Interreg
Austria-Hungary
European Union – European Regional Development Fund
REIN-Forest

The impact of climate change

on forests globally and in the Austrian-Hungarian border region

EDUCATIONAL MATERIAL FOR UPPER SECONDARY SCHOOL PUPILS AND TEACHERS

Impressum

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The educational material is a short and concise summary of the vast body of knowledge on climate change, its impacts on forests and the possibilities to reduce the damage caused. The aim is to present this important issue that affects our daily lives in an interesting and relevant way. If you are interested in further information on the subject, we recommend the following internet resources as a starting point:

www.masfelfok.hu
www.karbonkalkulator.hu
www.zoobudapest.com
www.klimavaltozas.oee.hu
www.nfk.gov.hu
www.climate.nyme.hu
www.erti.naik.hu
www.agrarklima2.nyme.hu
www.upmforestlife.com
www.eea.europa.eu
www.proholz.at
www.scientia.hu
www.fao.org
www.etwinning.net
info.bml.gv.at 01
info.bml.gv.at 02
www.klimafitterwald.at
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Foreword

DEAR TEACHERS!
DEAR UPPER SCHOOL STUDENTS!

Climate change is increasingly affecting our daily lives and we are facing the consequences in all areas of life. It is important that students learn as much as possible about these issues, even in addition to their compulsory education, as they can do much to protect our climate from a young age.

We hope that our publication will be a useful addition to your biology lessons. As well as trying to collect the most important information, such as:

- climate change,
- the impact of climate change on forests,
- forest management,

we want to enhance the knowledge of upper secondary school students with interesting information and facts about the Austrian-Hungarian border forests, with the promise of interactive and experiential learning and teaching.

Figure: The role of trees

Introduction

Climate change is one of the biggest environmental challenges of our time. The changes taking place are having a significant impact on forest resources. At the same time, forests are one of the most important tools for climate protection and for mitigating the negative effects of climate change.

In the EU, forests can neutralise around 8.9% of greenhouse gases (2018).

While we can do a lot to protect our climate, we must also pay special attention to protecting our forests and planting new ones.

PROTECT OUR FORESTS!

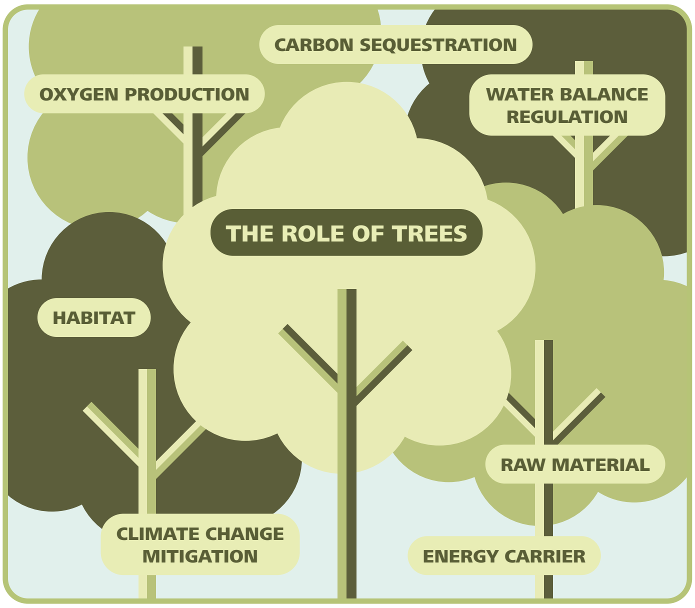


Figure: The role of trees

Climate change

CLIMATE AND THE CONCEPT OF CLIMATE CHANGE

CLIMATE: *the set of long-term weather conditions on Earth.*

The natural factors that determine the Earth's long-term weather patterns operate in a system, constantly interacting with each other. Temperature, air pressure, wind, humidity, sunshine and precipitation play a key role in shaping climate.

Our planet's climate has been changing since the beginning of the Earth's history. The most important natural factors influencing climate are solar radiation, the Earth's orbital characteristics, changes in continental plates, volcanic activity, greenhouse gas concentrations, the presence of water in the form of surface ice or clouds. However, the last few decades have witnessed an accelerating, larger-scale change in climate forcing, one of the main causes of which is human activity.

