

Learning Intentions

For students to:

- Investigate, collect and present evidence
- Work effectively in a group
- Use new vocabulary such as: finite and renewable resources, mitigation, contraction and convergence, off-setting carbon and carbon credits

Context:

- graph displaying varying use of CO₂ by different countries
- information on how long people live, literacy levels, types of jobs people do and energy use per person

Resources

Provided

- Graph on national emissions per capita in 2002
- Student worksheet – Talking graphs

Needed

- Atlases providing country statistics

Links to National Curriculum subjects

Science KS3

Analysing and evaluating evidence about energy use (1.1b)

Geography KS3

Enquiry and skills (1a, 1c, 1d, 1f, 2a, 2c)

Knowledge and understanding of places (3a, 3b, 3c, 3d, 3e)

Patterns and processes (4a, 4b)

Environmental change and sustainable development (5a, 5b)

Breadth of study (6d, 6e, 6h, 6i, 6j, 6k)

1. Talking graphs

Overview

'Talking graphs' encourages students to consider energy use in different countries. Students will carry out independent research and use this information to explore the potential impact of CO₂ on the environment and to consider questions of justice.

Teaching activity

This activity works well if students have studied China and the United States. It is particularly suited for GCSE level or for students who have almost finished the National Curriculum Key Stage 3 curriculum, as it is helpful if they understand development indicators.

- 1 Provide students with atlas notes about countries.
- 2 Give students flags of two countries; some might choose to select other countries where they have more knowledge, eg. France and India.
- 3 As a group, discuss the ways in which these countries are different using the sheets from the atlases.
- 4 Introduce the idea of CO₂ emissions and the role of cars, planes, factories, etc in emitting CO₂.
- 5 Ask the students in pairs to look at the graph and discuss the questions on their worksheet 'Talking graphs'.

Questions include:

- How do you think the countries produce CO₂?
 - If the weather changes and there is less food due to flooding or drought, who will be able to afford to buy food in your countries?
 - If the ice at the poles melts, which country might be worst affected by sea flooding?
 - Should either of these countries change their practices? Should one alter more than the other?
- 6 Use the concluding discussion to introduce the concept of contraction and convergence (see http://en.wikipedia.org/wiki/contraction_and_convergence for more information). Plants are one of the biggest carbon stores and play a significant role in mitigating CO₂ emissions. Much is made of planting trees to off-set climate change but plants can acclimatise to extra levels of CO₂ (see page 18 in Plants and Climate Change: which future?). Discussions could focus on off-setting, as some pupils may have thought about paying for trees to be planted when they fly.

Students are likely to believe that re-cycling will have the greatest impact on reducing waste. However, it is important for them to understand that transport, food packaging and processing generate a great deal more waste. Increasing population is also a common factor in the rising need for energy. To appreciate this, students can look again at the graph.

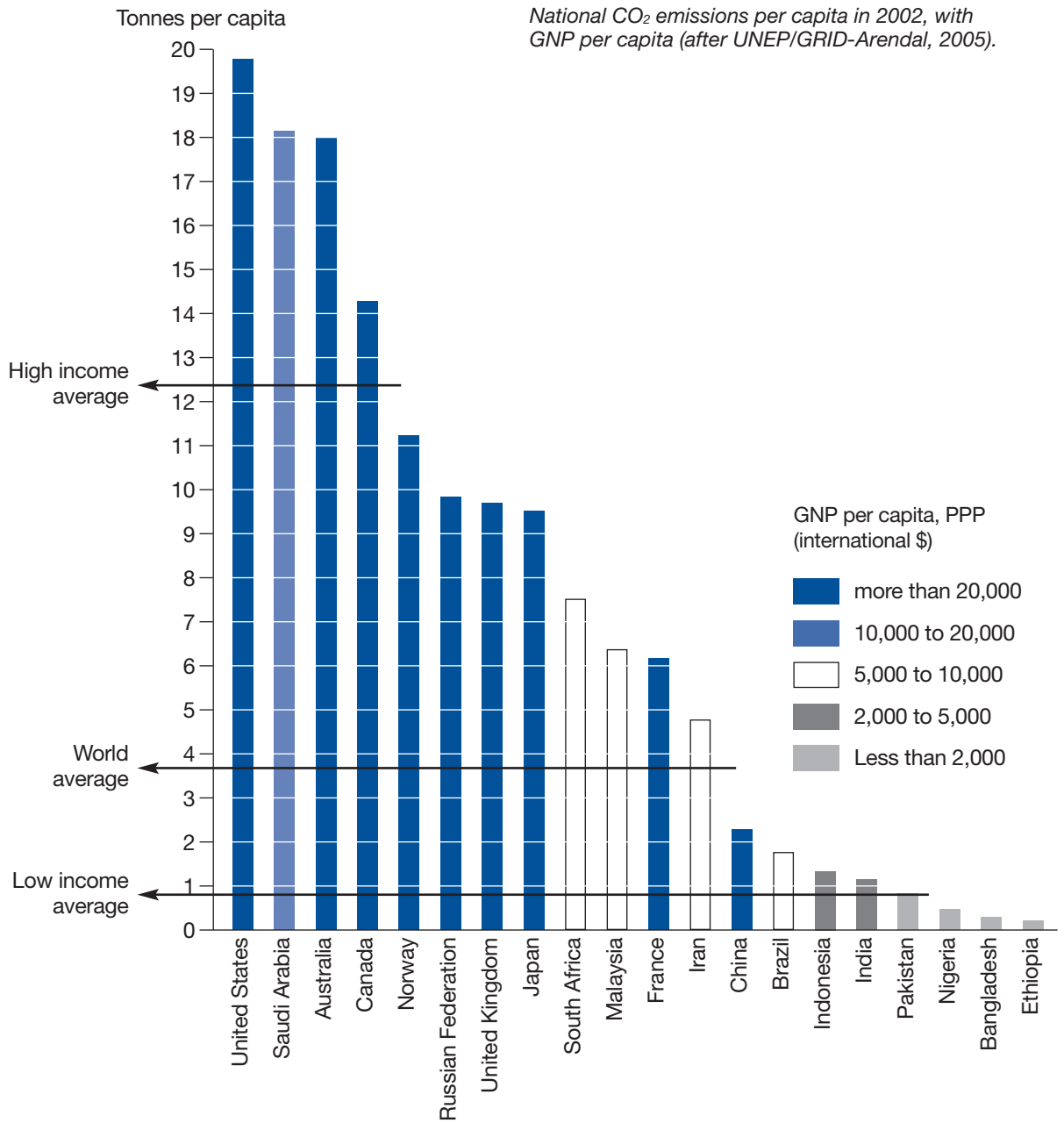
Follow up activities for students

See Making a difference section of the worksheet.

