Primary

7–11

Counting trees

Teacher guide and worksheets

National Centre for Earth Observation

NATURAL ENVIRONMENT RESEARCH COUNCIL

Earth Observation science for a changing planet

esa biomass EODetective

Contents

If you have any comments or questions about these materials, please email **EODetective@NCEO.ac.uk** We would love to hear about how you have used them and see what your students have produced!

Overview

Activity summary

These classroom resources support students learning about the forested areas of the Earth: where they are, which are diminishing, and which are increasing. They provide opportunities to discuss the reasons for these changes. Students use photographs alongside their own experience to consider how difficult it can be to count trees and find out how the Biomass satellite will help. An optional activity or demonstration introduces how the instrument on the satellite works. The pack can be used alongside study of rainforest ecosystems.

Time needed

1 hour, not including optional activity, but can be split into two shorter sessions

Prior learning

- Plants, including trees, need water, sunlight and soil to thrive.
- Animals, including us, depend upon plants in various ways.

Learning outcomes

- Identify the major tropical and temperate forested areas of the Earth.
- Suggest why the number of trees in these areas may be changing.
- Evaluate the impact of such changes
- Explain how we could count the trees in an area.
- Know that the Biomass satellite will help us count trees in places it is difficult to travel to or see from above.

Key words

wood, forest, (tropical) rainforest, climate, deforestation, agriculture, ecosystem, biome, climate zone, vegetation

Curriculum coverage

These points may be touched on or emphasised depending on how you choose to use the materials. Some may be addressed through extension activities.

England

Science

- Pupils should be taught to recognise that environments can change and that this can sometimes pose dangers to living things. (Year 4 PoS)

Geography

- Pupils should be taught to locate the world's countries … concentrating on their environmental regions … (KS2)
- Pupils should be taught to describe and understand key aspects of physical geography, including climate zones, biomes and vegetation belts … (KS2)

Scotland

Sciences

- I can identify and classify examples of living things, past and present, to help me appreciate their diversity. I can relate physical and behavioural characteristics to their survival or extinction. (SCN 2-01a)
- I can use my knowledge of the interactions and energy flow between plants and animals in ecosystems … (SCN 2-02a)

Social studies

- I can discuss the environmental impact of human activity and suggest ways in which we can live in a more environmentally-responsible way. (Soc 2-08a)
- I can consider the advantages and disadvantages of a proposed land use development and discuss the impact this may have on the community. (Soc 2-08b)
- By exploring climate zones around the world, I can compare and describe how climate affects living things. (Soc 1-12b)
- By comparing my local area with a contrasting area outwith Britain, I can investigate the main features of weather and climate, discussing the impact on living things. (Soc 2-12a)

Wales

Science and technology

- I can recognise that what I do, and the things I use, can have an impact on my environment and on living things. (PS2)
- I can explore relationships between living things, their habitats and their life cycles. (PS2)
- I can describe how living things compete for specific resources and depend on each other for survival. (PS3)

Humanities

- I can recognise the distinctive features of places, environments … and how these may change. (PS2)
- I can describe and give simple explanations about the impact of human actions on the natural world … (PS3)

- I can describe and give simple explanations on how and why some places, spaces, environments and landscapes are especially important to different people and for different reasons. (PS3)
- I can locate and give simple explanations for the distinctive features of places, spaces … in the wider world. (PS3)
- I can describe spatial patterns of places, environments … in the wider world. (PS3)

Health and wellbeing

- I can understand that decisions can be made individually and collectively, and that they can be influenced by a range of factors. (PS3)

Northern Ireland

The world around us

- Pupils should explore the effect of people on the natural … environment over time. (KS2)
- Pupils should explore how place influences the nature of life. (KS2)
- Pupils should explore ways in which people, plants and animals depend on the features and materials in places … (KS2)
- Pupils should explore change over time in places. (KS2)
- Pupils should explore positive and negative effects of natural and human events upon a place over time. (KS2)
- Pupils should explore how change is a feature of the human and natural world and may have consequences for our lives and the world around us. (KS2)
- Pupils should explore the effects of positive and negative changes globally and how we contribute to some of these changes. (KS2)

