Viewpoints

ON ACTIVE FOREST MANAGEMENT

ÖSTERREICHISCHE BUNDESFORSTE

Preamble

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More attention has recently been paid to the forest and just how important it is for humans (both as individuals and society as a whole) than has been done in a long time.

Why? Because of the outbreak of a pandemic, and due to business, politics and civil society all recognising the growing evidence of the urgent need to take action on climate change – both with respect to mitigating its effects and adapting to its consequences.

The interests that various parties have in long-term forest conservation and forest use are extremely diverse, and sometimes contradictory too. They cover the production, long term-availability and future use of wood (Europe's most important renewable raw material), its role in transforming both business and society into a bioeconomy, expanding the competitiveness of the forestry and timber sector and its value chains, the increased need for protection against natural hazards, the growing demand for recreational and leisure opportunities within forests, the promotion of forest biomass and soils as CO_2 sinks, and safeguarding biodiversity in dynamic and highly complex ecosystems. The list could go on and on. It is the job of Austrian Federal Forests (ÖBf) to take into account the various stakeholder groups' interests and needs in the context of managing the Republic of Austria's natural land that falls under its remit, with a view to managing it in a well-balanced way and reaching the broadest consensus possible.

Thrilling political discourse exploring how the areas where humans and nature (in the broader sense) and humans and forests (in the narrower sense) come into contact with one another ought to be developed is taking place at both national and international level. The Austrian Forest Dialogue and the EU Forest Strategy would be the institutional processes that the course of forest policy should be set in.

Should humans backtrack from or actively intervene in the forest in the fight against climate change, or in their efforts to create a bioeconomy? While the EU Forest Strategy takes more of a conceptual approach to large-scale disuse in this controversial issue of forest disuse versus forest use, Austrian Federal Forests is committed to using forests both actively and sustainably. Sustainable and integrative forest management is being practised with the aim of forest conservation.

ÖBf would like to use this publication to emphasise its licence to operate with scientifically reasoned arguments and, in so doing, make a constructive contribution to the political debate. Seven viewpoints were drafted. Reflections and summaries are provided for each of them, using current scientific papers, not to mention federal forest strategies and projects, as a basis. These contributions are made with varying intensity depending on how complex the subject area is and how available research results are. After all, just as the forest doesn't have roles, per se, but is assigned them by humans, the question of how the forest as a natural resource ought to be used in future should also be less ideologically charged and more of an evidence and knowledge-based discussion. In this sense, we consider ourselves responsible and are open to dialogue.

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ÖBf's viewpoints at a glance

Austrian Federal Forests – which is always guided by its goal of stable, climate-fit and vital forest conservation in the long term – would like to use this publication to substantiate its viewpoints on active forest management using results from current scientific work and make a well-founded contribution to the current "forest disuse versus forest management" debate at a European and Austrian level.

Seven areas of interest were selected for this purpose. They form the framework that the challenges between the conflicting priorities of nature, humans and the economy were addressed within.

① Biodiversity

Integrative forestry is conducive to biodiversity. Ecological objectives that promote the diversity of both species and habitats form part of its management models.

② CO_2 sink

Near-natural, sustainable forest management helps to ensure constant tree growth and thus continuous carbon capture in wood. While disused forests do indeed build up larger stocks over a certain time compared to managed forests, sooner or later they reach a state of equilibrium where their sequestration drops because build-up and depletion processes balance one another out.

③ Bioeconomy

The use of wood (a renewable raw material that is available in significant quantities close by) is indispensable in Austria if the economy is to be transformed into a bioeconomy. Diverse and smart material use that keeps wood-based products in the economic cycle for as long as possible takes priority. Wood's thermal recovery processes make a major contribution to the greening of Austria's domestic heat and energy market. In this respect, types of wood for which there are no other higher-quality utilisation options at present take precedence. Research, development and innovation may help with speeding up the substitution of high-energy materials, fossil-based plastic products and fossil fuels. This will help to cut CO_2 emissions and, at the same time, reduce the energy sector's dependence on imports.

④ Jobs *and* Creating value

Job security is being provided to a significant and politically relevant degree in forestry and the downstream value chains. The products and services created are making a considerable contribution to the economic success of all the stakeholders involved, and are leading to direct and indirect tax benefits. Intensifying timber construction may generate significant momentum on the labour market in terms of the bioeconomy.

⑤ Protection forest

Forests provide protection against avalanches, rockfall, mudslides and soil erosion, and reduce the risk of flooding due to their water retention capabilities.

Requirements concerning forest performance in this respect are constantly on the rise, because climate change means rainfall is both stronger and more frequent. At the same time, the protection that forests provide is being compromised and reduced by more frequent and longer drought periods and the insect disasters that follow, not to mention recurring forest fires. These are all threats caused by climate change. Active management of protection forests is absolutely essential to restore, maintain or improve their performance in this regard, and is also a far more affordable and more near-natural response than technical torrent and avalanche barriers.

⑥ Recreation *and* health

Increasing urbanisation has resulted in the clearly noticeable trend of people spending their leisure time in forests for recreational purposes – and this development has only been reinforced by the restrictions on freedom of movement implemented due to the Covid-19 pandemic. Forests offer people a wide range of opportunities and services that will help them improve their personal wellbeing and benefit their health. Most of them are linked to forest development with tracks, paths and trails. Forest owners are responsible in two respects (they are liable as the owners of the paths, and they have to balance various people's interests) and do not receive any payment for this role.

⑦ The forest of the future – *climate-fit forests*

Our forests are hugely affected by the consequences of climate change. Frequent extreme weather conditions (like long drought periods and extreme occurrences such as storms and heavy rainfall) weaken forests and make them more vulnerable to insect damage. The results of such conditions are large amounts of damaged timber and cleared areas. Forward-looking forest management immediately restores the stock in accidentally cleared areas through afforestation. It focuses on tree species, mixtures and origins that are best adapted to both the site and the climate conditions to be expected in the future.

Natural regeneration is actively promoted by means of planting additional vegetation and introducing appropriate maintenance and hunting measures. This allows forests to adapt to climate change more quickly and ensures that forest services are continuously provided.

① Biodiversity

Viewpoint

Integrative forestry is conducive to biodiversity. Ecological objectives that promote the diversity of both species and habitats form part of its management models.

Scientific statements

Measuring Biodiversity

According to Geburek et al. (2015), it is impossible to exactly record or even measure biodiversity in the forest in its entirety. To do that, we need indicators that map as many different stages of biodiversity as possible in a scientifically sound manner. The existence of habitat trees (tree species, number), standing and fallen deadwood (tree species, dimensions, degree of decomposition, number), the genetic diversity of forest trees and the connectivity and fragmentation of forest habitats are frequently cited in the examined literature as being key components in preserving biodiversity in forests (Kraus & Krumm, 2013; Walentowski & Blaschke, 2014; Schmidt, 2015).

A forest biodiversity index (FBI) was devised by Geburek et al. in 2015 at the Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW). This index approximately describes biodiversity in Austrian forests using selected state, pressure and response indicators covering different areas of biodiversity – genetic diversity, species diversity and ecosystem diversity. A list of the indicators and a brief description outlining how to interpret them can be found in the annex. A 60-point FBI – based on all the indicators – was determined for the whole of Austria's federal territory, suggesting a relatively high level of forest biodiversity. A set of 65 sustainability indicators for Austria's forests was developed in 2014 as part of the Austrian Forest Dialogue, in line with the (seven) areas of activity set out in the 2020+ Austrian Forest Strategy, and updated in 2020 to facilitate comparability throughout Europe. Actual and target values (the achievement of which is evaluated in quantitative terms) are defined in the comprehensive indicator report. The "biodiversity in Austrian forests" area of activity is covered by a set of 15 indicators (see the annex). The "protected forests" indicator is particularly worth mentioning, because it is classified according to the specifications set out by Forest Europe and one of the classes is "protection through active management".

Commercial Forest vs. disused forest – a comparison

Central Europe's forests have been systematically changed by silviculture practices since the late 17th century. Virgin forests no longer exist on a significant scale. Even disused forests are directly or indirectly subject to anthropogenic influences like air pollution, climate change or forest fragmentation. Large predators like bears, wolves or lynxes are absent in many places due to human activity. This results in unnaturally high populations of game (red deer, roe deer and wild boar in particular), alongside other factors. So development that is completely free from human impact is not possible, even in forests where there is a ban on use (Dieler et al., 2017; Schulze & Ammer, 2015).

Dieler et al. (2017) discovered that forest management per se does not necessarily have to affect biodiversity adversely. They included 49 studies with a total of 197 comparisons from all over Central Europe in their meta-analyses examining structural diversity between managed and unmanaged forests. The biodiversity of both flora and fauna and forests' structural features were taken into consideration too, as were the silvicultural systems applied, the effects they have on the forest structure and the period that has passed since the forest fell out of use. The biodiversity of managed and unmanaged forests differed only slightly, as long as the disruption caused by management remained moderate too. Here, the silvicultural system applied played a key role (target diameter harvesting regime, permanent forest systems, natural regeneration, etc.). Near-natural silviculture mimics natural disruption through the likes of patch cutting, for example.