Assessment

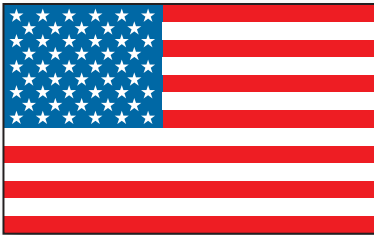
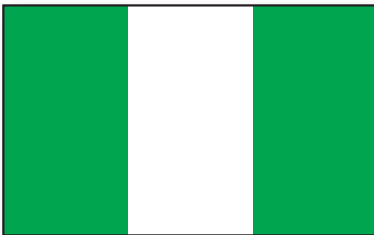
Students worksheets can be assessed for levels of response

- No recognition of role of CO₂ climate change
- Some recognition of role of CO₂ on climate change
- Notice made of small details and an awareness of the role of CO₂ in climate change
- Awareness of the role of a responsible citizen to alter the factors which are causing climate change



1. Talking graphs

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Discussion

Use the following questions to frame your discussion:

- In what ways do your countries produce CO₂?
Country 1
Country 2
- If the weather changes and there is less food due to flooding or drought, who will be able to afford to buy food in your countries?
Country 1
Country 2
- If the ice at the poles melt, which country would be worst affected by sea flooding?
Country 1
Country 2
Why?
- Should either of these countries change their practices? Should one alter more than the other?

Making a difference

Some people choose to lessen (mitigate) the amount of CO₂ they produce from transport (eg. car journeys, flights) and electricity use by buying carbon offsets. This involves people paying a sum of money to support projects that produce renewable energy. You can find out more about this on the internet.

- Find out what activities and/or projects can be used to off-set carbon emissions?
- If you planted trees what kind of trees would you plant and why?

Remember that an old tree will store much more carbon than a young tree. Also some trees are better than others for providing habitats for different species of insects and animals.

- Do you know how much CO₂ your family produces? Why not carry out a carbon audit?

There are plenty of carbon calculators on the website. Two that you might like to try are The Woodland Trust (<http://www.carbonbalanced.org/>) and Carbon Footprint Limited (<http://www.carbonfootprint.com/calculator.aspx>). For some of the calculations you will need an adult to provide you with information about how much energy your household uses. You may be surprised at the results and decide to help the planet by cutting your carbon emissions.

- What did you find out?
- Can you think of ways to cut your carbon emissions?
- What challenges do you face about cutting your carbon emissions?

Learning Intentions

For students to:

- Describe and explain environmental change
- Recognise how people may seek to manage environments sustainably
- Use new vocabulary such as competitive advantage and nutrient cycle
- Work effectively in a group

Context:

- Environmental activity
- Student sheet on bluebells and cow parsley

Resources

Provided

- Student worksheet – Competitive nature

Needed

- Space inside or outside the classroom

Links to National Curriculum subjects

Geography KS2

Enquiry and skills (1a, 1c, 1e, 2a)
Patterns and processes (4b)
Environmental change and sustainable development (5a, 5b)
Breadth of study (6e)

Geography KS3

Enquiry and skills (1a, 1f, 2a)
Knowledge and understanding of places (3d,
Patterns and processes (4b)
Environmental change and sustainable development (5a, 5b)
Breadth of study (6d, 6e, 6j, 6k)

2. Competitive nature

Overview

'Competitive nature' is an activity designed to demonstrate how plants compete with each other for natural resources - warmth, light, water and nutrients. Students are asked to reflect on the outcome of the game and consider the impact of climate change on two plant species.

Teaching activity

- 1 Give the students the worksheet on bluebells and cow parsley. In particular, stress that the bluebells and cow parsley both need water, light and nutrients and that cow parsley responds well to warmth.
2. Explain that you are going to play a game. In total this will take about 10 minutes, from explaining to playing. The aim of the game is to stimulate discussion. The bluebells should win because they need fewer climate variables. However, climate change could mean that the cow parsley wins.

The game

- Select two students (or ask for volunteers) – one to represent bluebells and the other to represent cow parsley.
- The rest of the group represent the natural resources. Ask them to select actions to depict these resources - water (e.g. fingers wiggling as hand moves downwards), light (e.g. hands framing the face), nutrients (e.g. hands clasped together to form a ball) and warmth (e.g. hugging themselves).
- Position the flowers and resources so that they are back to back.
- Ask the resources to each use an action to depict a natural resource.
- Ask the bluebell and cow parsley to do the same (the bluebell can only choose between water, light and nutrients while the cow parsley can also choose warmth).
- Still carrying out their actions, ask the students to turn and face each other. Students who match the actions of the flowers become either bluebells or cow parsley, moving to the other side of the group.
- If the flower chooses an action that is not matched by the resources, then the flower must sit down for the next round as it does not have the resources to grow (mimicking nature).
- The flowers continue choosing resources until they are all used up.
- Count the number of bluebells and cow parsley.
- The objective of the game is to see which flower wins the competition to live in woodland – cow parsley or bluebell.
- Play the game again and explain to the students that the climate has increased in temperature. Every time the 'cow parsley' selects the resource 'warmth', it now gains two of the students matching the action for 'warmth'. This is to represent how well cow parsley grows in warm weather.
- Which flower wins?

3. Follow the game by discussing the questions on the worksheet



Follow up activities for students

Students could be encouraged to monitor flowering times of bluebells and cow parsley in their school garden or park.

Assessment

Student worksheets assessed for levels of response

- No recognition of role of climate change on bluebells and cow parsley.
- Some recognition of role of climate change on bluebells and cow parsley.
- Notice made of small details and an awareness of the role of climate change in the timings of flowering times of bluebells and cow parsley.
- Awareness of the role of a responsible citizen to alter the factors which are causing the change in flowering times.

2. Competitive nature

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Bluebells (*Hyacinthoides non-scripta*)

The bluebell is considered Britain's national flower. It grows from a bulb and its flowers are sweet smelling. The bell-shaped flowers stand upright when they are in bud, but hang downwards when they are open. Bluebells seen in large numbers, in woodlands, create the effect of a blue carpet. Although they can be found all over Britain, they are globally threatened and British populations represent 30% of the world's total.

Bluebells prepare their leaves and flowers in underground bulbs during the summer and autumn. This means that in cold weather they are able to use the resources stored in their bulbs. The shoots emerge from early January, before leaves from trees block some of their available sunlight. Other plants - such as cow parsley (*Anthriscus sylvestris*) or dandelions (*Taraxacum officinale*) - need warm weather before they are able to grow. With warmer springs brought on by climate change, cow parsley and dandelions will be able to start growing earlier.

The Spanish bluebell (*Hyacinthoides hispanica*), which has unscented flowers, grows more quickly than the British bluebell. Bees also help to cross-breed the British bluebell with the Spanish bluebell, increasing the British bluebells threat to survival.



