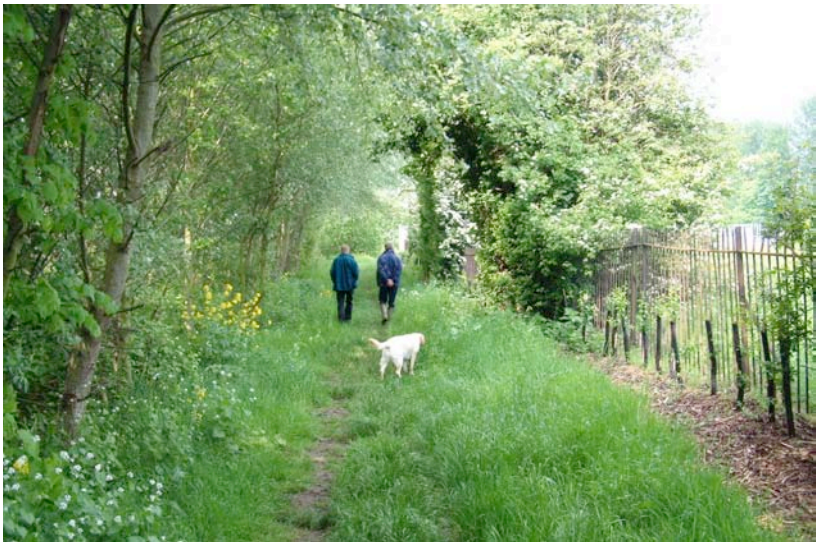
Woodland Regeneration in a Restored Quarry

QUARRY PRODUCTS ASSOCIATION

The National Curriculum at Key Stage 4
SC1 Scientific enquiry: 2
SC2 Living things in their environment: 3, 4a, 4c



Through this module pupils will be encouraged to

- Research and use existing scientific knowledge
- Decide on the appropriate use of first-hand observations or secondary sources
- Set up a pilot study and consider key factors; make testable hypotheses
- Design suitable recording sheets and analysis spreadsheets with accurate calculations at an appropriate level of precision
- Use a range of equipment appropriately and safely, recording to appropriate levels of precision
- Decide on how to present observations
- Evaluate results in the light of original hypotheses and scientific knowledge
- Consider anomalous data and the quantity and reliability of their own data
- Suggest improvements to methods and design further investigations
- comment on the suitability and sustainability of the management methods employed in the woodland in the restored quarry
- The subject of woodland in restored quarries will be explored in the context of the habitats provided in suitable locations. However the work will be equally relevant to woodland in other situations.

SC1 Scientific enquiry: 2
SC2 Living things in their environment: 3, 4a, 4c
(Quarry-Linked adapted unit)
Woodland regeneration in a restored quarry

Key Stage 4 Single Science

ABOUT THE MODULE

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WHERE THE MODULE FITS IN	CURRICULUM LINKS	RESOURCES (items marked * shown in resource design sheet)
Following the National Curriculum at Key Stage 4, the following areas will be addressed: • Use of scientific knowledge • Decisions on use of first-hand observations or secondary sources • Pilot study • Consideration of key factors • Setting testable hypotheses (making predictions) • Sampling strategy and sample size • Safely and appropriately using a wide range of equipment • Making and recording reliable observations and measurements • Assessing reliability levels • Data presentation • Accurate calculations • Evaluating original hypotheses • Using scientific knowledge to explain and interpret • Considering anomalous data and reliability of data • Do we have sufficient evidence? • Suggest improvements to methods and ideas for further investigations	• numeracy, • ICT • literacy • chemistry • design technology • Citizenship **KEY THEMES** • how does woodland regeneration affect adaptation and competition? • sustainability of the woodland • photosynthesis and nutrient uptake • pyramids of biomass and energy transfer • role of microorganisms	• computer network for internet access and worksheet design and production • Virtual Quarry Resource – information on local woodlands • digital cameras for production of plant identification resources • gridded quadrats*, canopy cover tubes* (could be produced in DT lessons); • clinometers. ranging poles, 30m measuring tapes (available very cheaply from 'Pound shops'); • old metal knitting needles (charity shops) • soil pH kits • identification keys for woodland plants*, trees* and woodland litter invertebrates* • large polythene bags • low power binocular microscopes or x10 hand-lenses, plastic teaspoons, paint-brushes • sorting trays

EXPECTATIONS

at the end of this module pupils should

Understand how to research and use existing scientific knowledge	By using library facilities and internet research to access previous work on woodlands
Be able to decide on the appropriate use of first-hand observations or secondary sources	By looking at what is known about a suitable local site (Virtual Quarry Resource – information on local woodlands; Local Wildlife Trust and Woodland Trust websites) and deciding what further information is needed
Understand how to set up, carry out and interpret a pilot study	By visiting a local woodland site (real or virtual) and considering key factors and setting testable hypotheses
Be able to design and produce suitable recording and analysis sheets with appropriate levels of precision	Using ICT facilities with the help and support of both Biology and ICT staff or downloading suitable worksheets from Virtual Quarry Resource
Be able to design and produce fieldwork equipment – e.g. quadrats and canopy cover tubes	Using DT facilities with the help and support of both Biology and DT staff

Use this and other equipment appropriately and safely, recording to appropriate levels of precision	After carrying out risk assessments and deciding on appropriate precision level for the different recordings (see resource sheets)
Decide on how to present observations	Using appropriate methods to show in the clearest way possible differences, similarities and relationships between data sets
Evaluate their own results	in the light of their own original hypotheses and scientific knowledge, considering anomalous data and the quantity and reliability of their own data
Suggest improvements to methods and design further investigations	Looking at the problems they encountered, any 'quick fix' solutions employed, and any other information which would be useful
Comment on the management methods being used in the woodlands which has been investigated and on the sustainability of the woodlands	Suggesting any management changes which would improve woodland ecosystems Commenting on the sustainability of the activities which they have carried out – i.e. trampling, collecting invertebrates

Follow-up work focuses on the use of the pupils' own data to relate to ecological theory and to use their results to demonstrate

- adaptation and competition
- the effects of different canopy regimes on photosynthesis
- the role of ground vegetation and trees in nutrient uptake
- the development of the idea of pyramids of numbers (which in woodland can be inverted with one tree supporting thousands of herbivores) into pyramids of biomass
- the importance of considering seasonal variation and the whole year cycle
- the importance of detritivores (comminution) in assisting microorganisms in their ecological role as decomposers

Key Stage 4 Single Science:
Woodland regeneration in a restored quarry

Teacher Summary
Introduction
The work involved in 'Woodland regeneration in a restored quarry' relates to:

SC1 Scientific enquiry
- 2 investigative skills: planning, obtaining and presenting evidence, considering evidence

SC2 living things in their environment:
- 3a variation – environmental causes
- 4a distribution and relative abundance can be explained using ideas of interdependence, adaptation, competition and predation
- 4c the importance of sustainable use and management of woodland

It is designed
- to build on knowledge and understanding gained at Key Stage 3
- to allow pupils to use a range of complementary skills in ICT and DT to support the science fieldwork investigation and subsequent presentation and analysis.