Windfall and beetle sites can also be found in managed forests, just like in unmanaged ones. According to Dieler et al. (2017), there are fewer and fewer differences in structural diversity as the observation period lengthens. Structural diversity can even be deliberately promoted at landscape level by implementing a variety of silvicultural measures. Synergy between different stocks (that also include monocultures) is extremely important for forest biodiversity. The focus should be on the spatial level and the heterogeneous nature of resources, which is reflected in the fact that open, closed and differently structured stocks are positioned side by side (Heinrichs et al., 2020). Schulze & Ammer (2015) examine the question of whether forest management is hazardous to biodiversity. Their research in Germany is limited to vascular plants (trees, shrubs and herbaceous plants).

They discovered that, since species loss records began roughly 250 years ago, not a single species of vascular plant linked to forest habitats has been lost in German forests despite management. No species of plant that doesn't also grow in commercial forests has been found in unmanaged forests; conversely, a larger number of endangered species were found in similar managed areas. So, in the final analysis, disuse has no positive effects on vascular plants' biodiversity at least over many decades, during which time protected forest stocks close and form a dense canopy (Schulze & Ammer, 2015).

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The narrow-leaved helleborine is a characteristic species of lime-beech forests

But the picture would change if we were to pay attention to the likes of lichens in addition to vascular plants. As Kraus & Krumm (2013) demonstrate, lichens have the largest number of extinct and endangered species. Whether this is due to management methods or other reasons like air pollution remains an unanswered question.

Scherzinger (1996) illustrates that placing forest areas under protection can also lead to loss of relevant species during the course of generational change (turnover). The reasons for this are random development and what is often the small size of unmanaged areas.

Scherzinger suggests that the greatest possible biodiversity arises precisely from synergy between natural and cultural landscapes, since human intervention can have a positive impact on biodiversity on the one hand, and near-natural stocks can also be monotonous and populated by relatively few species on the other. What is more, productive forest sites tend to have less vegetation diversity because few tree species are extremely dominant. But Scherzinger states that the thesis of proximity to nature equalling biodiversity has been proven wrong, since "habitat heterogeneity" leads to increased biodiversity. Heinrichs et al. (2020) even prove that process protected areas may initially experience a loss of biodiversity compared to commercial forests.

Excessive game populations and selective biting are the main factors behind severe flora depletion, particularly with respect to the diversity of forest regeneration. Fir, which is an ecologically important species, is often entirely absent. Bloated game numbers are also the most important factor affecting the diversity of herbaceous flora over a large area. If hunting measures are inadequate, Schulze & Ammer (2015) believe that the forest could end up poorer in terms of tree species and herbaceous plants.

In commercial forests, certain structures (like very old trees or temporarily large amounts of deadwood) exist to a lesser extent than in virgin forests, which makes species that are dependent on them rare. According to the WWF, for example, Austria's forests are home to around 2,800 forest-dependent species of beetle, 115 of which are relicts of virgin forests that depend on structures typically found there (wwf.at/dasschuetzen-wir/wald/wald-in-oesterreich). Schulze & Ammer are of the opinion that larger, unused areas and alternative protection concepts are necessary if the populations of certain endangered species are to be stabilised. Heinrichs et al. (2020) support this thesis. After just a few decades of disuse, highly specialised species in particular benefit from process protection areas.

The concept of process protection linked with forest disuse was originally conceived as a form of forest use (Sturm, 1993). Common objectives of nature conservation (such as the promotion of rare species, the preservation of communities of native species, or a high level of diversity) are more likely to be maintained as by-products of dynamisation than they would be if they were pursued directly. A current study conducted by Environment Agency Austria illustrates that the strictly protected areas in Austrian national parks are making a considerable contribution to the conservation of what are known as "wilderness species" (Zulka, 2021).

Mature oak forests are the preferred habitat of the stag beetle and the great Capricorn beetle

Promoting and increasing biodiversity in commercial forests

When a silviculture strategy pursues biodiversity and structural diversity, the yield and mortality risks can be spread, forest stability can be increased and ecosystem services can be improved (Walentowski & Blaschke, 2014). Forests with high habitat diversity and biodiversity, not to mention high genetic diversity, are less vulnerable to issues like extreme weather and insect pests and incur lower follow-up costs. So maximum biodiversity is a fundamental goal to aim for in all forests.

The WWF is supporting a six-point programme to improve nature in Austria's forests (Enzenhofer, 2021). The key message on the website suggests that, in forests managed comprehensively and sustainably, humans benefiting from the forest services is not the only plus point – preservation of biodiversity is yet another advantage of this approach. Schmidt (2015) maintains that species typically found in forests are unaware of use and protection concepts. They respond to structures.

Forest managers can significantly promote and strengthen biodiversity by taking the following measures:

- Preserving and promoting natural forest communities
- Growing stable mixed forests
- Promoting oak and pioneer tree species
- Preserving and promoting structural diversity
- Enriching deadwood (standing and fallen)
- Leaving habitat trees
- Leaving softwoods in regenerations and crops, and allowing specimens to grow into older age categories
- Establishing pockets of old wood as stepping stones
- Designing blooming forest edges and roadsides in forests.

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Deadwood provides a habitat for a number of endangered species

ÖBf's activities

The forest biodiversity index for ÖBf land

In 2015, ÖBf tasked the Federal Research and Training Centre for Forests, Natural Hazards and Landscape with using the set of indicators to determine an FBI for ÖBf's land. Its score is 67 points. Yet for methodological reasons, the score refers exclusively to the state indicators and the pressure indicator. The benchmark for Austria as a whole, determined based on this methodology, is 56 points.

Contractual nature conservation

77,692 ha or 9 % of all of ÖBf's land (as at 2021) have been placed under process protection as a result of numerous contractual nature conservation agreements. 31,208 ha of this amount are forests. The protection categories include national parks, nature conservation areas where use is prohibited, wildernesses, core areas of biosphere parks and natural forest reserves.

Strategic long-term "Ecology & Economy" project

ÖBf is developing strategies, concepts and measures based on scientific findings as part of the strategic long-term "Ecology & Economy" project. In this respect, it is relying on longer-term cooperative relationships with NGOs like Birdlife Austria, the WWF, the Austrian Nature and Biodiversity Conservation Union (NABU) and Austria's Environmental Umbrella Organisation. The cooperation is based on mutual appreciation and respect, promotes constructive dialogue among the different user groups, and produces valuable findings. The measures are being implemented on a large scale throughout ÖBf for the purposes of bird conservation (birdlife.at/page/publikationen), for example, and for greater forest biodiversity (wwf.at/artikel/fuer-mehr-artenvielfalt-in-den-waeldern-deroesterreichischen-bundesforste/).

The specific requirements are as follows:

- Leaving five habitat trees/ha final use, leaving deadwood of 25 m³fo/ha on average (result of sample inventories 2017 to 2019: 29 m³fo/ha); planting 150 rare tree and shrub species annually per territory
- AIdentifying biodiversity pockets as process protection areas by 2020 (489 areas across ÖBf land covering 1,034 ha in total)
- Protecting wild bees by planting wild fruit bushes, sowing wild flowers, leaving deadwood structures and promoting certain tree species like willow, poplar and linden trees
- Establishing ecological land use management, where both the preservation and restoration of habitats and species, not to mention process protection, are defined as areas of activity
- Adapting growing targets to the potential natural forest community – taking climate change into account.

The vital process of adjusting game populations to levels that habitats and silvicultural measures can sustain, as described above, forms part of the project too. The implemented measures – leaving five habitat trees, increasing the amount of deadwood, identifying biodiversity pockets and networking habitats – will be evaluated together with Birdlife Austria in the Styria forestry operation starting in 2021. The aim is to assess the impact that these measures have on biodiversity, focusing on birdlife.

Summary

Disuse and alternative protection concepts are required to a limited extent to purposefully protect endangered species with special habitat requirements and to stabilise their populations. The forest biodiversity index score of 60 points calculated by the Federal Research and Training Centre for Forests, Natural Hazards and Landscape for the whole of Austria suggests that there is a relatively high level of forest biodiversity.

Forests that are managed in a sustainable, integrative and near-natural way are highly biodiverse. Forest managers can actively maintain and increase this high level of biodiversity by taking a multitude of easy-to-implement measures.

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② CO_2 sink

Viewpoint

Near-natural, sustainable forest management helps to ensure constant tree growth and thus continuous carbon capture in wood. While disused forests do indeed build up larger stocks over a certain period of time compared to managed forests, sooner or later they reach a state of equilibrium where their sequestration drops because build-up and depletion processes balance one another out.

Scientific statements

Storing carbon in forests

Forests make a vital contribution to climate protection. Trees remove CO_2, a greenhouse gas, from the atmosphere by growing through photosynthesis. Once they've converted it into carbon, they store it long-term in the tree's aboveground and underground biomass, as well as in deadwood, in the litter layer and in the soil. Forest soils can capture CO_2 in the long term if the supply of leaf, needle and root litter, not to mention deadwood residue, increase the carbon stock in the soil humus. Without forests, the atmospheric CO_2 concentration would be 30 % higher (Hasenauer, 2014). Forest ecosystems' storage capacity depends on the site-specific conditions, growth, forest structure and composition of tree species.

