USING THE SCHOOL PLAYING FIELD TO MEET THE PRACTICAL REQUIREMENTS ASSOCIATED WITH ECOLOGY SUBSTANTIVE KNOWLEDGE IN CURRENT BIOLOGY EXAMINATION SPECIFICATIONS IN ENGLAND

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Abstract

Examination specifications in England for General Certificate of Secondary Education (GCSE) and General Certificate of Education Advanced Special/Advanced (GCE AS/A) Level examinations changed from 2015 onwards to reflect education reforms affecting curriculum design and assessment set out in the government white paper of 2010 [1]. This prevented coursework, practical examinations, and modular examinations from contributing to external qualifications for learners leaving school at sixteen and eighteen years old. Substantive and discipline knowledge were to be tested by written end of course examinations [1].

For science subjects, practical coursework and examinations were replaced by a list of required practical activities accredited by teachers that help learners answer questions about practical and investigation skills on their final examination. These are the same for all the examination boards serving English schools, and the Assessment and Qualifications Alliance (AQA) specifications for GCSE and GCE AS/A Level Biology [2] [3] can be used as typical examples.

A previous International Academy of Technology, Education and Development (IATED) conference proceedings paper [4] discussed the use of a natural ecosystem on Merseyside in the northwest of England by pre-service science teachers to teach ecology. Using the school grounds is an alternative strategy that avoids some of the challenges associated with conducting fieldwork away from the school environment. School playing fields are a surprisingly diverse ecosystem with plants adapted to differing niches and distributed according to several abiotic environmental factors that can fluctuate over short distances e.g. soil pH, trampling, mowing, light exposure, nitrate depletion*, etc.*

GCSE and GCE AS/A level required practical activities [2] [3] linked to the ecology sections of the specifications are discussed. Examples demonstrate how random and systematic sampling using quadrats on school fields can be effective in demonstrating the distributions of species, linking this to the measurement of abiotic factors. The practical requirement for GCE AS/A Level is very similar to GCSE and using a version of Association Analysis developed on Field Studies Council [5] field trips is discussed as a strategy for progression.

Keywords: ecology, STEM, required practical, teacher subject knowledge, fieldwork, sampling, estimating populations, association analysis, school playing field.

1 INTRODUCTION

Examination boards in England introduced required practical work for science examinations for teaching in 2015 to comply with curriculum and assessment reforms initiated by the Government Education White Paper of 2010 [1]. The white paper re-established the substantive and discipline knowledge of subject disciplines as the unit of curriculum design and prohibited practical course work and examinations from contributing to grades for General Certificate of Secondary Education (GCSE) and General Certificate of Education Advanced Special/Advanced (GCE AS/A) Level qualifications [1]. The Assessment and Qualifications Alliance (AQA) specifications for GCSE and GCE AS/A Level Biology [2] [3] can be used as typical examples for the purposes of this discussion of required practical work supporting the teaching and learning of ecology at GCSE and GCE AS/A Level. The required practical activities must be accredited by teachers and intend to help learners prepare for written end-of-course examination questions that test science investigation skills, termed disciplinary knowledge [2] [3]. A previous conference proceedings paper [4] discussed the use of a local ecosystem to deliver required ecology practical work and the degree to which this supports the learning of ecology concepts, termed substantive knowledge, at GCSE and GCE AS/A Level. The current paper discusses the use of the school environs, particularly the school playing field, to deliver these required ecology practical activities.

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The Field Studies Council [5] and Council for Outdoor Education [6] have long argued the case for field work and other types of education outside the classroom. Their position is that there are positive social, psychological and health benefits associated with education outside the classroom, and that learners benefit from investigating the environment directly through better understanding and recall of complex concepts. However, there can be compelling resource, health and safety, and management issues that preclude teachers from planning field trips away from the school site particularly if they would require travel and overnight stays [4]. There are advantages to such field trips [4] but it would be incorrect to assume that the required ecological practical activities can only be delivered away from school. Further, most outdoor environments in England that would be suitable for school-aged learners to visit are managed to some degree. For an ecologist, habitats within the school grounds are examples of managed natural systems and part of a mosaic of interrelated systems in a geographical area. The school playing field constitutes a managed ecosystem, similar to grazed grassland. Here, however, mowing substitutes for grazing, trampling by players during lessons and other pupils during breaks replaces trampling by herbivores and other animals, and re-seeding is an artificial, systematic human activity rather than a natural and random event due to wind, animal, and sensor dispersal mechanisms.