Specific topics addressed include
- adaptation
- competition
- photosynthesis
- nutrient uptake
- the role of detritivores and microorganisms
- energy transfer
- the development of pyramids of numbers into the concept of pyramids of biomass.

Health and safety and sustainability issues are also addressed during the investigation.

Why use a restored quarry?
- Restoration often has to start from scratch
- it is often carried out in stages which gives an opportunity to look at woodland of different known ages
-

Preparation – site selection
The teacher should select a suitable local site (e.g. in restored quarry, via virtual quarry resource or local woodland). Ideally a woodland with in a restored quarry showing different stages in succession and two contrasting areas or, if this is not possible, one with secondary data from a previous survey available, is selected. If possible aspect, altitude, geology and soils should be as similar as possible to minimise unwanted variables. Risk assessments must be downloaded (from VQ website) or carried out and the investigation should be fully costed (coach transport etc.) and all necessary permissions obtained.

The lessons and practical sessions

The unit ideally comprises eight sections (four class sessions, two practical sessions in the field and one practical/class session) supported by homework/personal research:

Classroom session 1:

- brief revision of knowledge and understanding
- setting the scene
- allocating preliminary research

Coursework/homework

- preliminary research via virtual quarry resource

Classroom session 2:

- presentation of pupils' research
- deciding on what will be investigated
- what further information is needed? Can it be gained from secondary sources or is practical investigation needed?
- preparation for pilot study – instructions on what to bring (lunch, suitable clothing, notebooks & pencils, digital cameras etc,)

Practical session 1 (fieldwork):

- a brief look at the two areas to be studied
- selection of sample areas avoiding edge effects, footpaths, anomalous areas
- collection of preliminary samples of plant leaves for identification and preparation of worksheets
- collection of preliminary samples of leaf-litter for invertebrates and field identification using FSC foldout chart

Classroom session 3:

- recap on practical session 1
- get pupils to suggest, and agree on, hypotheses – trees, plants, ground vegetation, invertebrates
- sampling methods which will test these hypotheses are now designed and suitable equipment discussed

Practical session 2 (fieldwork):

- detailed investigation of the two areas of woodland to test the hypotheses which the pupils have suggested
- identification in the field and careful release of invertebrates collected
- teacher collects pupils' data sheets for safe keeping

Classroom/practical session: data collation and presentation

- hand data sheets back
- pupils enter data into prepared spreadsheets
- after auditing printouts of all results are given to pupils

- groups of pupils are allocated different sections of the data and asked to prepare displays which help to decide whether to accept or reject each hypothesis

Coursework/homework

- internet research on individual species and their adaptations
- preparation of presentation by each group - who will say what

Classroom sesssion 4: summing it all up

- brief (5 minute maximum) presentation by each group
- review of methods used and suggested improvements, further research
- discussions on adaptation and competition and ways of avoiding competition
- revisit the idea of pyramids of numbers – why is it too simplistic?
- introduce the idea of pyramids of biomass and explain why animals, plants and leaf litter have not been weighed
- final discussion on management and sustainability of the woodland

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Preparation for the unit

Classroom session 1: introduction

In the first lesson, ask the pupils to tell you what they already know about

- food webs
- pyramids of numbers
- energy transfer
- adaptation and competition

Then tell them that they will be doing practical work - an investigation into parts of a local woodland.

If a quarry is used

- emphasise that it is not a natural habitat
- it is the result of industrial activity
- ask the pupils what was obtained form the quarry

For all sites

- Hand out or project maps showing the site
- Ask pupils initially asked to research the chosen site using secondary sources.
- Information is needed on
    - the age of the woodland
    - trees and other plants recorded
    - soil and underlying geology
    - local climate.
- Ideally groups of pupils choose a specific topic from this list to research.

Coursework/homework

Sustainability of the woodland

By asking the questions below pupils will be able to

- Decide on the appropriate use of first-hand observations or secondary sources
- Research and use existing scientific knowledge

Is woodland in a restored quarry sustainable?

- should the woodland be allowed to regenerate naturally or should it be planted? Why? consider costs and benefits of the alternatives
- are the species used suitable? Do they match what occurs locally? Are they suited to the local climate, soil and geology? look at local natural/semi-natural woodlands – secondary data (internet – English Nature or local Wildlife trust). Visit virtual quarry.
- is the management appropriate? Will current management lead to an increase in diversity? – secondary data (internet – English Nature or local Wildlife trust). Visit virtual quarry.
- is the woodland large enough? – secondary data (internet – English Nature or local Wildlife trust). Visit virtual quarry.
- is it close enough to local natural/seminatural sites? – secondary data (internet – English Nature or local Wildlife trust). Visit virtual quarry.

what effects will our investigations have on the woodland? (trampling, removal of invertebrates). Will they affect the sustainability of the woodland?

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Practical session 1 (fieldwork): Pupils carry out a pilot study which involves:

- a preliminary visit to 2 contrasting areas of the woodland or, if only one area is available, an area for which secondary data exists
- identification of the main plant species present (FSC Guide to Woodland Plants, Guide to trees)
- a brief look at leaf-litter invertebrates in 2 areas (FSC Woodland name trail)
- setting up initial predictions (e.g 'there are more plants in area 1 than in area 2'; 'there is more light reaching the ground in area 1'; 'there is more leaf litter on the ground in area 2'; 'there are more invertebrates in the litter in area 2'; 'the soil will be different in the 2 areas' etc.
- decisions on how to sample trees, ground vegetation and invertebrates – sample area, sampling strategy (random or systematic) and methods (quadrats – plain, gridded for plants, counting trees, volume samples for invertebrates in leaf litter; ways of measuring light)
- if the work is being compared with secondary data then the same strategies and methods should be used
- a very brief pilot sample from each area
- careful collection of whole leaves from each tree and ground plant species

Coursework/homework/teacher preparation
Leaves from the trees and ground plants can be scanned to produce identification aids – printed at about life-size. named and laminated they will be very helpful.

A set of scans is provided as a resource.

Identification resources

There are 3 excellent colour guides in the Field Studies Council's 'Fold-out Chart' series:

- Woodland name trail
- Woodland plants
- Tree name trail

All available from

FSC Publications
Preston Montford
SHREWSBURY
SY4 1HW

Tel.: 0845 345 4072 **Fax:** 01743 852101

Email: publications@field-studies-council.org

Website: www.field-studies-council.org

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Classroom session 2: presentation of pupils' research, preparation for pilot study

Ask pupils to consider what happens as woodland grows up.

- How does woodland regeneration affect adaptation and competition?
- what happens to the trees?
- how do they affect the soil and climate of the woodland as they grow up?
- what effect will this have on the ground plants and on invertebrates? What adaptations might be successful?