Mayer (2021) estimates that there are around 989 million tonnes of carbon stored in Austria's forests. Aboveground and underground biomass (trunk wood, branches and needles, deadwood and roots) account for 41 % of this figure, while 59 % is attributable to humus and mineral soil. Both the total carbon stocks and the distribution of carbon in the individual forest compartments vary a great deal depending on the composition of tree species, the management method, the climate and other local factors (Krüger et al., 2012).

However, the absorbed CO_2 in wood and soil is released again when deadwood decomposes, soil humus is mineralised or forest stocks burn down (Bolte et al., 2021). The carbon sequestration to carbon release ratio determines whether forests are carbon sinks or carbon sources.

Impact that (non-)management has on storage capacity

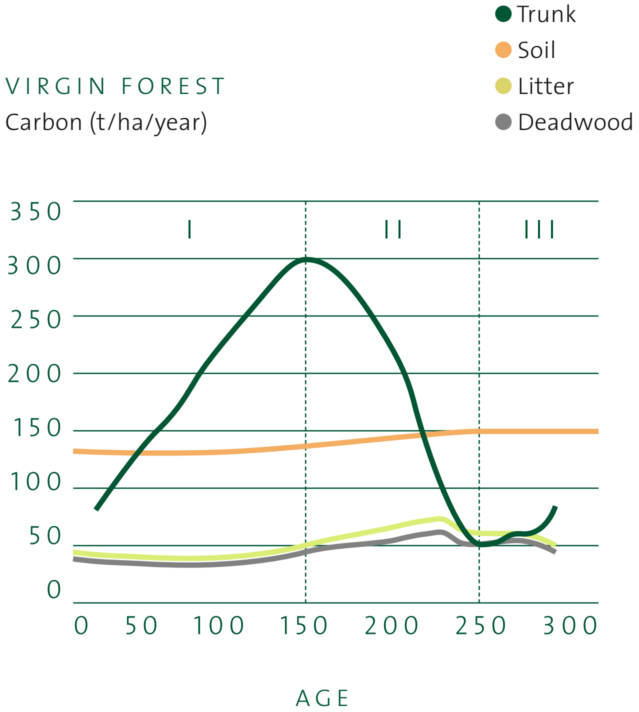
The carbon captured in trees' biomass is at its greatest when the annual growth over the entire area is as high as possible. A mixture of tree species that develop different canopy and root spaces ensures that the trees can use the growth-determining supply of light, water and nutrients in a partly complementary manner. The mixture also promotes increased growth and carbon capture and reduces vulnerability to damage (Bolte et al, 2021). Hasenauer (2014) states that large-scale forest ecosystems that have been undisturbed by human activity for centuries are, on average, in a state of equilibrium where approximately the same amount of carbon is captured as is simultaneously released into the atmosphere through decomposition processes. Figure 1 (A–C) below – which is often used in publications and shows that (in the long term) management leads to higher carbon storage in commercial forests – provides a direct comparison between virgin and commercial forests.

Well-structured mixed forests store particularly large amounts of carbon

A)

VIRGIN FOREST

Carbon (t/ha/year)



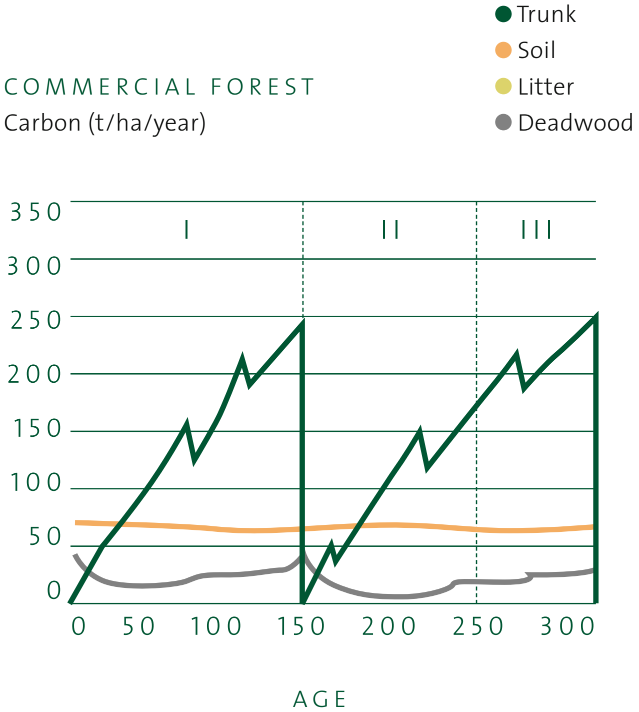
Virgin forest: Carbon constant, full 300-year life cycle, no management, no substitution effects

Fig. 1: Capturing carbon in virgin and commercial forests. Source: Hasenauer (2014)

B)

COMMERCIAL FOREST

Carbon (t/ha/year)



Commercial forest: Carbon captured, 150-year felling cycle, carbon is not released in the forest.

C)

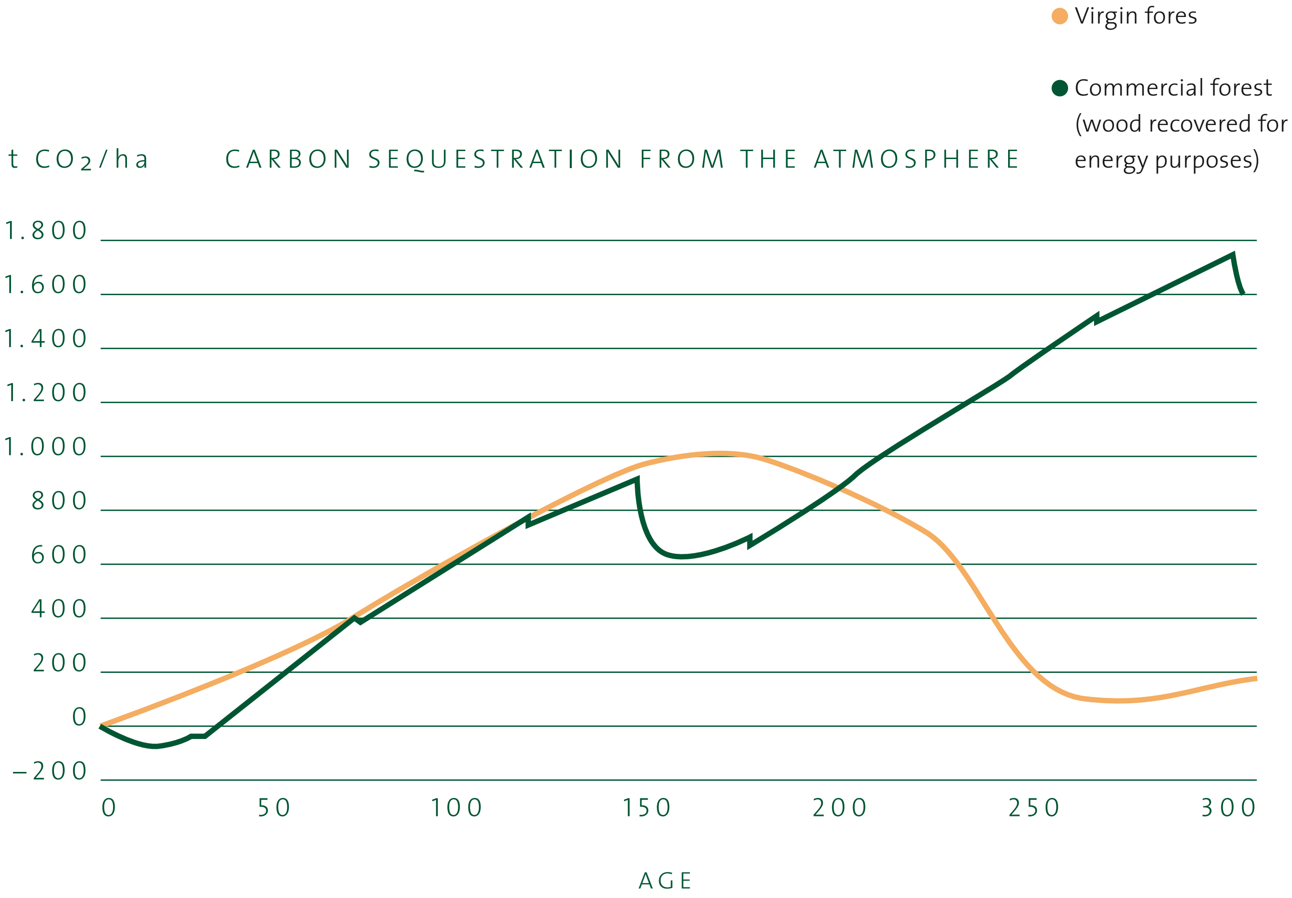


Abb. 1 (A, B, C): Effects on the carbon cycle – a comparison between virgin and commercial forests. Assumptions: 300 ha virgin forest with an ideal distribution of age categories (1 ha = 1 year, etc.), in total over all stocks, no impact on the amount of CO_2 in the atmosphere (CO_2 neutral) and thus no sequestration (carbon release and carbon absorption ±0).

