Forest and climate change

LES VE ŠKOLE
ŠKOLA V LESE

TEACHER'S GUIDE AND WORKSHEETS FOR STUDENTS

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Dear friends!

These worksheets are based on the principles of constructivist pedagogy and critical thinking methods which they further develop.

The theme of climate change is divided into five chapters. The Big Idea, Essential Questions and Enduring understanding are specified for every chapter.

*Each lesson has a **title** and clearly **defined objectives**. Most lessons are based on a 3-stage learning model of **evocation, understanding** and **reflection**. For each lesson an **evidence of learning** is suggested.*

It is recommended that students evaluate each lesson at its end – reserve about five minutes for this. A suggestions of how such assessment could look like is proposed at the end of this set of worksheets on the example of Forest and CO_2 lesson: Students are first asked to express what activities they liked the best, then they should comment if they preferred to work in groups, pairs or individually and they should also sum up whether they have learnt something new or not. Such assessment can help you plan further work with your students.

THE MEANING OF USED SYMBOLS

Task for students

Information for teachers or students

Key for teachers

Suggested time allowance

CONTENT

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Forest and CO_2

INSTRUCTIONS FOR TEACHERS AND WORKSHEETS FOR STUDENTS

THE BIG IDEA:

Forests represent a living pump which makes CO_2 circulate between the air, plants, animals and soil. Forests are important players on the global climate scene because they keep the concentration of CO_2 in the atmosphere balanced.

ESSENTIAL QUESTIONS:

1. What is the relation between forest ecosystems and global climate?
2. What is the role of forests in the carbon cycle?
3. How can we influence whether forests fix or release CO_2 in the atmosphere?
4. What is the best way to use wood in order to limit the emission of CO_2 into the atmosphere?

ENDURING UNDERSTANDING:

1. A healthy forest helps to balance CO_2 in the atmosphere. Forests are key players in carbon dioxide cycle on a global scale: photosynthesis and decomposition which occur in forests have impact on CO_2 concentration.
2. Carbon in forests is fixed in the trees, soil and soil organisms.
3. During the combustion of wood, the amount of CO_2 released into the atmosphere equals the amount absorbed by a tree during its growth. That's why we call wood a CO_2 neutral resource.
4. There are many ways of making forests function as carbon sinks instead of carbon source, i.e. making them release carbon dioxide back to the atmosphere more quickly than absorbing it during photosynthesis (e.g. regular renewal of forests, forest soil protection, sustainable use of wood).

BRIEF DESCRIPTION OF THE LESSONS:

Lesson 1 introduces the role that forests play in the carbon cycle. The main topic is photosynthesis and the growth and decomposition of forests.

Lesson 2 builds upon the knowledge gained in Lesson 1 and puts it into the context of global climate. It deals with the contribution of forests to the process of balancing the concentration of CO_2 in the atmosphere.

The theme of Forest and CO_2 is divided into two parts:

Lesson 1: Forest and CO_2 (120 min)
Lesson 2: Forest, Carbon Cycle and Climate Change (145 min).

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Lesson 1:
FOREST AND CO_2

OBJECTIVES:

- Students will describe how trees fix CO_2.
- Students will give example of a process during which CO_2 fixed in a tree is released. They will explain the process.
- Students will explain the meaning of the following sentence: Wood is a renewable source of energy.

MATERIALS:

Worksheets, pieces of wood (ideally shared in a pair), non-transparent bag/basket, pictures of forest, 5–8 copies with representations of the following molecules: O_2, H_20, $C_6H_{12}0_6$ to be shared in a group, toothpicks, plasticine – 3 different colours, a symbol of the Sun (e.g. an orange), green stickers or green leaves (same amount as the number of students), fireproof tray.

AGE: 13–15 years

TIME: 120 min

WHERE: Inside activity

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Lesson 1: FOREST AND CO_2

EVOCATION (10 min)

Where does wood come from?

Put pieces of wood (small branches, wood blocks, chips...) on the tables before students come into the classroom, or if the students are already there, let them pull them from a bag or basket. A piece per pair will do.

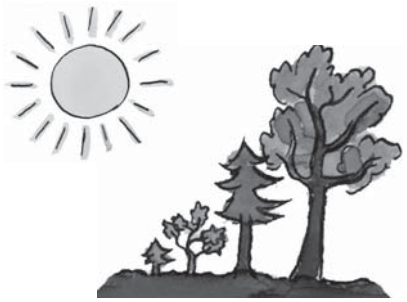
Write on the board: "Where does wood come from?"

Hand out the worksheets. Students will answer the three questions in the task called "Where does wood come from?" They shall first fill in the gaps labelled "My opinion". Then they'll ask their classmates for other ideas. They'll write down the answers which sound correct or plausible under "Others' ideas". It doesn't have to be completely new ideas, it can be something that develops or adjusts their original answers. The gaps labelled "Further information" remain blank. During this task, students should try to remember what they already know. That's why they shouldn't read the text in the lower part of the worksheet yet. You can fold the sheet so they cannot see the text.

UNDERSTANDING (60 min) (20 min)

Parts A, B, C and D represent an integrated block where students confront their original ideas with what they've learnt.

A: Sunlight makes a tree grow



1. TEXT ANALYSIS

Students read the text "Sunlight makes a tree grow". They compare new information from the text with what they have filled in the chart above. Then they fill in the "Further information" gaps. After that, they write down the equation of the photosynthesis. They try to figure out what has happened with the energy from sunlight. They don't have to come up with the correct answer now; they can do it after the following game.

2. PHOTOSYNTHESIS GAME

MOTIVATION:

Young forest grows and needs to stock energy, i.e. to transform CO_2 to glucose.

PROCEDURE:

1. Make groups of 4–5 students. Each group represents a different type of forest (you can give each group a picture of the forest they represent) and they will make their own stock of energy.
2. Discuss with students: What do you (as a forest) need for your growth? What substance will you need? (Students can answer directly or can look into the worksheets for the answers).
3. Write on the board which colour of plasticine represents hydrogen (H), which represents oxygen (O) and which is carbon (C). Make models of the molecule of H_2O and CO_2 together with students – use plasticine for atoms and toothpicks for the bonds between the atoms. Exhibit the models in the classroom so that everybody can see them.

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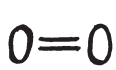
Lesson 1: FOREST AND CO_2

4. Hand out plasticine (the three colours), toothpicks and copies with representations of molecule models into each group. The students will first make atoms of hydrogen, oxygen and carbon (small balls of plasticine in respective colours). Then they will join them together with the help of toothpicks and thus make models of the molecules of CO_2 and H_20 which they will subsequently need to represent photosynthesis. They should make as many models as they manage in the given time. They should decide themselves the proportion of the molecules of water and carbon dioxide they'll need to represent photosynthesis. Let them work for five minutes. After that, each group should have at least 6 molecules of H_20 and 6 of CO_2 (or a multiple of 6).
5. Now, students will, through the process of photosynthesis, make as much stock of CO_2 as possible. Ask them what else they need to effectuate the photosynthesis. The correct answer is the Sun (place the symbol of the Sun visibly at the front after this answer) and the green pigment called chlorophyll which you find in the leaves (students will represent the leaves – hand out the green stickers or leaves which the students will stick visibly on them).
6. During the game you can pretend that day turns into night (you express this by showing or hiding the symbol of the Sun). The photosynthesis occurs during daytime, not at night, but respiration happens both day and night. Students thus can transform CO_2 and H_2O to glucose and O_2 only by daylight.
   While making molecules of glucose, they can use the picture of glucose model, or you can make a glucose molecule from plasticine and exhibit it visibly for them. Let students simulate the process of photosynthesis for 10 minutes. Each group should by then produce at least one molecule of glucose.
7. Look at the models of glucose molecules together and check whether they are alright. Each group should now have some atoms left which they haven't used for making glucose. What element is it? Student should identify oxygen which is a "left-over" of photosynthesis released in the air by the plants.
8. Reflect briefly upon the game. What did students realise during the game? Get back to the former question: "What has happened with the energy of the sunlight?" What was the most demanding to do? Probably it was the production of glucose. It was difficult because there are many bonds between the atoms and it is not easy to range atoms correctly to make this compact molecule. And that's where the energy goes – the solar energy transforms to chemical bonds of glucose molecules.

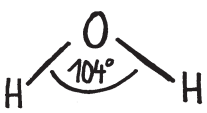
Photosynthesis equation: $\mathbf{6\ CO_2 + 6\ H_20\ (+\ sunlight) - C_6H_{12}O_6 + 6\ O_2}$

Carbon from carbon dioxide is not incorporated only in wood, but also in tree leaves or roots. It gets released into the air from fallen leaves, branches or dead roots thanks to certain microorganisms, but some amount of carbon is permanently fixed in the soil. If we remove a felled tree from the forest, in fact we remove biomass, or in other words quite large quantity of carbon from the ecosystem. If we manage forest sensitively (e.g. if we leave some part of biomass after logging in the forest or if we don't drain forests unnecessarily), the ecosystem still functions as carbon sink. But in forests which are extensively transformed – e.g. by being burnt, logged, or by changes in forests' water regime – most carbon incorporated in the trees releases back into the air.

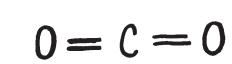
OXYGEN



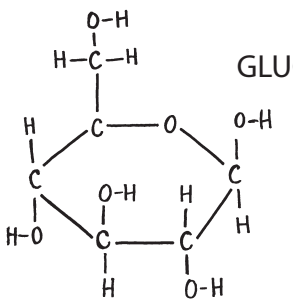
WATER



CARBON DIOXIDE



GLUCOSE



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B: Burning the wood

MOTIVATION:
The forest has produced enough building material for its growth and is now mature. It's time for the man to use its wood for building houses, making furniture or for heating.

