
ESS papers hand you field data and ask what it shows, how it was collected and how far it can be trusted; the internal assessment asks you to collect your own. Both reward the same habits: a sampling method that is random or systematic for a reason, enough samples, the right index or test, and limits stated honestly.

Sampling in the field

Random sampling – quadrats placed at coordinates from a random number generator over a grid laid on the site. Use it to compare two areas that are each fairly uniform

Systematic sampling – quadrats at regular intervals along a transect. Use it where conditions change along a gradient – away from a path, up a shore, into a woodland

Stratified sampling – random samples within each distinct zone, in proportion to its area, so a small but different habitat is not missed

Enough samples: plot the cumulative number of species against the number of quadrats; stop when the curve levels off. Quadrat size the same way – large enough to contain most species, small enough to count.

Percentage cover for plants that cannot be counted (grasses, mosses): the proportion of the quadrat's 100 small squares the species covers. Abundance scales (ACFOR) are quicker but subjective.

Measure an abiotic factor at every quadrat with the same instrument at the same time of day – a light meter, soil and water probes, a thermometer – so it can be tested against the biotic data.

Measuring the abiotic environment

Soil moisture – weigh a sample, dry it in an oven at about 100 °C until its mass stops changing, weigh again. $\text{Moisture} = \text{mass lost} \div \text{wet mass} \times 100\%$

Soil organic matter – heat the DRIED sample strongly in a crucible until constant mass: the organic matter burns off. $\text{Organic matter} = \text{mass lost} \div \text{dry mass} \times 100\%$

Water quality – dissolved oxygen (probe or Winkler titration), BOD (the drop in dissolved oxygen of a sample kept dark at 20 °C for five days), nitrate and phosphate (test kits), turbidity (Secchi disk or turbidity tube), pH, temperature, flow rate (a float timed over a measured distance)

Indicator species and biotic indices – kick-sample the stream bed for a fixed time; score the invertebrates by their tolerance of pollution. Many sensitive groups (stonefly and mayfly nymphs) mean clean, oxygen-rich water

Primary productivity – harvest the plant material in a quadrat, dry it to constant mass, and repeat after an interval: the gain in dry biomass per m² per year is NPP. In water, light and dark bottles give $\text{GPP} = \text{NPP} + \text{respiration}$

Worked calculation: Simpson's diversity index :

Two meadows were sampled with ten random quadrats each. Both have five species, so the same richness; the index also measures evenness. $D = N(N - 1) \div \sum n(n - 1)$, where n is the number of each species and N the total.

species	A	B	C	D	E
meadow 1, n	10	8	6	4	2
meadow 2, n	26	1	1	1	1

1. Meadow 1: $N = 30$, so $N(N - 1) = 870$. $\sum n(n - 1) = 90 + 56 + 30 + 12 + 2 = 190$. $D = 870 \div 190 = 4.6$.
2. Meadow 2: $N = 30$, so $N(N - 1) = 870$. $\sum n(n - 1) = 650 + 0 + 0 + 0 + 0 = 650$. $D = 870 \div 650 = 1.3$.
3. Meadow 1 is more diverse: its individuals are spread more evenly among the species. Meadow 2 is dominated by species A.

A higher D means higher diversity and, often, a more stable ecosystem less affected by disturbance. Compare D only between sites sampled with the same method and effort.

Worked calculation: the Lincoln index : ()

45 woodlice were caught under logs, marked on the underside with a dot of non-toxic paint and released. Two days later 60 were caught, 12 of them marked.

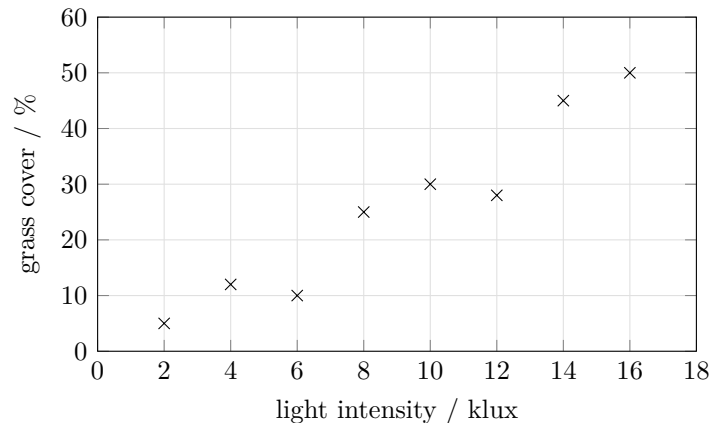
1. Population size = (first catch $\times$ second catch) $\div$ marked in second catch.
2. = $(45 \times 60) \div 12 = 225$ woodlice.

Valid only if the population is closed (no births, deaths or migration in between), marks do not wear off, harm the animal or make it easier to catch, and the marked animals have had time to mix back in. It suits mobile animals; plants and sessile animals are sampled with quadrats.

Worked analysis: light and plant cover along a transect :

Eight quadrats were placed at 5 m intervals from inside a woodland out to its edge. At each, light intensity was measured at ground level and the percentage cover of grass estimated.

quadrat	1	2	3	4	5	6	7	8
light / klux	2	4	6	8	10	12	14	16
grass cover / %	5	12	10	25	30	28	45	50



A scatter graph with no line joining the points; the test below asks whether the pattern is significant.

1. Null hypothesis: there is no correlation between light intensity and grass cover.
2. Rank each variable from 1 (lowest) to 8. Light ranks 1–8 in order; cover ranks 1, 3, 2, 4, 6, 5, 7, 8. The differences d are 0, -1 , 1, 0, -1 , 1, 0, 0, so $\Sigma d^2 = 4$.
3. Spearman's $r_s = 1 - 6\Sigma d^2 / (n(n^2 - 1)) = 1 - 24/504 = 0.95$.
4. The critical value for $n = 8$ at $p = 0.05$ is 0.738. 0.95 is greater, so reject the null hypothesis: there is a significant positive correlation.

A correlation does not show that light causes the change: soil moisture and trampling also change towards the edge. Measuring them too, at the same quadrats, lets you discuss the alternatives.

Evaluating a field investigation

Name limitations that come from the method: one visit, at one season and time of day; a small number of quadrats; percentage cover judged by eye; light that changes as clouds pass.

Match each improvement to its limitation: repeat at different seasons; more quadrats, until the species–area curve levels off; two people estimating cover and averaging; light readings logged continuously with a data logger.

Ethics belong in an ESS method: minimise trampling, return logs and stones as found, release animals where they were caught, and get permission for private land.

Link the result to the wider system: what the pattern means for management of the site, and how far a result from one site can be applied to others.