In contrast, 300 ha of commercial forest with an ideal distribution of age categories (1/2 felling cycle means 2 ha per age category) has a positive effect due to substitution effects (energy recovery only, no material use – replacement of fossil carbon, 1 t forest carbon replaces 2.7 t fossil CO_2). The sequestration shown (CO_2 equivalent: green line) is roughly 1,603 t CO_2 in total = 5.34 t CO_2/ha/year. Unlike the virgin forest situation, carbon or CO_2 is not released through decomposition processes (red line); rather, it is harvested and released into the atmosphere during the course of energetic utilisation.

Atmosphere: Here, carbon sequestration by the forest is shown, not the carbon, because it is assumed that the element will be released in the form of CO_2 during the burning process, and it is not included in the graph here. Actual substitution effects when fuel oil is replaced by beech firewood is included. Substitution effects due to the material use of wood and the intermediate storage effects of carbon in wood products are not illustrated. Conversion from carbon to CO_2 is based on the atomic weight in the ratio of 12:44 (C:CO_2).

However, as the scientific calculations for the Bavarian Forest National Park that were cited in a press release show, the stable balance that Hasenauer refers to will only be reached in around 100 years – by which time the carbon stocks in forests will have increased (press release published by the Bavarian Forest National Park on 13 February 2020). A team of researchers has calculated the future CO_2 storage in the Rachel-Lusen area under five different climate scenarios. The strength and frequency of disruptive events like windfall and bark beetle infestations were changed depending on the extent of climate change. The development of the carbon stock in the tree population with all the aboveground and underground components, not to mention in the soil, was observed over the course of 200 years. The simulations revealed that aboveground carbon storage increases by 40 to 100 % over the next 100 years, while underground carbon storage rises by 10 % over the next 50 years.

Compared to the starting value from 2012, the carbon stock stored in this way increases significantly during the period under review. At present, Austrian forests' average stock is about 350 m^3 fo of wood per hectare – well below the 500 to 700 m^3 fo found in Central Europe's virgin and natural forests (Huber et al. 2021). So there is still considerable potential with respect to the storage volume. In scientific terms, an increase in this volume is known as "proforestation".

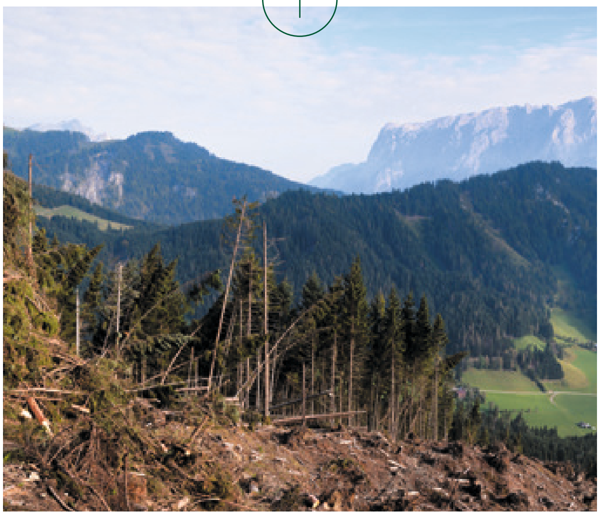
Luyssaert et al. (2008) also use their model calculations to demonstrate that temperate and boreal forests that are 200 years old or older still store an average of 2.4 ± 0.8 t carbon per ha annually. Around 16 % is bound in the trunk biomass, and 31 % in branches, needles and deadwood. Hence, roughly 54 % of the carbon is captured in roots and organic soil matter. Although the biomass continues to increase over centuries, Luyssaert et al. (2008) observed a certain degree of age-related decline in growth once trees hit the other side of 80 years old.

According to Bolte et al., old, stock-rich forests have a high carbon sink capacity in the tree biomass and the soil. This can be maintained for a long time through careful management, sparing use and ongoing (re)forestation or improved permanent forestation.

However, the younger forest stocks that experience high annual wood growth usually provide greater carbon sequestration. The data that the National Forest Inventory compiled for the whole of Germany reveals, for example, that annual growth for forests that are 21 to 40 years old is twice as high as for forests that are over 140 years old (Bolte et al., 2021).

Older and taller populations with high timber stocks are generally more vulnerable to biotic and abiotic risks like wood-decay fungi, bark beetle and windfall (Schulze et al., 2021). Forests created after large-scale disruptive events like fires or windfall can become sources of CO_2. This is particularly true when disruptive events lead to an increased rate of deadwood, litter and soil organic matter decomposition that exceeds the carbon build-up during regeneration (Luyssaert et al., 2008).

Windthrow area in Pongau forestry unit



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The management method has an influence on the storage capacity and, consequently, substitution effects too. If forest use is intensified (e.g. if stocks are reduced due to the felling cycle being shortened), the carbon sink of the forest's living biomass decreases, while the carbon stored in wood products increases. If larger quantities of wood are available, material and fuel substitution both increase too. By contrast, if use is extensified, the stocks in the forest increase over a certain period and carbon is stored in the living biomass and deadwood. This is then followed by an equilibrium and decay phase. But, for this, less or no carbon is transferred to the wood product sink, and thus fewer or no effects of material or energy substitution are achieved (Klein & Schulz, 2011).

Impact that climate change has on the carbon storage capacity

Mayer (2021) suggests the following as the potential negative effects that climate change is having on forests' ability to store carbon:

> Reductions in growth caused by long drought periods, and thus a reduction in carbon capture in the wood

> Accumulation of large-scale events that are disruptive to forests, such as fires, windfall, drought damage and insect infestations, and thus increased amounts of damaged timber and fewer stocks (due to an increase in extreme weather)

> A rise in the soil temperature (on the disrupted land, due to the lack of shade), and considerable carbon release (due to increased microbial breakdown activities)

> Generally increased micro-organism activity (due to the soil heating up), and thus greater amounts of CO_2 are released into the atmosphere.

The positive effects that climate change might have (e.g. due to the forest boundary moving upwards) are irrelevant in this context given the low impact this has on the carbon storage capacity.

Impact that climate change and the management method have on the carbon storage capacity

The large-scale CareforParis project funded by the Climate and Energy Fund yielded significant and, accordingly, highly regarded findings. They were described in individual posts by various authors in a comprehensive information release published by the Federal Research and Training Centre for Forests, Natural Hazards and Landscape. For six different management scenarios in Austrian forests, the aspects examined include how the CO_2 balance could develop up to the year 2150 under different climatic changes and adaptation strategies (see Figure 2). The description of the scenarios used can be found in the annex.

Reference (RCP 4.5)
Reference (RCP 8.5)
Disasters (RCP 8.5)
Shortening of felling cycle (RCP 8.5)
Tree species changeover (RCP 8.5)
Stock build-up (RCP 8.5)

Figure 2: Yearly change in forest's total carbon pool (aboveground and underground biomass, deadwood and soil carbon). Source: Ledermann et al. (2020)

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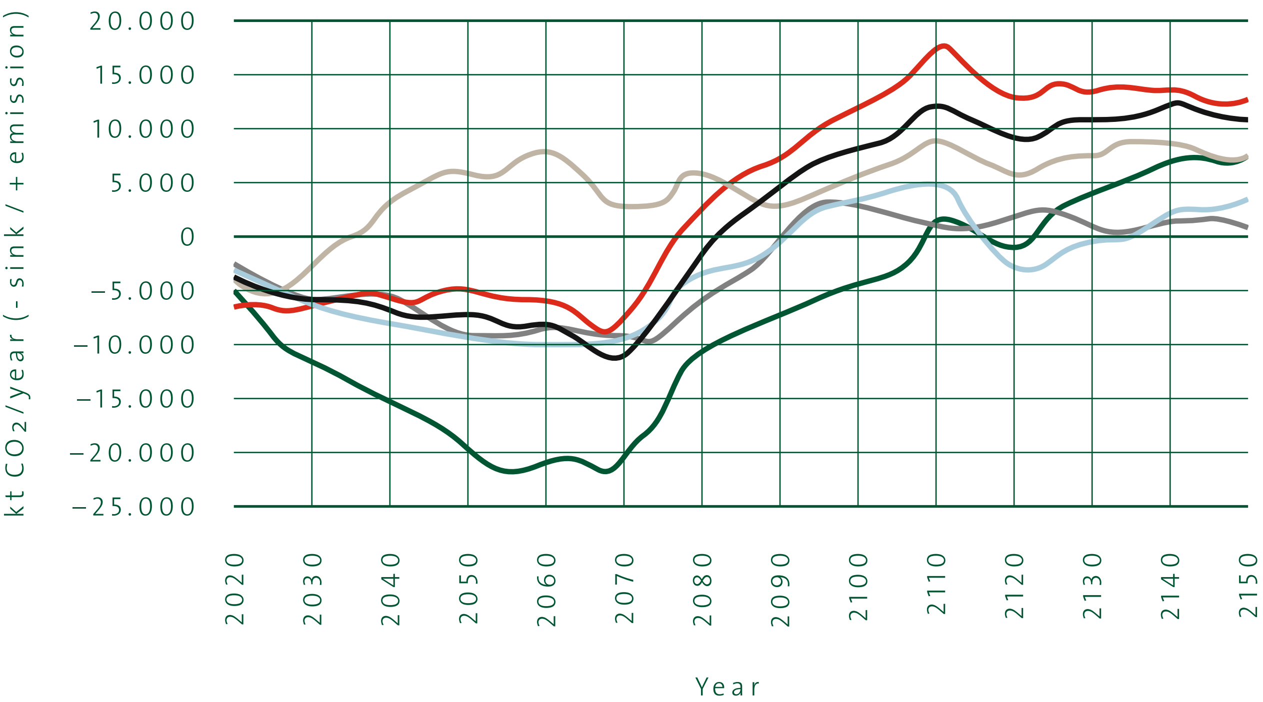

Accordingly, Austria's forests will still be a net CO_2 sink in the coming decades. But this will happen sooner or later depending on the scenario (Ledermann et al., 2020). When exactly varies considerably depending on the management method. If the felling cycle is shortened, this will happen after just 15 years; in the "stock build-up" scenario, the forest will only become a source of CO_2 after around 90 years. With the exception of the "shortening of felling cycle" scenario, the sequestration increases until 2070 under all scenarios, but then it rather abruptly reverses and subsequently switches relatively quickly to becoming a CO_2 source. This behaviour is attributable to the fact that, in Austrian forests, preference is given to use in locations with favourable yields, which is why the ongoing growth rate declines from the year 2070 onwards. Climate change is then the main explanation for the decline in growth from 2100 onwards (Ledermann et al., 2020).

