ACTIVITY BRIEF

Ecology and Simpson's Diversity Index

The science at work

Ecologists, such as those working for the Environmental Agency, are interested in species diversity. This is because diversity is usually proportional to the stability of the ecosystem: the greater the diversity the greater the stability. The most stable communities have large numbers of species which are fairly evenly distributed in good-sized populations. Pollution often reduces diversity by favouring a few dominant species. Diversity is therefore a factor in successful conservation management.

A **diversity index** takes into account the number of species present, as well as the abundance of each species. Species **diversity** should not be confused with species **richness**. The number of species per sample, e.g. plants in a 1 m^2 quadrat, can be used as a measure of richness. Or a consolidated species list may be built up of *all* the species found in a habitat or ecosystem over a period of time. These are useful for comparing different areas, but just counting species will not allow comparison of diversity.

Your brief

Environmental scientists use a variety of different methods to compare diversity in different ecosystems and to monitor the progress of conservation measures. One of the most popular methods is to use the relative abundance of different species to calculate Simpson's Index of Diversity.

You can investigate this by using ordinary playing cards as 'species' to generate data to calculate Simpson's Index, D.

$$D = \frac{\sum n(n - 1)}{N(N - 1)}$$

where N = the total number of organisms of all species and

n = the total number of organisms of a particular species

from which Simpson's Diversity Index, 1 – D, is found.

Once you have an understanding of the method works you can obtain and analyse your own data.

Use:

- *Practical sheet: Using cards to investigate Simpson's Diversity Index*
- *Practical sheet: Finding Simpson's Diversity Index for an ecosystem*

PRACTICAL SHEET

Using cards to investigate Simpson's Diversity Index

You will need

- one pack of 52 standard playing cards

  The cards represent nine possible species:

Species A: all picture cards (jacks, queens and kings)	**Species B**: odd numbered clubs	**Species C**: odd numbered clubs
Species D: even numbered diamonds	**Species E**: even numbered diamonds	**Species F**: odd numbered hearts
Species G: even numbered hearts	**Species H**: odd numbered spades	**Species I**: even numbered spades

- copies of the recording sheet

Procedure

Work with a partner to investigate the following communities:

Community 1

Shuffle the cards. Count out 26 cards, this is your sample. Using the *Recording sheet*, note how many of each species (A to I) you have in your sample. Tally your results by putting an upright line in the appropriate box, /. Complete the table to calculate the Simpson index.

Note: you can make 'gates' *////* with each fifth tally to make counting easier

Community 2

Remove seven jacks, queens or kings from the pack of 52 cards to leave five cards for every 'species'. Repeat as for Community 1.

Community 3

Remove the jacks, queens and kings and one of the suits from the pack of 52 cards to leave you with three suits and six 'species' with five cards each. Repeat as for Community 1.
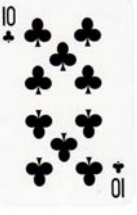
Community 4

Make up a further community of your own to investigate. Use all of the 'species' but alter the relative numbers of cards to get the lowest diversity that you can.

Questions

Make notes to answer these questions:

1 Why is 1 – D rather than D used as a measure of diversity?

2 Two factors affect diversity scores: (a) what are they? (b) what effect do they have?

3 How could you ensure reliability?

Recording sheet

Species		Tally	Total, n	n - 1	n(n - 1)
clubs	Odds				
	Evens				
diamonds	Odds				
	Evens				
hearts	Odds				
	Evens				
spades	Odds				
	Evens				
Totals		N =		$\sum n(n - 1) =$	
		N - 1 =	$D = \dfrac{\sum n(n - 1)}{N(N - 1)} =$		
		N(N - 1) =	1 − D =		

PRACTICAL SHEET

Finding Simpson's Diversity Index for an ecosystem

If you have already sampled an area, you may be able to use the data to calculate Simpson's Diversity Index. All you need is the number of different species and the number of times each species was found (frequencies). If you are to compare ecosystems, you must use the same sampling method and compare the same organisms. So, you might look at diversity of the invertebrates in a clean and a polluted stream or the ground flora (vegetation) or insects in a woodland compared to a field.

If you already have suitable data (for example from a quadrat study or kick sampling in a stream), calculate Simpson's Diversity Index. Note that a single calculation is not much help, you need to be able to compare different areas sampled using the same technique.