Background information for teachers

The importance of forests

The benefit of trees that is perhaps most widely spoken about is their role in regulating climate. Carbon dioxide (CO_2) captured from the atmosphere is combined with water and converted into sugars during photosynthesis. Some of these sugars are broken down during respiration (so some CO_2 returns to the atmosphere) but other chemical reactions incorporate some of the sugars into the tissues of the plant (the biomass) so locking away (sequestering) CO_2 – which is, of course, a greenhouse gas that makes a major contribution to the greenhouse effect. Trees and woody plants tend to store carbon for a longer amount of time than grasses and other plants which have shorter life cycles or are sources of food for more animals (peatlands and soils can store carbon for even longer), and tropical forests store more carbon than temperate forests.

A plea on behalf of colleagues teaching in secondary schools

It is tempting to talk about plants 'breathing in CO_2' and 'breathing out oxygen' because comparing with animals/us makes an invisible process easier to understand. This idea is implied when forests are referred to as 'the lungs of the planet'. However, the comparison and analogy hide the facts that plants respire as well as photosynthesise, and that animals breathe in air but absorb just one gas from the mixture. They also reinforce the idea that respiration is the same as breathing. The common misconceptions and blurred everyday usage of a specialist term are things that secondary science teachers struggle to get students to 'unlearn'.

If you talk instead of plants taking in/absorbing *more* CO_2 than they give out to the air, or that they *store* some of the CO_2 they take in, and avoid comparisons with what animals do, you will make it easier for your students to understand more complex topics they meet later.

Changes in tree cover

Earth observation satellites view our planet using both visible light and other types of electromagnetic radiation. Satellites supported by national and international programmes gather data from each point on the Earth every week or so. Scientists can use this to build maps land use (such as **ESA World Cover**) including the area of forests and the average height of trees within them. Using machine learning, new data from an area can be quickly compared with older data and changes spotted quickly. A team from the UK and Kenya, led by Heiko Baltzer (NCEO, University of Leicester), have developed a system called Forest Alert that can detect illegal logging in real time.

However, not all changes to forest area are the result of logging.

- Many forests, especially temperate forests in places like Scandinavia and the rest of Western Europe, are managed for growing timber so decreases in tree cover are due to harvesting and, if the forest is sustainable, matched by new planting elsewhere.
- Forests may be cut down for fuel wood or/and burnt to create fields for grazing animals or growing crops. In the Congo basin and Central America , for example, this has been happening for centuries. Where populations are low, and can leave previously used areas to regenerate while they clear another, such shifting agriculture is sustainable.
- In more recent decades, large areas of the Amazon and Indonesian rainforests have been cleared to produce soy and palm oil, respectively. These are valuable commodities: most soy is used to produce animal feed (people only directly consume a small amount) and palm oil is used in a vast range of foods and other products.

- Wildfires are increasingly threatening forests, particularly the boreal forests of Canada and Siberia.
- Forested areas may be cleared for urban development or housing, 'drowned' when dams are built to provide electricity, or destroyed by mining or quarrying.

Biomass and Geo-trees

The European Space Agency (ESA) Biomass satellite mission is the brainchild of science lead Shaun Quegan (NCEO, University of Sheffield). The satellite was built by Airbus in the UK and, at the time of writing, was due to be launched on 29 April 2025 from Kourou in French Guiana. It will orbit the Earth and send down radar pulses that can pass through clouds and the canopy of a forest. The trunks and branches of trees reflect these pulses back up to the satellite. Scientists can use the reflected pulses to gradually build a 3D model of the forest. This will allow us to better understand the amount of carbon captured and stored in tropical forests.

Meanwhile, scientists across the world – such as Mat Disney (NCEO, UCL) – are involved in a programme called Geo-trees. They collect information using instruments on planes and drones. In forests that are easier to get to and into, they can measure and count trees directly or use a technique called lidar that makes 3D pictures like those that will come from the Biomass satellite.