Cow parsley (*Anthriscus sylvestris*)

Cow parsley is one of the most familiar wild plants of the British countryside. Most roadsides are lined with the white flowers throughout the month of May. The plant has a number of local names; hedge parsley, wild chervil and Queen Anne's lace - the latter arose from the days when Queen Anne travelled in May, people believed the roadsides had been decorated especially for her.

The growth of cow parsley is usually suppressed with cold winters. However, a study by Kew Gardens has shown that, with changing climate, cow parsley is now flowering on average nine days earlier than it was 20 years ago.

- Which flower won the game?
- Why do you think this flower won the game?
- What do bluebells need to grow?
- What does cow parsley need to grow?
- Which flower will be more successful if our climate becomes warmer? Why is this?
- What can be done to save the British bluebell?

Learning Intentions

For students to:

- Analyse evidence and draw and justify conclusions
- Work effectively in a group
- Use new vocabulary such as aquatic plants, over-fishing, predators, bio-mass and invasive species
- Use an atlas

Context:

- Case study about invasive plant species and water
- Statement cards

Resources

Provided

- Case study – invasive species plus map to show location of Akosombo Dam
- Image of water hyacinths on lake
- Student worksheet - where have the fish gone?

Needed

- Atlases
- Computer—depending on the detail of the atlases, this may not be needed

Links to National Curriculum subjects

Geography KS2

Enquiry and skills (1a, 1c, 1e, 2a, 2c)
 Knowledge and understanding of places (3c, 3d, 3e)
 Patterns and processes (4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6c, 6e)

Geography KS3

Enquiry and skills (1a, 1c, 1f, 2a, 2c)
 Knowledge and understanding of places (3a, 3c, 3d.)
 Patterns and processes (4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6d, 6e, 6h, 6i, 6j, 6k)

3. Where have the fish gone?

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Overview

'Where have the fish gone?' is a mystery activity. Students are given a series of cards containing information. Working in small groups, they are asked to sort out and use the information to make a story. From this, students are asked to come up with an explanation as to why there are no fish in the Akosombo Dam. Sorting cards allows pupils to handle materials and for some pupils this is a useful way of introducing longer writing.

Teaching activity

- 1 Photocopy the cards and provide a set to each group of students (in threes or fours).
- 2 Ask the students to sort out the cards and come up with a story to explain where the fish have gone. Students can be encouraged to explore different ways of working with these materials. For example:
 - Reading and then spreading the cards out on a table. This allows everyone in a group to know the 'facts'.
 - Work out those points which are not relevant to the main question and have a reject pile, or separate these into a different section on the table.
 - Link up points in a sequence to tell a story.
 - Put the cards onto a large sheet of paper and draw links between cards. Extra notes or ideas can also be made on the sheet of paper to help with discussion.

The idea behind this activity is that students begin to think about an event for which there is no clear explanation. Some of the information on the cards is extra to solving the 'mystery'. Mysteries work on the basis that there are lots of possible answers. This activity is sufficiently open-ended to allow more able students to come up with a range of ideas for the absence of fish.

- 3 Show the students the photograph of the water hyacinths on the Dam. This should answer some of their questions and help them understand that there are stories behind a simple picture. It's important to remember that this mystery has no definite answer: the photograph gives only one aspect of the problem. Poverty over-fishing, disease and predators will also be possible factors.
- 4 Ask the students to find out where the Akosombo Dam is located. If they are only using atlases, you may need to tell them that the Dam is in Ghana.
- 5 If time permits, you can use the cards as a simple framework for extended writing.

Assessment

Pupil worksheets assessed for levels of response

- No recognition of role of climate change on fishing
- Some recognition of role of climate change on fishing
- Notice made of small details and an awareness of the role of climate change in the growth of invasive species and its effect on fish
- Awareness of the role of a responsible citizen to alter the factors which are causing the change in plant life and aquatics.

Visits to botanic gardens

This activity is suited to either a school grounds or a botanic garden as it relies on knowledge of aquatic plants. Botanic gardens may have water hyacinth or similar species to show pupils.

Case study - Invasive species

The water hyacinth (*Eichhornia crassipes*) originates from the Amazon but now threatens native biodiversity globally. Its growth rate is among the highest of any plant known; the species is able to double its mass in 12 days and can grow faster than it can be cleared. These species form dense mats that cover thousands of hectares, preventing sunlight and water from getting into the water and choking out other species. This results in a loss of livelihood (fishing), decrease in available water and even a threat to power generation. The Akosombo Dam in Ghana is under serious threat from the water hyacinth.

The water fern *Azolla* spp. is an invasive plant species, widely introduced globally via ship's ballasts, for example in the Caspian sea (Global Invasive Species Database, 2005). The species provides a haven for mosquito larvae in Africa.

Acacia nilotica has been declared a weed of national significance in Australia. Though introduced to provide shade for sheep it causes significant damage to cattle production by reducing pasture production. In terms of the environment, the species increases soil erosion and water loss through transpiration. *A. nilotica* has vast potential distribution and actively expands its range. Climate change will likely increase areas at risk of invasion (Kriticos *et al.*, 2003).



Where have the fish gone from the Akosombo Dam?

The water hyacinth comes from the Amazon but can grow in lots of places.

The water hyacinth grows on the surface of calm water in places such as dams and lakes.

Many plants such as the water fern grow on the surface of lakes.

Dams are used to stop flooding and hold back water to use when there is a drought.

Places far away from the sea can have fish in their lakes and people catch these to make money.

Fish are farmed in many lakes and provide valuable protein for local people's diet.

Fish need oxygen in the water, sunlight and nutrients to live and grow.

Plants need water, nutrients, sunlight and carbon dioxide to grow.

Some plants take years to spread out over an area.

Water hyacinth can spread out over twice the area it started from in 12 days.

Lakes and dams can be used to make electricity.

The Akosombo Dam has water hyacinth growing on the lake behind the dam.

Water hyacinth forms thick mats of stems and leaves that cover thousands of hectares of water, stopping sunlight and water from getting into the water and choking out other types of plants.

People living near the Akosombo Dam are very poor and would like to have a better income.

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3. Where have the fish gone?
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3. Where have the fish gone?



- Look at the information on the cards
- Sort the information out to see if you can create a story
- Which cards are useful to tell a story?
- Are there some cards that need more information? Ask your teacher to help you.
- What do you think has happened here? Why are there no fish? Can you come up with a good reasoned explanation?
- Where is the Akosombo Dam? Use an atlas to find the Dam and draw a map to show its location.
- Why do you think people who live near the Akosombo Dam are poor?

This activity is called a mystery and as in all mysteries we are not always sure about the answer.