CLIMATE CHANGE: *a significant and sustained change in climate, i.e., the Earth's long-term weather patterns, at a local or global scale that affects the Earth's entire ecosystem.*

In addition to changing the structure of the vegetation on the ground, human presence affects the climate by releasing aerosols that reflect some of the sun's radiation and by releasing greenhouse gases into the atmosphere (for example, through the burning of fossil fuels, animal husbandry or deforestation).

CHANGES IN TEMPERATURE

Greenhouse gas emissions have increased significantly compared to pre-Industrial Revolution times. This has led to a 1°C increase in the global average surface temperature today.

GREENHOUSE EFFECT: *a natural process whereby gases in a planet's atmosphere trap the sun's rays. In the case of our Earth, it means that the planet's atmosphere traps the sun's rays. This prevents the heat energy from escaping because some of it is reflected by the atmosphere. As a result, the temperature of the surface and lower atmosphere will be higher.*

The number of heatwave days in the Austrian-Hungarian border region is steadily increasing. Summers are hotter and the seasons often merge. Long periods of drought are becoming more frequent. Not only in winter, but also in the whole period from October to March, the number of frosty days is decreasing. The number of various pathogens and insect pests is not reduced by the cold, and late frosts pose a serious threat to plants.

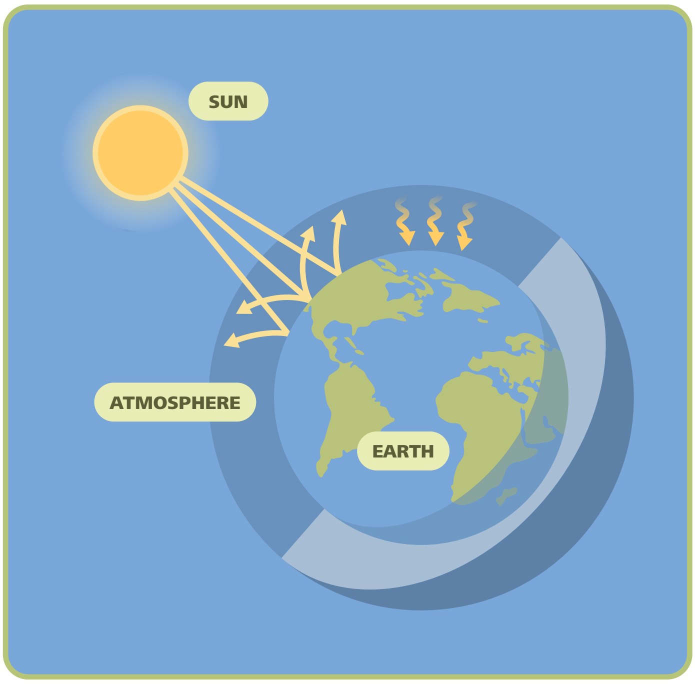


Figure: Greenhouse effect

CHANGES IN PRECIPITATION

Climate change is affecting the entire water balance on Earth. The acceleration of hydrological cycles is leading to very high or extremely low precipitation in some places. Both are very serious problems. While heavy rainfall causes floods and **flash floods, prolonged periods of low precipitation** lead to drought and drinking water shortages.

***FACTS** It is projected that by 2050, the number of urban dwellers suffering from water scarcity will reach 1.9 billion. In 2018, Cape Town, with a population of 4 million, was affected by water shortages, which forced it to limit water use to 50 litres per capita per day. By comparison, the full flush of an average flush toilet tank uses 6-8 litres of water, the average adult uses 2-2.5 litres, while a shower uses 50 litres, a dishwasher 15-20 litres and a washing machine around 50 litres.*

Image: Desertification

CHANGES IN CLIMATE BELTS

As a consequence of climate change, a significant shift in climate belts is expected in the future.
If greenhouse gas emissions continue at the current rate, the area of icecap, tundra and taiga climates will generally decrease, while the area of temperate, arid and savanna climates will increase.

***TAIGA CLIMATE:** also known as subarctic climate. It is considered the most extreme temperate climate: it has the greatest annual temperature variation; summers are relatively warm, and winters are harsh.*

***CLIMATIC TIPPING POINTS:** critical, irreversible changes that occur after a certain warming level. Examples include the melting of Arctic ice sheets.*

CLIMATE CHANGE IN THE AUSTRIAN-HUNGARIAN BORDER REGION IN THE RECENT PAST

Austria and Hungary currently belong to the **temperate continental climate zone**, but of course the climate of individual regions can be strongly influenced by topography.