If you need to collect data you will need further instructions from your teacher. One advantage of using this particular index is that you only need to be able to distinguish species, you do not need to identify them.

Representative sample

You may be restricted by time and only able to take a limited number of samples. If you have time to make a more serious study, you can use a simple technique to test that you have a sample that is truly representative of the area that you a studying. This is done by keeping a cumulative species total as each random sample is taken, i.e. the total number of different species that have been found to date. This is plotted against the sample number. After no more species have been found for three or four samples, you know that you are likely to have found them all.

Try this for practice

The following data were obtained for woodland vegetation using randomly placed 1 m^2 quadrats.

Trial number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of species	9	14	17	18	19	21	22	23	23	24	24	24	24	24	24

Plot the data and suggest the point at which sampling could stop.

Teacher notes

This activity links to

OCR Unit 14 Ecology and managing the environment, and

AQA Unit 16 Ecology, conservation and recycling.

For both units, students must carry out an ecological study.

OCR Unit 14: Ecology and managing the environment

Students must:

produce evidence of your investigation on ecology and managing ecosystems

This evidence needs to include:

***AO3:** a planned investigation of an ecosystem.*

To gain the highest marks, student should:

- *demonstrate a thorough knowledge and understanding of the relationship between the organisms, their physical environment and each other in ecological succession*

- *use appropriate scientific terms and conventions accurately*

- *research the effect of agricultural practice, human habitation and greenhouse gas production on ecosystems and biodiversity, selecting a wide range of relevant information and presenting it clearly and logically*

- *evaluate the information available and justify the choice you included*

- *organise information to evaluate the scientific, moral and ethical reasons for preserving ecosystems and species diversity*

- *describe a range of methods used to manage ecosystems and preserve species diversity*

- *interpret, explain and evaluate a range of data relating to the success of a project managing one ecosystem*

- *carry out complex calculations on ecological data involving the statistical analysis of the data obtained (e.g. chi-squared or t test)*

- *obtain the correct solutions to an appropriate degree of accuracy and demonstrate an understanding of the significance of the outcomes.*

AQA Unit 16 Ecology, Conservation and Recycling

Students must:

produce a portfolio of evidence which considers the ecology of an ecosystem and the impact mankind has had on the environment.

Their portfolio of evidence should contain

A. details of an ecological survey, including food chains, food webs and energy flow within a chosen habitat including:

- *the identification of a particular habitat*

- *an account of research undertaken in relation to the ecological survey. This will include and explanation of techniques which could be used*

- *the use of a suitable sampling technique, to estimate the distribution and/or numbers of organisms and use this information to estimate population size*

- *a summary of the physical and biological characteristics of the habitat based on the findings of your sampling*

- *details of feeding relationships including food webs and food chains based on the findings of your sampling*

- *energy flow within the habitat based on the findings of your sampling*

This activity introduces students to the Simpson's Diversity Index which they may wish to use in the ecological study.

Practical sheet: Investigating Simpson's Diversity Index

This can be completed in a single lesson. Some students find the concept of species diversity quite difficult, confusing **diversity** with species **richness**. This simple exercise allows them to rapidly generate data and use a structured recording sheet to calculate Simpson's Index, D, and Simpson's Diversity Index, 1 – D.

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

The two factors affecting diversity, richness and evenness, are investigated by creating and comparing:

- a high diversity community with a fairly even distribution of species

- a community with one dominant species

- a community with fewer species

- a community with the lowest possible diversity index using nine species (students need to work this out – use all the court cards, but only one card of each other "species")

Requirements

For each pair:

one pack of 52 standard playing cards

four recording sheets

Recording sheet

This is designed to allow straightforward calculation of D and 1 – D.

Answers to questions

1 Why is 1-D rather than D used as a measure of diversity?
It's more logical and less likely to cause confusion. The scale then gives a score from 0 to 1 with higher scores showing higher diversity (instead of being associated with low scores).

2   Two factors affect diversity scores.

(a) What are they?
Species richness (or species total) and evenness (or conversely, unequal distributions).

(b) What effect do they have?
An increase in either leads to an increase in diversity. The more species the higher the diversity, but if they are not evenly distributed, for example if one species is much more abundant, diversity falls.

3   How could you ensure reliability?

Check that a representative sample has been obtained, e.g. by comparing scores for different samples to see if they are consistent.