Learning Intentions

For students to:

- Work effectively in a group
- Use new vocabulary such as: alpine plants, competition, migration
- Describe and explain environmental change
- Recognise the implications of climate change on mountain flora

Context:

- Environmental activity
- Information sheet on alpine plants and mountains

Resources

Provided

- Pictures of Alpine plants and alpine environments
- Information sheet on alpine plants and mountains

Needed

- A long rope
- Chalk signs on floor to mark the various vegetation zones
- Cards with names of plants and zones
- Space in the playground or garden, preferably with a slope

Links to National Curriculum subjects

Geography KS2

Enquiry and skills (1a, 1c, 1e, 2a, 2c)
Knowledge and understanding of places (3c, 3d, 3e)

Patterns and processes (4b)
Environmental change and sustainable development (5a, 5b)
Breadth of study (6b, 6e)

Geography KS3

Enquiry and skills (1a, 2a, 2c)
Knowledge and understanding of places (3a, 3c, 3d,)
Patterns and processes (4b)
Environmental change and sustainable development (5a, 5b)
Breadth of study (6d, 6e, 6j, 6k)

4. Alpine plants in trouble

Overview

'Alpine plants in trouble' demonstrates the impact of climate change on alpine plants. Following a discussion about alpine plants, students participate in an activity in which they represent different plants living on Mount Kenya. As the climate warms students decide where to move to. Discussion and further reading helps students consider the wider implications of climate change on alpine plants.

Teaching activity

1 Run the alpine plant activity. Ideally this should be played out on a slope, with a rope stretched across an open area. Mark the area with the various heights (see below). Explain to the students that the rope represents the slope of Mount Kenya (5,200 metres high).

- Divide the students into six teams. Each team represents the plants from a different vegetation zone.
 - 1 **Lowland** – 1,000 metres – grassland and thorny scrub
 - 2 **Cultivated zone** – up to 1,800 metres – tea, coffee, beans, bananas, potatoes
 - 3 **Montane forest** – 2,000-2,500 metres – juniper trees, African olive trees, elderberry shrubs, herbs such as mint and clover
 - 4 **Timberline forest** – 3,000-3,500 metres – small trees such as African rosewood, Giant St. John's Wort and flowers such as lobelia and violets
 - 5 **Heath land** – 3,500-3,800 metres – shrubs such as heathers and sage
 - 6 **Alpine zone** – 3,800-4,500 metres. The vegetation is sparse at this altitude as plants are exposed to ice which can uproot and damage seedlings. Plants include tussock grass, giant lobelias, gladiola, lichens and moss.
 - 7 **Nival zone** – 4,500 metres – this is the area above the vegetation line
- Ask one student from each team to line up along the rope to represent a plant from their vegetation zone.
- Each plant produces seeds and a new plant is created. Ask the students (plants) to invite another member of their team to join them in their vegetation zone.
- Explain that the climate is warming. Discuss with the students what they think will happen to the plants.
- The plants again produce seeds and two new plants are created. This time the new plants are able to survive further up the mountain because of the warmer climate. Two members of their team join them on the mountain.
- Continue with the plants producing seeds and their offspring moving further up the mountain.
- Finish the activity with a discussion about the implications of climate change on alpine plants.

2 Provide the students with the information on alpinines and ask them to complete the worksheet.

This activity could be linked to activities 2 and 3 where issues of out-competing species are discussed.

Follow up activities for pupils

Students could read and discuss the two case studies 'Trees with nowhere to go' (page 44) and 'Climate change impacts on boreal forests' (page 52) from *Plants and climate change: which future?* (www.bgci.org/climate/whichfuture/).

Assessment

Pupil worksheets assessed for levels of response

- No recognition of role of climate change on plant zones on a mountain.
- Some recognition of role of climate change on plant zones on a mountain.
- Notice made of small details and an awareness of the role of climate change in the movement of plant zones on a mountain.
- Awareness of the role of a responsible citizen to alter the factors which are causing the change on mountain slopes.

Visits to botanic gardens

This activity is suited to either a school grounds or a botanic garden as it relies on knowledge of alpine plants, trees and space to play the game. Visiting during spring or summer, when alpine plants are in flower, would be an ideal time as students can engage with the beauty of alpinines.

4. Alpine plants in trouble



Alpine plants and mountains

The alpine zone is at the very top of mountains, it is the limited area between the ending of the treeline and the summit of the mountain. Alpine environments are harsh and plants must adapt if they are to survive. Alpine plants are often small and have wonderful flowers. The word alpine comes from the Latin alpes which means 'high mountain' – places which are cold, windy and snowy.

A common feature of alpine plants is to have deep roots. This helps keep them upright in an area where gravity is constantly pulling soil down from the sides and tops of mountains. It also helps them reach water and nutrients.

Alpine plants are generally low in height. The reason for this is two-fold. Wind is always present in arctic-alpine environments and smaller plants are not as exposed to wind as taller plants are. Low growth also means a better chance of staying covered by snow which is one of the best insulators against extreme cold. Temperatures in arctic-alpine regions are generally low but the air temperature at the soil surface is always warmer than just above, so low plants keep themselves warmer simply by their short height.

Many alpiners have evergreen leaves. This feature allows them to start photosynthesizing as soon as the air temperatures rise above freezing. Fuzzy leaves are also common and this helps protect alpiners against drought conditions. Most alpiners bloom and set seed within weeks of the melting snow. Flower colour is important. White flowers can trap some heat and is attractive to general pollinators. This is important in a region where pollinator activity is low. Blue and purple flowers trap more heat than white and this colour is also more attractive to bumblebees which are relatively common in alpine regions. Bumblebees can be active at temperatures much lower than other insects can tolerate. The more flowers produced, at the same time, the better the chances of being seen and visited by pollinators. This is why alpine plants often have spectacular floral displays.

As temperatures increase, there is only so far upwards these alpine plants can move before they are literally pushed off the top of the mountain. Plant species from lower slopes, like grasses and shrubs, will be creeping up the mountainsides at the same time, further threatening the little alpine plants.

Some alpine plants need snow to act as a protective cover. In some alpine regions there is less snow cover because of climate change. This means these plants are unlikely to be able to survive.

Questions

- How are alpine plants adapted to wind and cold temperatures on mountains?
- Why are the flowers of alpine plants often very bright colours?
- Why are alpine trees and plants vulnerable?
- Where is Mount Kenya? Use an atlas to find the mountain and draw a map to show its location.