Students answer the questions from the worksheet.

The teacher lights a match or a skewer to illustrate the burning. This can help the students to think about the forms of energy released during burning (light, heat).

Read the text B in the box. Ask students to interpret the text. Ask them which expressions they don't understand and explain everything which is not clear.

C: Dead wood decays and decomposes

MOTIVATION:
A mature forest grows old. Some trees are broken, dry and rotten. Branches fall from the old trees... The dead parts of the trees are called woody debris or dead wood. What happens with it? The wood decomposes thanks to tiny microorganisms, insects and fungi, while CO_2 releases into the air or soil.

Students answer the questions from the worksheet. A picture accompanying the questions can help them. Discuss the process of decomposition of organic mass in the forest. What organisms participate in this process?

As homework students can look up some of these organisms and bring their pictures to the next lesson.

D: Looking back

Students compare carbon balance of forest and how it varies according to its stages of growth.

They mark on the positive and negative part of the axis if CO_2 gets incorporated or released to the air, according to their judgement.

CO_2 Balance in Forest's Life Cycle

A young growing forest is a natural carbon sink (it stores carbon from the CO_2 in the atmosphere), i.e. it uses more CO_2 for its growth than it releases to the air. It is during its growth (when the trunks get thicker) and maturity that the forest incorporates carbon in the biomass. Does it mean that forest functions as carbon sink during its whole life cycle?

To tell whether a forest is a carbon sink or a carbon source, we need to know the net increase of biomass in the forest. The net increase of biomass is a difference between the total volume of new biomass and woody debris (branches, bark, dead trees...) over a time unit (e.g. a year). Biomass in a mature forest (120–130 years old) does increase, but the total volume of wood, i.e. volume of carbon stored in it, increases very slowly. The net increase of a mature forest is smaller than that of a young growing forest. Even though mature trees still need CO_2 for their growth, large portion of their biomass decays – branches and trunks of old trees drop and decompose and thus the forest loses its biomass.

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As a mature forest grows old, the balance between storing and releasing of CO_2 is settled. A very old forest (300–400 years old), with far more decaying dead trees than young seedlings, releases more CO_2 than it sequesters.

This behaviour of CO_2 balance within forests' lifecycle is based on scientific models, in other words it is a certain simplification. Different types of forests have different characteristics (tree types, speed and efficiency of photosynthesis, temperature, humidity). That's for example why the point when the balance between storing and releasing of CO_2 is attained may differ for various types of forests. The years given in the worksheets are therefore only approximate.

REFLECTION (may also serve as EVIDENCE OF LEARNING)

30 min

Information leaflet

At the end of the lesson, students shall make an information leaflet. This will serve as a reflection of what they have learnt. The teacher can assess their product according to the criteria they agreed upon.

Explain the task to the students: everybody shall make a leaflet to illustrate the circulation of CO_2 between a tree and its surrounding. The leaflets should describe how trees incorporate CO_2 as well as how they release it. Students shall explain that wood is a renewable energy resource. The readers of the leaflet will be students of the same age.

Make a list of criteria of a good leaflet together with the students; let them formulate the criteria themselves. Write the criteria on the board or a sheet of paper and exhibit them visibly. Examples of criteria are suggested below.

Students can make the leaflet in class or at home (in that case, students should copy the criteria in their exercise books). Assess students' products according to the criteria. Indicate how well each criterion has been met, comment your assessment.

EXAMPLES OF CRITERIA

- The title of the leaflet is catching and corresponds with its content.
- The size of the leaflet is A4 or A3.
- The text is written neatly, the size of the letters makes it possible to read the text from a meter's distance.
- The leaflet informs about the way trees incorporate and release CO_2.
- The leaflet explains why it is that wood is called renewable energy resource.
- The author and sources of information are indicated in the leaflet.
- The leaflet can be handmade or printed.

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KEY TO THE ACTIVITIES IN THE WORKSHEETS FOR STUDENTS

What does wood need in order to grow?

Wood, as well as the other parts of the plants, is made of substances produced by the plants during photosynthesis. Thus, same items which are necessary for the photosynthesis to occur must be present (i.e. CO_2, water, sunlight, chlorophyll). Other prerequisite for the wood to grow are various mineral substances.

What (chemical elements) is wood composed of?

Wood is mainly composed of: cellulose (40–50 %), lignin (20–30 %) and hemicelluloses (20–30 %). It is important for the students to realise that all these components contain carbon, hydrogen and oxygen. There are other substances present in the wood. These are for example terpenes, lipids, vexes, pectines, tannins, sterols or turpentines.

Where does the energy for the growth of trees come from?

The energy comes from the sunlight which is transformed during the photosynthesis.

On both sides of the photosynthesis equation, there should be the same elements in equal quantity. Amount of energy on both side of the equation should also be equal. So what has happened with the energy of the sunlight? Where do we find it on the right side of the equation? What do you think?

The energy has transformed into the bonds of complex chemical compounds produced during the photosynthesis, i.e. primarily into the bonds of glucose.

What happens when wood is burning?

Students can write down any ideas they come up with – e.g. it smokes, it heats, the wood sparkles, cracks...

What is left after wood has burnt? What is released into the air?

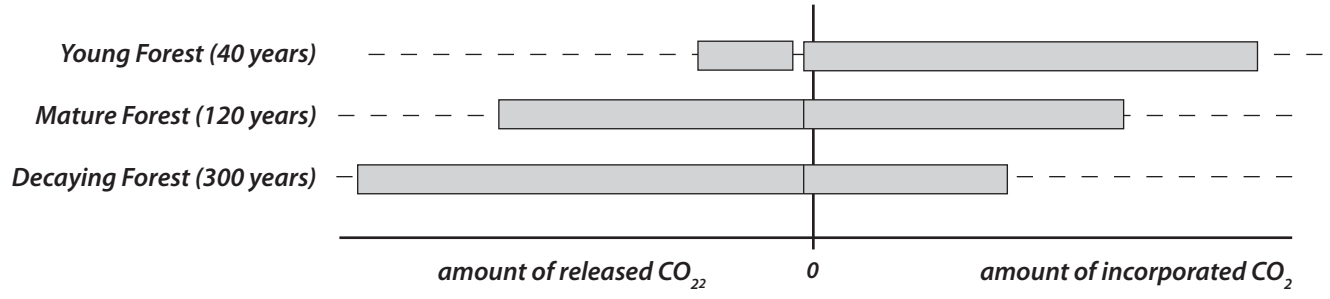
Ash is left after the wood has burnt, and it's mainly vapours and CO_2 that is released into the air.

The energy fixed in the wood is released during the burning. How can we perceive this energy?

The released energy manifests itself as light and heat of the burning wood.

Do you know another process where complex substances change into simpler ones while CO_2 is released into the air? Describe it:

It is for example decomposition of organic substances to inorganic ones. This happens while woody debris decays in the soil.



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Lesson 1: FOREST AND CO_2

➔ **What does wood need in order to grow?**

My opinion	Others' ideas	Further information

➔ **What (chemical elements) is wood composed of?**

My opinion	Others' ideas	Further information

➔ **Where does the energy for the growth of trees come from?**

My opinion	Others' ideas	Further information

Solar energy makes the tree grow

Trees fix a lot of **CO_2** and **water** during their lives. Thanks to the photosynthesis, they are able to change these simple substances into a complex **molecule of carbohydrate – glucose**. To do so, a tree needs a lot of energy – it gets it through its leaves which capture the **energy from the sunlight**. We can express the process of photosynthesis by a simple equation:

carbon dioxide + water + solar energy → glucose + oxygen

Glucose is the main source of energy for the plants, but it can also produce **cellulose**, the main component of **wood**. Energy can be stored in cellulose (wood) for a long time, before it is released back into the air. In other words, carbohydrates represent energy source for plants. Similarly, the wood is a source of energy for people – the energy can be released during combustion, or burning. Burning is actually a process reversed to photosynthesis. During **combustion**, **oxygen** is used, and CO_2 and **vapour** gets into the air.

➔ **Use these substances to write the equation describing the production of glucose ($C_6H_{12}O_6$) into the box below:**

O_2 **H_2O** **CO_2** **$C_6H_{12}O_6$** **solar energy**

→

➔ **On both sides of the photosynthesis equation, there should be the same elements in equal quantity. Amount of energy on both side of the equation should also be equal. So what has happened with the energy of the sunlight? Where do we find it on the right side of the equation? What do you think?**

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Lesson 1: FOREST AND CO_2

Burning the Wood

➔ **What happens when wood is burning? What is left after wood has burnt, what is released into the air?**

The forest has produced enough building material for its growth and is mature now. It's time for man to use its wood for building houses, making furniture or for heating.

➔ **During combustion, cellulose in wood and thus also glucose transforms back to simple substances. Which element is necessary for combustion? Fill in the gap:**

glucose + ____ → carbon dioxide + water + energy

➔ **The energy fixed in the wood is released during the burning. How can we perceive this energy?**

When we **burn wood**, the same amount of CO_2 as the tree had incorporated through photosynthesis during its life is released back in the air. That is why growth of a forest and burning of wood keeps **CO_2 balance in the atmosphere** and we say that wood is a **CO_2 neutral material**.

Dead Wood Decays and Decomposes...

➔ **Do you know another process besides burning where complex substances change into simpler ones while CO_2 is released into the air? Describe it:**

Most of the trees are old, many are dry, broken or dead. Among fallen trees and rotting wood, new seedlings start slowly growing.