The best conditions for capturing carbon during growth – and at the same time for adapting forests to climate change – are closed, often mixed, ecologically stable forests grown in line with local conditions. Such stock build-up is often achieved in managed forests, where the stock density and mixture are controlled so that trees have optimum growing conditions (Bolte et al., 2021).

ÖBf's activities

Since 2010, as part of its climate protection strategy ÖBf has been calculating its forests' sequestration each year in line with the international standard using the gain-loss method. This sequestration is the result of the positive balance of carbon sequestration through annual wood growth and annual timber harvesting due to use. The net sink was around 1.1 million t CO_2 on average over the last decade. The aim is to maintain and, if possible, increase the total existing sink, storage and substitution potential on balance by upping growth, stock and use.

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Summary

In scientific discourse, the crucial points for evaluating the forest's carbon sequestration lie in determining the period under review on the one hand and taking substitution into account on the other.

The carbon stock can be increased temporarily by shutting down commercial forests. But the level and length of time for which this increased stock level can be maintained while the climate is changing is unclear, and depends, among other things, on the disruptive regimes that become more intense under climate change. Considerable sink benefits can be demonstrably achieved even in sustainably managed forests.

Efficient use of wood is at least as important as, or even more important than, viewing forests as "carbon pools". This is because CO_2 is still bound in wood products. What is more, wood can be used to replace high-energy materials and fossil fuels themselves.

③ Bioeconomy

Viewpoint

The use of wood (a renewable raw material that is available in significant quantities close by) is indispensable in Austria if the economy is to be transformed into a bioeconomy. Diverse and smart material use that keeps wood-based products in the economic cycle for as long as possible takes priority. Wood's thermal recovery processes make a major contribution to the greening of Austria's domestic heat and energy market.

In this respect, types of wood for which there are no other higher-quality utilisation options at present take precedence. Research, development and innovation may help with speeding up the substitution of high-energy materials, fossil-based plastic products and fossil fuels.

This will help to cut CO_2 emissions and, at the same time, reduce the energy sector's dependence on imports.

Scientific statements

Both bioeconomic and climate protection demands can be met if wood, as a raw material, is continuously provided in a sustainable and reliable manner. Since carbon is stored in forests on the one hand – see viewpoint 02 ("CO_2 sinks") – and in wood products on the other, they make a key contribution to climate protection (Braun et al., 2020).

Storing carbon in timber products

Wood that doesn't rot in forests because it is used in buildings, furniture and other products, and that therefore releases the bound CO_2 again, acts as an "external storage system" for carbon; about 920 kg of CO_2 is bound in 1 m3 of wood. Material use delays the natural carbon cycle. It prevents CO_2 from being released into the atmosphere in the medium term at least (Hasenauer, 2014). Schellnhuber (2021) underlines just how hugely important forests and woods are in tackling the climate crisis by way of his current appeals entitled "Reforesting the Planet" and "Retimbering the City". Wooden buildings in particular are long-lasting and store carbon in large quantities. Backed up by scientific statements and shaped in slogans like "Holz nützen – Klima schützen" ("Use wood – Do the climate good"), this message is also communicated in campaigns and on ProHolz Austria's own website, www.holzistgenial.at (proHolz 2021).

Solid wood house in Sankt Johann in Pongau

Substituting energy-intensive raw materials and fossil fuels

Wood is normally used as part of a cascading process, at the end of which thermal recovery takes place and the ash is then subsequently thrown into landfill or composted (Hasenauer, 2014; Schellnhuber, 2021). The use of wood means that materials like steel, concrete, bricks and plastic, not to mention material composites made of these materials and produced (previously) using high amounts of mostly fossil energy, can be replaced (material substitution). Wood can be used for energy generation purposes at the end of its product life. It is therefore a substitute for fossil resources like natural gas or crude oil (energetic substitution). Fossil fuels have a higher calorific value than wood, which is why more carbon has to be consumed from wood than from fossil fuels to achieve the same energy performance (Schulz & Klein, 2011). Despite this, energy substitution also relieves the pressure on the atmosphere, since less CO_2 bound as carbon in fossil fuels for millions of years is released, and it is replaced by sustainably managed wood, which is a renewable resource (Bolte et al., 2021). According to Weiß et al. (2020), the emissions avoided per harvested m^3fo of trunk wood from Austrian forests is currently around 0.46 t CO_2 equivalents on average. What is more, there is an average of 0.14 t CO_2 equivalents due to the associated net increase in the wood product pool ("net" because wood products are also disposed of at the end of their lives). Substitution plus "external storage" thus add up to 0.6 t CO_2 equivalents per m3fo of trunk wood harvested. This value can be changed, and is higher the more durable wood products are made from the wood used, the longer the wood products are used and the more energy-intensive the manufacturing process for the substituted products is. Efficient use of resources and a long life are also important for wood products to improve their greenhouse gas balance (Weiß et al., 2020).

When providing wood for thermal use, care must be taken to ensure that the extraction of biomass does not lead to the degradation of the forest site. Branches, brushwood and leaves (the main nutrient carriers for trees) should remain in the forest to ensure that the sites remain productive (Hasenauer, 2014).

Since fossil fuels are used to operate engines (a process for which there are next to no alternatives), greenhouse gases are also released during wood production – albeit to a much lesser extent than in the provision of other raw materials. The average emissions generated during the production of one solid cubic metre of wood in Austria were examined for the first time at the University of Natural Resources and Life Sciences (BOKU) as part of a comprehensive project. Under the title "TILCA – an ecological audit of wood supply from the forest site to the mill, taking new technologies into account", the team of researchers examined the entire life cycle of Austria's most important renewable resource – from growing forest plants, to accepting wood at the mill – and prepared a life cycle assessment. Kühmaier et al. (2021) discovered that, in Austria, 26.18 kg/m^3 CO_2 equivalents on average are emitted for supplying wood from the forest site to the mill.

Biomass determined for thermal utilization

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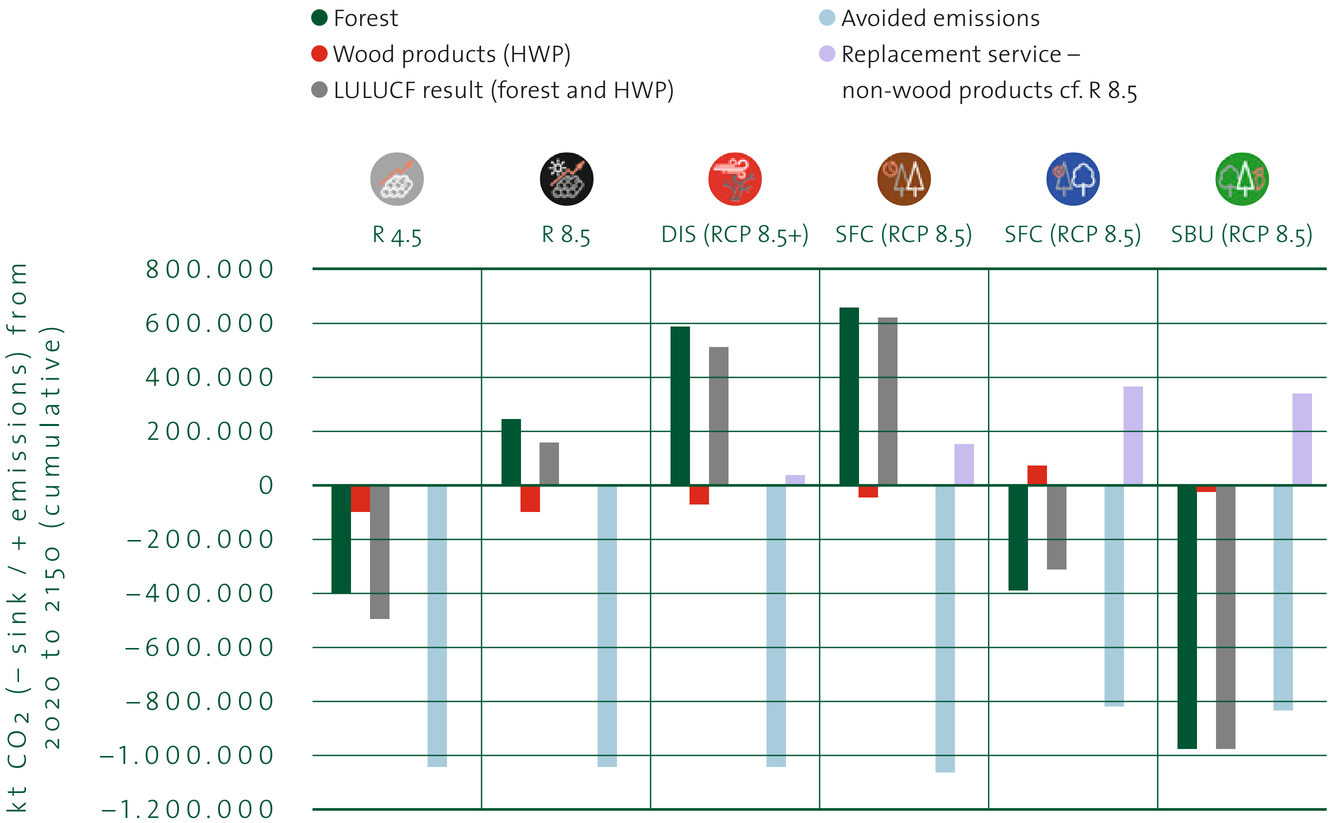
Around 920 kg of CO_2 equivalents are stored in 1 m^3 wood – with the ratio thus being 1:35. So the wood supply process can definitely be described as climate-friendly. But the study still showed that there is potential for improvement. Road transport has the most to offer within the supply chain. Savings in CO_2 emissions can be achieved by shortening transport distances, increasing rail's share of the transport mix, cutting fuel consumption and using non-fossil fuels.