The required ecology practical activity for GCSE Biology involves estimating the population of a species and using sampling techniques to investigate the effect of an environmental factor on the distribution of a species [2]. At GCE level, the required ecology practical is associated with the two-year A-Level course and investigates the effect of a named environmental factor on the distribution of a given species [3]. For this to work using a school playing field, it needs to contain an area where there is variation in at least one easily measurable environmental factor and at least one species that demonstrates zonation. It is not necessary for the selected environmental factor to cause the zonation of the species. As most school playing fields in England would meet these criteria, this paper discusses the questions: Which species are commonly found on school playing fields in England that track variations in abiotic environmental factors? How can these be utilised to deliver the required ecology practical activities?

The activities and approaches discussed have their origins in field work activities delivered by Field Studies Council [5] ecology tutors at the Drapers' Field Centre, Rhyd-y-creuau, in North Wales who encouraged the author as a biology teacher to deliver their own centre assisted ecology activities. They were adapted for use on school playing fields with groups of learners unable to attend field centres. Later, they formed part of a subject pedagogy module at a Higher Education (HE) qualified teacher status (QTS) provider in partnership with schools in the northwest of England. Pre-service science teachers on Initial Teacher Education (ITE) programmes have also given feedback leading to further amendments.

2 METHODOLOGY

This practitioner research constitutes a pedagogical investigation. Data was derived from literature review, document analysis, participant observations, and evaluations of ecology practical work conducted with school age learners and pre-service science teachers, on school and HE institute grounds. This took place during normal learning, teaching and assessment activities undertaken as a biology teacher in school, or as an ITE programme subject tutor. No other primary data was collected from participants. Following British Educational Research Association (BERA) guidelines there are no ethical issues in the anonymous reporting of the findings [7]. The literature used can be found in the References. The AQA Biology Specifications for GCSE and GCE AS/A-Level [2] [3] are referred to throughout the paper and were last downloaded from the AQA website on April 30th, 2023.

3 MAIN ARGUMENTS

3.1 Required ecology practical activities

The AQA GCSE and GCE AS/A Level biology specifications [2] [3] allow teachers and learners free choices in several areas when planning ecological investigations that comply with required practical activities. They may choose a species from any biological kingdom [2] [3] and link it to any factor using the sampling technique they think most appropriate. However, utilising plant species appears to achieve the maximum range of Apparatus and Techniques targets found in the specifications [2] [3] and Working Scientifically targets at GCSE [2]. The use of the mark and recapture method for estimating the population of a motile animal is described in A-Level specification subject content [3] but this is not directly linked to the assessment of practical work section. Similarly, neither specification designates that the distribution of the organism must be linked to variation in an abiotic factor [2] [3]. However, the combination of a plant species and an abiotic environmental factor again allows teachers and learners to maximise the range of Working Scientifically and Apparatus and Techniques goals delivered by the required ecology practical activity [2] [3]. The GCSE specification suggests the use of systematic sampling along a transect line [2] [4], an approach that is especially useful when other environmental factors vary across linear zones (Fig. 1). At GCE A Level, random sampling allows the demonstration of statistical analyses named in the specification [3].