Comparing information about the same forests from Geo-trees and Biomass will give scientists confidence that results from places where only one programme works are correct.

Practical notes

- Worksheets are designed for single use and can be copied in black and white.
- Resource sheets may contain larger images for you to insert into your classroom presentations or print for display, additional information for students, or data for them to work with. These are best printed or copied in colour but may be reused.
- Students may need a pen/pencil and their exercise book or paper as well as the materials listed for each activity.
- You will need to print sufficient copies of any worksheets and resource sheets you plan to use in advance and, in some cases laminate or/and cut into separate cards. If any additional preparation is required, it is described below the resources list.
- The presentation to go with this activity can be downloaded, along with any additional supporting files, by following the links to this pack on **STEM Learning** or the **NCEO website**. The presentation may include slides in addition to those referenced in the activities (e.g. one listing the learning outcomes). You can edit these as required.
- Suggestions for differentiation, home learning and assessment are included at appropriate points in the description of each activity.

Health and safety

In all activities, we have assumed you will continue to follow your usual procedures relating to, for example, movement within the learning environment, use of equipment, trips and spills, first aid and online safety. Since the details of these vary, even within an individual school, we have not listed them every time. However, we have highlighted any additional specific hazards to inform your risk assessment.

Changing forests

Resources

- Slide pack: Counting trees
- Worksheet 1 (2 pages)
  Some students may find it easier to work with this if the two pages are copied side-by-side on an A3 sheet.
  Alternatively, you could print only the map, Worksheet 1.2, and describe the tasks to students or display the questions (they are included in the slide pack) for them to answer on the back of the map or in exercise books.
- Coloured pencils
- Atlases or/and access to online maps

You may want to print some copies of slides 4 and slide 9, 10 or/and 11 for students who need additional support.

Suggested sequence

1. Discuss the word 'forest' with students. What do they understand by it? Is a forest different from a wood? If so, how? Note that there is no universally agreed definition: in Norman times, a forest was a royal hunting ground and could include places that had no trees at all! However, we usually use the word to mean a large area covered mostly or entirely by trees.

2. Use e.g. Think–pair–share to quickly review the many reasons why trees and forests are important to us. If it is a while since students have considered this, you might want to remind them using a video such as **this one from BBC Bitesize**. Underscore the idea that trees help to control the climate by absorbing and storing carbon dioxide (CO_2) from the air.

3. Show slide 4, a map of places that had significant tree cover in 2000. Discuss the map with students, drawing on what they already know about what trees need to grow (sunlight, water, a certain amount of warmth) and any work you have already done about climate zones or biomes.

4. Distribute the worksheet and ask students to answer questions 1 to 3 (on slides 5–7). Slide 8 can support self or peer marking if you wish to check these answers before moving on.

5. Show slide 9, 10 or/and 11 – choose the one which is most appropriate to your class. Discuss what the coloured dots/colours of the countries show. Draw students' attention to places where there are concentrations of dots/countries of both colours or just one. What might be going on in each place? You could summarise their ideas on a flipchart / separate whiteboard, either before or after the next step.

6. Ask students to answer questions 4–6 from the worksheet (slides 12 & 13). Students could evaluate the answers of their peers (using slide 14 to help with Q5 & Q6) or you could collect worksheets for more formal assessment.

You could split the lesson here, if required.

7. But how do scientists measure the number of trees to see if forests are growing or shrinking? Let's start in a city.
   a. Show slide 15 and ask how we could count trees in a place like this. (Walk along and count!)

b. Show slide 16 and ask if their method would work here. (Yes, but they might want to split the area between them because there are so many trees.)
c. Continue like this through slides 17 to 21 asking:
    - What we could do if the trees are not in a line or regular pattern. (They might do something to mark the trees they've counted like tie some string on them.)
    - What if we can't get to the trees because they're in someone's garden? (Ask the owner to do it, or for permission.)
    - What if there's too much stuff growing between the trees? (Take a picture from above using a drone or an aircraft or a satellite – see slide 20.)
    - What if the picture we take has clouds in it? Or the trees are so tightly packed we can't tell where one starts and another ends (slide 21)? And what about smaller trees that don't reach the top of the canopy? Is there a way to see through both clouds and the canopy?