According to projections based on scientific models, climate change will lead to an **increase** in the number of extremely hot days, i.e., days with **maximum temperatures above 35°C**, in the Austrian-Hungarian border region. The average monthly mean temperature in July over the last two decades has even exceeded 20°C in the Austrian Alpine region.

The occurrence of extreme precipitation increases, leading to flash floods. The uneven distribution of precipitation will lead to more frequent droughts - making agricultural production more difficult and increasing the risk of surface fires. The average annual rainfall in the Austrian border region over the last three decades is around 700 mm, combined with 1750 hours of sunshine per year in this region. The main problem in this region is not the amount of precipitation but rather its uneven distribution.

Globally, **average wind speeds are decreasing** but the **number of storms associated with weather cyclone activity is increasing**.
Storm damage is causing significant destruction to both natural vegetation (windthrown trees in forests - windthrow) and to agriculture and the built environment.

Climate change is expected to **shift and transform vegetation climate zones**. In general, the region will see a decrease in the proportion of forested areas, further a westward shift of the boundary of closed forest stands (oak and beech) and a significant increase in the proportion of steppe zones is expected.

The relationship between climate change and forests

FORESTS OF AUSTRIA AND HUNGARY

Almost 21% of Hungary's land is forest, more than half of which is state-owned. Austria has about 47% forest cover. In both Hungary and Austria, the amount of forested land is increasing every year due to afforestation. The standing volume, i.e., the total volume of living trees, in the Hungarian forests is about 399 million m^3, while the same figure for Austria is 1.17 billion cubic metres. On an annual basis, neither country uses all of its current annual increment, Hungary uses half of it and Austria about 88%.

CURRENT ANNUAL INCREMENT: *The increment in a specific year of a tree or population of trees with respect to a specific variable, usually the area (m^3/hectare).*

Forest cover in the Austrian-Hungarian border region is around 30% on both sides of the border. Taking into account the conditions in the individual countries, this value is considered low forest cover in Austria, whereas in Hungary the border edge is considered high forest cover. Both historical and climatic factors have an influence on the development of the current forest stands in the border area and on management practices. The zonal structure naturally applies to both sides of the border, so that the tree species structure reflects the stable climatic conditions of the past centuries.

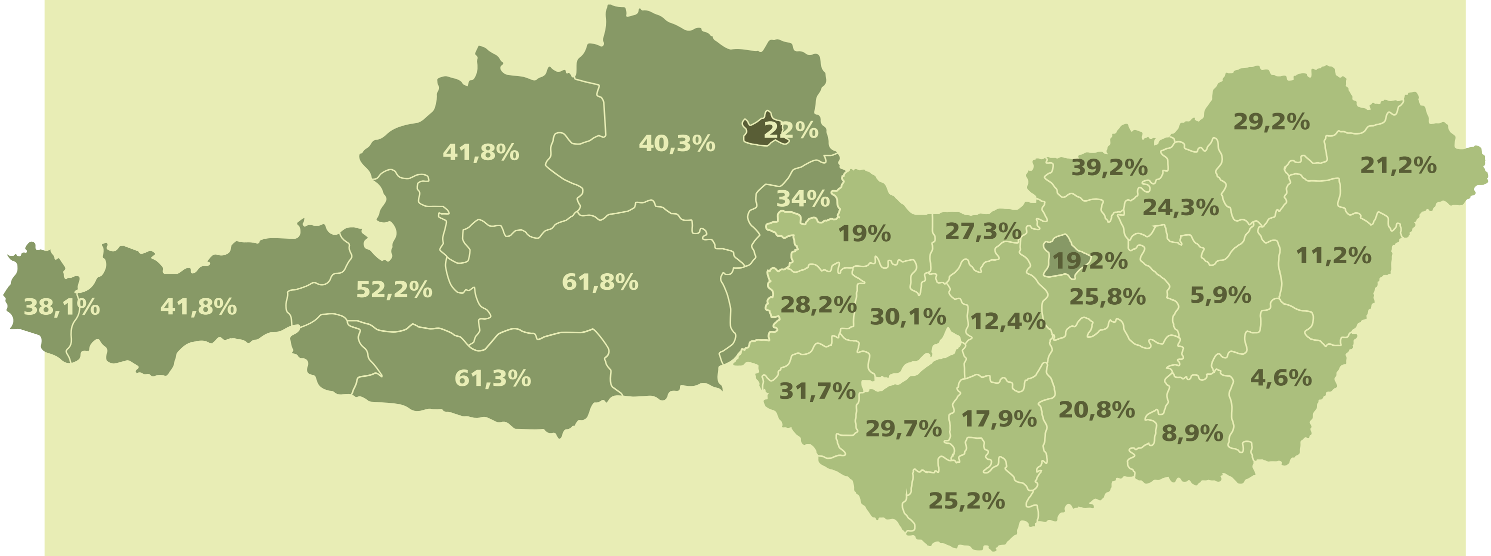


Figure: Austria and Hungary forest cover
Source: Based on data from www.nfk.gov.hu and www.geo.bfw.ac.at