**Practical sheet: Finding Simpson's Diversity Index for an ecosystem**

A version of the recording sheet which could be used for the students own results can be found at the end of this document. If necessary, e*xtra rows can be added to allow for more species.*

An estimate of diversity can be found for any set of data that allow the total number of species and the occurrence of each species to be found. Data purely for the purpose of calculating this index can be found rapidly if species are simply distinguished, rather than identified.

If students are set this task they will need to decide or be given clear instructions for the sampling technique to be used to ensure fair comparisons of different areas can be made.

Representative sample

The data provided show the total plateaus at 24 species after 10 quadrats, suggesting that no further samples were needed after about the 12th quadrat.

Woodland plant species
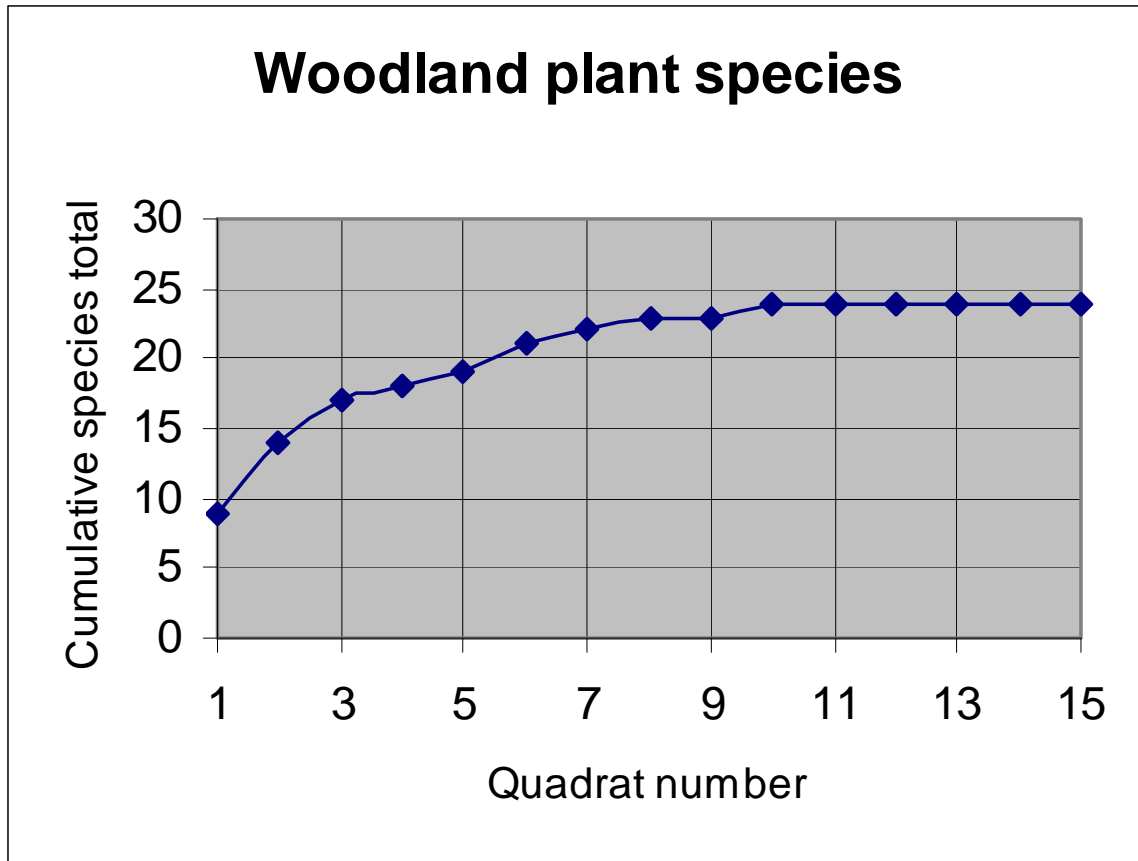
This technique is a useful test for optimum sample size and can be applied to other situations such as finding densities.

Recording sheet for field work

Date

Description of ecosystem investigated

	Species found	Tally	Total, n	n - 1	n(n - 1)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Totals	N = N - 1 = N(N - 1) =			$\sum n(n - 1) =$ $D = \dfrac{\sum n(n - 1)}{N(N - 1)} =$ $1 - D =$	