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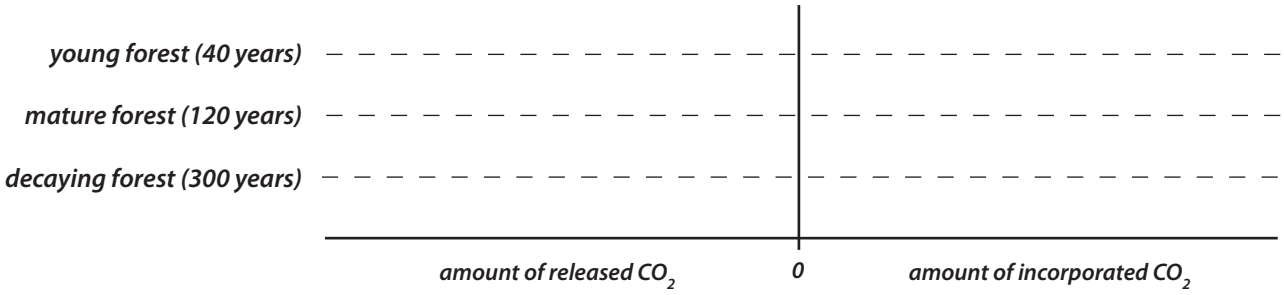
Looking Back

➔ **Trees in the forest are of different age. Estimate how much CO_2 will the trees release (mark on the left side of the axis) and fix (on the right side of the axis) in young, mature and decaying old forest.**



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Lesson 2:
FOREST, CARBON CYCLE AND CLIMATE CHANGE

OBJECTIVES:

- Students will describe how forests influence concentration of carbon dioxide in the Earth's atmosphere.
- Students will compare the amount of stored carbon in various world biomes. They will indicate areas with the ecosystems representing the largest carbon sinks on the Earth on a map of the world.
- Students will propose at least three specific recommendations on how people should treat forests in a way that enhances their function of carbon sinks.

MATERIALS:

world map of biomes (vegetation zones), "Carbon Cycle and Forests" poster (TEREZA Association), computer with a player (e.g. Windows Media Player), overhead projector, screen (white wall will do), A5 sheets of paper (one/pair), a scotch tape (or something to fix sheets of paper on the wall (activity 2), worksheets, copies of "Man influences climate through forests."

TO DO BEFORE THE LESSON:

Download the clips illustrating the carbon cycle from the given websites (see Activity 2) and try if you can play them on the computer you'll use in the classroom (install a compatible player, if necessary).

For Activity C, copy the texts (see Annex on page 20) for all the students. Each student shall work with one story.

AGE: 13–15 years

TIME: 145 min

WHERE: Inside activity

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EVOCATION 10 min

Forest and climate – what is the link between them?

Students try to figure out what is the link between forests and climate. Make sure students understand the term CLIMATE.

PROCEDURE:

Students think about the link between the forests and climate. They write their opinions where indicated in the worksheets. If this is too difficult for them, help them: write on the board the words that can inspire them (e.g. temperature, shadow, moist moss, vaporisation, carbon dioxide in the atmosphere).

Students answer the question 2 – they try to figure out what the link between forests and carbon dioxide is.

Based on their answers, discuss with students the influence of forests on climate. Let them discover the role of the "pump" that the forests play. This pump circulates CO_2 between the air, living organisms and soil (see the first point of the text below).

What Is the Link between Forests and Climate?

The relation between the forests and climate can be described on several levels:

Forest ecosystems play a unique role in the global carbon cycle: they store large amount of this element. Forests balance the concentration of carbon dioxide in the atmosphere by absorbing and releasing carbon dioxide. If the global forested area diminished considerably or if forests stopped storing CO_2, we could expect that large amount of CO_2 would be released into the atmosphere. Because CO_2 is a kind of gas that increases the greenhouse effect, the increase of its concentration in the atmosphere could have a significant impact on climate. For more information see "Carbon Cycle and Forests" poster (TEREZA Association 2008).

Forests participate also in the water cycle. When redundant water evaporates from tree leaves, energy is consumed and thus the surrounding temperature drops. This means that forests increase not only humidity but also decrease temperature of the air. For more information see the Forest and its Microclimate in the Context of Global Climate lesson.

Another link between forests and climate concerns forests' capacity to produce wood. Wood is a renewable resource, sometimes called a CO_2 neutral resource. This means that its use doesn't add extra CO_2 into the atmosphere. If we burn wood, the amount of released CO_2 equals the amount that the tree has incorporated during its life.

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Lesson 2: FOREST, CARBON CYCLE AND CLIMATE CHANGE

UNDERSTANDING 60 min 55 min

Parts A, B, C and D represent an integrated block where students confront their original ideas with what they've learnt.

A: The Role of Forests in Global Carbon Cycle

To better understand the importance of forests in the global carbon cycle the students shall work with the scheme in the worksheet. You can also use the poster "Carbon Cycle and Forests" issued by TEREZA association for schools participating in "Forest at School – School in Forest" program in 2008.

To illustrate the role of forests in the carbon cycle use the short clips which are referred to bellow. The clips were produced by NASA (National Aeronautics and Space Administration), an American research organization which focuses on research of the Earth and the Universe. Under NASA patronage, research projects which map the climate conditions on the Earth and record the weather and climate changes are carried out. NASA has a wide database of satellite pictures and other tools (such as models or animations) which help us better understand various processes occurring in the nature. Some of these products are available on the internet for free use to scientists as well as schools.

We have chosen two short clips concerning the role of forests in carbon cycle.

CARBON CYCLE

– a clip made by scientists in NASA Goddard Space Flight Center. It is an animated simulation of the circulation of carbon between atmosphere and vegetation (forests). The clip is almost a minute long and it is not accompanied by a commentary.

Clip annotation:

Carbon dioxide together with water and nutrients from soil are the basic prerequisite of trees' growth. Trees absorb carbon dioxide (marked in violet) from the air in their biomass; trees grow. We can observe an annual cycle: a tree loses part of its biomass when its leaves fall in autumn while it releases some of the incorporated CO_2 back to the atmosphere. The animation also illustrates the whole life cycle of a tree: an old tree decomposes and releases CO_2 back into the air. We can accelerate this process by burning the tree, as we can see at the end of the clip (see the black smoke representing the released CO_2).

The clip can be downloaded from NASA webpage:
http://svs.gsfc.nasa.gov/vis/a010000/a010000/a010006/index.html
It is available as a MPEG-1 file of 5 MB (it is the first link to the right of the picture).

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NET PRIMARY PRODUCTIVITY

– an animation made of satellite pictures representing monthly net primary productivity on the Earth (from February 2000 to February 2009). Net primary productivity (= net increase of plants' biomass) shows the intensity of the photosynthesis, i.e. the volume of CO_2 absorbed by plants from the air.

Clip annotation:

The darker the shade of green, the more intensive the photosynthesis in given area, i.e. the more CO_2 the plants absorb from the air. The net primary productivity is indicated in g C/m^2/day. On the timeline under the map, you can see what year is represented; in the upper left corner, months are indicated. You can observe a huge increase of photosynthesis activity in the northern hemisphere in temperate forests and taiga. In winter, the forests in the northern hemisphere are little active. Forests in the tropics are active all year long. Every summer, the activity of forests in the northern hemisphere is so big that it regularly decreases the global concentration of CO_2 when the growing forests literarily suck CO_2 in.
The clip shows a ten year period which enables students to observe repeatedly the regular cycle of winter stagnation and summer activity of forests in the northern hemisphere.

The clip is available for download from NASA Earth Observatory website:
http://aerthobservatory.nasa.goc/GlobalMaps.
In the menu on the left, chose Net Primary Productivity and a map with notes in English will open up.
You can play the clip by clicking on the arrow in the middle under the picture. For saving the clip, go to Download a Quicktime animation of this dataset placed on the right side of the text.
Size of the animation: 4 MB.

1. FORESTS IN CARBON CYCLE

If you don't use the carbon cycle animation go to the next activity in the worksheet where students work with "Forests in Carbon Cycle" picture, in other words start with point 5.

1. Play Carbon Cycle clip to the students, don't comment it. You can replay it several times. Students shall write key words into the worksheet, i.e. the expressions from the clip that seem crucial to them. They work individually. When they're finished, let them discuss in pairs what the clip represents. If necessary replay the animation. If they ask for it, you can help them (e.g. by pointing out that violet bubbles floating in the clip representing CO_2).
2. Each pair makes up an outline for a commentary to the clip. The outline must have a catching title and 5–8 sentences describing what happens in the clip. Students write down the title and the sentences in the worksheets. Remind them that the clip is less then a minute long, therefore the commentary must be rather brief.
3. Read up the titles proposed by all the pairs and let some of the pairs read up their whole commentaries while playing the clip. After playing the clip with several commentaries, you can read up your own or use the clip annotation from this sheet. Explain everything students don't understand about the clip.
4. Let the students write down the moments in the clip they considered as important. They shall then write down questions they thought of when they were watching the clip in the worksheets.
5. Students work independently with "Forest and Carbon Cycle" picture from the worksheet. They should realize what parts of forests participate in incorporating carbon in the forest and in releasing it to the air. They shall mark the places in forest

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where carbon is stored (they can use crayons). They'll also write down into the scheme the processes of the carbon cycle in the forest.

6. Students share their ideas: they present their opinions on where carbon can be stored in the forest. Go to the next activity.