TEMPERATE FORESTS, ZONATION

ZONATION: *the zonal distribution of the species of a community as a result of environmental variation.*

The Austrian and Hungarian complex **forest communities follow the zonal structure of temperate forests**. As altitude increases, average temperatures decrease and humidity increases, which essentially determine which tree species thrive in which zone. With climate change, these two parameters are expected to change.

According to the forest climatic classification, the forest-steppe climate is typical of the lowlands, the Turkey-oak climate of the lower hills and some plains, and the hornbeam-oak and beech climate of the hills and mountains. The names of the climate classes refer to the predominant tree species.

Both the leaves and fruit of the **sessile oak** are distinctive and easily recognisable. The bark is grooved. Its wood is hard, a valuable industrial raw material.

The **beech forest** is also typical. Between the smooth-barked straight trunks under the closed canopy, herbaceous plants are present in open patches in the spring.

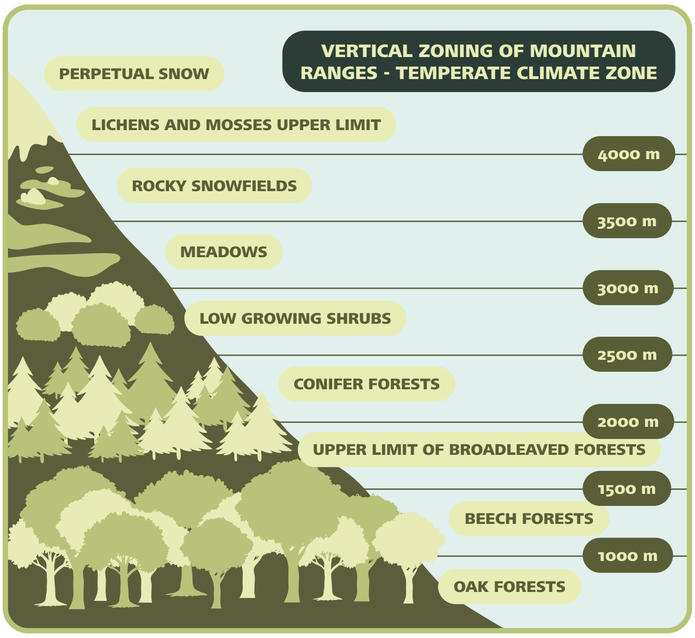


Figure: Vertical zoning of mountain areas

Image: Untamed beech in the Pre-Alps

Image: Leaves and fruits of beech
Source: © Dr. Korda Márton

Image: Leaves and fruits of sessile oak
Source: © Dr. Korda Márton

IMPACT OF CLIMATE CHANGE ON FOREST COVER

In recent years, in the border areas, logging has been necessary in large parts of beech, oak and spruce forests due to deteriorating health conditions. Climate change will also lead to a decline in the growth of certain tree species, with lower growth expected if rainfall is a limiting factor

Spruce evaporates more water than it absorbs when the humidity decreases, thus weakening it. With less resin being produced, it cannot defend itself against pests (e.g., bark beetles), so the tree weakens further and then dies. This is the so-called a damage chain.

Image: Spruce mortality in the Austrian-Hungarian border region
Source: © Dr. Csóka György

BIODIVERSITY: *It can be interpreted at the level of species diversity (species biodiversity), but it can also be interpreted as the diversity of the intraspecific heritable material of species living in a habitat (at the level of genes - genetic biodiversity). In fact, the Earth is a collection of billions of individual living organisms and the interactions between them.*

Climate change also poses a serious threat to biodiversity, as it reduces the extent of natural habitats and causes entire communities to disappear. The shift in forest climate zones can also be attributed to climate change.