Pupils decide on what will be investigated

- what further information is needed? Can it be gained from secondary sources or is practical investigation needed?
- preparation for pilot study – instructions on what to bring (lunch, suitable clothing, notebooks & pencils, digital cameras etc,)

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Classroom session 3: Setting up hypotheses and designing the investigation

- recap on the pilot study and secondary data
- look at the predictions made during the pilot study and turn them into testable hypotheses. Discussion might include:
  - 'there are more plants in area 1 than in area 2', 'there are more invertebrates in the litter in area 2'
  - do we mean 'more individuals' or 'more kinds' or both?
  - 'there is more light reaching the ground in area 1'
  - this is already a testable hypothesis
  - 'there is more leaf litter on the ground in area 2'
  - what do we mean by 'more'? is it deeper, denser?
  - 'the soil will be different in the 2 areas'
  - what do we mean by 'diffferent'? is it deeper in one area, more acid in one area?

- then get pupils to suggest, and agree on, hypotheses – trees, plants, ground vegetation, invertebrates: for example
  1. there will be more trees in area 1 (the younger area)
  2. the trees in area 1 will be smaller
  3. less light will reach the ground in area 2 (the older area)
  4. there will be more kinds of ground plants in the younger area
  5. there will be more leaf litter in area 2 (the older area)
  6. there will be more kinds of invertebrates in the litter in area 2 (the older area)
  7. the soil will be more acidic (the pH will be lower) in area 2 (the older area)

sampling strategies and methods which will test these hypotheses are now designed and suitable equipment discussed, e.g.:

- working areas: need to be large enough to reduce impact but far enough from woodland margins, rides or footpaths to avoid 'edge effects'
- strategies: random sampling gives least bias and fairest comparisons for ground vegetation, soil and invertebrates but trees are best counted and measured individually. Random number tables are needed; the random numbers should include zero and should be in increments which are the size of the gridded quadrat. For example, if the quadrat is 0.5m x 0.5m and the working area is 10m x 10m, then the numbers should include 0, 0.5, 1, 1.5, 2 ………… 8.5, 9, 9.5. If no random number tables are available most mobile phones will generate them or pupils can draw numbered corks from a pot.
- sampling methods:

1. trees: count all trees and measure them. How do we measure trees? Simple clinometer, measure along a slope.
2. light: 'canopy cover tubes' to record canopy cover on a simple scale:
   - 0 = no branches or leaves visible
   - 1 = up to _ of the grid occupied by branches or leaves
   - 2 = _ - _ of the grid occupied by branches or leaves
   - 3 = _ – _ of the grid occupied by branches or leaves
   - 4 = more than _ of the grid occupied by branches or leaves

   Canopy cover tubes while not as sophisticated as light meters are not expensive and do give as much useful information about light levels reaching the ground. If light meters are to be used it is necessary to obtain a matched pair of readings for each quadrat – one reading right out in the open (to give a reference point) and one at the quadrat position. Light at the quadrat position is then expressed as a % of the light in the open. Obviously there has to be a totally open area close by for this method to be practical.
3. Ground plants: gridded quadrat 500 x 500mm, subdivided into 25 equal squares; record number of squares in the quadrat containing each plant species
4. soil: soil pins (charity sop knitting-needles!) to measure depth, soil pH kits to measure acidity
5. invertebrates: after recording the plants in the gridded quadrat remove it and put all the leaf litter from the quadrat in a large labelled polythene bag

If equipment is not readily available, discussions with the DT department may give opportunities for pupils to make the necessary items such as gridded quadrats and canopy cover tubes.

Pupils can now design recording sheets.

- These can be as simple as a series of pictures with boxes next to them or more sophisticated Excel spreadsheets
- for the IT aficionados these can be incorporated into data collation workbooks but it is crucial that the field recording sheets, computer worksheets and results summary sheets maintain a uniform appearance.

Pupils can discuss levels of precision here – they will be different for e.g. tree height (cm) and soil depth (mm).

Health and safety

Pupils can think about safe use of equipment

- it is not only non-random but also dangerous to throw gridded quadrats around.
- if ranging poles are to be used to mark out the corners of the working area then they are not to be used as javelins!

- canes should have an inverted filmpot on the top to avoid potential eye damage
- when walking through woodland take care to avoid tripping over roots or allowing low branches to whip back
- leaving litter is not a sustainable activity!

Ideally there should be one member of staff per 8 pupils at the most and if suitably CRB cleared parent volunteers are available then 1:4 is ideal.

Before the fieldwork visit

- give each working group of pupils the task of listing what they will be doing in the field
- ask each group to describe one aspect of the work to the rest of the class.

‘QUESTIONS ABOUT QUADRATS’ can also be found on the SAPS (Science & Plants for Schools) website at:
http://www-saps.plantsci.cam.ac.uk/osmos/os25.htm#web

Osmosis 25

Download OSMOSIS 25 PDF (806KB)

OSMOSIS 25 SPRING 2004

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Plant biotechnology . . . at The Scottish Crop Research Institute

The Scottish Crop Research Institute (SCRI) is located in Invergowrie, near Dundee. SCRI is a major international centre for basic, strategic and applied research into crop-based bioscience and related environmental sciences. Staff include graduate scientists, visiting workers and research students and links are maintained with 300 Institutions worldwide.

Research at SCRI is organised into broad themes:
Mechanisms and Processes, Genes to Products and Management of Genes and Organisms in the Environment. Research focuses on three main crops (potato, barley and soft fruit) and a number of pathogens and pests, with additional work on a wider range of temperate crops.

Aerial view of the Scottish Crop Research Institute (SCRI), an important centre for research in plant biotechnology and improvement of crop plants
© SCRI (2003)

Plant biotechnology

The term 'biotechnology' was first used in 1919 and covers many aspects of modern biology, chemistry and environmental studies. Plant biotechnology has the potential to generate valuable products such as nutritionally enhanced foods, safe, cheap and effective plant-based pharmaceuticals or plants with environmental advantages. Plants are highly efficient natural refineries and large quantities of valuable products can be produced in small areas safely and relatively cheaply.

It may be surprising to learn that 90% of the world's population relies on only 15 crop species for their food. These species include the cereals - rice, barley, wheat, rye, maize, sorghum and millet - together with coconut, potato, cassava, soya bean, groundnut, sweet potato, faba bean and banana. For much of the past two centuries, science and good farming have enabled food production to keep pace with population growth. Major advances in plant biotechnology during the last 25 years have widened the scope and precision of crop plant improvement but today, increases in crop yields (of about 1% per year) are lagging behind the 1.8% increase per year in the human population. This 'production deficit' is widening due to factors such as climate change, erosion, pests and diseases. Political pressure is another factor that can prevent significant expansion of agricultural production.

Modern plant biotechnology is largely based on two key technologies: the isolation, cloning and transfer of DNA and the ability to regenerate plants from single cells or pieces of tissue. Progress in molecular genetics, including gene discovery and sequencing, has led to the use of plants for the 'manufacture' of a wide range of recombinant DNA products. By 2002, over 50 million hectares (an area approximately the size of Spain!) of genetically modified (GM) plants were being grown worldwide. These crops were mainly soya, cotton, maize and oilseed rape, and most were grown in the USA, Canada, China and Argentina. None were grown in Europe, other than those for experimental trials.

Initially, genes inserted into GM crops conferred traits such as herbicide or pesticide resistance. Current worldwide research is aiming to produce plants with other benefits, including:

- improved nutritional qualities (e.g. "Golden Rice")
- high value "pharming" where plants are used as factories to produce antibodies, vaccines, diagnostics, vitamins or entirely new synthetic drugs.