2. CARBON IN SOIL AND VEGETATION

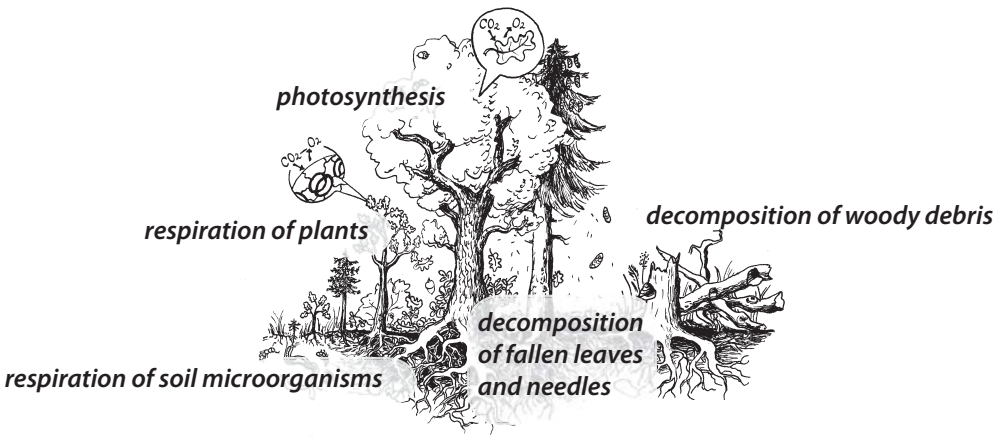
1. Students shall categorize the places where carbon is stored according to whether the places are above or under ground. They can use the previous picture or their own experience.
2. In the worksheet, students match the biomes with the pictures representing the proportion of carbon stored above and under ground characteristic for the given biome. The schemes help them estimate which ecosystem represents the biggest carbon sink on the Earth (on land).
3. Hand out atlases with maps of vegetation zones (world biomes) into groups. Students shall find the biomes mentioned in the previous task. Ask further questions from the task in the worksheet.

KEY TO THE ACTIVITIES IN THE WORKSHEETS FOR STUDENTS

FORESTS IN CARBON CYCLE (page 21)

1. Carbon is stored in all parts of the forest, e.g.: in leaves, branches, trunks, seeds or roots of the trees, in herbs, moss, mushrooms and fungi; in the organisms living underground as well as on the ground; in soil and soil microorganisms; in decayed wood

2.



CARBON IN SOIL AND VEGETATION (page 23)

2. 1 – tropical forest, 2 – temperate forest, 3 – field, 4 – steppes (treeless plains of temperate zone), 5 – taiga.

4. For details see the table and the box below.

Which land biome stores most carbon? Taiga.

Which biome fixes most carbon in its overground part, i.e. in vegetation? Tropical forests.

Which biome fixes most carbon in its underground part, i.e. in soil? Taiga.

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Estimate the proportion of carbon stored in our forests above ground (in vegetation) and underground (in soil).

Less carbon is stored above ground than underneath; the proportion is about 3:5.

What happens with the stored carbon when we cut down the forest and leave there a pasture or field instead of it? Where does the carbon from the forest go?

Part of the carbon is released into the atmosphere (by decomposition of organic debris from the trees, by releasing from the uncovered soil, by burning of wood); another part is removed from the forest (timber).

How and where can we preserve the carbon when cutting down trees so that it doesn't get immediately back to the atmosphere?

We can prevent this by sustainable use of timber (e.g. as a building material or for production of furniture) and by replanting the uncovered soil by new trees.

Carbon Is Stored in Vegetation and Soil.

The places where carbon is stored can be divided in general into two categories: those above ground and those underground. Surprisingly enough, more carbon is stored under the ground, i.e. in the soil and roots, then in the vegetation above the ground. The amount of stored carbon differs according to biome or ecosystem.
To give you an idea, see the table representing the amount of carbon stored in various biomes. The table is taken from IPPCC Special Report on Land Use, Land-Use Change and Forestry 2000. Carbon stored in a biome is given in petagrams of carbon (Pg C) which corresponds to gigatons Gt (1 Gt C = 1 billion tons = 10^{12} kg). The numbers are valid for both vegetation (overground parts) and soil (underground parts). Total mass of carbon in each biome is also indicated. Finally, you can see the mass of carbon in a biome per unit of area, which reveals for instance that wetlands represent a significant carbon sink, despite the fact that they occupy minimal area of the planet's surface.

Biome	**Area** (10^6 km^2)	**Carbon Stored (Pg C= Gt C)** Vegetion	Soil	Total	Relative (Gt/10^6 km^2)
Tropical Forests	17.6	212	216	428	24
Temperate Forests	10.4	59	100	159	15
Taiga (Boreal Forests)	13.7	88	471	559	41
Tropical Savannas	22.5	66	264	330	15
Steppes (Temperate Zone)	12.5	9	295	304	24
Deserts/Semi-deserts	45.5	8	191	199	4
Tundra	9.5	6	121	127	13
Wetlands	3.5	15	225	240	69
Agricultural Ecosystems	16.0	3	128	131	8
TOTAL	151.2	466	2011	2477	16

Source: IPCC: Special Report on Land Use, Land-Use Change And Forestry 2000

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B: Magical Photosynthesis

To illustrate storing of carbon in different vegetation zones, use Net Primary Productivity clip. If you decide not to use the animation, go directly to point 3.

1. Play the clip. Because it is a rather complex animation comment it while you're playing it for students (see the clip annotation).

2. Afterwards, let students discuss the following questions:
   - Where in the world is photosynthesis most intensive? Why? What kind of vegetation is there?
   - How does the intensity of photosynthesis change over the year? In what parts is photosynthesis most intensive in summer and in what parts in winter (in the northern hemisphere)? Why is it so?
   - What is the role of tropical forests in absorbing CO_2 from the air? And that of temperate forests and taiga?

3. Work with those pictures in the worksheet which represent important parts of the clip (picture A and B) and with the picture representing the annual behaviour of the concentration of atmospheric CO_2 (picture C). The legend to the picture is identical with the legend to the clip (see therefore the clip annotation on page 9).

4. Picture C represents the annual behaviour of the atmospheric CO_2 concentrations. Students shall interpret the chart. Help them if necessary – take into account their experience with interpretation of simple charts (With the beginners, you can start by asking questions such as 'What season do we have now?', 'Show in the chart the month we have now', 'What does axis X represent? And axis Y?').

5. Students mark in the chart the month with the highest concentration of CO_2 (let them mark it as MAX) and the lowest one (mark as MIN). They mark in colour the season of the most intensive vegetation growth.

6. Let students compare the world map representing the intensity of photosynthesis in June (picture A) and in December (picture B). What differences can they point out? Help students make clear the relation between the chart and pictures A and B: In spring and summer, photosynthesis is very intensive in the forests of the northern hemisphere. As you can see in the chart, in this period these forests take in more and more CO_2 form the atmosphere, its concentration in the air gradually drops until it reaches its minimum in October. Contrarily, from autumn to winter, there is little photosynthesis going on in the northern hemisphere.

7. Students answer the questions related to pictures A and B. They should have a world atlas so they can compare the maps in the worksheets with the maps there.

8. At the and, all students shall sum up in couple of sentences what was the most important they've learnt from the pictures and they write it down in the worksheet.

Sdružení TEREZA

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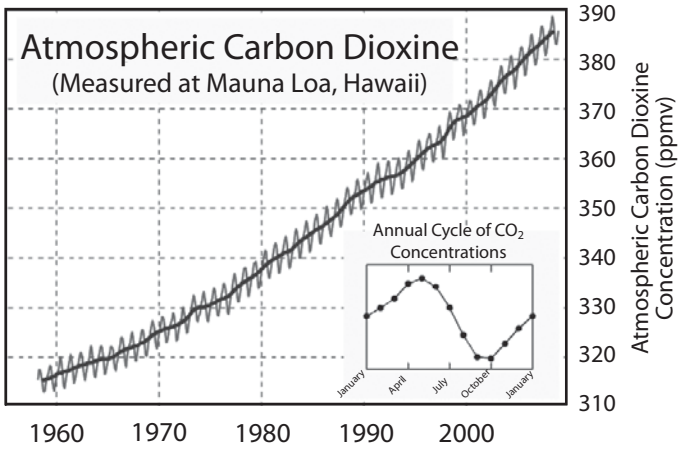
Annual behaviour of the atmospheric CO_2 concentration and the role of forest ecosystems

The curve in the chart shows clearly the regular annual decrease of atmospheric CO_2 from June to October. In all likelihood, this is influenced by the fact that summer is the season of growth in the northern hemisphere and the intensive photosynthesis removes a lot of CO_2 from the atmosphere. The increased photosynthesis in summer period in the northern hemisphere can be seen in Net Primary Productivity clip. The important role is played here by temperate forests, especially by taiga where high quantity of CO_2 is stored (see the table in Carbon in Soil and Vegetation task).
The annual fluctuation in the atmospheric CO_2 concentrations can be observed in longitudinal records of the atmospheric CO_2 concentrations taken in Hawaii. These measurements are also known as the Keeling measurements from Mauna Loa (see the picture below). The whole curve representing the measurements made since 1958 up today can be found at http://scrippsCO_2.ucsd.edu/data/in_situ_CO_2/monthly_mlo.csv



EXPLANATORY NOTE:
ppm = particles per million = 1 millionth

Source: http://globalwarmingart.com/wiki/File:Mauna_Loa_Carbon_Dioxide_png

C: Man Influences Climate through Forests

Students work with stories of several people whose lives are somehow connected with forests (see Annex on page 14). Each of the four characters tries to prevent climate change – their attitudes and activities differ but they all have something to do with the forests.

1. Students work in groups of four. Hand out the texts with the stories so that each student in the group has a different one. Each student works with one story. Let them read the texts.

2. Regroup the students. Students try to find other students with the same story. At the end, there will be four groups of students with the same story. Within the group, they will tell each other what they've learnt in the story. Their task is to identify what their character does to prevent climate change. They agree on what is the most important information they will then share this information with the rest of the class who don't know their story.

3. Regroup the students back to the former groups (with four different stories). Students present their stories to others in the group (they should mention where the story takes place and who is the main character) and tell what their character does to prevent climate change and what it has to do with forests.

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4. Students summarize (in three sentences) the gist of the stories into the worksheet. At the end, sum up all the stories together. Check that the students have understood the stories and identified the main ideas. To verify this, you can ask the following questions:
   - How can I prevent that soil releases CO_2?
   - How can I use wood in a way that slows down releasing CO_2 back into the air? Give specific examples.
   - What kind of fuel increases concentration of CO_2 in the air? Is it wood or coal?