Modelling in the careforparis project

In the CareforParis project, one of the aspects examined was the greenhouse gas effect of Austria's forest-based sector. It was analysed using six different scenarios: two reference scenarios with different climate models, and the scenarios of increased disasters (DIS), greater use due to shortening the felling cycle (SFC), tree species changeover (TSC) and stock build-up. Details of the scenarios used can be found in the annex. As shown in Figure 3, the results were interpreted for the forest (green bar), harvested wood products (HWPs, red bar), forest plus HWPs (grey bar) and avoided emissions due to wood products throughout the entire life cycle (dashed blue bar). Necessary fossil emissions compared to the reference scenario if wood products are eliminated due to a reduction in use or for other reasons (dashed purple bar) were also calculated (Weiß et al., 2020).

It is clear that, under the assumptions made, the forest may become a significant source of emissions over the period under review until 2150 and, so, the approach of replacing abiotic raw materials with wood products and the emissions avoided in this way have the most to offer within the forest-based sector for climate protection purposes (Weiß et al., 2020).

Figure 3: Cumulative emissions (+) or sinks and avoided emissions (−) resulting from the scenarios in the simulation period from 2020 to 2150. Source: Wei et al. (2020)

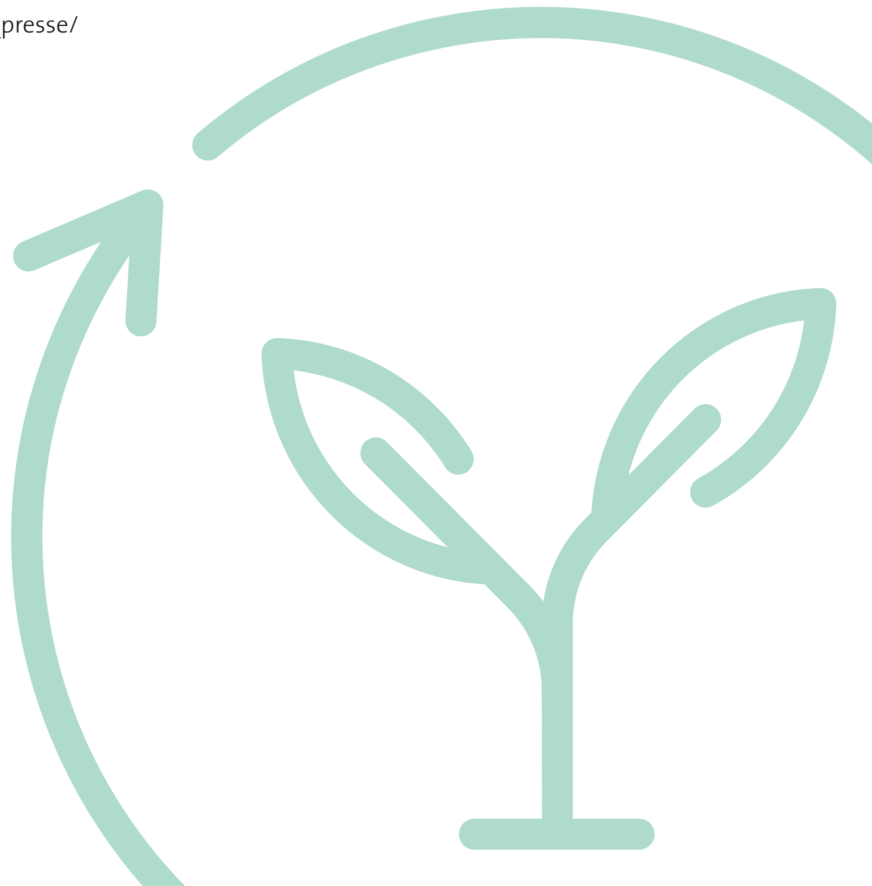


If atmospheric CO_2 reduction measures are discussed, the increase in the timber stock in disused forests and the associated sequestration are often cited as arguments in favour of disuse. However, Wei et al. (2020) believe that a strategy like this is unproductive for several reasons. This is because the wood products that are no longer used have to be replaced by products made from other materials. If people were to stop using wood throughout the whole of Austria, additional fossil greenhouse gas emissions amounting to 12 million t CO_2 equivalent per year would be produced immediately.

This equates to roughly 15 % of Austria's annual greenhouse gas emissions at present. Additional sinks would be absolutely vital to completely neutralise the additional fossil CO_2 in the atmosphere. An ageing forest only compensates for the lack of wood harvesting to some extent, and steadily less so until the sink ultimately comes to a complete standstill due to the build-up and decomposition processes in the forest balancing one another out (Weiß et al., 2020). There is also a risk of the sequestration being lost or reduced due to the consequences of climate change.

ÖBf's activities

Since 2021, ÖBf has been actively involved in the "Waste2Value" research project led by BEST – Bioenergy and Sustainable Technologies GmbH – to promote the development of non-fossil fuels. In both theory and practice, it addresses the production of biofuels from residues such as woodchips, sewage sludge and industrial residues (best-research.eu/de/news_presse/news_aktuell/view/342).



Summary

There are limits to carbon storage in the forest. Climate change means it is highly unlikely that Austria's forests will be able to maintain their carbon sequestration in the long term.

So the strategy for decarbonising society in the long term and successfully transforming the economy into a bioeconomy must focus on substitution. Products with a large carbon footprint must be replaced by intelligent, innovative products and energy sources made from wood (a renewable raw material). But for this to happen, sustainability and proximity to nature in forestry management are both absolutely essential, as is the attempt to keep products in the materials cycle for as long as possible.

Forest disuse only relieves the pressure on the atmosphere to a lesser extent and only for a limited period of time.

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④ Jobs *and* creating value

Viewpoint

Job security is being provided to a significant and politically relevant degree in forestry and the downstream value chains. The products and services created are making a considerable contribution to the economic success of all the stakeholders involved, and are leading to direct and indirect tax benefits.

Intensifying timber construction may generate significant momentum on the labour market in terms of the bioeconomy.

Scientific statements

Forests cover almost 48 % of Austria's land area. With around 4 million ha of forest area, Austria is one of the most densely forested countries in the European Union. Austria's forests and sustainable forest management practices form the foundation of a diverse and complex value chain. As part of two recently published studies, the importance of Austria's forestry and timber sector was examined with regard to employment effects and economic relevance. The results reported by Kleissner (2021) – in a study commissioned by the Economica Institute for Economic Research on behalf of the Association of the Austrian Timber Industry – and Sinabell & Streicher (2021) differ slightly in that the areas of the value chain under review were marked out differently (see the annex for details).

Jobs

The wider forestry and timber industry employed around 176,300 people in 2019, which was equivalent to a 3.9 % share of Austria's entire employed population (Kleissner, 2021). Sinabell & Streicher (2021) determine a figure of 167,875 employees for the entire forestry and timber cluster (core area and sectors that have close ties, as well as other industries). This corresponded to a 4.0 % share of all those in employment. In addition to employees working in the private sector, there are other human resources employed in public administration, in several interest groups (Chambers of Agriculture, Land & Forstbetriebe Österreich, the Chamber of Commerce

Wood harvesting in the Wienerwald biosphere reserve

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and their professional associations), and in research and development, not to mention in specialised training facilities like the Kuchl Technical School for the Wood Industry, the Federal Higher Technical Institute for Forestry in Bruck an der Mur and the University of Natural Resources and Life Sciences. According to Kleissner (2021), around 300,000 jobs are being safeguarded along the entire forestry and timber industry's value chain. So one in 15 jobs is attributable to the forestry and the timber industry. This figure is used in widespread communication too, by the likes of proHolz Austria (2020).