Learning Intentions

For students to:

- Use appropriate fieldwork techniques and instruments
- To draw plans
- Work effectively in a group

Context:

- Outdoor activity
- Use of maps and compasses

Resources

Provided

- Background information for teachers - case study 'Effects of drought on growth of beech (*Fagus sylvatica*) trees'
- Worksheet for students

Needed

- Compass and map of the area for each pair of students
- Clip boards, pencils, paper and reflective card
- Cameras (optional)
- Tree identification sheets or books
- Sheet of A3 paper per group
- Access to five deciduous trees – e.g. beech, oak, horse chestnut. These trees may be found in the school grounds, local park or botanic garden

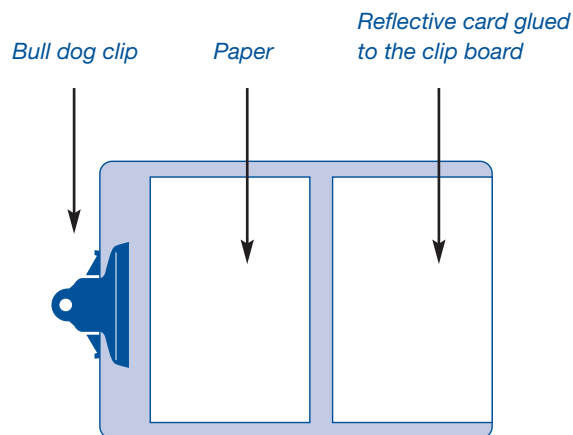
5. Close encounters with trees

Overview

This two part activity encourages students to become aware of the links between weather and trees. Students work with their peers to collect data using drawings or photographs. They also make notes about the weather and surroundings so they can refer back to this data at a later time. Ideally, the activity should be carried out at the end of summer (September) and then again in late spring or summer (June, July).

Teaching activity

- 1 Divide the students into groups of six. Designate a tree to each group.
- 2 Give each pair of students a map of the area, a compass and a clipboard, prepared as in the diagram below.



- 3 Ask each group of students to note exactly where their tree is located on the map.
- 4 Following the instructions on their worksheets, students place themselves at different locations beneath the tree. Get them to draw a section of the tree's canopy in detail. If it is a dry day then they can lie down. If not, the reflective strips on their clipboards will help them view the canopy without getting a cricked neck. If the students have cameras, they could also look up and take a picture of a section of the tree. If the tree is large, students will need to clearly define the segment they are drawing – picking out significant branches to delineate their segment before they draw the detail.
- 5 Ask the students to make notes about the weather and to observe whether the tree is displaying evidence of stress –for example, brown, yellow or shrivelled leaves, loss of leaves, wilted leaves, cracked bark and fruit dropping earlier than expected.
- 6 Ask the students to use a compass to note which way they are facing and to mark this on their diagram so they can return to the same spot for a repeat visit later in the year. Also ask them to note the date.
- 7 In class, ask each group to produce a collage of their drawings to represent their tree canopy. Encourage groups to discuss what they observed and the differences between their trees. If their drawings show evidence of stress (see above) discuss with them why this might be. Discuss what will happen as the climate warms.

Links to National Curriculum subjects

Geography KS2

Enquiry and skills (1a, 1b, 1c, 1e, 2a, 2b, 2c, 2e)
 Knowledge and understanding of places (3a, 3c, 3d, 3e)
 Patterns and processes (4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6e)

Geography KS3

Enquiry and skills (1a, 1c, 1d, 1f, 2b, 2c)
 Knowledge and understanding of places (3a, 3c, 3d)
 Patterns and processes (4a, 4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6e, 6j, 6k),

Follow up activities for students

Find time later in the year for the students to visit their trees again and carry out the same activity. Ask the students to carry out a comparison of their collages.

Carry out the activity over a number of years. Try to do it at the same time each year so that students can build up a picture of change over time.

Assessment

Pupil discussions assessed for levels of response
 No recognition of change (if there was change)
 Some recognition of change

Visits to botanic gardens

Botanic gardens usually have many trees that can be used for this activity. Educators working in botanic gardens could build up a display of collages over a number of years and this could form the basis for a discussion about change over time.

Note

Many school activities outside the classroom involve counting which is valuable for the development of numeracy. This activity however, focuses on collecting knowledge visually and encourages students to observe and pay attention to detail, without necessarily measuring.

Case study

Effects of drought on growth of beech (*Fagus sylvatica*) trees

A study of *Fagus sylvatica* trees in Catalonia in Spain showed that populations of the species toward the southern limits of the species' distribution are increasingly limited by drought. Further, the region is expected to warm in the future. The study looked at annual growth levels over the past 50 years and found a rapid recent decline of southern range-edge populations, starting in approximately 1975. By 2003, growth of mature trees had fallen by 49% when compared with predecline levels. The decline is not seen in populations at higher altitudes, therefore the effects of drought (less water, higher temperature) is impacting tree growth.

5. Close encounters with trees

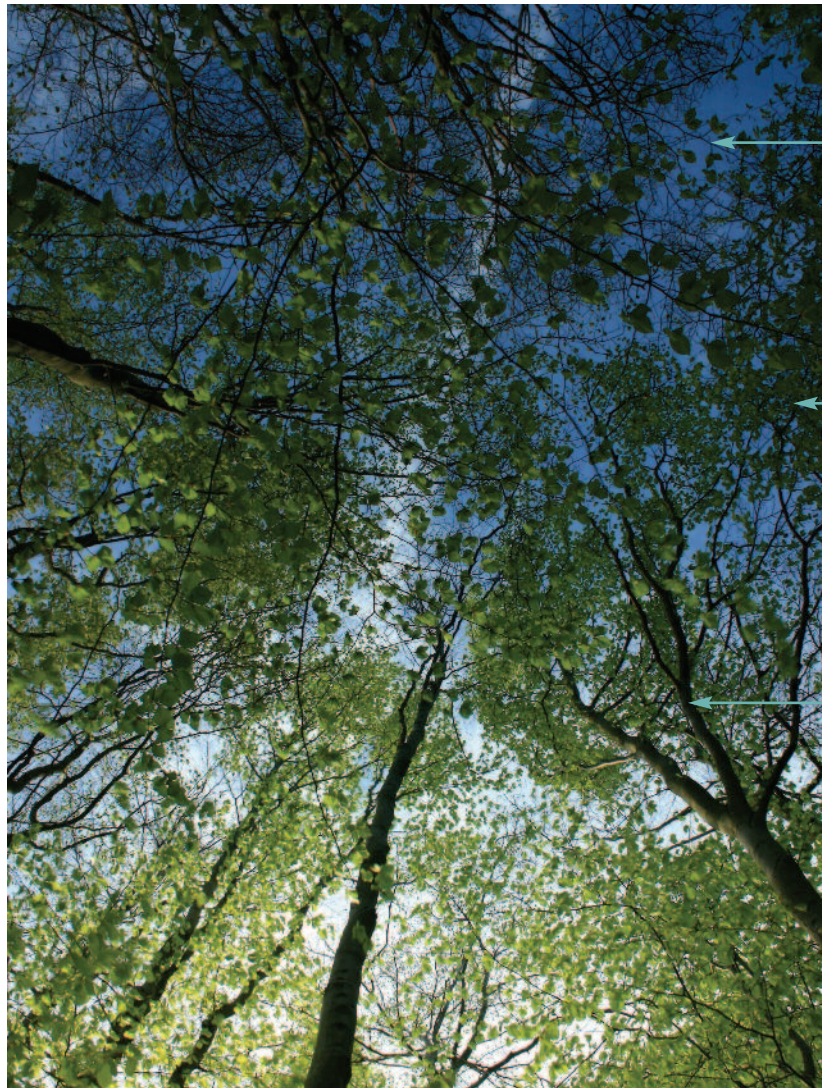
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A study of beech trees in Catalonia (north east Spain) showed that drought is having an impact on how far south these trees are able to grow. For the past 30 years beech trees in the south have been growing much slower than beech trees in the north. This region is set to get warmer with climate change. The study concluded that the effect of drought (less water, higher temperature) is impacting on tree growth.