8. To explain a way around this problem, let's look at a similar picture with no clouds (slide 22). Is there something odd about these trees? Well, yes: if we look at it from the side (slide 23) we can see what it really is! Explain that it's the woody bits of a tree that help us to count them and – perhaps more importantly – are most important for protecting the climate. When trees turn CO_2, (a gas in the air that helps make the world warmer) into wood, it can't get back into the air for a long time. This means the part of the broccoli tree we'd be interested in is that shown on slide 24 – the bit many people throw away even though you can use it to make great soup and tasty chips!

9. Slide 29 shows a computer image of the Biomass satellite which will be able to see through leaves and small branches to measure the woody parts of real trees in tropical forests. Scientists and engineers from ESA countries (see flags on patch on slide 30) have been working on the Biomass mission since 2005, and the programme will cost millions of pounds.

You could insert the optional 'How Biomass sees trees' demo or activity here.

10. So, we have lots of ways to see if the number of trees in an area is growing or shrinking. If there are local examples similar to those in the images, you could ask students the best way to count the trees in those places. Make clear that the simplest method that works in each case is the best: using an aircraft or a satellite to get a picture when we can count trees ourselves wastes lots of energy and money.

11. To elicit what students have learnt from the lesson, ask them why the Biomass mission matters: why have so many people from so many countries been working together for so long (and governments spending so much money) to find out more about trees on our planet?

Answers

See slides.

How Biomass sees trees

Resources

Sharp knife (not for student use)

Step 1

- Cardboard box at least as tall as broccoli stem
- Picture of desert or fields landscape (Resource sheet 1 or 2), enlarged as required and set in the bottom of the box – desert gives better contrast and so is easier
- Phone or tablet connected so projector/board so students can see camera image (using e.g. **VDO.ninja** or **Iriun webcam**)

OR

- Slide pack: Counting trees

Step 2

- Large stem of broccoli (per two groups if whole class activity)
- Visualiser or phone/tablet connected as above

Step 3

- Large stem of broccoli
- Metal or wooden skewers (not for student use)

Preparation

Clean and dry the broccoli.

Step 1

Cut the stalk of one stem so it can stand upright on the landscape print in the high sided box.

Step 2

For a demo or each pair of groups: remove the 'canopy' from a stem of broccoli then cut the 'trunk' in half lengthways then widthways to make 1 cm thick half circles. Each section should be able to stand upright so two groups can rebuild half the 'tree' lying down.

Step 3

Cut the 'trunk' of the stem widthways into slices around 1 cm thick (make them thinner if it's difficult to get the skewer through). Keep the 'canopy' as a single piece. Use skewers to pierce down the top of the broccoli through the centre of each section to rebuild the tree with gaps. Keep this hidden to start with.

Suggested sequence

Step 1

1. Explain that the Biomass satellite allows us to find out more about trees – not just count them.
2. Slowly pass the phone over the box and challenge students to find the 'tree' on the feed. Or use slides 25 and 26 or/and slides 27 and 28. Each pair of slides is set so that when you click the second, the image appears to move over the screen to a new position, bringing the 'tree' into view. Slides 27 & 28 are more challenging than slides 25 & 26.
3. Ask how to tell the age of a tree. Even students unaware of growth rings will probably be able to link age to the height or/and thickness of the trunk. An image from a camera on a drone, plane or traditional satellite can't tell us either of these, but Biomass can.

Step 2

4. Explain that this is because the 'camera' on Biomass uses special rays/beams that can see through the canopy and 'take a photo' of 'slices' of the trunk. Give each group a set of half-circle slices and challenge them to arrange them to build a complete picture of the tree. If demonstrating, you could get one student to make the tree under the visualiser or ask a pair/two small groups of students to race to rebuild the tree.