REFLECTION (may also serve as EVIDENCE OF LEARNING) 20 min

A letter to politicians

Students will write a letter to political representatives who are going to participate in a conference on new legislation concerning forest management. Students shall demand at least three things they believe will promote such forest management which helps forests function as carbon sinks. They should base their demands on the arguments they've learnt in activities A, B, and C.

1. First, set up criteria for assessing the letters. The criteria can be decided by the teacher, or students can help with their formulation.

   Examples of criteria:
   - The letter is 200 words and it's written neatly.
   - There are at least three demands towards the politicians concerning prevention of climate change (related to forest management).
   - Each demand is explained and supported by arguments justifies its importance.
   - The letter has all aspects of a formal letter: it has a salutation, date, proper ending phrase, and signature.
2. Students write the letter (individually – therefore suitable as homework). They can use the worksheets as well as other sources.
3. Assess individually all letters by a written comment under the letter.

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Annex to Lesson 2:

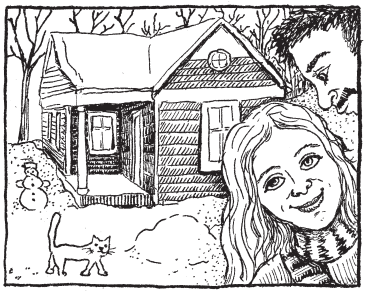
Man Influences Climate through Forests

IN DEEP FORESTS OF CENTRAL BOHEMIA

I've been a forester for a long time. Of course, I care for the forest. First of all, I want my forest to be healthy, manifold and useful for man as well as animals and even the tiniest microorganisms. Only then is a forest in balance and it can more easily resist storms or beetles. Some people criticize it when there are rotten branches and stubs on the ground, but I'm proud of that. Fallen parts of trees, even whole trunks may seem dead, but in fact they are full of life: there are hundreds of insects living there as well as fungi and tiny bacteria which are very important for the forest. In dead wood, lots of carbon that the trees had absorbed from the air during their lives, is stored. If we removed or burnt all fallen parts of trees, we would deplete the forest of carbon.

IN NORTHERN BOHEMIA

It is often mentioned that forest felling releases high quantity of harmful carbon dioxide which accumulates in the atmosphere and causes the warming of our planet. But I think that if we lumber reasonably, it cannot be that bad with carbon dioxide. We just have to afforest the logged areas as quickly as possible. It is the new tree-cover that prevents unnecessary releasing of carbon from the uncovered soil into the atmosphere. Moreover, growing trees take in carbon dioxide from the air because they need it for their growth. And of course, I don't allow burning of branches left after the lumbering in the forest. It's better to leave them as they are. When they decompose gradually, they release carbon much more slowly than if you burn them.



SOME PLACE IN EASTERN BOHEMIA

Our house is quite common. What I like about it though is that it's all made of wood. My husband is always saying that we live in a natural conserve full of carbon dioxide. And I must agree with him: all the carbon that the trees had taken in from the air is conserved in the boards, planks and beams. Because we used wood to build our house, it did not release carbon back to the air. The same happens if you buy a wooden table instead of plastic one, for instance. Moreover, we have saved loads of carbon dioxide that would otherwise be wasted on production of bricks or cement.

ON BORNEO, AN ISLAND IN INDONESIA

They were here just yesterday. Wanted to buy our forest allotment. They're gonna cut it down and turn it into a plantation of oil palm. Offered good money, but Dad says it would be a sin to sell it. He, as well as the others from our village and the neighbouring ones refused. Just imagine: our beautiful wild and plentiful tropical forest would disappear and so would the parrots, snakes, butterflies and flying squirrels! I can understand that people who are totally down and out sell their forest. But we and the others have decided to wait. My Dad says that it's good to leave the forest as it is. And not only because of the animals living there, but also because of climate. I don't understand it that much, but one thing I do. If you burn the fertile green forest and turn it into a poor plantation you lose something precious and that causes trouble in the atmosphere and influences whether we have enough water. That's why we won't sell the forest yet. Daddy and the others believe that soon a rich tropical forest will have more value than a burnt land and plantation.

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Forest and Climate – What Is the Link between Them?

1. **How is forest influenced by climate? And the other way round? Give at least three examples and write them next to the arrows.**

2. **What do you know about forests and CO_2? What is the link between them?**

Forest in Carbon Cycle

1. **Mark in the picture all places in forest where carbon is stored:**

2. **Mark in the picture where in forest the following processes take place:**

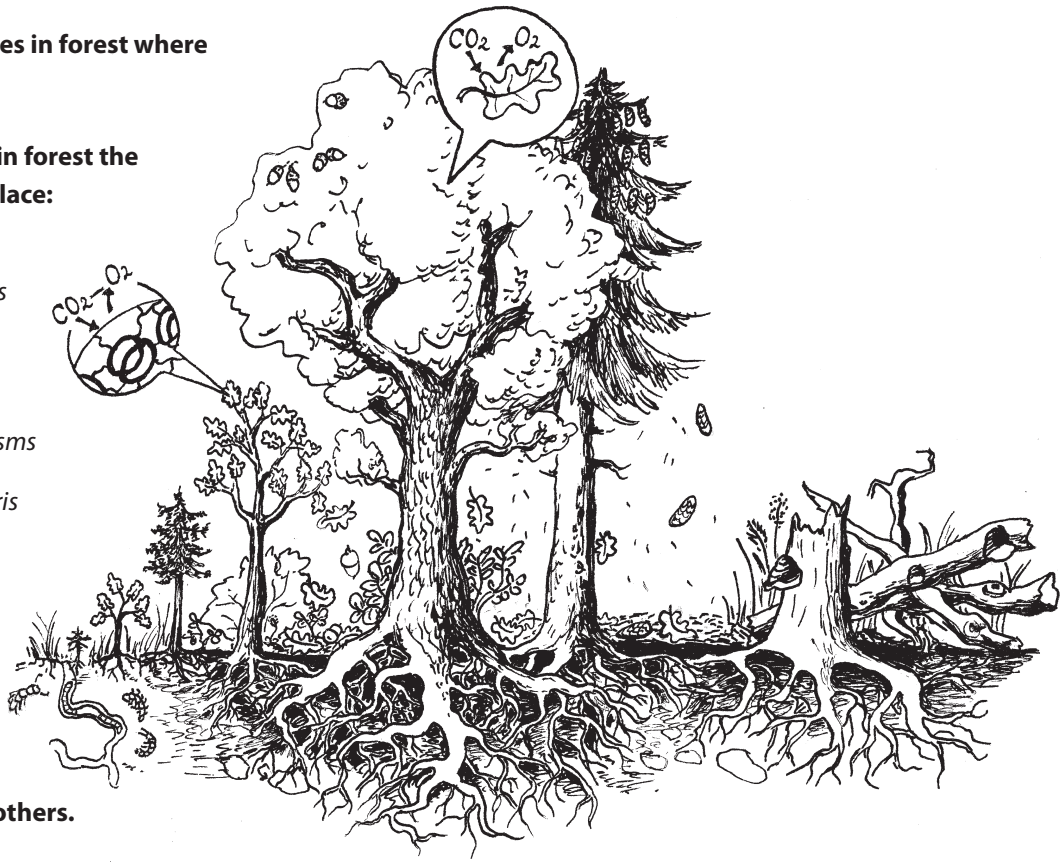
   photosynthesis

   decomposition of fallen leaves and needles

   breathing of plants

   breathing of soil microorganisms

   decomposition of woody debris



3. **Share your ideas with others.**

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The Role of Forests in Carbon Cycle

1. **Watch the Carbon Cycle clip.**
   Write down the words you think are important or those describing what happens in the clip.

Key words:

2. **Discuss in the group what the clip represents. If necessary, play the clip again.**
   Set up an outline for a commentary to the clip. The outline must have a title of the clip and 5–8 sentences describing what is going on in the clip. Write down the outline.

Title:

Outline:

3. **Play the clip and read your commentary.**

4. **What parts of the clip did you consider important? Write down the three most important ones:**

   I think that this was important:

   1.

   2.

   3.

   What questions did you think of when you were watching the clip? Is there anything more you would like to find out about the topic? Write down three questions:

   My questions:

   1.

   2.

   3.