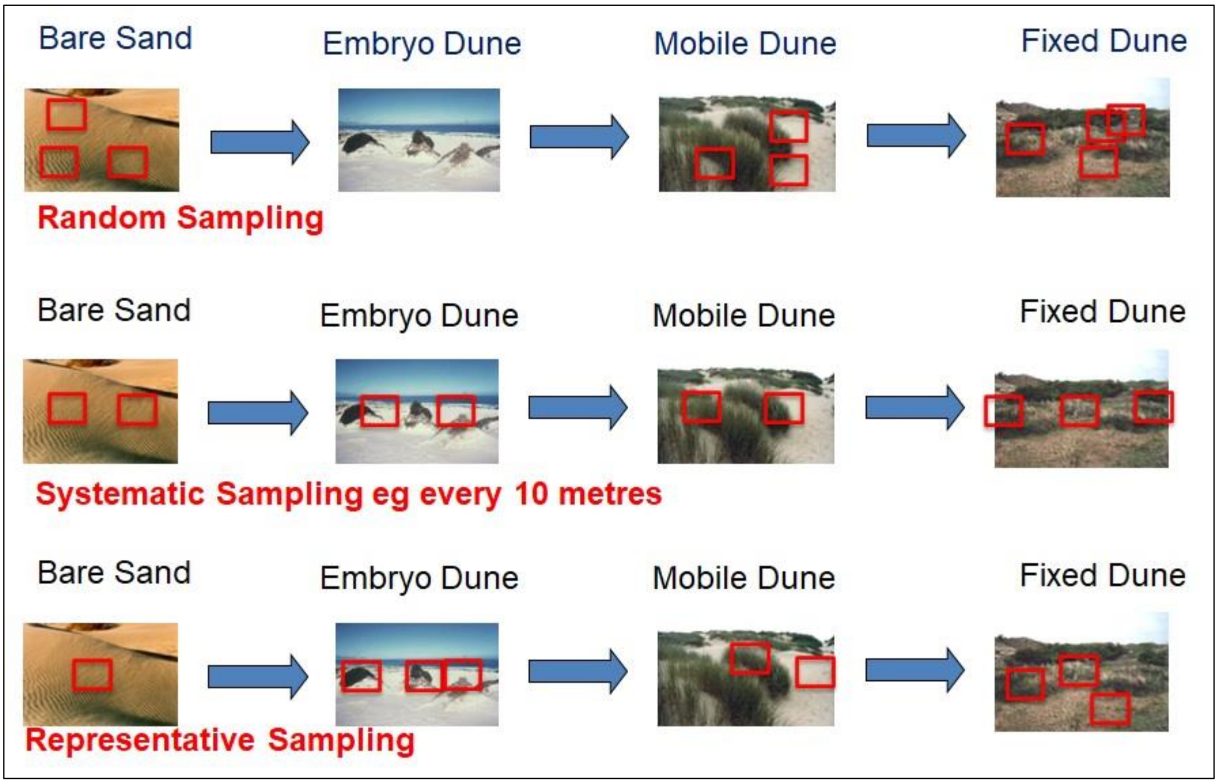


Figure 1 Sampling approaches using a transect line to indicate to learners the distribution of plant species showing linear change, e.g. a coastal sand dune ecosystem.

This discussion will assume that many GCSE biology teachers reading the specification [2] would pragmatically guide learners to choose to investigate the possible link between the distribution of a plant species and an abiotic factor using a transect line or broad belt transect sampled at suitable intervals. At GCE A Level it will assume random sampling along a transect line or broad belt or within a designated area and the measurement of an abiotic environmental factor. Using random sampling techniques allows the opportunity to use comparison of means or, if more appropriate, correlation coefficients, both designated as required mathematical content by the AQA specification [3]. A more challenging investigation uses association analysis based upon Chi squared calculations (also required [3]) based upon contingency tables to ascertain if two species are found together or apart more often than expected. The explanations for negative or positive associations can lie in niche separation and overlap, or the direct effects of biotic environmental factors such as interspecific competition and mutualism. Measuring abiotic factors helps identify possible contributors to niche overlap or separation.

The number of quadrats placed, and quadrat size are other considerations when discussing ecological sampling techniques with learners. A quadrat is simply a portable sample area. The more quadrats that can be placed, the more precise and accurate can be the indication of a species' distribution. However, against this the teacher managing the practical activity needs to consider several areas: the curriculum time available for sampling and taking measurements; learner attributes such as motivation, skill levels and behaviour; and whether it will be appropriate to use individual or collated class results. Collating results increases the sample size and encourages collaborative group work but introduces the variable of subjective differences between the data collectors.

Each quadrat placed needs to be a suitable size for the habitat to be sampled. Too large a sample area and all the species present in the habitat will be found in most of the quadrats and any differences in their distribution will be invisible in the results. Investigating mosses on tree trunks, a small circular wire frame ten centimetres in diameter would be appropriate. On a school playing field a square wireframe fifty centimetres by fifty centimetres, or a $0.25m^2$ quadrat, is often used.

The quickest way to use such quadrats is to record the presence or absence of a species in the sample area. The results are then collated from multiple quadrats and used to calculate the percentage frequency of quadrats that the species was present. As quadrat size decreases compared to the habitat sampled, percentage frequency becomes a closer approximation to percentage cover. The smallest quadrat possible is a point quadrat. In school ecology, these are often knitting needles used with a ruler rather than elaborate point frames illustrated in equipment catalogues. The ruler is placed on the ground and the point placed in the ground at ten equidistant points along it. All the different species touched as the needle is lowered vertically onto the correct place on the ruler are recorded. For point quadrats percentage frequency approximates percentage cover, but this is only accurate and precise if many points are recorded in a sampling area. However, as each placement of the ruler records ten points, they are less time consuming to use than might be expected. Quadrating is a non-destructive, objective method for estimating plant populations and distributions and both percentage frequency and cover are acceptable. Simply counting plants in a quadrat is possible with some species with suitable growth forms but can be problematic if tillering or other asexual reproduction strategies make it challenging for learners to decide the extent and number of individual plants.

3.2 The characteristics of school playing fields

School playing fields in England are surprisingly diverse grassland ecosystems that are managed to varying extents depending on school budgets. Turf may have been laid originally, bare ground seeded, or existing grassland used. They are not expected to equal the high standards of grounds used for professional sports, or domestic cultivated lawns. However, they should provide safe and sustainable playing surfaces for school physical education classes and sporting activities. The field will be maintained and reseeded annually or at need. Mowing will be regular in summer months to make sure that the turf is short and fit for purpose. Regular watering and use of fertilisers are not typically part of management plans, partly due to the regular wet weather in England. There is a tendency to use reseeding to repair patches of bare ground. Schools in England are not exempt from hosepipe bans in times of drought.