While GM techniques are potentially important, plant biotechnology includes useful technologies that do not involve gene transfer from other organisms. These include the following:

- **Micropropagation** - a scaled-down version of growing new plants from cuttings. In the laboratory over 1 million exact copies of the plant can be generated in one year! SCRI uses micropropagation to speed up breeding programmes. In the potato industry in Scotland, 65% of seed potatoes now originate from test tubes.
- **Cell suspension cultures** - these are a plant "soup" of selected cells, used to generate high value products such as anti-cancer drugs, colours and flavours. In Taxol research for example, the use of suspension cultures derived from living yew trees allows mass production of the drug. Without this technology, six one hundred-year-old plants would be destroyed to treat one patient. At SCRI cell suspensions of such species as potato, tobacco and barley are widely used in research programmes.
- **Protoplasts** - each leaf of a plant contains over a million cells. Leaves can be treated with enzymes to strip away the cell walls and produce protoplasts, which are effectively 'naked' plant cells. At SCRI, protoplasts are used routinely in studies into cellular development. Protoplasts can also be fused with cells of another species producing somatic hybrids - an important scientific tool with potential as a non-GM means of crop improvement.

Research programmes at SCRI are directed towards understanding the fundamental mechanisms underlying plant growth and differentiation, and pest and disease resistance.

GM and geneflow

Gene-flow is not a new concept as crops and arable plants (weeds) have competed and exchanged genes since the beginnings of agriculture. The arable plants are an important part of the biological structure of arable fields. They support more invertebrates (many benign or beneficial) than crop species and provide diversity of material for food webs in the soil. It is essential to reach a balance that allows continued food production to meet our needs whilst maintaining a resilient, sustainable habitat.

At SCRI, studies with oilseed rape (*Brassica napus*) have looked at evolution in fragmented populations. Measuring and predicting crop purity has become necessary following applications by seed companies to grow GM crops in Europe. SCRI was part of the independent consortium involved in farm-scale evaluations of herbicide-resistant GM crops for the UK government, looking at the effects of these crops on arable food webs, feral populations, competition and gene exchange with feral, wild or nearby crop species. For more information on the farm-scale evaluations, see *Further reading*.

Bee on oilseed rape. Studies with oilseed rape (Brassica napus) *have made useful contributions to the GM debate - SCRI has been involved in farm-scale evaluations of herbicide resistant GM crops*
© SCRI (2003)

A sixteen year old "Nuffield Bursary" school student, carrying out a 6-week laboratory based project, during the summer of 2003, with assistance from SCRI scientists
© SCRI (2003)

SCRI and its links with education

The speed at which new advances are occurring in all areas of research means it can be difficult to keep science teaching up-to-date. SCRI is committed to helping teachers by providing a service that includes access to information, meeting with SCRI scientists and demonstrations of equipment or techniques to staff and pupils. SCRI has a full-time Education Officer, who works with children, teachers, other educators and the general public to increase interest in and knowledge of today's science. SCRI is also a LEAF (Linking Environment and Farming) Innovation Centre, pioneering and publicising new approaches in sustainable land management.

For more information about SCRI, you can contact Sharon Neilson, (SCRI Education Officer, email: S.Neilson@scri.sari.ac.uk); Sarah Stephens, (Science Communications, email: S.Stephens@scri.sari.ac.uk); Dr Steve Millam (Plant Biotechnology and its role in human health and nutrition, email: S.Millam@scri.sari.ac.uk)

Further reading:
SCRI: www.scri.sari.ac.uk
DEFRA (GM): www.defra.gov.uk/environment/gm/index.htm
Golden Rice: www.biotech-info.net/golden.html
Plant Molecular Farming Discussion (Canada):
http://www.inspection.gc.ca/english/plaveg/bio/mf/molecule.shtml
Farm-scale Evaluations:
www.defra.gov.uk/environment/gm/fse/
LEAF: www.leafuk.org
The Nuffield Foundation: http://www.nuffield.org/award

Sharon Neilson (Education Officer)
Scottish Crop Research Institute, Invergowrie

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The wonderful world of wee things... a microworld in a hanging drop

Do all microorganisms look the same? Can they move and change shape? What do they feed on? How small are they . . . and **are** they actually **alive**?

For full details go to Student Sheet 25.

News from SAPS

Personnel changes
Over the past few months we have had a number of changes in personnel within SAPS. Kirsty Menzies, who has been with the SAPS Biotechnology Scotland Project since October1995, left us at the end of September 2003 to embark on an MSc programme in *Information and Library Science*. Kirsty has been a pivotal member of the SAPS programme and she will be sorely missed. We are very fortunate to have been able to secure the services of Anne Adams at SSERC, together with additional support from Jane Inglis at Dollar Academy, and so we hope that "normal service" will continue to be the order of the day! Kath Crawford who has been full-time with SAPS since September 2000 is now spending half of her time on the 5-14 Improving Science Education programme within SSERC. We are fortunate that Pam Ferguson and Lucy Payne, both at Dollar Academy, have agreed to take on the delivery of some of our workshops.

Many of you will now be familiar with Debbie Eldridge's contribution to the SAPS programme (see http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/ssheet23.htm) from her work on photosynthesis. We are delighted to say that Debbie is now working with us for one day per week for the foreseeable future and we hope that she will be able to run some workshops together with spending time on curriculum development.

A new base for SAPS in Scotland
The SAPS office, previously located in the Institute for Cell and Molecular Biology at the University of Edinburgh, has recently moved to new accommodation at the Scottish Schools Equipment Research Centre (SSERC). Members of the team can be contacted at:
SAPS Biotechnology Scotland Project, SSERC, St Mary's Building, 23 Holyrood Road, Edinburgh EH8 8AE (tel: 0131 558 8212; fax 0131 558 8191). There is a new general e-mail address for SAPS in Scotland: saps@sserc.org.uk

Schoolteacher Fellowship
Robinson College at the University of Cambridge, in association with SAPS, is able to offer an annual fellowship in plant science for teachers in UK secondary schools and colleges. For the academic year 2003/2004 funds have been secured to allow for a teacher to spend one term at Cambridge working on a project related to the work of SAPS. The full cost of the Fellow's salary for the term is provided together with a grant for consumables and equipment. Accommodation within Robinson College is provided for the duration of the Fellowship. Initial expressions of interest to Paul Beaumont at the Cambridge office please.

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Questions about Quadrats

Interdependence is one of the five key science ideas at KS3. Whilst this can be taught theoretically, some practical fieldwork greatly enhances pupils' understanding. Almost certainly the fieldwork would entail looking at plant abundance and distribution and, of course, some work with quadrats!

A quadrat is a simple device for marking out a small area. For young children at primary school the quadrat is often a convenient way of focusing a pupil's attention on a particular small area. At secondary level, pupils should understand how quadrats can be used to sample a larger area. By recording information from a number of quadrats placed within a larger study area, they can obtain a representative sample of the whole area, which may be too big to describe in full.