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Carbon in Soil and Vegetation

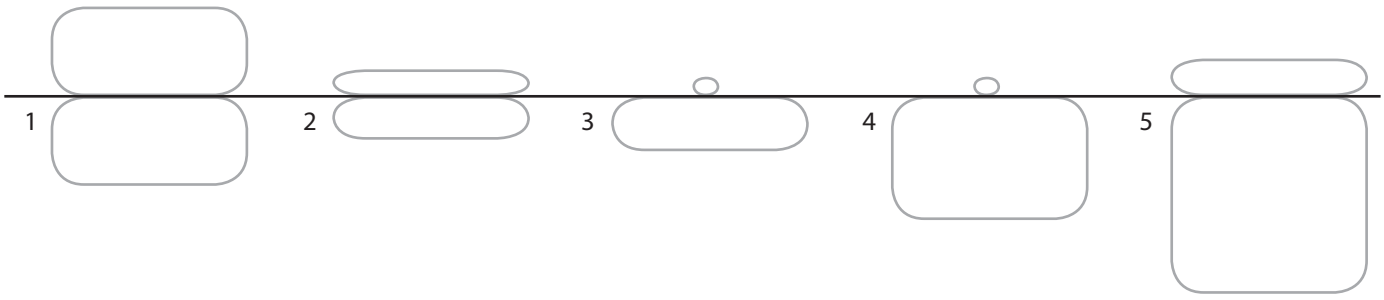
1. **Categorize the parts of the forest where carbon is stored according to whether they are above or under the ground. In what overground parts can carbon be stored? And where would we found it if we looked under the ground?**

ABOVE THE GROUND, CARBON IS STORED IN:

The ground

UNDER THE GROUND, CARBON IS STORED IN:

2. **On the Earth, carbon is not distributed evenly above and under the ground. Look at the schemes and match them with the biomes bellow so that it corresponds with the proportion of carbon fixed in overground and underground parts in a given biome. You can choose from the following biomes: tropical forest, taiga, temperate forest, field and steppe. The larger the box above or under the line, the more carbon is stored in the corresponding parts above or under the ground.**



FIELD | **STEPPE** | **TAIGA** | **TEMPERATE FOREST** | **TROPICAL FOREST**

3. **Find these ecosystems in the map of the world in your atlas.**

4. **Look at the schemes of biomes above and answer the following questions:**
   - Which land biome stores most carbon?
   - Which biome fixes most carbon in its overground part, i.e. in vegetation?
   - Which biome fixes most carbon in its underground part, i.e. in soil?
   - Estimate the proportion of carbon stored in our forests above ground (in vegetation) and underground (in soil).
   - What happens with the stored carbon when we cut down the forest and leave there a pasture or field instead of it? Where does the carbon from the forest go?
   - How and where can we preserve the carbon when cutting down trees so that it doesn't get immediately back to the atmosphere?

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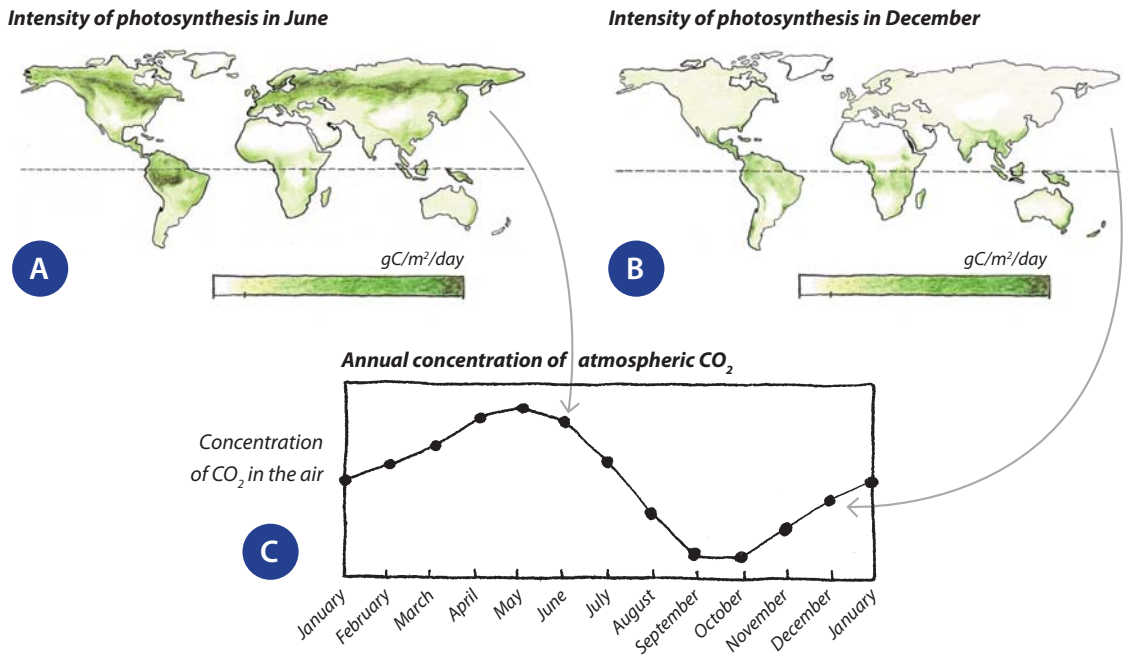
Magical Photosynthesis

Scientists can measure the speed of photosynthesis, for example by measuring how much carbon dioxide a specific type of forest takes in from the air per day. The more it takes in (i.e. the less it remains in the air), the faster the photosynthesis is. The following measurements show how concentration of carbon dioxide in the air changed in course of a year. As you can see in the picture, in some months less CO_2 was found in the air, in other months there was more CO_2 measured. The same curve shaped as a wave was measured repeatedly every year.



➔ **Mark in picture C**:

- Which month was there the lowest quantity of CO_2 in the air (MIN)?
- Which month was the concentration of atmospheric CO_2 highest? (MAX)?
- Which time of the year do plants in your country grow the most (mark in colour)?
- Find this time of the year in the chart and find out what happens with the concentration of atmospheric CO_2 at that time – does it rise or drop? Why is it so?

➔ **Study the maps (picture A and B) and answer the following questions:**

- In what parts of the world is photosynthesis the most intensive in summer?
- In what parts is photosynthesis the most intensive in winter?
- Why is it so?

➔ **Write down in 2–3 sentences what you've learnt from studying the picture:**

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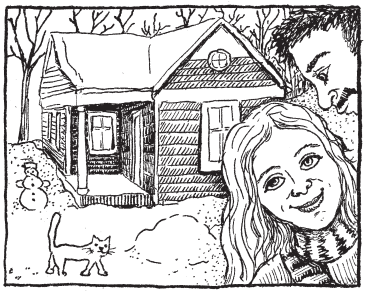
Man Influences Climate through Forests

➔ **Summarize how characters form each story try to influence climate through forests.**

IN DEEP FORESTS OF CENTRAL BOHEMIA

IN NORTHERN BOHEMIA

SOME PLACE IN EASTERN BOHEMIA



ON BORNEO, AN ISLAND IN INDONESIA

Write a letter to the politicians who are going to participate in an international conference where new treaties about forest management will be agreed on. Suggest at least three points concerning the prepared legislation so that it supports a forest management which makes forests function as natural carbon sinks. Support your demands with arguments.

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Forest and its microclimate; its relation to global climate

METHODOLOGY FOR TEACHERS AND WORKSHEETS

THE BIG IDEA:

If we understand the link between forest and its microclimate we can deduce the relation between forests and global climate.

Motto: ***"Microclimate is actually small macroclimate."***

ESSENTIAL QUESTIONS:

Why is climate in some forests dry and in some forests humid?
Why are forests important for the climate?
Can felling of a forest in the Czech Republic have impact on forests let's say in France?

ENDURING UNDERSTANDING:

Students are aware of individual factors contributing to the forest's microclimate and of the principles on which these factors and forest affect each other.

Students understand that an irreversible deforestation of large areas (e.g. areas in rain forests) can have impact on global climate.

BRIEF DESCRIPTION OF THE LESSONS:

Lesson 1 deals with the topic of climate factors related to forests and with basic interactions between these factors and forests. Students shall learn what the main climate factors are. On the example of a forest from their area which they are well acquainted with, they should realize all the implications of these interactions.

In **Lesson 2** a special discussion method is used to explain the impact of significant intrusions into forests (e.g. irreparable deforestation) on global climate. In this lesson students must use their previous knowledge about climate factors and impact of CO_2 on forest ecosystems.

Lesson 1: Forest and climate factors (45 min)
Lesson 2: Forest and global climate (90 min)

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Lesson 1:
FOREST AND CLIMATE CHANGE

OBJECTIVE:

- Students shall name the factors that affect climate in forests. They shall also interpret the relations between these factors and the forest.

MATERIALS:

worksheets, sheets of paper, something to write with

AGE: 9–12 years

TIME: 45 min

WHERE: Inside and outside activity

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Lesson 1: FOREST AND CLIMATE CHANGE

EVOCATION 10 min

We recommend to start with a motivation, for example:

Imagine that you're on holiday, let's say on a summer camp, at your granny's, or just at home and you've decided to go for a walk into the forest...it's a hot day, sun is shining, you are walking down a dusty path in the fields and suddenly you enter the forest...keep still for a while and just look around... think of what you hear and what you feel...

Write on the board:

- How did you feel before you entered the forest?
- How did you feel in the forest?
- Do you usually feel warm, cold, wet, dry, humid...in the forest?

Ask students to write down the answers into their exercise books.

Then ask students to read their answers up and write them on the board. Write down everything the students say. Don't judge their answers (you can just encourage them by comments such as "This is interesting, we haven't had that yet...").

Then react to their answers by follow-up questions:

- Why did some of you feel [wet, humid, cold and warm in the same time...] in the forest?
- Why do you think it's so?

Again, ask students to write their answers into their exercise books and then ask them to read up the reasons they've put down. Write the answers on the board. Again, don't judge them.

Divide students into groups – you can use the game on statues for that: Let them perform for example: a tree with a squirrel on it who holds a cone; a newborn fawn and its mother doe bending over it under a tree...

Children will be probably a bit noisy so it's good to agree on a signal (a word or a sound) after which they'll freeze. Encourage the children to try out several groups. We also recommend trying out several types of statues so that children divide into the groups according to their preferences.

After the children make the third statue, tell them to stay in the last group in which they'll start working on a new task.

UNDERSTANDING 30 min

Everyone in the group gets a text describing one factor that influences climate in forest.

Everyone in the group shall study the text in the following way:

- If a student finds new information in the text, s/he underlines it
- If a student finds information s/he already knows, s/he ticks it off.

Students shall write down the new and known information into the table in the worksheet.

After the students have read the text, they answer the questions below it. Then they sum up in two sentences the key information from the text.

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Afterwards, the students shall share the information from the text with the others in the group: each student shall show to the others a picture depicting how "his or her" macroclimate factor influences the microclimate in the forest. Students will use the information they've written down in the table to explain the picture. Each student has maximum 5 minutes for that.