In the Austrian-Hungarian border region, beech and sessile oak are indigenous, but on the Austrian side, deciduous species are also accompanied by larch, spruce and other coniferous species, which are indigenous to the zonal structure. Climate change will therefore certainly affect this border region, especially the sensitive tree species.

All tree species, including beech and sessile oak, have the genetic reserve to ensure their survival. The variability of their genetic material helps them to survive. Further adverse climatic conditions, however, will lead to the health deterioration and eventual disappearance of the tree population. It will be then replaced by other species. Experts are constantly monitoring the health conditions of the forests to ensure that the effects of climate change can be mitigated through appropriate forest management decisions.

NATURAL REGENERATION: *saplings that have naturally sprouted from seeds in the forest or are coppice shoots originating from stumps or roots are called natural regeneration.*

Image: Deciduous forest with a patch of natural regeneration

THE CONSEQUENCES OF CLIMATE CHANGE IN THE AUSTRIAN-HUNGARIAN BORDER REGION

In the Austrian-Hungarian border region, the **forest cover is complex**: on the Hungarian side, the beech, oak-hornbeam and sessile oak climates are also found, while in the higher regions in Austria, various conifer species are also present. Spruce is probably not native to the Hungarian areas of the border region. Nevertheless, it is a widespread species in the forests of this region, as its wood is widely used. The health status of spruce has been significantly degraded due to the damage caused by the **European spruce bark beetle** in this area.

FACT *In Central Europe, bark beetles are responsible for the destruction of around 40-60 million cubic metres of conifer trees (mainly spruce). In Austria, 51% of the forests are spruce. Spruce accounts for 69% of the timber harvested in Austria and 86% of the sawmill raw material. In Hungary, there were about 28.000 hectares of spruce forest in 1990, which decreased to a few hundred hectares by 2020 due to the destruction of the bark beetles.*

Image: Spruce damaged by bark beetle
Source: © Dr. Csóka György

Image: European spruce bark beetle
Source: © Dr. Csóka György

Along with climate change, a number of other forest pests have also appeared alongside the bark beetles. Damage from the Oak processionary is becoming more significant in a warming and dry climate. Changing climatic conditions promote the larval stage of the species. Longer drought periods have led to an increase in the populations of spongy moth, and thus their damage to forests has also increased. This has already affected beech trees. Beech is susceptible to foliage loss caused by the spongy moth, so the health of damaged trees deteriorates in the longer term.

In the last two decades, more non-native forest insect pests have been identified than in the last 110 years altogether. In the border region, for example, the chestnut blight, which is caused by a non-native fungus, is now also affecting sessile and pedunculate oak as well. But this category also includes the oak lace bug, which appeared in Hungary less than a decade ago.

The border areas are characterised by frequent, sometimes gale winds, which also cause significant damage to forests.

The following figure shows the vulnerability of beech and sessile oak trees and the projected future situation of populations at the end of the century in the Austrian-Hungarian border region. According to experts, beech stands will become vulnerable in lower elevations, while they will maintain their dominant position in higher altitudes. In contrast, sessile oak is more vulnerable on plains and hills, but sessile oak is expected to expand its distribution at the expense of beech in the higher altitudes of Austria.

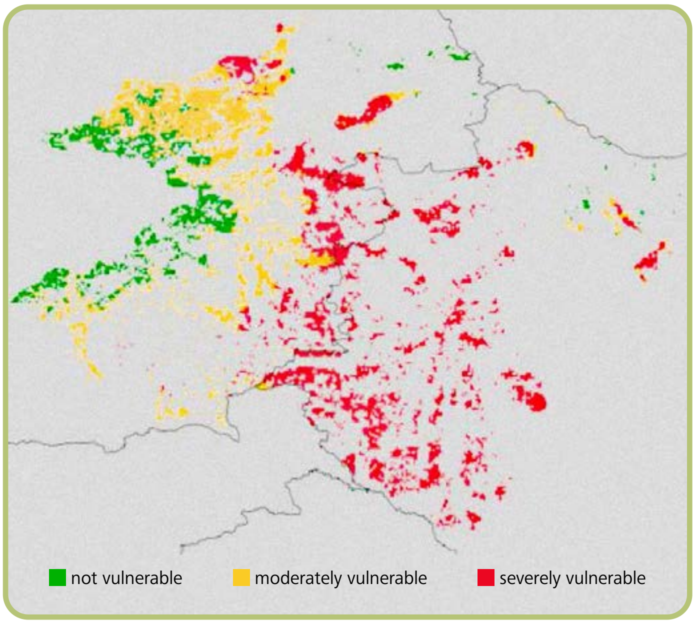


Figure: Vulnerability of beech (Fagus sylvatica) in the Austrian-Hungarian border region (2081-2100)
Source: vasmegye.hu