This article describes how quadrats can be used to help pupils at lower secondary level estimate the relative abundance of plant species. All the information given here refers to frame quadrats. (Point quadrats can be tedious and difficult for pupils to use and are probably best avoided at this level.)

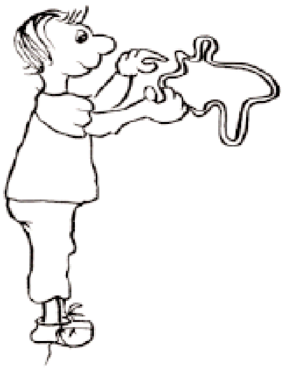
1. How is the study area chosen?
2. What size and shape should the quadrat be?
3. What should be recorded within the quadrat?
4. What strategy should be used for placing the quadrats?
5. How many quadrats need to be placed?

1. How is the study area chosen?

Choose an area that is large enough to be representative of the vegetation being investigated. You also need to consider the time available for the study and the number of pupils involved. The area must not be so big that it cannot be sampled adequately or so small that the habitat is damaged by trampling feet.

Generally a plot size of about 20 x 20 m is suitable for a class of 25 to 30 pupils. Correct identification is crucial to all ecological work. If identifications are incorrect, it becomes impossible to explain results. It is best, therefore, within the study area, to limit the selection to a few plants that are easy to recognise. You can easily make identification sheets for students by scanning or photocopying actual specimens.

The fold out chart series produced by the Field Studies Council offers useful help in the identification of plants in a wide variety of habitats including woodland, grassland and heathland.



2. What size and shape should the quadrat be?

In theory any shape of frame can be used but for many measurements you need to know the area of the quadrat so a square quadrat is the most popular.

The size of the quadrat is usually related to the size of the plants being studied. Here are some useful guidelines, given in the Open University Project guide.

- 10 cm x 10 cm quadrats - for very small plants, such as algae or bryophytes on tree trunks or walls
- 25 cm x 25 cm quadrats - for short grassland and other low-growing vegetation
- 50 cm x 50 cm quadrats - for long grass or heathland

Larger quadrats are difficult to handle and for plants such as trees and shrubs it is probably best to mark out plots on the ground with tape measures.

Making the quadrats
The easiest way to make a quadrat, approximately 25 cm x 25 cm, is to bend a metal coat hanger into a square. Cut off the hook and for safety cover the cut end with insulating tape. To make a larger quadrat, purchase stock wire from an ironmonger or farm supplier. You can then bend this into quadrats of any size required. As for the coat hanger, cover the joined ends in insulating tape. Use a brightly covered tape so that quadrats left lying on the ground are more easily found! To make small quadrats, e.g. 10 cm x 10 cm (for using on a flat surface like a wall), draw the shape on an acetate sheet.

3. What should be recorded within the quadrat?

Abundance means the amount of something. Pupils are often asked to make an estimate by eye of the percentage amount of ground covered by each species within the quadrat. This can be time consuming and such subjective measures are very prone to inaccuracies, especially with younger pupils. It is better to carry out one of the quantitative measures described below.

When working with plants, the two measurements of abundance commonly used are:
- the number of individual plants

- the area covered by the overground parts of the selected species

We will look at each in turn together with an example to show how the measure is used.

The number of individual plants - The pupil counts the number of individual plants of the selected species in each quadrat. The result can be expressed as number of plants per square metre. This measure is known as **density**.

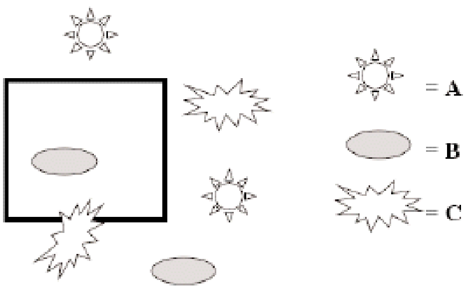
> ***Example***
> The chosen study area measured 10 m x 10 m (100 m^2).
> Pupils placed 8 quadrats, each 50 cm x 50 cm (a total of 2 m^2).
> A total of 24 daisy plants were found in the quadrats.
> So there were 12 daisies per m^2.

This is an easy concept for pupils to understand but has disadvantages. Individual plants are often not easy to distinguish, e.g. grasses. Even plants that appear separate may be joined underground. No information is obtained about the size of the plants but this may be of great importance ecologically.

The amount of area covered by the overground parts of the selected species - The greater this area, the more likely a plant is to occur within a quadrat. This measure is known as **plant frequency** and, ecologically, is a more useful measure than density, as both the size and number of individual plants contribute to the area covered.

Plant frequency is also quicker to measure than density. It is not necessary to measure the number of plants of each species within a quadrat but only to record their presence or absence. A species counts as present if any part of the plant lies within the quadrat.

Results are usually expressed as the number of times a species occurred in the quadrats as a percentage of the total number of quadrats placed.



Species B and C are present in the quadrat but species A is not

> ***Example***
> Daisies occurred in 15 of the 25 quadrats placed in the study area. Therefore, the percentage frequency of daisies is
>
> $$\frac{15 \times 100}{25} = 60\%$$

The size of the quadrat obviously affects the result and so the same size of quadrat must be used in the areas being compared. If the two areas being compared have very different sized plants it is probably best to use the quadrat size best suited to the taller vegetation.

Local frequency is a useful measure when working along a transect line (see below). For each station along the line a frequency figure can be obtained by using a "gridded quadrat". The number of small squares that each species occurs in is expressed as a percentage of the total number of squares in the whole quadrat. It is common to use a 50 x 50 cm quadrat, divided into 25 smaller squares. You can easily make these quadrats by using plastic mesh (purchased from a garden centre) and cutting it to the required size.

4. How should the quadrats be placed?

The aim is to remove personal choice as to where the quadrat is placed. "Throwing" a quadrat is not truly random.

We can approach sampling in two different ways: **random** sampling or **systematic** sampling. We will look at each in turn to see how it is carried out.

Random sampling - Ideally every place within the sampling area should have an equal chance of being sampled, each time a sample is taken.

To achieve this, place a tape measure along two sides of the area being studied. Then find random coordinates as follows:

- The length of one side of the quadrat forms the sampling interval. Then divide the length of the plot into these intervals e.g. if you use a 10 x 10 m plot and a 50 x 50 cm quadrat, the intervals will be 0, 0.5, 1.0, 1.5. . . 9.5, 10.
- Write the intervals on pieces of paper and put them into a hat.
- Let each pair of students draw out 2 pieces of paper. (Replace the first piece before taking the second.)
- Each student then finds his or her appropriate position along the tape measure. They turn into the plot at a right angle to the tape and walk into the plot until they meet. This is their sampling position.

Systematic sampling - This is most useful when a pattern in the vegetation is being investigated, for example when looking at the change in abundance of plant species across a pathway.

Lay out a tape measure and place quadrats at regular intervals along the tape measure. Make sure you choose an interval that is small enough to demonstrate any changes taking place. You can even place the quadrats end over end.

5. How many quadrats should be placed?

The sample size depends on how much variability is shown by the plants within the study area. For this reason, when working with younger pupils it is often best to try and avoid areas where plants show obvious clumping.