The Field Studies Council concise guide to the plants commonly found on playing fields [8] lists and illustrates fifteen broad leaved plants. These can be identified from their leaves and flowers and teachers may find distinctive plants that are found on their own school field and guide learner choices accordingly. The grasses commonly found on playing fields are Ryegrass (*Lolium*), Meadow Grass (*Poa*), Fescue (*Festuca*) and Bentgrass (*Agrostis*) [9]. Most learners will correctly identify a plant as a grass from its leaves. However, it is best not to ask learners to identify grasses to genus or species levels. Common grasses can be easily identified if the flowering heads are present, but these are often absent because the practical activity is conducted at the wrong time of year, or the grass was recently mown. It is difficult to identify the grasses just from their leaf characteristics and ligule shapes. This is also time consuming and often requires the skilled use of a hand lens.

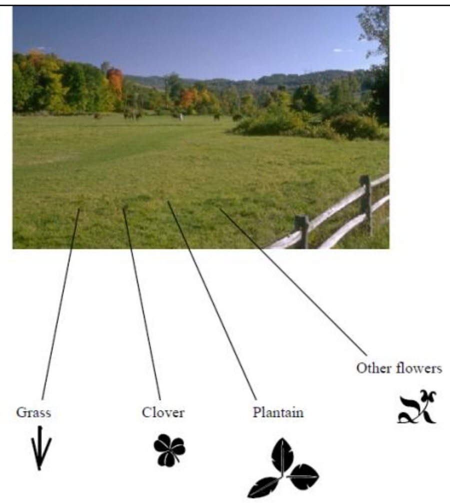
Grass meristems (growing points) are at the base of their leaves at ground level, unlike broad leaved plants that grow from apical meristems at their root and shoot tips. Grasses continue growing new photosynthetic leaf material even after grazing or mowing has removed leaf material rising above the ground. This has contributed to their position as the dominant plant group after which grassland ecosystems are named. So, grass will usually be found in almost every quadrat thrown on a school playing field. This means that they are usually unsuitable to study for the required ecology practical work.

However, there are several easily identified and useful species that demonstrate zonation on school playing fields due to their adaptations to the environment. Plantains (*Plantago*) are plants with extremely tough water conducting tissues in their leaves. They are resistant to trampling and may be found in areas close to paths and along the sidelines of games pitches where there is more bare ground. The rosette form of plantain tends to grow very flat to the ground and is also resistant to grazing and mowing and can outcompete grasses and other species in certain conditions. Clovers and vetches (*Trifolium* and *Vicia*) are legumes with root nodules containing nitrogen fixing bacteria and might be found more often in nitrogen poor areas of the field. Other plants such as self-heal (*Prunella vulgaris*), shepherd's purse (*Capsella bursa-pastoris*), yarrow (*Achillea millefolium)* and white and yellow composites like daisies and dandelions (*Bellis* and *Taraxacum*) may also be easily noticeable at certain times of year but are less easy to link to other factors.

The capability of learners to measure abiotic factors potentially affecting a species' distribution much depends much on a science department's budget in any particular secondary school or college. Edaphic (soil) factors can usually be measured quite cheaply using general equipment and consumables, although probes and data loggers are useful, if available, and often more accurate and precise. Soil pH can be determined using de-ionised water, a spatula or spoon, plastic tubs or beakers and Universal Indicator Paper. Sight comparisons to a colour chart is quick but subjective. Using indicator solution and a portable colorimeter improves upon this. Using a pH probe gives an objective measurement limited only by the accuracy of the probe and scale. However, although convenient and quick to measure, soil pH results often return inconclusive results when used for required practical work. This is because most plants demonstrate optimum growth between pH 5.5 and 7.5. Plants with optimum growth below pH 5.5 are termed calcifuges, and above pH 7.5 calcicoles, meaning to flee or love chalk respectively. At these different pH ranges, different minerals are soluble and available to plants that may have beneficial or toxic effects on plant roots for the different categories of plants. School playing fields in England often (but not always) exhibit too narrow a range of pH measurements to be useful in explaining plant distributions. Soil nitrate level kits used by gardeners can be quite easily obtained in England with colour comparison charts, and often demonstrate more variation across a playing field.