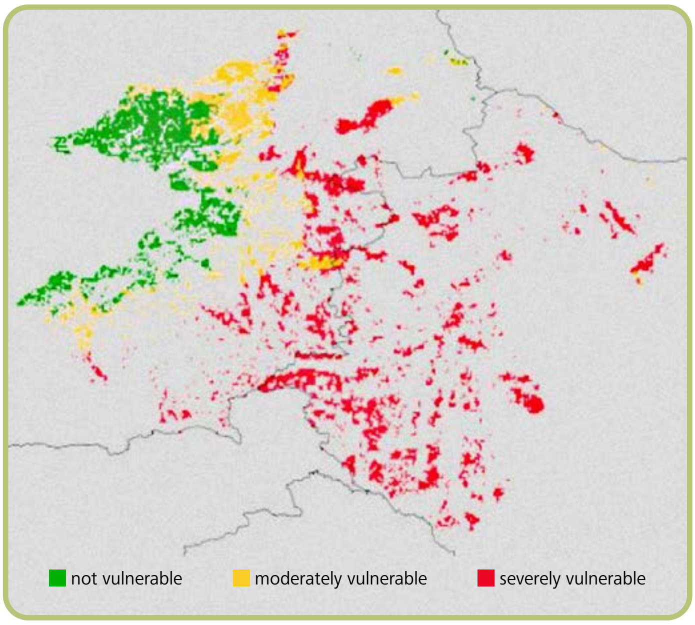


Figure: Vulnerability of sessile oak (Quercus petraea) in the Austrian-Hungarian border region (2081-2100)
Source: vasmegye.hu

The role of forest management in the fight against climate change

THE CONCEPT OF ADAPTIVE, CLOSE-TO-NATURE FOREST MANAGEMENT

The forest is essential for humans. The triple function of forests: conservation, ecology and tourism, and the provision of industrial raw materials, have been equally emphasised. Climate change, however, is reinforcing the strategic role of forests in maintaining a liveable environment. This includes the filtering of dust from the air, its beneficial effects on the microclimate, and the sequestration and incorporation of atmospheric carbon dioxide into the wood. The wood, the root system and but also the canopy of a tree are composed of high carbon components.

CLOSE TO NATURE FORESTRY: *an approach whereby forest managers can enjoy the products and services of the forest while respecting natural processes, sustainability and biodiversity.*

Cutting down a tree does not mean the destruction of the forest. Especially not if the wood from it is used permanently, for example to make furniture. The use of firewood in combustion systems with appropriate filters does return carbon to the carbon cycle, but unlike fossil fuels (e.g., oil, natural gas), it does not add more carbon to the cycle, only releases the carbon that has been sequested. Biomass produced by forests can also be used for heat production under certain conditions.

BIOMASS: *a biologically produced mass of organic matter, the sum of plant and animal organisms.*

Image: Black alder forest community, Hanság

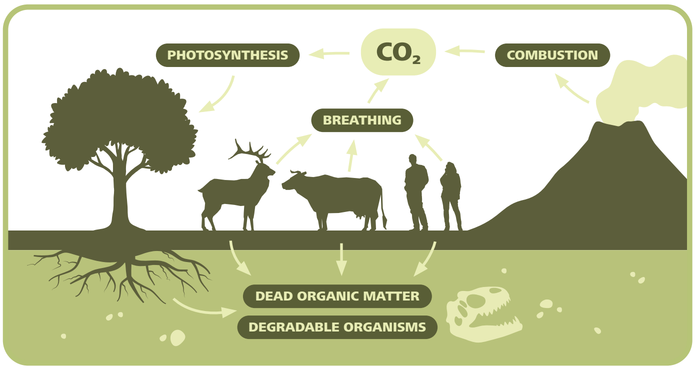


Figure: The carbon cycle

Image: Log yard in sawmill

A LITTLE FOREST MATHS

In a nearby park, find a tree with a small crown that you can easily estimate how many leaves it has. Collect some fallen leaves! Measure the leaf surface area using graph paper or a mobile phone app (e.g., Leafscan - www.leafscanapp.com). Using the total number of leaves you estimate, determine the leaf area of the entire foliage in m^2.