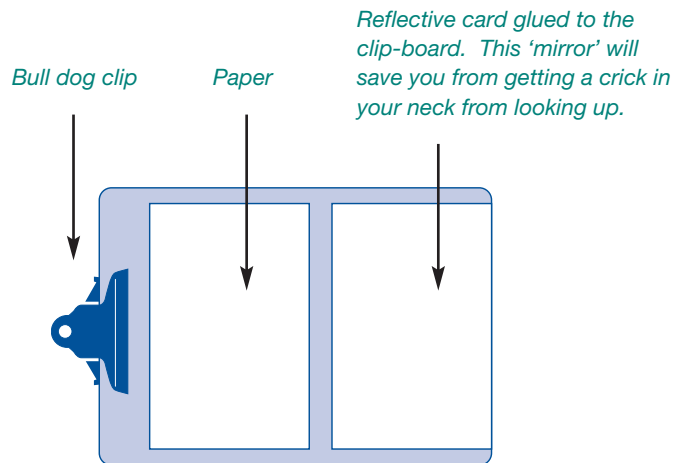
How often do you look up?

Have you ever stood under a tree and looked up?

Canopies are made up of branches, twigs and leaves



You need a clip board that looks like this:



Looking at the canopy of your tree

- Your group needs to select a deciduous tree (a tree that loses its leaves in winter). Mark where the tree is on your map. You need to do this so that you can find your tree again when you repeat this activity later on in the year.
- Find out what tree you are studying. Is it a beech? In May there are catkins and in October it will have beech nuts (changing weather patterns may change these timings). The bark is nearly always smooth even in big old trees.
- Each group member needs to choose a dry spot to sit or lie down. Use the compass to mark on your sheet the direction your head is facing. Also note the date. Space yourselves out so that you are looking up at different parts of the tree.
- Use your clipboard with its mirror to look up. You should find it easy to copy and draw your part of the canopy onto the piece of paper. You could also take a photograph. Try to show as much detail as you can. Notice whether there is any evidence that the tree is under stress - brown, yellow or shrivelled leaves, loss of leaves, wilted leaves, cracked bark, fruit dropping earlier than expected. Make a note of this and also of the weather.

Now or on your return to class

- Put your drawings (or photographs) together with those from your group and make a collage. This will give you the bigger picture.
- Discuss your collage and compare it with other groups. If your drawings show evidence of stress why do you think this might be? What might happen to your tree if the climate warms?
- Remember to keep your map and drawing safe as you will be repeating this activity later on in the year.

Learning Intentions

For students to:

- Analyse evidence and draw and justify conclusions
- Work effectively in a group
- Use new vocabulary such as phenology

Context:

- Poem by William Wordsworth
- Phenology information sheet

Resources

Provided

- Poem by William Wordsworth 'Daffodils'
- Worksheet for students
- Case study on Cherry blossom festivals

Needed

- Computers for research

Links to National Curriculum subjects

Geography KS2

Enquiry and skills (1a, 1c, 1e, 2a)
 Knowledge and understanding of places (3c, 3d, 3e)
 Patterns and processes (4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6e)

Geography KS3

Enquiry and skills (1a, 1c, 1d, 1f, 2a)
 Knowledge and understanding of places (3d)
 Patterns and processes (4a, 4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6d, 6k)

6. Blooming early

Overview

'Blooming early' encourages students to become aware of the effects of climate change on flowering times. Students explore why daffodils are blooming earlier each year and consider the implication for future cultural festivals.

Teaching activity

Questions that link personal meanings to certain dates in the calendar can be useful starters for a lesson about climate change, particularly if the lesson goes on to look at changes on the macro scale such as melting polar ice caps, which may not be part of the learners' experiences. Plants are so much a part of our everyday lives that we often miss the problems they face with climate change. It is only when we need them for a particular day that the problem stands out. Our own important days are also often linked to particular plants and can be a useful way of connecting students' thoughts to their environment.

- Read the poem 'Daffodils' by William Wordsworth to the students (see over).
- Ask the students what time of year they think Wordsworth wrote this poem. Explain to them that the poem was first written 200 years ago.
- Show the students the quotes from Hilary, and Glenys. What do they think is the reason for daffodils flowering earlier in the year? Kew Gardens has an information sheet about Phenology, which looks at the influence of climate on flowering times (<http://www.kew.org/ksheets/pdfs/K36-black.pdf>). There is evidence that daffodils have flowered earlier and earlier over the last 50 years.
- Ask the students what flowers are around for their birthday. What flowers might be around for their birthday in 25 years time, if the climate continues to warm. This could lead to an interesting discussion about flower cultivation.

My name is Hilary and I own a flower shop in North Wales. People here buy daffodils for St David's day on the 1st March. Usually, I can buy daffodils from local growers in time for the big day. I buy daffodils from Aalsmeer in the Netherlands, they have an enormous flower auction every day and lorries come over on a Tuesday with fresh flowers for my shop. Sometimes I buy daffodils from The Netherlands to celebrate St David's day. If we have a mild spring, like two years ago, then it is a problem, because the daffodils have finished, or people already have them in their gardens, and don't want to buy mine. If the daffodils get any earlier then I will have to buy them from colder places further north, from Scotland!

Hilary, 2009

My name is Glenys I remember daffodils in the garden for birthday parties as a child 50 years ago, but sometimes now there are no daffodils there on my birthday. Sometimes they are so early that they have finished by the middle of March. This year because the snow lasted a long time, there were more daffodils about than usual on my birthday.

Glenys, 2009

“I Wondered Lonely As A Cloud”

William Wordsworth

I wandered lonely as a Cloud
That floats on high o'er vales and Hills,
When all at once I saw a crowd,
A host, of golden Daffodils;
Beside the Lake, beneath the trees
Fluttering and dancing in the breeze.

Continuous as the stars that shine
And twinkle on the milky way,
They stretched in never-ending line
Along the margin of a bay:
Ten thousand saw I at a glance,
Tossing their heads in sprightly dance.