REFLECTION

At the end of the lesson, go back to the evocation from the beginning (*Imagine you're on holiday, let's say on a summer camp, at your granny's or just at home and you've decided to go for a walk into the forest...it's a hot day, sun is shining, you are walking down a dusty path in the fields and suddenly you enter the forest...keep still for a while and just look around the forest... think of what you hear and what you feel...*). Ask students to write a story which starts in this way:

"I am on holiday and I've decided to go to the forest..."

The story must:

- describe how students feel in the forest (warm/cold/...)
- explain why they feel so.

NOTE: If you don't have enough time for the reflection in the classes, students can write the story as their homework and read it at the beginning of the next lesson. To make the other students listen to their classmates' stories you can introduce the reading in this way:

"Listen to the stories your classmates have written. When they finish, tell us

- if the facts were correct
- what you liked/disliked about the story, what surprised you about it.

RECOMMENDATION:

It's good to have this lesson in a real forest in order to experience authentic feelings about the forest climate and the phenomena happening there.

EVIDENCE OF LEARNING

Divide students into groups so there is one "representative" of each factor tackled in the previous lesson there. Students' task is to recall as much about these factors as possible (at this stage, do not intervene). First, let them write the information on a paper, and then write what they've written on the board.

Underline (or add) the key words (*sunshine, reflection of the sunshine, precipitation, absorption of water by soil, transformation of sunshine, respiration, vaporization, drainage, temperature*) you will work with in this lesson and present the task you will do in the remaining time.

Each group should make a poster of a forest according to the following instructions:

"*The picture should represent a forest and everything what happens there when the sun shines on it, or when it rains there.*"

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You can exhibit the pictures on the walls in the classroom, if you like.

Agree upon criteria the pictures should meet.

EXAMPLES OF CRITERIA

- a title which matches well the picture
- the date and the names of the authors
- a motto, quote or a poem related to the topic
- the handwriting is neat, size of the letters is at least 5 cm.
- a brief description of the topic (relation between the forest and climate factors, in this case)
- graphics – use of photos, pictures, maps, charts, schemes, or a 3D product etc.
- blank space (1/4 of the poster) reserved for a mind map explaining the implications of whether there is sunshine or whether it rains
- a list of sources complying with the standards of quotation you use (in case of websites: the link + the organization which
- runs the website + the author if known)

To make the poster, students can use the information from Lesson 1

You can use these criteria to assess the students' work - as the criteria are known beforehand, students know what the assessment will be based on. You can also let students to assess each other´s work.

In summer, a grown-up tree with a shroud 10 m wide casts shadow and cools down its surrounding between 8 a.m. and 8 p.m. with average energy output of 24 kW which corresponds to the performance of 12 air-condition units.

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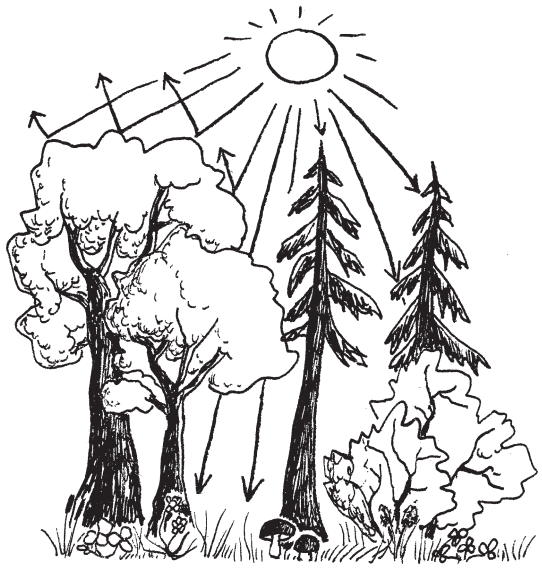
Sunshine

Sunshine is the source of most energy on the Earth. That's why it is one of the most important factors influencing the Earth's climate.
What is the relation between forest and sunshine? What happens in the forest when the sun is shining?
Trees can for example **reflect** the sunshine, mainly thanks to their leaves. Thus the larger the leaves are, the more sunshine they reflect. You can easily imagine this on the example of a pine wood: because pines have relatively thin needles which do not reflect much sunshine, we can feel warmer in a pine wood than in a broadleaved forest. Trees also **absorb** the sunshine. And guess what happens with the absorbed sunshine? A tree uses part of it for its growth, and it **transforms** the rest **into warmth**. If this warmth joins the vapours coming from precipitation it can start raining (for more see the text on Precipitation). We can conclude that the sunshine influences not only the temperature in the forest but also whether it rains there.

FOREST AND SUNSHINE

In the picture, you can see a forest and what happens with sunbeams (represented by the arrows) reaching the forest - part of them is reflected, part is transformed into the warmth and part reaches the ground.



✓ = KNOWN INFORMATION

<u>underlined text</u> = NEW INFORMATION

➔ **Sum up in two sentences what happens with the energy from the sunshine in the forest.**

➔ **What happens with sunshine where there is no forest (for example in the fields)? What difference between the temperature in a forest and that in the fields can you feel on a sunny day?**

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Precipitation

Have you ever noticed what happens in a forest when it rains there? Water dribbles down the trunks, drops from the leaves or falls on the ground. But have you wondered what happens with the water when it stops raining? Well, there's a whole range of possibilities.

For example, water can **sink into** the soil. And believe it or not, once the water sinks in the soil, it remains there pretty long. That's why forests are so important for keeping water in the landscape. Without them, water would quickly drain to the valleys and none of it would remain in the hills. In many areas, there would be no springs, no creeks and no drinking water in spring wells if it wasn't for forests.

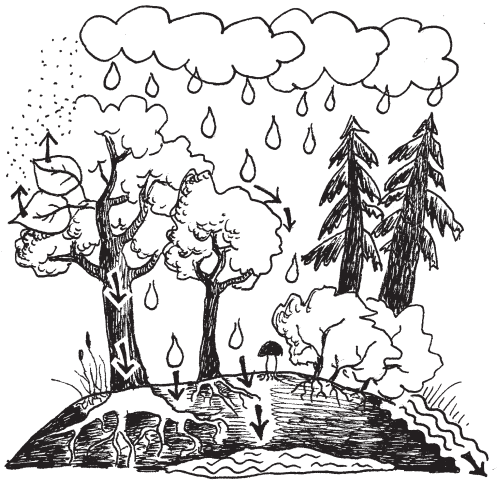
The sentence above suggests what happens with water that **drains off**. Small creeks which pop up in the forests after the rain become brooks, torrents and rivers which eventually stream into the seas and oceans.

And what happens with water which neither sinks nor drains? It **evaporates**. What does it mean? When the trees have enough water and it is warm in the forest (for example because the sun comes out after the rain), leaves or soil start evaporating the redundant water. Therefore it feels **more humid** in the forest than in the places where there are no trees.

Vaporization is also a reason why it rains more often above forests. The vapours accumulate in the form of clouds over the forests and it starts raining again. Of course, the forests must be quite large. If there are just few trees, the vapours disperse and won't make any clouds.

FOREST AND PRECIPITATION

In the picture, you can see what happens with a forest when it rains there. Part of the precipitation (arrows and drops) evaporates back to the air, part of it sinks into the ground and some part drains off the forest.



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<u>underlined text</u> = NEW INFORMATION

➔ **Sum up in two sentences what happens with the precipitation that falls in a forest.**

➔ **What would happen if there was for instance a field instead of forest? How could it influence the climate in the given area?**

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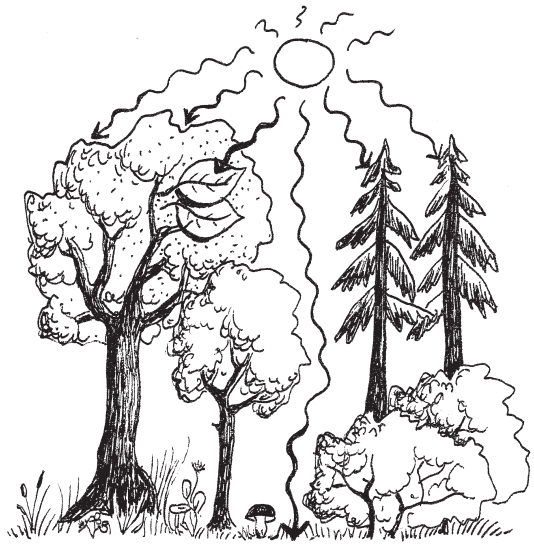
Temperature

For organisms living in forest (trees, plants, animals, fungi,...) temperature is very important. For example, trees cannot grow if the temperature drops below 3 °C or rises above 40 °C. Ideal temperature for most organisms to grow is between 20 to 30 °C.
The temperature is influenced mainly by the amount of **sunshine** that leaks into the forest ecosystem.
And do you know how the forest ecosystem treats the warmth coming from the sunshine?
Thanks to the warmth, **leaves can evaporate water** (which makes the forest humid), plants can **grow** (i.e. build the trunks or stalls, branches, leaves...) and **breath**.
Thanks to the trees and their shrouds, the soil beneath them **cools down** during the day, and remains **warmer** than its surrounding at night. And because the soil in forest is well protected in this way, it can produce **humus** which nourishes the trees.
Because tree shrouds **take in most sunshine**, they also have highest temperature during the day, while the ground beneath them is cooler. That's why it is said that forests **decrease** temperature compared to their surrounding during the daytime and increase it at night (The warmth accumulated by the trees during the day does not release so quickly). That's why at night it is less cold in the forest than let's say in the fields.

FOREST AND TEPMERATURE

In the picture, you can see what happens in the forest with the sunbeams turned into warmth (the arrows). In the shrouds, some (most) are changed into the warmth, some reach the ground.