Step 3

5. Reveal the reconstructed broccoli stem (or slide 24). Ask the students if they would be able to tell how old the tree is using a model like this made using data from Biomass.
6. Discuss how this could also give us information about the health and species of trees, and make it easier to track deforestation and protect forests.

Additional activities and questions

- Students could survey trees in the school grounds, in their street or a local park or copse. Some may also be able to use a field guide (such as those from the **Woodland Trust Tree ID for kids' series**) to identify the types of trees.
- Students could also explore if the school meets the **3+30+300 principle**. If appropriate, you could also ask children to find out if their homes also meet these criteria.
- Groups of students could each research a different type of forest (see **treehugger** or **thedailyECO** for more detail) to create a poster or presentation. What is the associated climate? What types of trees grow there? How tall are they? Are there different layers? What grows between or under the trees? What animals live there?
- As homework, students could ask older members of their family about changes in tree cover they have noticed during their lifetime. These might be local or in the places their parents/guardians/grandparents previously lived. What happened? What impact did it have on the person they are talking to and their community?
- Imagine there is a proposal to build a new housing estate on the edge of your town/village. It will mean cutting down some trees. The town/parish council need to decide whether or not to give planning permission to build it. Ask students to play the role of councillors and debate the proposal, allocating some to argue for it and some against it. You could give smaller groups more specific roles such as the developers, people who live in some grotty old flats, parents of children who currently play in the area, people worried about pollution and so on. You could also combine it with map work or/and ask the class to come up with a viable alternative location for the development or different ways of meeting the needs of those who would benefit from the new estate.
- An often-quoted version of the United Nations' Food & Agriculture Organisation (FAO) definition of forest is 'land with a tree canopy cover of more than 10 percent and area of more than 0.5 hectares. … The trees should be able to reach a minimum height of 5 m.' (This omits some important caveats!) Using this definition, much of the UK is forest. Investigate tree cover in nearby cities and towns using the **Forest Research UK urban canopy cover interactive webmap** to see if you live in a 'forest'. If there is no data for your ward, perhaps you could start to collect it!

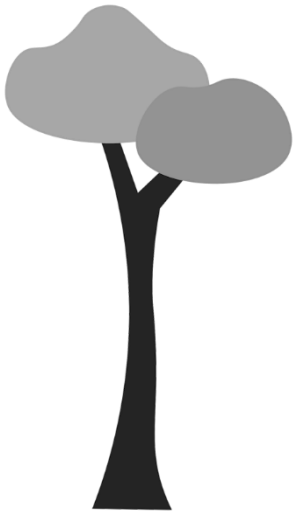
Changing forests

Name _____

1. Look at your blank map of the world.
   a. Use a coloured pencil to colour in the biggest forests.
      You can use the grey lines to help.
   b. Use the same colour to colour in the 'Forests' box in the key.

2. Use these words to label some of the forests:
   - Congo
   - Russia
   - Amazon
   - Indonesia
   - North America
   - South-east Asia
   - Sweden and Finland

   Hint: You could use an atlas to help.



3. Draw a tree next to the names of tropical rainforests.

4. Choose two different colours.
   a. Use one colour to show the main areas where there are fewer trees now than in 2000.
   b. Use another colour to show the main areas where there are more trees now than in 2000.

   Remember to add these new colours to the right boxes in the key.

