the quadrat.
8. Replace the 0.25 m^2 quadrat with the 1 m^2 quadrat. Repeat step 7 for the 1 m^2 quadrat.
9. Repeat steps 4–8 at least 10 times and preferably more, so that you have at least 10 repeats of percentage cover estimates with both frame and point quadrat methods and at least 10 density measurements for both the 0.25 m^2 quadrat and the 1 m^2 quadrat.

Notes on procedure

- If traditional point quadrat frames are available these could be used instead of a grid within a frame quadrat.
- Suitable plant species to survey on a school field might include dandelions, ribwort plantain, greater plantain or catsear. The species should be present in most quadrats and occupy at least 5% cover. Check the field in advance. Areas that are mown less frequently may be more suitable.
- This investigation is really two studies rolled into one. This will give a greater breadth of experience of using quadrats for both percentage cover and density measurements for little extra effort. If time is short, either the quadrat type comparison (steps 5 and 6) or the quadrat size comparison (steps 7 and 8) could be omitted.
- Coordinates should be determined and written down before going out into the field if the weather is inclement. Only the first digit of a randomly generated number is considered.
- Students often quote densities as numbers per quadrat and forget to convert into individuals per square metre.
- To address practical technique 5, students could make annotated drawings of unknown species in the field to aid identification later.
- Use spreadsheet software or other suitable software to process data for statistical analysis. This will help students cover practical technique 12 and CPAC 5a.

Answers to questions

1. Percentage cover is more appropriate because the grass plants are very abundant in this community and it is difficult to separate individual grass plants.
2. The more quadrat samples are taken, the more reliable the estimate of mean population will be. The number must be large enough to minimise the effect of anomalies, but not too large to be carried out in the time available. You could plot the cumulative mean population against the number of quadrat samples. When the mean has stabilised, meaning that it changes very little from one sample to the next, this indicates a sufficient sample size.
3. It is important to sample randomly to get a true representation of the population and avoid investigator bias. If plants are not evenly spaced throughout the study area, then it might be tempting to go to those places where the plants are or to throw a quadrat in that direction, resulting in a population estimate that is greater than the true population.
4. Answers will depend on students' findings. A single large quadrat is likely to record more species than a small one. Small quadrats are quicker to count, so more samples can be taken and a wider range of the habitat can be covered. However, they would not be suitable for large species. It is difficult to keep a count of large numbers of plants in a big quadrat, so numbers may be under- or overestimated.
5. Results gathered using point quadrats are more objective but may be less precise. Each point may account for several per cent within one quadrat; in a quadrat with 16 points each 'hit' is worth 6.25%. Point quadrats are more likely to miss the presence of species with low abundance. Frame quadrats rely on some estimation of percentage cover by eye, which may be subject to investigator bias.

Sample data

Quadrat size/m^2	Sample type	1	2	3	4	5	6	7	8	9	10	11	12	13	14
0.25 (with 16 points)	Point 'hits'	1	0	2	3	0	4	1	0	1	2	1	3	4	0
0.25	Cover estimate (%)	5	2	14	19	0	25	4	5	7	14	10	20	20	2
0.25	Number of plants	8	3	20	29	0	33	7	8	10	22	12	26	28	3
1.00	Number of plants	40	10	60	115	3	125	27	35	36	89	45	105	109	8

table A Field records for population measurements of ribwort plantain.

	Ground cover (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Mean
Point quadrat	6	0	13	19	0	25	6	0	6	13	6	19	25	0	10
Frame quadrat	5	2	14	19	0	25	4	5	7	14	10	20	20	2	11

table B Percentage cover of ribwort plantain estimated by point quadrat calculated from figures in table A, compared with estimation within the whole quadrat frame.

Quadrat area/m^2	Density/m^{-2}														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Mean
0.25	32	12	80	116	0	132	28	32	40	88	48	104	112	12	60
1.00	40	10	60	115	3	125	27	35	36	89	45	105	109	8	58

table C Density of ribwort plantain (plants per square metre) estimated using quadrats of different sizes.