3.3 GCSE required ecology practical work using school fields

At GCSE level the AQA required ecology practical work provides an opportunity to support the examination requirement for working scientifically relating to formulating hypotheses based upon theory and observation [2]. It is always good practice to ask learners to walk around the sample area and make general observations to try and answer ecological questions: What organisms can they see? How many are found where? Why do you think that might be? Fig. 2 shows a work sheet intended to help GCSE students do this by introducing a quick and subjective way of estimating plant populations using the ACFOR scale. Learners then try to explain a chosen plant's distribution in terms of other factors they have noticed. The teacher can develop this into a discussion of the issues raised previously regarding sampling, measuring and estimating plant distribution to test the learners' ideas. It should be noted that the worksheet represents stylistically a restricted number of common plants: grass long as straight leaves, plantain as a rosette and clover as three leaves arising from one point. This does not preclude learners from noticing and choosing other plants for study as the activity progresses. The main criteria for allowing the investigation of additional plant species is that it is distinctive and easily recognisable.



Walk the sample area.
Use the ACFOR scale to estimate the abundance of the following plants.

	Grass	Clover	Plantain	Others	Mud
Abundant					
Common					
Frequent					
Occasional					
Rare					

Use the QUADRAT METHOD to check your findings.

Figure 2 Worksheet: The ACFOR scale as a subjective but quick method of estimating plant distributions.

Learners' hypotheses can be tested using a broad belt transect starting from the edge of the school field and progressing towards the centre. Individuals or pairs can place quadrats, lining up at right angles to the transect line at suitable intervals according to the space available. If the learners record the presence or absence of the plant or plants that have been chosen, the group's results can be pooled at the end increasing the total number of quadrats placed. Abiotic factors can be measured at each sample point. The data can be presented descriptively plotting kite diagrams (Fig. 3) of plant distributions with the abiotic measurements plotted underneath to see if the patterns match. Alternatively, scattergrams of percentage frequency or cover and abiotic factor measurements can be plotted. Fig. 4 demonstrates possible outcomes and valid conclusions from scattergrams generated by such GCSE ecology investigations.

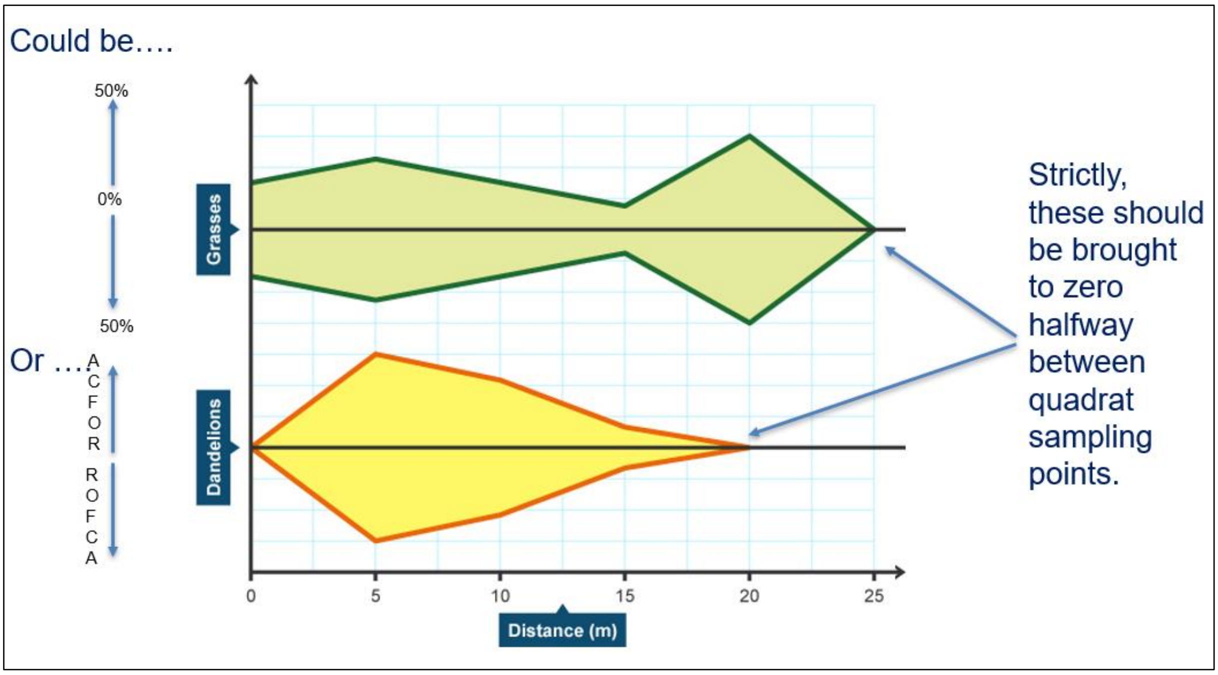


Figure 3 Using Kite diagrams to demonstrate the distribution of organisms along a transect line or belt.