5. Why do some places have **more** trees now than in 2000?

   _____

   _____

   _____

6. Why do some places have **fewer** trees now than in 2000?

   _____

   _____

   _____

Changing forests

Name _____

Links

Teaching packs

More teaching materials related to Earth observation can be downloaded from the **NCEO website**, **EO Detective on STEM Learning** and **ESA Education Teachers corner**. Of particular relevance, although possibly aimed at adjacent age ranges, are:

- **Colour in the Earth with Tim Peake**
- From the ground and from the sky (**simple version, STEM Learning** / **more complex, ESA**)
- What do trees do (Biomass 4–7), which overlaps with this lesson
- Measuring trees (Biomass 11–14)
- **Exploring rainforests** using Google Earth to measure the changing extent of particular rainforests (aimed at 11–14 so you may need to adapt a little)
- **Papercraft satellites** from Dynamic Earth on STEM Learning

Earth observation

On YouTube, **Satellite – What are Earth observation satellites?** from Airbus is an animated introduction to some of the roles EO satellites play.

An **ESA video about Sentinel 1** explains how radar satellites work by comparing with cameras, X-rays and ship-based radar.

On the **NCEO website** there is an **About EO** page in the education section that gives an overview aimed at teachers and older pupils. Other pages and news items give more detail about specific areas.

Forests

Every two years, the FAO publishes a report, **The State of the World's Forests**. This document is a good way of finding out about the most current trends and issues. Although the language is too complex to use directly with most students, you may want to adapt some of the case studies or charts to use for literacy or numeracy activities on a forests theme.

The **All types of forests and why they are important** video from Nature Journal covers just what the title suggests. It is long, but has been split into chapters which makes it more useful.

There is also a **Forest Kids - Biodiversity game** covering these ideas from ESA and the FAO.

Forest Alert, Biomass and Geo-trees

The Forest Alert system is described by some of its creators and users in a **YouTube video**.

There are links to the latest news and pictures at the bottom of the page on the **ESA website about the mission**, and there is a **Biomass playlist** on the ESA YouTube channel. This includes a **launch highlights video** and another showing the **first images from the satellite**.

Although the methods used are quite complex, you may want to show students excerpts from some of the animations showing how the satellite travels around the Earth, or films of people working on the satellite.

More information about **terrestrial laser scanning (TLS)**, the ground-based method used to build 3D images of trees, can be found in an NCEO news article from November 2023, which links through to the **home page of the Geo-trees project**.

Acknowledgements

Activities in this pack are based on ideas developed by Kristian Suszczenia (University of Oxford) for an event at the Oxford Natural History Museum in 2024.
The pack was written by Catherine Fitzsimons (NCEO, University of Leicester).

Image credits

Biomass patch: ESA
Front cover/slide 1: ESA/ATG medialab
Worksheet 1.1: extract from graphic by Sabrina Schmidt from Pixabay
Worksheet 1.2: Clker-Free-Vector-Images from Pixabay /CAF
Slides 4, 8 & 10 (tree cover 2000): Hansen/UMD/Google/USGS/NASA
accessed through Global Forest Watch 21 March 2025
Slides 7, 8 & 10 (tree graphic): extract from graphic by Sabrina Schmidt from Pixabay
Slides 9 & 10: **Hansen et al. 2023** (loss); **Popatov et al. 2022** (gain)
both accessed through Global Forest Watch 21 March 2025
Slide 11: **Popatov et al. 2022** accessed through Global Forest Watch 25 March 2025
Slide 15: Pavlo Klein on Unsplash
Slide 16: Michael & Diane Weidner on Unsplash
Slide 17: Marc Pell on Unsplash
Slide 18: J Shim on Unsplash
Slide 19: Zdeněk Macháček on Unsplash
Slide 20: Nathan Queloz on Unsplash
Slide 21: Imagery © 2025 Planet Labs (Costa Rica, 9 Feb 25)
Slides 22–24: CAF (broccoli) Łukasz Winiarski from Pixabay (background)
Slides 25 & 26, Resource sheet 1: Contains Copernicus Sentinel 2 data (2025) Mauritania cloudless mosaic January
Slides 27 & 28, Resource sheet 2: Contains Copernicus Sentinel 2 data (2024) Russia/China cloudless mosaic July
Slides 26 & 28: hrm on Adobe Stock (education licence)
Slide 29: ESA/ATG medialab
Slide 30: ESA–P. Sebirot (photo); ESA (patch)
Slide 31: ESA