One particular economic advantage of the forestry and timber industry is that it creates jobs in rural areas and regions with weak structures. It is not without reason that Sinabell & Streicher place the evaluations of employment at regional level at the very core of their observations. For the first time ever (!), they are determining how many Austrian residents are actively employed in the forestry and timber industry cluster at district level. This cluster accounts for 4 % of all 94 districts on average. In many districts, it accounts for more than one in ten jobs, making it one of the most important (or even the most important) employer in the district. This is also illustrated in map form (see Figure 3). In Hermagor, St. Veit, Murtal and Waidhofen an der Ybbs (the dark green districts), 10 % and more of the jobs are allocated to the core area of timber and sectors that have close ties to it.

Value creation and tax benefits

Figures on the economic relevance of Austria's forestry and timber sector can be found in the Kleissner (2021) study. The companies that operate within the forestry and timber industry generated direct gross value added of EUR 11.3 billion in 2019, thus representing a 3.2 % share of Austria's total economic output. Looking at the forestry and timber industry's entire value creation network, gross value added in excess of EUR 20 billion was achieved in 2019. The forestry and timber industry therefore generated every seventeenth euro of Austria's gross value added.

The forestry and timber industry made a key contribution to the federal budget and social security institutions in 2019, directly and indirectly generating EUR 8.7 billion in taxes and duties.

The timber industry prepares wood as a raw material for many other sectors, trades and industries. This makes wood the starting point for many other uses. Every euro generated in the timber industry is the trigger for another 90 cents in turnover in Austria's economy. One harvested solid m3 of wood with an assumed average revenue of EUR 55 creates value of up to EUR 673 in a refined, further processed form.

ÖBf's activities

ÖBf employs more than 1,000 staff at a total of around 100 sites spread throughout Austria. By doing so, it is ensuring a regional presence and safeguarding jobs in rural regions. Since the public limited company was established in 1997, it has contributed around EUR 550 million to the federal budget in dividends, usufruct fees and income taxes. The municipalities received around EUR 1.5 million in real estate taxes and more than EUR 2 million in municipal taxes in 2020.

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Summary

If you widen the forestry and timber industry cluster's value creation boundaries, it provides employment for more than 300,000 people in Austria.

The major economic advantage is that the jobs can also be found in rural regions that often have weak structures; they aren't limited to the central regions. The value creation effect triggered by one harvested solid m3 of timber can achieve revenue that is on average more than 12 times higher. The federal budget and social security system benefit from the sector's economic clout too.

5 Protection forest

Viewpoint

Forests provide protection against avalanches, rock-fall, mudslides and soil erosion, and reduce the risk of flooding due to their water retention capabilities. Requirements concerning forest performance in this respect are constantly on the rise, because climate change means rainfall is both stronger and more frequent.

At the same time, the protection that forests provide is being compromised and reduced by more frequent and longer drought periods and the insect disasters that follow, not to mention recurring forest fires. These are all threats caused by climate change. Active management of protection forests is absolutely essential to restore, maintain or improve their performance in this regard, and is also a far more affordable and more near-natural response than technical torrent and avalanche barriers.

Scientific statements

Almost 48 % of Austria's land area is covered by forest. Of the more than 4 million ha of forest, 1.25 million ha (roughly 31 % of the forest area) are categorised as protection forest. ÖBf currently manages approximately 510,000 ha of forest area, around 154,000 ha (or one third) of which is classified as protection forest too. 339,000 ha are commercial forests; the rest are non-forested areas like forest roads and timber storage yards. The protection of human settlements and infrastructure is absolutely vital in mountainous regions. But protecting a site from the elements (wind, water or gravity, for example) is also a service in demand in the lowlands, on the likes of shifting sand soils. Given its ability to retain water, the forest also prevents the risk of flooding. The demands placed on the protection forest's performance increase as more tourist developments are created and inhabited areas are expanded. Developments are moving ever closer to areas categorised as protection forests. At the same time, global warming is increasing the likelihood of extreme and stormy weather and, therefore, the potential for risk (Hildebrandt, 2006). This is why science always focuses on analysing which forest management method efficiently enables high forest protective performance in the long term (Rammer, 2015). In 2020, a protection forest centre was set up at the forest campus in Traunkirchen to raise awareness, pool knowledge and transfer technology. This endeavour involved four cooperation partners: the Austrian Federal Ministry of Agriculture, Regions and Tourism (BMLRT), the Federal Research and Training Centre for Forests, Natural Hazards and Landscape, ÖBf and the University of Natural Resources and Life Sciences.

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The protection forest protects the Hallstatt World Heritage Site from mudslides and rockfall

Targeted forest management

Active forest management in protection forests can be adapted to the targeted protective performance. Certain adjustments to the silviculture approach and maintenance measures may enhance the desired protective effects. Yet in many cases, the crucial success factor is regulating game populations, as also demonstrated by votes taken in the context of the forest and hunting dialogue.

The number, type and diameter of trees that the forest management method can control are the determining factors in the forest's protective capacity against rockfall. Dorren et al. (2005) argue that the protection a forest provides is essentially determined by the number of trunks, the average chest-height trunk diameter (CHD) or the diameter distribution. This also involves selecting suitable tree species that have high wound healing capabilities and can absorb as much kinetic energy as possible, both as individual trees and as part of the stock. These questions have been explored in many projects, rockfall experiments and simulation models (Dorren et al., 2005; Kalberer, 2006; Gerber, 2019).

Natural spruce forest protects against rockfall

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The experiments conducted by Dorren et al. (2005) revealed that large trees are not the only things that make a rockfall protection forest effective. Well-structured tree populations with a wide range of diameters and a mosaic of different forest development phases provide the best protection against rockfall too. Deciduous trees like beech and sycamore can absorb more energy when stone comes into contact with trees than conifers can. Species of tree that have robust and resistant bark (maple, larch and pine) offer better protection than pure spruce forests since they have a high healing capacity. Rammer (2015) explicitly addresses the contrast between managed and unmanaged forests.

He developed a rockfall model that can be used to simulate individual trajectories, and then linked it to a model of a forest ecosystem that enables dynamic simulation of managed and unmanaged forest stocks. After many tests, the connected model was applied to a 40-ha area in the Austrian Alps. The long-term effects of different management strategies on both rockfall protection and wood production indicators were analysed. In total, over the 100-year simulation, the management methods that were specifically designed with the forests' protective performance in mind continually delivered the best protective performance. While the scenario for forests that were not actively managed showed good protective performance at the start of the simulation, this declined towards the end of the century.

A Swiss example demonstrates that management measures can even render investments in technical protection superfluous. The performance of both the forest and other biological protection measures was determined using calculations in a protection forest on a mountain pass road in the Lower Engadine region. It was clear that no rockfall nets were needed on around half of the approximately 400 m long stretch affected. They were only required where the forest was thinned (Fitze, 2015). When it comes to the water balance, plant cover and soil are the determining factors. Plants stabilise the soil through their network of roots, which develops their storage capacity depending on what type they are. This reduces the formation of runoff and lowers the risk of flooding during rainfall. The impact of interception is basically similar, but on a much smaller scale. The more water that is retained by needle, leaf and bark mass through evaporation, the smaller the runoff into the soil (Hegg, 2006). So forests in channel areas make a marked contribution to protecting against floods and gravitational processes (Lechner et al., 2015).

Markart et al. (2006) come to very similar conclusions. They have studied and analysed forest vegetation's hydrological performance in numerous torrent drainage basins in the Eastern Alps. The forest structure and the composition of tree species have a major influence on interception performance, water runoff and protection against soil erosion after rainfall events. Closed forests deliver a higher interception performance and provide more effective protection against soil erosion. A multi-layered structure of mixed forests of different ages, herbaceous plants, moss layer, humus layer and mineral soil slows down the formation of runoff. The flood peak during heavy rainfall is significantly delayed and far lower in forest drainage basins, and the tendency towards landslides taking place is considerably reduced. The Swiss Institute for Snow and Avalanche Research (SLF) also provides important insights for forest management. The share of wintergreen tree species should be 50 to 70 % as a bare minimum, because some of the snow lands on the treetops, where it is not available to form avalanches. The SLF has developed its very own software package, RAMMS (Rapid Mass Movement Simulation), to simulate natural hazards and assess the impact of protective measures.

Forests in channel areas make a marked contribution to protecting against floods and gravitational processes

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The value of the protection forest

Technical replacement measures are required if the green infrastructure mentioned can no longer adequately deliver its expected performance. The value of protection forests can be derived from the costs spent on building and maintaining them. But putting figures on the costs isn't all that easy. Science works with different technical useful lives and takes different barrier construction techniques into account. The Protection Forest Action Programme mentioned states that technical measures that are more than 100 times as expensive as natural forest protection are required to achieve the protection forests' current level of protection.