1 m^2 of foliage sequesters 150 g CO_2 on average over the whole growing season. A human exhales 480 mg CO_2 per minute at rest. Calculate how many small trees would sequester the CO_2 exhaled by the class in one class period?

OPTIONS FOR MITIGATING THE EFFECTS OF CLIMATE CHANGE ON FORESTS

NATURAL FOREST: *a forest of native tree species that approximates the natural conditions and is appropriate to the habitat. Such a forest is characterised by various age classes and a diverse forest structure. Mixed stands mean that the trees and tree species in the forest are of different ages.*

The basic functions of the forest are equally important in forest management. These functions are the **protective** (protective forests and protected areas), the **public welfare** and the **economic functions**. Which one of these functions is emphasised in a forest is expressed in terms of the forest's function (also defined by law): accordingly we can speak of protection, conservation, park or timber-producing forests.

Close to nature forestry, whether in public or private ownership, can help combat climate change in the future. Natural processes promote the development of an ideal tree species structure and ensure genetic diversity. Grouped, mixed forest structure improves forest resilience to extreme weather.

In November 2004, a devastating windstorm swept across the High Tatras. As a result, 12,000 hectares of forest fell or were damaged, more than twice the area of the Sopron Mountains in Hungary by comparison! In the affected area, there were forests of unmixed species - i.e., almost only one tree species - and of the same age, which could not withstand the adverse weather conditions.

Natural regeneration helps maintain the genetic stock of trees. To some extent, foresters can also help a forest to develop a suitable structure by artificial regeneration with well-chosen seedlings or other propagating material (acorns, seeds).

It is not only the genetic diversity of the species that is important, but also the species diversity of the stand. Mixed forests are also more resilient to extreme weather events and to the increasing incidence of non-native pests. These communities also make better use of available resources and habitat opportunities, are more valuable from a management point of view, and may provide additional timber volume.

MIXED FOREST: *Forest or woodland consisting of different species either between or within specified areas.*

There are also forest areas in the Hungarian-Austrian border region that have been exempt from planned forest management for several decades, i.e., foresters have not carried out any logging or artificial forest regeneration. These areas are called **forest reserves**. In forest reserves, experts periodically carry out surveys of the natural processes of forest structure change. The experience gained here is incorporated into forest management practice.

Image: Forest reserve in the border region with lying dead wood

THE ROLE OF URBAN GREEN SPACES

URBAN GREEN SPACES: *in cities, in the built environment, green spaces are areas covered with green vegetation, overgrown and planted.*

GREEN SPACE: *a category of land use subject to special legislation, a priority area of green space. Green spaces can only be public spaces. These include public parks, public squares, playgrounds, etc.*

Urban green spaces **trap significant amounts of dust and absorb urban noise**. Plants evaporate heat from their surroundings, **cooling them**. They also **provide shade and alter thermal radiation patterns**. Shrubs and trees allow precipitation to infiltrate into the soil over a longer period of time, thus **improving soil water retention**.