If the area is fairly uniform ensure that at least 2% of the total area has been sampled by the quadrats. This should give a reasonable size sample.

> ***Example***
> The plot is 20 m x 20 m (400 m^2)
>
> 50 x 50 cm square quadrats are being used, so there are 4 quadrats to the square metre.
>
> It would take 1600 quadrats to cover the whole area.
>
> To cover 2%, we would need 32 quadrats.

If you have a class with 24 pupils divided into 12 pairs, each pair needs to do at least 3 quadrats. You may wish them to do more as part of the learning process, but make sure the grass is not over-trampled!

Dr Anne Bebbington,
Field Studies Council, Juniper Hall

References

Chalmers, N and Parker, P (1989) The OU Project Guide (second edition) Occasional Publication 9 Field Studies Council

Identification fold-out charts are available from the Field Studies Council. A publications list can be obtained from: Field Studies Council Publications, Preston Montford, Shrewsbury SY4 1HW.
www.field-studies-council.org Tel: 01743 852140

Key Stage 4 Single Science:
Woodland regeneration in a restored quarry

Practical session 2 (fieldwork investigation)
Each group writes their group number and the names of the recorders on their recording sheets before leaving for the woodland.

Check recording sheets and equipment on leaving the classroom and again on arrival at the working site.

Ask pupils to look at an area just outside the working area and to try to match the plants they see with the picture sheets. A few minutes spent doing this will dramatically increase the reliability of recording!

Then ask the class to record plants, soil pH, light levels and to collect leaf-litter invertebrates **in a specific order** Each group should

1. find their first quadrat position using a pair of random coordinates (e.g. 1.5, 4). One member walks 1.5m up one side of the area while another walks 4m up the adjacent side. They then walk into the area and they meet at the sampling position.
2. plae the gridded quadrat is placed on the ground and for each plant species (the list may be complete, or selective, depending on the number of species present) note the number of squares (out of 25) in which it occurs
3. record the number of different kinds of plant in the total area of the quadrat
4. carefully examine the leaf litter and surface soil within the area of the quadrat is and record the presence of different layers (if any) – are there differences in colour, degree of leaf brakdown?
5. put the leaf litter and surface soil from within the area of the quadrat into a labelled plastic bag which is then sealed and kept in the shade.
6. measure and record the pH of the surface soil
7. finally one member of the group stands in the centre of the quadrat position (after removing the quadrat) and looks vertically upwards through the canopy cover tube. Canopy cover is scored.

Sample size
The total number of quadrats put down for plant recording should ideally cover 1 – 2% of the sample plot; i.e. in a 10m x 10m plot an area of 1 – 2 square metres (4 – 8 quadrats of 50 x 50 cm) but probably a minimum of 16 is needed to emphasise the need for reliable data.

For leaf-litter samples one bag per group from each of the 2 areas is as much as can be examined in a reasonable time.

When all the quadrats have been completed, line up the whole group along one edge of the area and tree recording begins.

- assign a small group of pupils to help identify the trees and designate one as recorder.
- the group advances across the area; each time a pupil comes into contact with a tree he or she shouts 'stop' and the tree is identified and tallied
- then measure the trees to the required accuracy (e.g. 5.45m) using the most suitable method available (see appendix – measuring trees)

Ideally,identify and count invertebrates (careful handling) as soon as possible after capture, then released on site. They should be kept in the shade while awaiting examination

Handling and returning invertebrates – care and sustainability
It is critically important to handle invertebrates carefully and to return them to the place where they were found.

- they are fragile and slow-growing
- careless handling and drying out will kill them
- repeated removal will dramatically reduce populations; for example Pill millipedes need 10 -11 years to reach maturity and to reproduce!
- depletion will affect the results of future fieldwork
- depletion will also dramatically affect the woodland ecosystem!

Weighing invertebrates is not recommended, even though pyramids of biomass will be discussed later. Weighing is stressful and damaging to most invertebrates!

Leaving the site
Carefully check back in equipment and carry out a litter sweep.

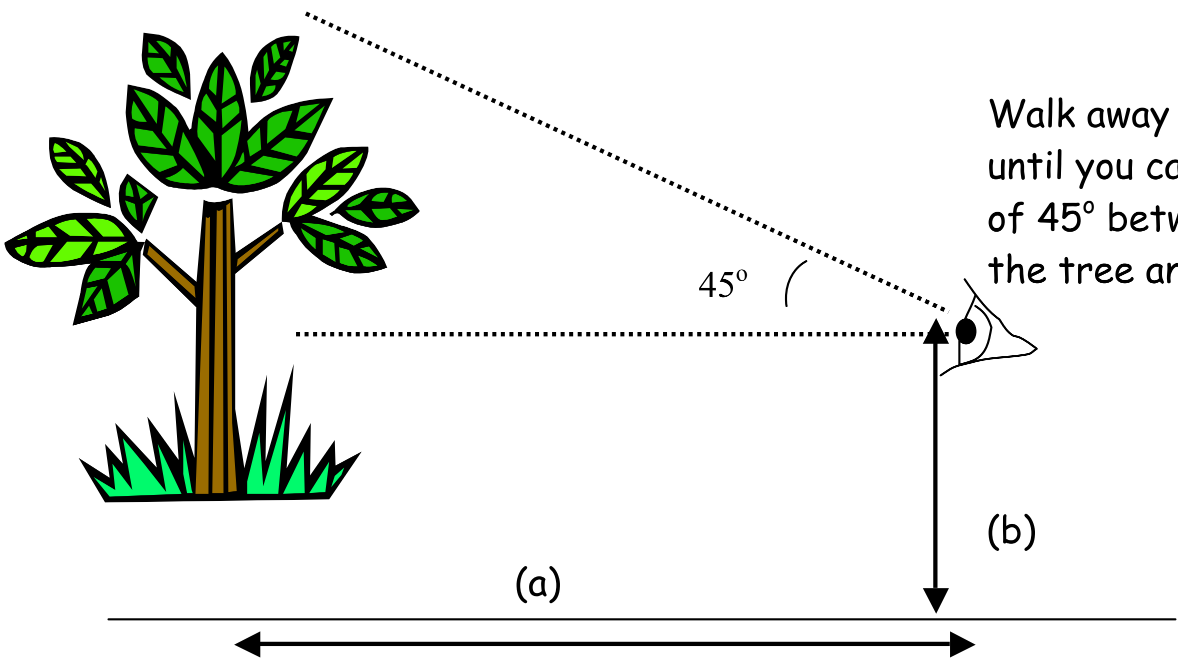
On return to the classroom collect in recording sheets for safe keeping.
Before leaving pupils are asked to think about ways of collating presenting their findings.