✓ = KNOWN INFORMATION

<u>underlined text</u> = NEW INFORMATION

➔ **In the text, you've learnt that forests help diminish differences in temperature during the daytime and during night. Sum up in two sentences how this happens.**

➔ **What would happen if the forests didn't balance the differences between the temperature during the daytime and during night? How could it influence the climate in the forest's surrounding?**

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Lesson 2:
FOREST AND GLOBAL CLIMATE

OBJECTIVE:

- Based on the information on forest microclimate and links between forest and carbon, students shall judge whether forest logging can contribute to global climate change.

MATERIALS:

Paper hats of six different colours, worksheets.

AGE: 13–15 years

TIME: 90 min

WHERE: Inside activity

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Lesson 2: FOREST AND GLOBAL CLIMATE

EVOCATION 20 min

Evocation is divided into two parts – a general one (Evocation 1) and the evocation related to the topic of forest's role in global climate change (Evocation 2). Because it is a rather abstract topic, we suggest going through both parts.

Evocation 1:

Write two key expressions on the board: **FOREST** and **GLOBAL CLIMATE CHANGE.**
Make students discuss in pairs what the possible links between these expressions can be. Let them write down their suggestions. Afterwards, write students' answers on the board. Do not judge these.

Evocation 2:

Introduce the following question: *"Does forest logging and permanent deforestation contribute to global climate change?"*
Ask students to write their answers to their exercise books; then let a couple of students read them up for the others.
Tell the students that you will use a special discussion method to explore the topic. This should help them to look at the issue from various perspectives and to make up their own mind.
Divide students into six groups representing six hats. Explain the meaning of each hat.

White hat = objectivity, mere facts, figures, information

- look at the problem without emotions, explaining or arguing
- give all the available facts, data and information related to the problem
- don't make value judgments about the arguments, don't assess or categorize them
- others can ask you further questions related to the facts or figures

Red hat = emotions and feelings, impressions, intuition

- forget the facts and express your feelings and impressions
- try to describe your feelings, manifest them
- try to be spontaneous, don't make value judgements about your feelings nor try to argue for them
- others are not allowed to judge your feelings – this could block your spontaneity and stop you from reaching to the solution

Yellow hat = optimism, affirmative attitude, opportunities

- focus on all the positive aspects and opportunities related to the issue
- be deliberately optimistic, not spontaneously euphoric
- explore advantages and support them with arguments

Black hat = pessimism, impossibility

- you are a critical judge, opposite of the yellow hat, but not bitter
- compare given options against reality and previous experience, point out possible snags
- don't mix logical arguments with impressions – there's no room for emotions here

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Green hat = creativity; fruitful, creative, motivating, provocative ideas

- bring up any suggestions for actions that could be taken
- you don't have to say anything, you can only think about these solutions that should be mentioned later in the session

Blue hat = regulation, couching, detachment, reflection

- try to manage the discussion so that representatives of all hats get the opportunity to speak
- sum up the opinions of the others during the debate
- try to prevent quarrels

UNDERSTANDING

Exhibit the proposals of the six hats. Let all the groups read them and then make them work with the worksheets. Their task is to add a couple of proposals to each hat according to the hat's characteristics.

Then let the group present their arguments.

The discussion can be carried out in two ways:

- The arguments are presented consecutively group by group – in this way, students train different approaches to a problem and ways of looking at it, students map various perspectives consecutively
- Representatives of individual hats react to each other in a lively discussion. This way, however, requires that students are used to this technique and master it.

Make a circle with the students, let them present their statements and manage the discussion so that you explore the issue thoroughly and so that you reach a conclusion.

REFLECTION

Let students answer the introductory question into their exercise books. Make them support their answers with arguments.

EVIDENCE OF LEARNING

Students' task will be to choose an argument form each hat and join them into one text.

TIP: This is a rather demanding technique which requires some training. Therefore we recommend to try it first with a simple and concrete question such as "Shall we cut down the tree next to our school?"

Students also don't have to present too many arguments and they can thus spend a part of the lesson making the paper hats themselves.

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Does logging and permanent deforestation of large areas contribute to global climate change?

WHITE HAT

- Forest ecosystems fix a lot of CO_2 which plants and trees use for their growth. If we cut down forests and don't replant them, CO_2 is released into the atmosphere and the greenhouse effect increases.
- Balanced distribution of moisture and low vaporization from the forest soil make forests react better to summer dries. In this way, forests help cooling down their environment.
- Our arguments: .....

  .....
- Our arguments: .....

  .....

RED HAT

- I believe that everything is interconnected. That's why I'm afraid that massive woodcutting can have a great impact on the planet's climate.
- I'm worried that before we agree on this issue (i.e. before all politicians do that), too many forests (especially tropical forests) will be cut down and we lose too much (a lot of undiscovered plant species will be extinct, the emissions will increase ...).
- Our arguments: .....

  .....
- Our arguments: .....

  .....

YELLOW HAT

- This is a very interesting issue and I'm convinced that if we look closely at it we come to interesting conclusions and we will be able to reach better understanding of how things work on the Earth.
- Let's try to solve the issue! And maybe the number of sustainably managed forests will grow.
- Our arguments: .....

  .....
- Our arguments: .....

  .....

Záchrana Tereza

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Lesson 2: FOREST AND GLOBAL CLIMATE

BLACK HAT

- It's possible that we still don't have enough information about the relation between the production of CO_2 and forests' lifecycle.
- World climate is a very complex issue with many factors at play and it is therefore very difficult to tell what impact cutting down of 1 ha (i.e. 100 x 100 m^2) of a forest will have on the planet's climate.
- Our arguments: .....

  .....
- Our arguments: .....

  .....

GREEN HAT

- Let's first come up with a hypothesis concerning this issue and gather as much information which would either support or refute the hypothesis as possible.
- We shall first try to find out what the experts and the public think about the issue.
- Our arguments: .....

  .....
- Our arguments: .....

  .....

BLUE HAT

- Have you already mentioned all the facts or do you need to add something?
- Do you want to mention any further worries or impressions concerning the topic?
- Has everybody had their say?

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LITERATURE

Forest and CO_2

in Czech language only (names of the journals)

National Geographic – Czech rep., 2004, no. 2, p. 44–73
Vesmír 88. 2009, no. 7–8, p. 492–493
Vesmír 88. 2009, no. 7–8, p. 496–500. WWW: http://www.vesmir.cz/clanek/lesy-v-globalnim-kolobehu-uhliku

in English

Keeling, C. D., Piper, S. C., Bacastow, R. B., Wahlen, M., Whorf, T. P., Heimann, M. & Meijer, H. A. Exchanges of atmospheric CO_2 and $13CO_2$ with the terrestrial biosphere and oceans from 1978 to 2000. I. Global aspects. 2001, SIO Reference Series, No. 01–06, UC San Diego: Scripps Institution of Oceanography, San Diego.
WWW: http://escholarship.org/uc/item/09v319r9
Intergovernmental panel on climate change [online]. 2009 [2009-10-26]. WWW: www.ipcc.ch
Concentration of CO_2, Mauna Loa, Hawai, 1958–2009. [online]. 2009 [2009-10-26].
WWW: http://scrippsCO2.ucsd.edu/data/in_situ_CO2/monthly_mlo.csv
NASA Earth Observatory [online]. 2009 [2009-10-26]. WWW: http://earthobservatory.nasa.gov
NASA Goddard Space Flight Center [online]. 2009 [2009-10-26]. WWW: http://svs.gsfc.nasa.gov
Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N. H., Verardo, D. J. & Dokken, D. J. (Eds.): IPCC Special Report on Land Use, Land Use Change and Forestry , IPCC, 2000. WWW: http://www.ipcc.ch/ipccreports/sres/land_use/

Forest and its Microclimate; Its Relation to Global Climate

in Czech language only (names of the journals, books, associations,..)

De Bono, E. Six huts (*How to think*). Praha: Argo, 1997.
Friends of the Earth Czech Republic, 2008. WWW: http://www.hnutiduha.cz/index.php?cat=publikace&id=2
Friends of the Earth Czech Republic, 2007. WWW: http://www.hnutiduha.cz/index.php?cat=publikace&id=2
Giono, J. The man who plant in the trees. Praha: Vyšehrad, 2000.
Steel, J.L., Meredith, K.S., Temple, Ch. & Walter, S. Reading, writing and discusion in all subjects. Praha: Kritické myšlení, 2007., p. 9–12
Steel, J. L., Meredith, K.S., Temple, Ch. & Walter, S. Another strategies for developement of the critical thinking. Praha: Kritické myšlení, 2007., p. 44
Varianty (eds.). Bohouš and Dáša: Climate in stress. Praha: Člověk v tísni, o.p.s., 2009.

in English

Easterling, W.E., Aggarwal, P.K., Batima, P., Brander, K.M., Erda, L., Howden, S.M., Kirilenko, A., Morton, J., Soussana, J.-F., Schmidhuber, J. & Tubiello, F.N. Food, fibre and forest products in Climate Change 2007:
Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L., Canziani O.F., Palutikof, J.P., van der Linden, P.J. & Hanson C.E.(Eds)., Cambridge, UK: Cambridge University Press, 2007, p. 273-313.
WWW: http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter5.pdf

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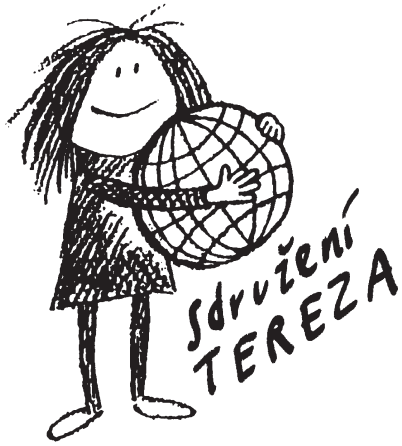

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Teacher's Guide and worksheets for students in programme Forest at school – school in the Forest

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