The waves beside them danced;
but they
Out-did the sparkling waves in glee:-
A Poet could not but be gay
In such a jocund company:
I gazed---and gazed---but little thought
What wealth the show to me had
brought:

For oft when on my couch I lie
In vacant or in pensive mood,
They flash upon that inward eye
Which is the bliss of solitude,
And then my heart with pleasure fills,
And dances with the Daffodils.

Published in Collected Poems, 1815

Follow up activity

Using the information from Kew's phenology sheet ask students to draw a pictogram that shows the change in flowering dates for a range of plants. Ask them to predict which month these plants might flower in 25 years time.

Encourage the students to use the internet to find out more information about other festivities which use flowers and rely on them being in season (See the case study below on the flowering cherry festival in Japan).

Keep a school phenology diary, encouraging students to note flowering times of plants around the school.

Assessment

Pupil worksheets assessed for levels of response

- No recognition of role of climate change on plants and flowering times
- Some recognition of role of climate change on plants and flowering times
- Notice made of small details and an awareness of the role of climate change in the timings of flowering times
- Awareness of the role of a responsible citizen to alter the factors which are causing the change in flowering times.

Visits to botanic gardens

This activity is very well suited to a botanic garden as it relies on knowledge of plant flowering times.

Case study: Cherry blossom festivals

Phenology is the study of the timing of natural events – like when flowers first appear, when leaves first start to grow on trees, when insects appear and when birds come back from their migrations. It can also be used to study the end of a season – for example, when leaves fall from trees.

For hundreds of years people have recorded and documented these kinds of events and it's becoming even more important in light of climate change. Spring is happening earlier and earlier each year – so phenological records are becoming increasingly important because they are proof that the natural world is already responding to climate change. Of all the characteristics of plants that relate to climate change, the timing of flowering is the one for which there are the most observations.

One example of this comes from Japan. In Japan cherry blossom festivals, called 'Hanami', are hugely popular and culturally significant. Every year, since the 9th Century, huge festivals and celebrations are held throughout the country as the blossom appears on the cherry trees. During modern festivals, people of all ages spend time outdoors, enjoying the beauty of the cherry blossoms by day and by night, with their family, friends, and workmates. Festival activities include eating seasonal foods, such as bamboo shoots, rice cakes with red beans, and wild vegetables, playing games, listening to musical instruments and singing.

Because of this the flowering times of cherry blossom have been recorded and documented for over around 1,200 years. This unbroken record can help us to reconstruct the past climate and demonstrate the local increase in temperature associated with climate change and urbanisation. All together, the flowering record shows a six-week range in flowering dates from as early as late March to as late as early May. Extreme flowering dates are scattered throughout this period.

However, after approximately 1830 flowering times become progressively earlier. By the 1990s average flowering times had become earlier than at any time previously during the entire flowering record.

This record is probably the longest annual record of phenology from anywhere in the world and shows that cherries are currently flowering earlier than they have at any time during the previous 1200 years and that this is due to temperature increases.

Ref: Richard Primack and Hiroyoshi Higuchi; *Climate Change and Cherry Tree Blossom Festivals in Japan*, *Arnoldia*, 65:2, 14-23

6. Blooming early

“I Wondered Lonely As A Cloud”

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Which is the bliss of solitude,
And then my heart with pleasure fills,
And dances with the Daffodils.

Published in *Collected Poems, 1815*

- Which month of the year was Wordsworth wandering in the Lake District?
- Read the quotes below from Hilary and Glenys. What do you think is the reason for daffodils flowering earlier in the year?

My name is Hilary and I own a flower shop in North Wales. People here buy daffodils for St David's day on the 1st March. Usually, I can buy daffodils from local growers in time for the big day. I buy daffodils from Aalsmeer in the Netherlands, they have an enormous flower auction every day and lorries come over on a Tuesday with fresh flowers for my shop. Sometimes I buy daffodils from The Netherlands to celebrate St David's day. If we have a mild spring, like two years ago, then it is a problem, because the daffodils have finished, or people already have them in their gardens, and don't want to buy mine. If the daffodils get any earlier then I will have to buy them from colder places further north, from Scotland!

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Glenys, 2009

- Every year, for the past 50 years, scientists at Kew Gardens have collected information on the flowering times of plants. There is evidence that daffodils have flowered earlier and earlier over the last 50 years. See the Phenology Information Sheet from Kew Gardens.
- What flowers are around for your birthday? What flowers might be around for your birthday in 25 years time, if the climate continues to warm?
- In pairs, discuss the way in which your families use flowers to celebrate certain days, or use the internet to find out about flowers and festivals. What happens if the flower is difficult to find? Some good information is available about red roses for St Valentine's Day for example. Red roses are specially flown in from Kenya as roses do not usually flower in Britain in February.

Learning Intentions

For students to:

- Explain how a living thing works
- Collect and record evidence
- Analyse evidence and draw conclusions

Context:

- Outside in the environment
- Tree identification books

Resources

Provided

- Students worksheet

Needed

- Access to trees for students to study
- Tree identification books
- Paper for students to draw, make notes and to do bark rubbing
- Viewfinders – one per student

Links to National Curriculum subjects

Science KS2

Ideas and evidence in science

(1a, 1b)

Investigative skills (2b, 2c, 2j, 2k, 2l)

Life processes and living things

(1c, 3c)

Science KS3

Scientific thinking (1.1b)

Practical and enquiry skills (2.1c)

Communication (2.3a)

The environment, Earth and the

universe (3.4c)

Geography KS2

Enquiry and skills (1a, 1b, 1c, 1e, 2a)

Environmental change and sustainable development (5a, 5b)

Geography KS3

Enquiry and skills (1a, 1c, 1f)

Knowledge and understanding of places (3a, 3c, 3d,)

Patterns and processes (4b)

Environmental change and sustainable development (5a)

Breadth of study (6d, 6j, 6k)

7. The life of trees

Overview

'The life of trees' encourages students to look closely at trees and think carefully about the functions of different parts of trees as well as the overall importance of trees. Students use view finders to observe two trees and carry out a number of small scale investigations. They then make comparisons and discuss their findings.