Measuring trees

Tree height

There are several ways of doing this. Here are two of them:

Using a clinometer



Walk away from the tree until you can form an angle of 45° between the top of the tree and your eye

The height of the tree in metres will be:

Your distance from the tree in metres **plus** the distance from your eye to the ground in metres, that is (a) + (b)

Using a ruler and a friend:

1. Hold a ruler straight out in front of you and line it up with the tree. Make sure that you can fit the whole tree into the length of the ruler!
2. Ask a friend to stand under the tree and record
   - how many centimetres tall he or she seems to be on the ruler
   - how many centimetres the tree seems to be on the ruler
3. Now do this sum:
   a. Work out your friend's real height in centimetres divided by what he or she measured on the ruler
   b. Then multiply this figure by the height of the tree on the ruler.

For example: your friend is 1.5m tall (150 centimetres). He or she measures 2 centimetres on the ruler. The tree measures 25 centimetres on the ruler.

The height of the tree is:

$$\frac{150}{2} \times 25 = 1875 \text{ centimetres or } 18.75 \text{ metres}$$

<u>Using a ruler and a 2m ranging pole</u>

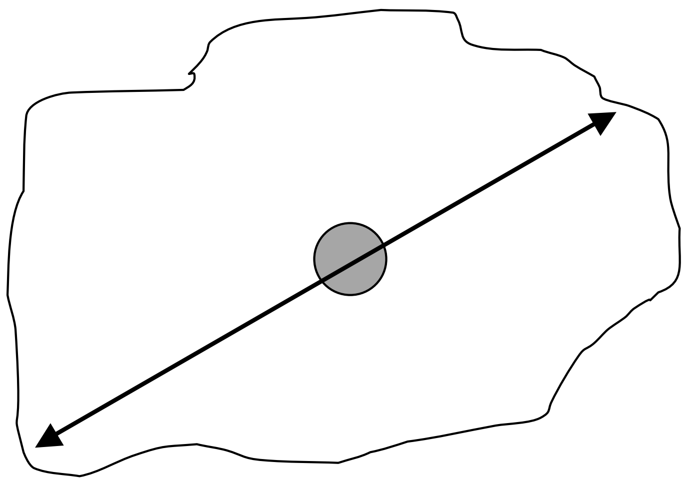
1. Hold a ruler straight out in front of you and line it up with the tree. Make sure that you can fit the whole tree into the length of the ruler!
2. Ask a friend to stand under the tree, holding a ranging pole vertically against the trunk, and record
   - how many centimetres tall the ranging pole seems to be on the ruler
   - how many centimetres the tree seems to be on the ruler
3. Now do these calculations:
   - divide the apparent height of the tree in cm by the apparent height of the ranging pole in cm
     for example tree appears to be 30cm, ranging pole appears to be 5cm so calculation is 30/5 = 6
   - multiply the result by the actual height of the ranging pole (2m) so the calculation is 6 x 2 = 12 and the height of the tree is 12m.

Girth (circumference) of the tree trunk

This is usually measured 1.3 metres above the ground and is the distance round the trunk.

Tree canopy

Measure the broadest spread of the canopy, for example:



A bird's eye view!

50 Random coordinates for use with 0.5m x 0.5m quadrats in a 10 x 10m area

Number	6	11	7	5	19	19	9	1	5	20
Distance (m)	3.0	5.5	3.5	2.5	9.5	9.5	4.5	0.5	2.5	10.0
Number	16	17	16	13	5	3	6	19	16	9
Distance (m)	8.0	8.5	8.0	6.5	2.5	1.5	3.0	9.5	8.0	4.5
Number	9	20	18	7	4	7	17	4	14	2
Distance (m)	4.5	10.0	9.0	3.5	2.0	3.5	8.5	2.0	7.0	1.0
Number	16	5	3	11	18	14	13	19	19	3
Distance (m)	8.0	2.5	1.5	5.5	9.0	7.0	6.5	9.5	9.5	1.5
Number	11	12	15	17	12	18	11	10	17	19
Distance (m)	5.5	6.0	7.5	8.5	6.0	9.0	5.5	5.0	8.5	9.5

If more random coordinates are needed then the pairs can be reversed, that is

6	11	becomes	11	6
3.0	5.5		5.5	3.0

Key Stage 4 Single Science: Woodland Regeneration Study Resource Sheet

KEY STAGE 4 SINGLE SCIENCE:

WOODLAND REGENERATION STUDY

RESOURCES NEEDED

Computer network for internet access and worksheet design and production

Virtual Quarry Resource – information on local woodlands in restored quarries

Information may also be available from English Nature, Woodland Trust and local Wildlife Trust websites

Digital cameras, photocopier, laminator for production of plant identification resources

Plastic gun clinometers.

ranging poles or canes

30m measuring tapes (available very cheaply from 'Pound shops');

Old metal knitting needles (available very cheaply from charity shops)

Soil pH kits

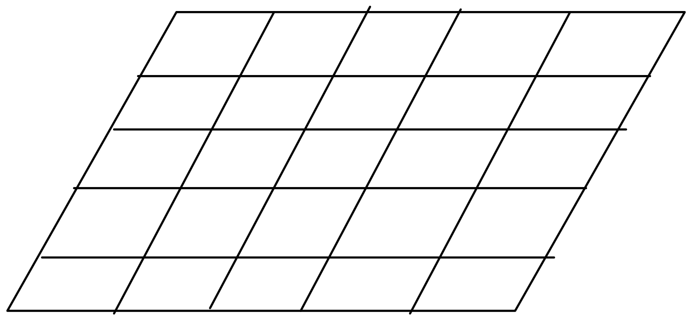
Large polythene bags for leaf-litter collection

Hand-lenses (or credit-card sized Fresnel lenses), plastic teaspoons, paint-brushes

Sorting trays – large white ice-cream or 'spread' cartons are good

Gridded quadrats and canopy cover tubes (could be produced in DT lessons);

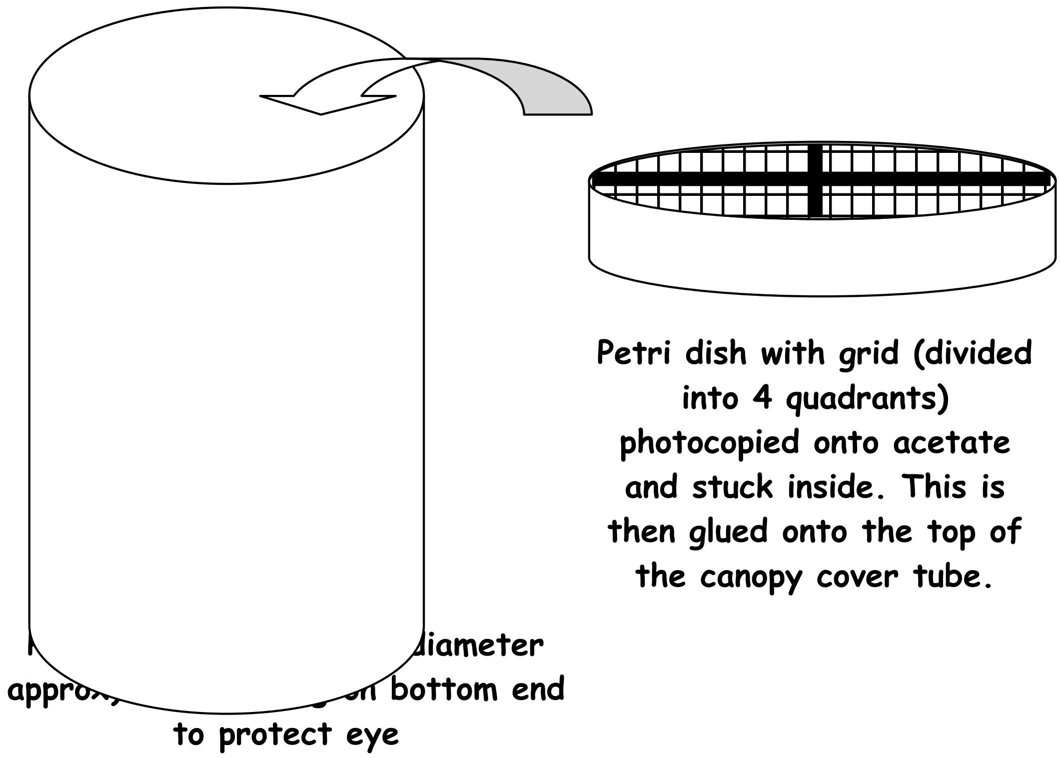
gridded quadrat – each side 0.5m, divided into 25 equal squares