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Safety

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All the maths you need

- Estimate results.
- Find arithmetic means.
- Construct and interpret frequency tables and diagrams, bar charts and histograms.
- Understand the principles of sampling as applied to scientific data.
- Select and use a statistical test.
- Identify uncertainties in measurements and use simple techniques to determine uncertainty when data are combined.

Equipment

- 0.5 m × 0.5 m quadrat with grid
- 1 m × 1 m quadrat
- 10 m tape measure or rope marked at 1 m intervals
- random number table or calculator
- identification guide
- clipboard

Diagram

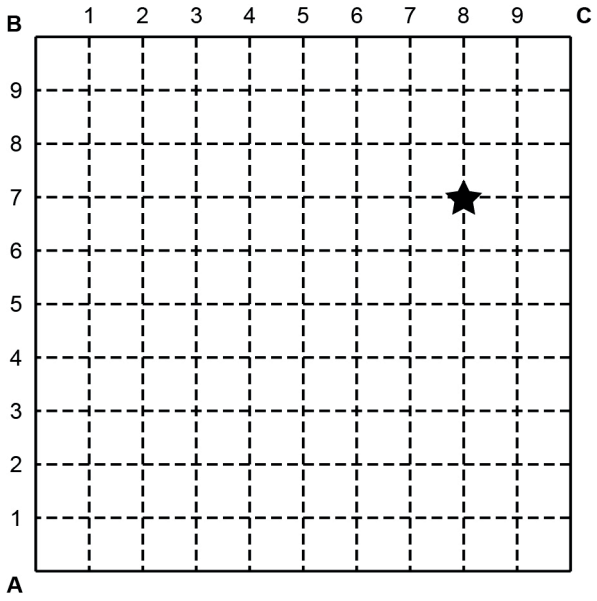

fig A Using random coordinates on a grid to determine the positions of quadrat samples. The coordinate (8, 7) is indicated with a star.

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Analysis of results

1. Calculate the percentage cover for each point quadrat using the formula:
$$\frac{\text{number of hits}}{\text{number of available points}} \times 100 .$$
2. Convert your counts in step 7 to a measurement of density, expressed in individuals per square metre, for both quadrat sizes.
3. Draw a bar chart to compare the mean percentage cover estimates using both methods. Add error bars to show the maximum and minimum values for each method.
4. Use the Student's *t*-test to determine whether there is any significant difference between the density estimates from the two different-sized quadrats. Start by writing the null hypothesis and the alternative hypothesis. Then, if possible, use a computer spreadsheet package to process your data. Set your data out as shown in Student Book Section 10.1.7 and use the spreadsheet formulas to calculate the mean, sum and square values. Write a short paragraph to state whether there was a significant difference between the two density estimates at the 5% probability level.

Learning tips

- The word 'quadrat' is often misspelled in student investigations. If you use word processing software, make sure that is not auto-corrected to 'quadrate' or 'quadrant'.
- A 0.5 m × 0.5 m quadrat has an area of 0.25 m^2. Do not assume the area is 0.5 m^2.

Questions

1. Would density or percentage cover be more appropriate for measuring the abundance of grass within your quadrats? Explain your answer.
2. How did you decide how many repeat quadrats to measure and how could you check whether you completed enough repeats?
3. Why was sampling carried out using random numbers to position the quadrats?
4. Describe any differences between your density estimates using large and small quadrats. Evaluate the advantages and disadvantages of using each.
5. Discuss the advantages and disadvantages of using point quadrats and frame quadrats.

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- Dress appropriately for wet and cold weather. Wear sunscreen in summer months.
- Wear eye protection when making gridded quadrats as wire under tension can snap.

Equipment per student/group	Notes on equipment
0.5 m × 0.5 m quadrat with grid	One per group. Gridded quadrats can be purchased or grids can be added using string or copper wire at even intervals. Ideally, add four wires vertically and horizontally to create 25 squares each of 10 × 10 cm.
1 m × 1 m quadrat	One per group
10 m tape measure or rope marked at 1 m intervals	Two per group
random number table or calculator	One per group
identification guide	Suitable to identify the main plant species in the grassland area under study
clipboard	One per group

Notes