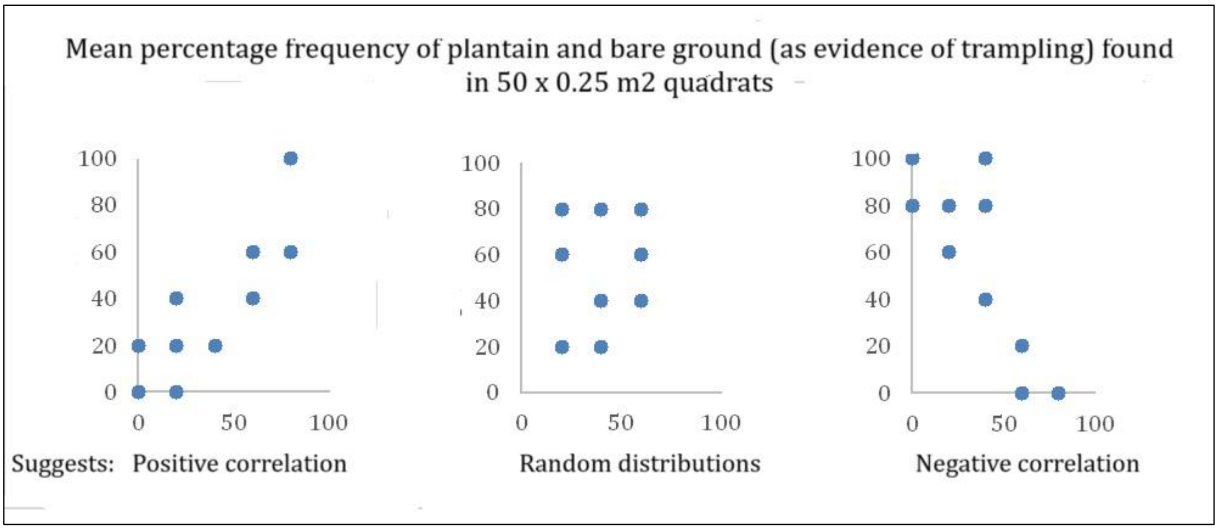


Figure 4 Examples of possible scattergram outcomes of an ecology investigation into trampling as one factor that could affect plantain distribution on a school field.

3.4 GCE A-level required ecology practical work using school fields

The use of different sampling techniques accesses different sections of the AQA A-level mathematics requirement of the biology specification [3]. Systematic or random belt sampling along transect lines with point quadrats for plant cover, or $0.25m^2$ quadrats for plant frequency together with the simultaneous measurement of an abiotic factor generates paired data. This lends itself to the use of non-parametric correlation coefficients [3] such as Spearman's Rank [10]. Random sampling along a transect or within a marked-out area also allows association analysis using Chi squared calculations [3] [4] [10]. However, a common mistake for biology learners is to apply Chi squared analysis to measurements of abiotic factors when it should only be applied to counts or percentage frequencies [10]. Measurements of abiotic environmental factors can be used to help distinguish between niche effects and the direct effect of biotic factors on plant distributions.

For random placement of quadrats, learners will need access to random number tables or generators to determine where their quadrats are placed. Most calculators or laptops can be used to generate a series of random or pseudo-random numbers. They can be generated by drawing cards, numbered 0 to 9 in pairs from a well shuffled packet containing equal numbers of each card. the first card drawn represents the tens and the second the units of one- and two-digit numbers. This allows cards drawn in pairs to generate numbers from zero to ninety-nine. If a tape measure is used as a transect line those numbers can then be used to indicate how many centimetres to move along it before placing the next quadrat. If a designated area is sampled randomly tapes can be used as boundaries and the random numbers as x,y coordinates. Alternatively, learners can spin a pencil and walk the number of steps indicated by each random number in the direction of the pencil lead (once they have retrieved the pencil) (Fig. 5). Learners working in pairs can place at least ten quadrats within a single period (30 minutes) so that a class can easily generate data from fifty to a hundred quadrats in a short time. This is sufficient for non-parametric statistical analyses. Studies using point quadrat frames generate ten points at each placement.