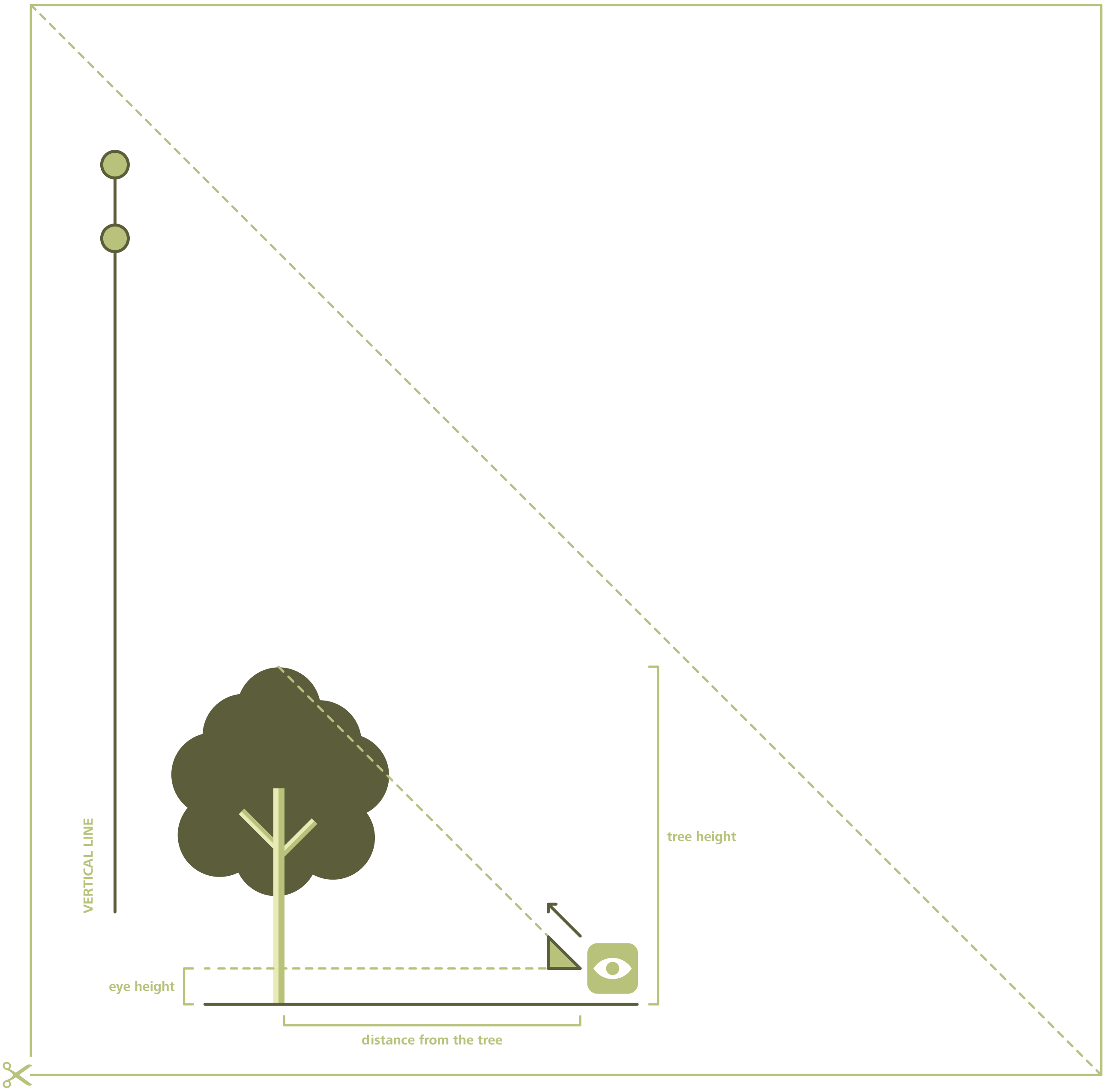
Image: Urban green space

The health of trees in green spaces should be regularly monitored. The responsible experts in the municipality record the data of each tree in a green space register and record the necessary management. Visual inspections are supplemented by instrumental measurements by the tree inspectors, which can be used to detect possible decay in the tree without damaging the tree. The instrument used is the acoustic tomograph, which provides condition data by measuring the speed of sound propagation in the wood body. Static or dynamic root tests can be used to determine how much wind gusts can uproot a tree. If a tree is considered to be a hazard, its crown is fixed, if necessary felled or, if necessary, the whole tree is felled, with the replacement of course being ensured.

Image: Leaf photosynthesis measurement instrument

Image: Acoustic tomography tree scan

The green spaces associated with the city are home to many species, including protected species. Various songbirds, bat species, insect species find a home in our parks, but one of the best-known protected species, the eastern hedgehog, is also associated with these areas. Maintaining, protecting and properly managing urban green spaces is therefore not only important for city dwellers, but also for nature conservation.



MAKING A TREE ALTIMETER

Make the following tree height measuring device. Find the tallest tree you know in your area. How many times bigger than your tallest classmate?

Materials needed

20-25 cm cord length, small weight (larger bead or button), thick straw, tape or glue, pencil to punch holes into the paper

Preparation of the tree height measuring tool

Cut the square along the lines, then fold it in half along the diagonal to make a triangle. Punch a hole into the paper at the two points on the vertical line, then rewire and tie the string so that you have the small weight on the end of the string. Glue the two triangles together, then tape the straw to the fold line.

How to use the tool

Hold the triangle up to your eye so that you can see through the straw and the string is parallel to the vertical line. The tool is on level. Walk backwards or forwards from the tree until you can see the top of the tree through the straw. Measure how far you are from the tree with a step or tape measure, then add your eye level and you get how tall the tree is!

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