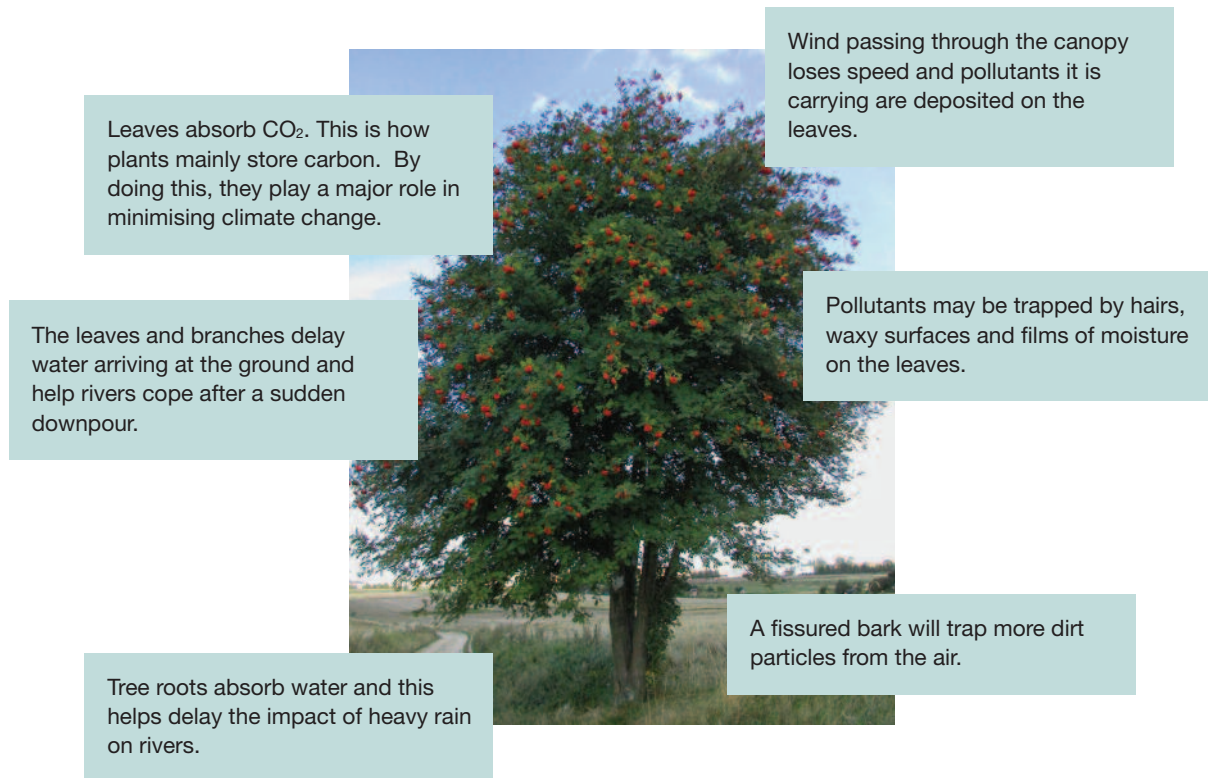
Teaching activity

- It is best to do this activity in the spring or summer when deciduous trees are in full leaf.
- Give each student a worksheet and a view finder. Information is provided on the worksheet for students to understand how trees help regulate the environment.
- Ask students to find two different trees, and carry out the activities on their worksheet with each tree.
- Following the activity ask the students to discuss their findings in groups.

Visits to botanic gardens

A botanic garden would be an ideal place in which to carry out this activity.

7. The life of trees



Things to do

Look for two trees to compare. Perhaps choose a large tree and a small tree.

Use a view finder to make sketches of your trees, then carry out the following activities:

- Estimate the number of large branches around the edge of the tree.
- Estimate the number of leaves on a branch
- Draw and label a leaf.
- Look for evidence of the size of the roots.
- Examine the bark. Take a bark rubbing and describe the pattern.
- Compare the noise levels and shade under your tree and out in the open. Is there a difference?
- Find out the name of your trees.

Questions to consider

- What are the main differences between your trees?
- How do the trees delay water getting to the ground?
- Would one tree be more efficient than the other in delaying water getting to the ground?
- Do either of the trees have roots sticking up from the ground? What implications does this have for any human activity under the tree (eg. mowing grass, parking cars)?
- What do you think happens to rain if there are no trees? Consider the impact on rivers.
- Why do you think it is important to plant trees in cities?

Learning Intentions**For students to:**

- Explain environmental change
- Work effectively in a group
- Use new vocabulary such as biomass and peatbogs

Context:

- Environmental activity
- Causes and effects cards

Resources**Provided**

- Causes and effects cards

Needed

- internet

Links to National Curriculum subjects**Geography KS2**

Enquiry and skills (1a, 1c, 1e, 2a)
 Patterns and processes (4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6e)

Geography KS3

Enquiry and skills (1a, 1f, 2a)
 Knowledge and understanding of places (3c, 3d,)
 Patterns and processes (4b)
 Environmental change and sustainable development (5a, 5b)
 Breadth of study (6d, 6h, 6j, 6k)

8. Causes and effects**Overview**

'Causes and effects' helps students understand the impact of climate change on plants. Groups of students are provided with a set of cards to sort into strings of linked cards. From this they produce their own table of causes and effects

Teaching activity

- Cut out a set of cards for each group of students and mix them up.
- Divide the students into groups of three or four and provide each group with a set of cards
- Ask the students to cluster the cards into threes, to show the links between causes and effects.
- Encourage them to discuss the findings
- Ask the students to produce their own table of cause and effects and write a summary paragraph.

Cause	Effect	Response

8. Causes and effects

.....

Cause	Effect	Response
Industry, cars and aeroplanes produce more and more CO ₂ .	Increase in CO ₂ in the atmosphere causes trees and plants to grow more.	American poison ivy (Toxicodendron radicans) uses extra CO ₂ to produce more biomass and becomes more poisonous.
Climate change has meant that summers in some places are warmer and last longer.	Longer summers with hot weather delays frost which triggers chlorophyll in leaves to decay and this makes the leaves change colour	Leaves on trees in the United States of America have duller leaves in the autumn because of climate change.
Heavy frosts are important for encouraging buds to break. These buds eventually become fruit.	Warm winters in England have caused blackcurrants to have less juicy fruit.	It takes 16 years to develop strains of a fruit and if climate change keeps happening then some fruits may disappear before we can develop new strains resistant to drought.
Cold climates are important for some trees like the yellow birch.	With milder winters, trees are becoming less hardy.	Yellow birch used to be able to cope with frosty conditions but now they are dying back after late frosts.
Some areas are having less rain because of climate change.	Beech trees need to have enough water to grow and they do not like it when the weather is too hot.	Beech trees now grow in areas further north in Europe than they used to be found in the past.
Climate change is causing the bogs of Siberia to melt much earlier than in the past.	Peatlands hold large quantities of methane which is a Greenhouse Gas - 21 times worse than CO ₂ .	Large areas of Russia are covered in snow. Until now this snow has reflected the heat but now it is melting. Because the land is darker it is absorbing heat and this is increasing the warming effect.
Industry, cars and aeroplanes produce more and more CO ₂ .	CO ₂ increases the risk of plant and tree leaves freezing at warmer temperatures.	Maidenhair trees are affected by their leaves freezing in temperatures that they used to be able to cope with.