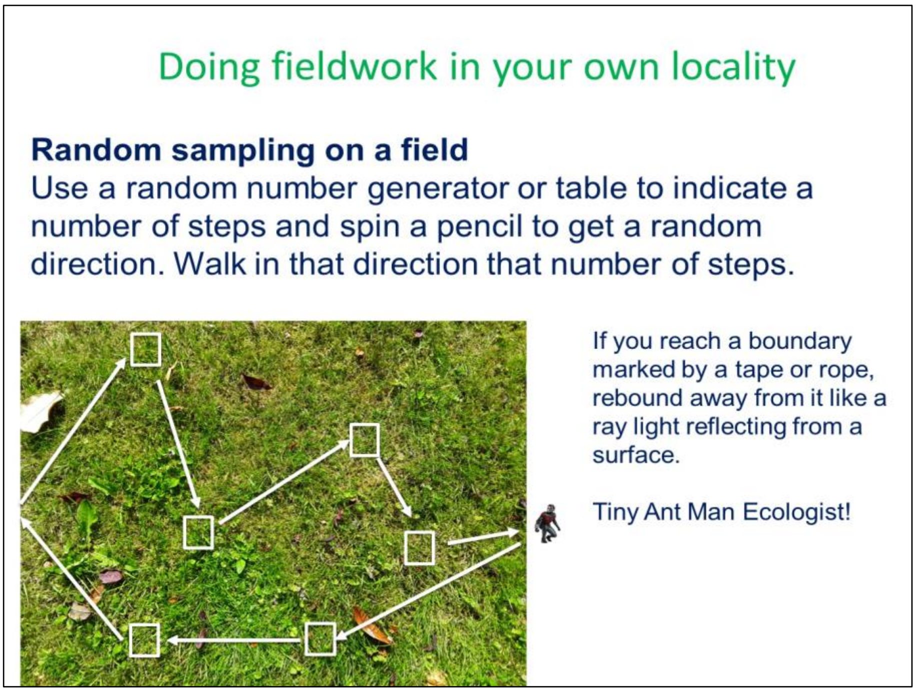


Figure 5 Teaching slide used to model a random sampling technique suitable for use on a school field.

In written AQA examinations, A-Level learners may be required to carry out with instructions statistical procedures on secondary data, in order to demonstrate understanding of the laws of probability, and how to interpret the results of statistical analyses [3]. Fig. 6 shows a typical set of results entered into a spreadsheet set up to speed up the calculation of Spearman's Rank correlation coefficient. The learners manually manipulated the spreadsheet data to sort and rank the percentage cover and soil nitrate measurements, but the spreadsheet deals with the repetitive and final calculations. Learners could work an example from first principles in a theory lesson for practice and to understand how the analysis works. The example in Fig. 6 indicates that the results demonstrated a significant negative correlation between percentage cover of Dutch Clover (*Trifolium repens*) and nitrate levels with a probability of error of 0.05

or less. This was consistent with the knowledge that clovers are legumes with a mutualistic relationship with nitrogen fixing bacteria in their root nodules and don't rely on external sources of nitrogen to the same extent as other competing plants on the playing field.

Plant/Dutch Clover % cover	Nitrate 0/10/20 or 50mg/kg	rank n	rank s	d	d2
100	0	1	9.5	-8.5	72.25
80	0	2	9.5	-7.5	56.25
70	0	3.5	9.5	-6	36
70	0	3.5	9.5	-6	36
60	10	5.5	5.5	0	0
60	10	5.5	5.5	0	0
50	0	7	9.5	-2.5	6.25
40	20	8	3.5	4.5	20.25
20	0	9	9.5	-0.5	0.25
10	20	10	3.5	6.5	42.25
0	50	11.5	1.5	10	100
0	50	11.5	1.5	10	100
			totals	0	469.5

r=1-((6*sumd2)/(n(n2-1)))

r= -0.642

Pairs	Critical values regardless of sign	
	5%	1%
10	0.648	0.794
12	0.591	0.777
14	0.544	0.715
16	0.506	0.665

Figure 6 Example of using a spreadsheet to calculate Spearman's Rank r, showing a significant negative correlation (p=0.05) between nitrate levels and percentage cover of Dutch Clover (Trifolium repens).

Fig. 7 illustrates the use of a spreadsheet for association analysis based upon Chi squared calculations [10]. This is a long-established approach in ecology studies [11]. The method requires an understanding of the laws of probability, a requirement of the AQA Biology specification [3]. This is necessary to calculate the expected counts. In the example, initial observations suggested that clover and plantain were negatively associated, found in different parts of the field more often than expected if their distributions were random with respect to each other. In any quadrat placed there are only four possible results. They will contain both plants, only clover, only plantain, or neither. Fig. 7 demonstrates the use of a contingency table, and of row and column totals to calculate the expected results.

Chi 2	Spreadsheet
Results:	No. of quadrats with
1&2	10
1 only	19
2 only	13
Neither	3

Plant 1	Clover
Plant 2	Plantain

Enter the Observed Results in the table.