sides can be wood with nylon fishing line divisions, or whole quadrat made of wire.

Key Stage 4 Single Science: Woodland Regeneration Study Resource Sheet

Canopy cover tube



Identification keys for woodland plants, trees and woodland litter invertebrates: Field Studies Council fold-out charts are convenient for fieldwork.

- Woodland name trail (minibeasts): FSC occasional publication no. 32. (This was written for Key Stage 2 – a more detailed Key Stage 3-4 version is in preparation)
- Woodland plants: FSC occasional publication no. 83
- Tree name trail: FSC occasional publication no. 81

All these are available from:

FSC Publications, Preston Montford, Shrewsbury SY4 1HW.

Tel. 0845 354 4072 fax 01743 852101

Email: publications@field-studies-council.org

Web site: www.field-studies-council.org

Headings	Put info in here
Study site:	
Grid reference	
Date	
Site descriptions:	
Site 1 description	
Site 2 description	

Species no.	Name
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Headings	Put info in here
Study area:	
Grid reference	
Date	
Site descriptions:	
Site 1 description	
Site 2 description	
Tree species present	
Species no.	**Name**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Headings	**Put info in here**
Study area:	
Grid reference	
Date	
Site descriptions:	
Site 1 description	
Site 2 description	

Animal no.	**Name**
1	Worms
2	Slugs
3	Snails
4	Spiders
5	Harvestmen
6	Mites
7	Woodlice
8	Pill Woodlice
9	Millipedes
10	Pill millipedes
11	Springtails
12	Earwigs
13	Bugs
14	Caterpillars
15	Moths
16	Fly larvae (maggots)
17	True flies
18	Ants
19	Wasps
20	Beetles

21	Beetle larvae
22	Centipedes
23	Land shrimps
24	Insect larvae

Key Stage 4 Single Science:
Woodland regeneration in a restored quarry

Classroom/practical session: data collation and presentation

- hand data sheets back
- pupils enter data into prepared spreadsheets
- after auditing give printouts of all results to pupils
- allocate different sections of the data to groups of pupils and ask them to prepare displays which help to decide whether to accept or reject each hypothesis

Data collation and presentation

This is best done using networked spreadsheets designed by members of the group but examples are provided (appendices). Each spreadsheet should contain a summary sheet which can be accessed and a suitable chart type or types discussed.

Ask pupils to work in small groups preparing 5-minute presentations of the results of different sections of the work

- plant abundance
- species richness
- number of trees
- soil pH
- leaf-litter invertebrates

and interpreting them, relating the results to the original hypotheses and suggesting improvements to the way the work was carried out.

Ask them to:

- decide who will present what (ideally each member of the group should have a specific task) and then prepare the presentation in which they
- outline the topic they have investigated
- restate the original hypothesis
- summarise the sampling method(s)
- summarise the results, with simple data tables and charts as appropriate
- draw conclusions about their results
- state whether the results fit in with the original hypothesis
- say what sources they have used in preparing the work (books, web sites, acknowledgements of personal help)
- suggest refinements of methods
- suggest follow-up work (e.g. looking at light penetration at other times of year)

Coursework/homework

- internet research on individual species and their adaptations
- preparation of presentation by each group - who will say what

Headings	**Put info in here**
Study site:	
Grid reference	
Date	
Site descriptions:	
Site 1 description	
Site 2 description	

Species no.	**Name**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Headings	Put info in here	
Study area:		
Grid reference		
Date		
Site descriptions:		
Site 1 description		
Site 2 description		
Tree species present		
Species no.		**Name**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Headings	Put info in here
Study area:	
Grid reference	
Date	
Site descriptions:	
Site 1 description	
Site 2 description	

Animal no.	Name
1	Worms
2	Slugs
3	Snails
4	Spiders
5	Harvestmen
6	Mites
7	Woodlice
8	Pill Woodlice
9	Millipedes
10	Pill millipedes
11	Springtails
12	Earwigs
13	Bugs
14	Caterpillars
15	Moths
16	Fly larvae (maggots)
17	True flies
18	Ants
19	Wasps
20	Beetles

21	Beetle larvae
22	Centipedes
23	Land shrimps
24	Insect larvae

Key Stage 4 Single Science:
Woodland regeneration in a restored quarry

Classroom sesssion 4: drawing it all together

This begins with a brief (5 minute maximum) presentation by each group as above.
Then look at the class results as a whole, discussing any differences between sites and the possible reasons for them, and looking at pyramids of numbers.

However it becomes obvious that there are far more consumers than producers – there are not many ground plants and trees, but probably hundreds of invertebrates - and this leads to the idea that pyramids of biomass are a better reflection of an ecosystem (but practically impossible because of the damage which will be caused to the system).

Seasonal variation can also be considered – many species are absent at the time of sampling – and the fact that the tree canopy was not sampled is brought out. Also, what about birds and mammals? They are rarely seen, let alone sampled!

Discussion points should include:

- adaptations of woodland plants to low light regimes, e.g. storage of resources in a bulb (Bluebell) or rhizome (Dog's mercury, Bracken) to enable the plant to grow and mature before the tree canopy forms
- light - the reasons for using canopy cover tubes rather than light meters, changes in light intensity with season, movement of light patches within the woodland as the earth rotates during the day
- the role of trees and ground vegetation in nutrient uptake
- seasonal variations and the whole year cycle – the class sample is a 'snapshot in time'
- the way in which leaf-litter is broken down by detritivores which leads to an increase in surface area and enables decomposers to act more efficiently (here some simple maths looking at the surface area of a 5x5cm cube (each of the 6 sides has an area of 25cm^2 giving a total surface area of 150 cm^2) and then at the same cube broken down into 1x1 cm cubes (each of the 125 cubes has a surface area of 6cm^2 giving a total surface area of 750cm^2).

Finally

Don't forget to write to the landowner and send a set of results (and photographs of possible). This will not only provide useful information but also generate goodwill. Put the results on the school website – next year's classes will find them useful!