Observed No. of Quadrats:		Plant 1		
		Present	Absent	Totals
Plant 2	Present	10	13	23
	Absent	19	3	22
	Totals	29	16	45

Expected No. of Quadrats:		Plant 1	
		Present	Absent
Plant 2	Present	15	8
	Absent	14	8

o-e	Yates' Correction	d2	d2/e
-4.82	4.32	18.68	1.26
4.82	4.32	18.68	1.32
4.82	4.32	18.68	2.28
-4.82	4.32	18.68	2.39
		chi2=	7.25

There may be a negative assoiation.

1df, 5pc cv =3.84

There is an association, 5% chance of error.

Nitrate indicator		(x10 mg/kg)	
Both	1	2	Neither
0	0	0	0
0	0	1	0
1	0	1	0
0	0	5	
1	0	1	
0	0	0	
1	0	1	
1	0	5	
1	0	0	
1	1	1	
	0	1	
	0	0	
	0	1	
	0		
	0		
	0		
	0		
	0		
	1		

mean	0.60	0.11	1.31	0.00
sd	0.52	0.32	1.70	0.00
5pc	0.37	0.15	1.03	0.00

There was no significant difference between the nitrate levels in the soil in the quadrats containing both and quadrats containing just clover or plantain.

Mean nitrate levels were higher in quadrats containing just plantain compared to those containing just clover. (5% error)

Figure 7 Example of using a spreadsheet to demonstrate a significant negative association (p=0.05) between Dutch Clover (Trifolium repens) and Self Heal (Prunella vulgaris) suggesting niche separation that could involve nitrate levels.

The observed counts were quadrats with:

Clover and Plantain, 10

Clover only, 19

Plantain only, 13

Neither, 3

Total, 45

The probability of finding Clover in another quadrat would be 10 + 19 = 29 out of 45 or 0.64.

The probability of finding Plantain in your next quadrat would be 10 + 13 = 36 out of 45 or 0.51.

The probability of finding both in your next quadrat would be 0.64 x 0.51 = 0.33.

We would expect to find both growing together in 0.33 x 45 = 15 quadrats even if they were randomly distributed.

The expected counts for the other cells in the contingency table are found by simple subtraction from the Plant 1 column total (29-15=14), the Plant 2 row total (23-15=8), and either 22-14 or 16-8 = 8 (Fig. 7).

The spreadsheet illustrates the steps for calculating Chi squared for each pair of observed and expected counts and totals these for the contingency table, applying Yates' correction for one degree of freedom associated with a two-by-two contingency table [10]. In the example the two plants were found together in quadrats less often and alone more often than expected suggesting a negative association. The total Chi squared value was larger than the critical value for one degree of freedom [10] and the null hypothesis (that there was no difference between the observed and expected counts) was rejected with a probability of error of less than 0.05 or 5%.

Fig. 7 also indicates the soil nitrate data collected. Mean nitrate levels were calculated for the four quadrat categories. The standard deviations and 95% confidence levels for the means were also calculated. The 95% limits overlap for the quadrats with both or either plant alone. However, there was no overlap for the quadrats containing only plantain or clover, with clover occupying quadrats with significantly lower nitrate levels than plantain. This suggests that this abiotic factor could affect both plant distributions. Laboratory investigations would be needed to confirm the exact role of nitrate in the niches occupied by the plants within the school field ecosystem.

4 CONCLUSIONS

Many species commonly found on school playing fields in England demonstrate zonation. Grasses are the dominant plant group and tend to present everywhere unless human usage, edaphic or climatic conditions cause areas of bare ground. All the other species mentioned in this discussion can be found in zones on school playing fields in England. Some zonation is linear and some mosaic giving learners the opportunity to select a sampling method accordingly.

Establishing that plant distributions on a school field are associated with environmental factors, abiotic or biotic is usually more difficult given the constraints on curriculum time in schools that limit the number of quadrats that can be thrown and measurements that can be made. However, the required ecology practical component of GCSE and GCE AS/A-Level examination specifications [2] [3] is satisfied no matter the conclusions reached. The opportunity to discuss with learners their investigation design, sampling approach and data gathering methods will be the same, if positive, negative or no links between species distributions and other factors are demonstrated.

The use of systematic and random sampling techniques along transect lines, broad belts and within clearly defined sample areas is a useful approach to satisfy AQA required ecology practical activities, their associated assessment aims, and cross curricula mathematics requirements [2] [3].

Clear findings are possible when learners look for an easily recognised plant species and choose an objective method of data gathering, such as presence or absence in a quadrat or touch or no touch with a point quadrat. At GCSE level the aim is to produce sufficient points on a kite diagram to demonstrate zones or to place enough quadrats and take enough other factor measurements to be able to compare means. At GCE A Level twelve pairs of data is enough to demonstrate correlations between percentage frequency/cover and abiotic factor measurements using Spearman's Rank. A reasonable number of quadrats or point frames for association analysis is between 40 and 50. The AQA specifications do not preclude the collation of class results.

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