According to Gasperl (2014) and Reiterer (2012), the costs incurred in constructing a technical avalanche barrier are approximately EUR 300,000/ha. The total service life is assumed to be 100 years. An avalanche protection forest delivers this performance and represents an economic value of approximately EUR 3,000/ha/year. Hildebrandt (2006) quotes costs of between 160,000 and EUR 500,000/ha for barriers against sliding snow and avalanches. Since the costs are so high, they should only be used in priority object-protection forests.

Fitze (2015) states that the construction costs for rockfall nets in Switzerland are CHF 2,500/m. The Swiss Confederation, the cantons and the municipalities have been promoting protection forest maintenance to the tune of around CHF 150 million per year since the 1990s. Fitze believes that this money is well invested. He estimates the protection forest's economic value to be CHF 4 billion per year. The comprehensive "Value of Nature" study (Getzner et al., 2020) prepared for ÖBf contains highly sophisticated calculations. Table 1 contains the derivation of the annual production costs per ha for individual technical measures designed to replace the protection forest's performance. Compared to the annual costs for afforestation and maintaining a protection forest (EUR 1,440/ha), according to this calculation the wooden snow bridges (that mainly protect against avalanches) and steel nets (that mainly protect against landslides and rockfall) are five times as costly at around EUR 7,000/ha (see Table 1 for the calculation); other technical measures are even more expensive here.

Construction of steel avalanche barriers

Table 1: Production costs for technical measures to replace the protection forest's performance (price basis: 2015), Source: Getzner et al. (2020)

	Steel snow bridges	Rock shed[a]	Steel nets[b]	Snow nets	Wooden snow bridges[b]	Afforestation
Average manufacturing costs (EUR per unit or running metre)	1,100	15,000	500	1,400	250	40,000
Necessary quantity (per hectare)	600	100	600	600	600	1
Manufacturing costs (EUR per hectare)	660,000	1,575,000	315,000	882,000	157,500	40,000
Planning costs (share of manufacturing costs)	5.00 %	5.00 %	5.00 %	5.00 %	5.00 %	5.00 %
Planning costs (EUR)	33,000	78,750	15,750	44,100	7,875	2,100
Maintenance costs (share of manufacturing costs)	0.50 %	2.00 %	0.25 %	0.50 %	1.00 %	1.50 %
Manufacturing costs (EUR per hectare, calculated over 80 years[c], incl. replacement investments)	660,000	1,575,000	315,000	882,000	315,000	42,100
Present value of production costs (EUR per hectare)	875,942	3,400,018	374,407	1,170,578	410,188	79,025
Production costs (EUR per year and hectare, annuity)	15,959	61,944	6,821	21,327	7,473	1,440
Ratio of production costs for the afforestation measure[d]	11	43	5	15	5	–

Assumptions for the calculation:

Required interest rate: 1 %. The production costs are determined as a result of the calculation of the respective annuities; this takes into account the total costs over time (construction, planning and maintenance costs) in relation to the technical lifetime.

a) Basically protects one hectare, but also has effects on larger areas above.

b) Wooden snow bridges and steel nets are technically the most suitable measure to directly replace the forest's protective function.

c) The technical lifetime of selected measures is assumed to be 80 years at most; to ensure comparability it is assumed that measures with a shorter technical lifetime (e.g. wooden snow bridges) are new builds. The assumption in the calculation of an 80-year life time also corresponds to the assumptions of an 80-year felling cycle in the "intensification of forestry" scenario (see section 2.2). If the planning horizon is assumed to be 100 years, new installations will be built as needed; this makes hardly any difference in terms of planning not only due to the assumed discounting, but also due to the substantial forecast uncertainties that become apparent.

d) Other influencing factors that increase the need for technical barrier construction in the future (such as climate change and the potentially associated, large-scale and short to medium-term changes to the composition of tree species, which goes hand in hand with a decline in the protective function), are not taken into account in this situation because they do not influence the differences between the status quo and the hypothetical reference scenario.

Negative Influences of climate change

Both forestry and society are facing the paradoxical situation where climate change is increasing the need for forests to provide protection, and at the same time is reducing their ability to do so. Bebi et al. (2012) address the development of and performance delivered by protection forests under the influence of climate change. They learned that increased surface roughness caused by young trees or fallen wood (deadwood) in potential avalanche starting zones can make a very valuable contribution to preventing forest avalanches and particularly to reducing avalanches' reach. They also observe that the presence of advance regeneration was very important for achieving the best possible protective performance in the windfall areas examined. Natural regeneration of decaying wood might have started 20 years after the storm, but hasn't yet contributed considerably to increasing the protective performance on the land examined. This suggests, in general terms, that actively introducing advance regeneration in the protection forest or artificial afforestation is essential.

Large-scale disruption that can be caused by windfalls, bark beetle disasters and fire pose a particular threat to the protection that the forest provides. But bloated clovenhoofed game numbers, forest pastures and, subsequently, thinning and overgrowing with grass are also significantly instrumental in reducing the protection that forests offer (Hildebrandt, 2006; Bebi et al., 2012). The dryer and warmer summers to be expected in future increase the risk of mass propagation of the bark beetle and of forest fires, even in protection forests at higher elevations. We should expect an increase in the damage that sliding snow and snow breakage cause in protection forests over the coming decades.

Thinned and grassy forests provide little protection against natural phenomena like avalanches

Actively promoting protective performance

Both silviculture and hunting measures are required if a forest's protective performance is to be maintained, improved or restored. Such action has to be adapted to the site in question, the protective purpose and the general conditions. Temporary, transportable barriers are often required too. Potential silvicultural measures that aim to avoid different damaging events and, in many cases, also produce multiple benefits are – in the opinion of Bebi et al. (2012), Hildebrandt (2006) and Kalberer (2006) – summed up by the following key words and phrases:

Early maintenance and sensitive use-based interventions

> Creating forests with small-scale structures and different ages

> Forming packs of trees as stable stock elements

> Adjusting the target diameter to the sizes of rocks expected in rockfall protection forests

> Performing mountain selection cutting in groups

> Reducing stocks and diversifying tree species to reduce the risk of disruption caused by fire and bark beetle infestations

> Actively promoting advance regeneration

> Preserving the shrub layer

Promoting surface roughness

> Leaving trunks at least 1 m tall

> Laying down and securing felled or fallen trees across the slope

Protected afforestation

> Afforesting areas where no natural regeneration is to be expected with balled plants from seeds of an appropriate origin

> If necessary, temporarily protecting plants against sliding snow and avalanches by constructing technical barriers; the regenerating protection forest should be capable of taking over the structures' function after 30 to 40 years

Optimised management of deadwood

> Making careful use of the benefits of fallen deadwood (providing surface roughness, slowing down avalanches and rockfall, providing substrate for regenerating decaying wood) that is differentiated depending on the region and site

> Weighing up potential disadvantages (spread of bark beetle directly after disruptive events, stones temporarily stored behind decomposing deadwood, fine deadwood is flammable material)

Diversity of tree species

> Adjusting the selection of tree species to the site and the desired protective performance, taking climate change into account

> Ensuring the highest possible proportion of evergreen conifers in avalanche protection forests (ideally 70 %)

Preventing forest fires

> Paying increased attention to preventing forest fires in protection forests that are potentially at risk, through measures like thinning overly dense forests by planting low ground vegetation in southern exposures and promoting natural fire barriers

> Not leaving fine, highly flammable material (e.g. piles of branches following silvicultural activities) lying around

ÖBf's activities

In the trade-off between business success and economic benefit, ÖBf attaches a great deal of importance to economic considerations. This was supported by a 2017 report prepared by the Austrian Court of Audit and a follow-up review in 2021. So, wherever possible, ÖBf is implementing all the silvicultural measures proposed by the scientific community, not to mention extensive hunting measures supported by accompanying research. ÖBf is involved in around 30 land management projects.

ÖBf's protection forest strategy

ÖBf's protection forest strategy forms the strategic framework. It identifies the following main goals:

> Creating conditions that enable natural regeneration instead of artificial afforestation in as many areas as possible;

> Consistent forest management, such as managing young growth and thinning, not to mention carefully using old wood and avoiding clear-cutting;

> Ensuring further development by means of forest roads, if technically feasible; and

> Minimising the impact of grazing livestock and producing ecologically sustainable game populations.

All the stocks were evaluated according to a rating scheme using detailed remote sensing data and presented in a traffic light system to enable ranking according to how urgentlythe protection forest needs to be improved. Green means that the protective performance is guaranteed for the next 20 years and that there is no immediate need for action. Yellow indicates that, while the protective performance is still guaranteed, negative developments are already noticeable. Red signifies that the protective performance is visibly declining, so measures must be implemented within the next ten years. According to the 2018 assessment, 12 % of stocks are in the red zone, 62 % are in the yellow zone and 26 % are in the green zone. Figure 5 below shows a cartographic image using the Höllengebirge as an example.

Protection forest management methods and measures are substantiated in the strategic long-term "Ecology & Economy" project. These measures and methods involve the likes of the value of natural regeneration, promoting efficient hunting methods and withdrawing managed game damage centres, focusing on sensitive sites. The Höllengebirge protection forest was developed and presented to the public in 1990.

In addition to ÖBf and the torrent and avalanche barrier construction authorities, the Upper Austrian hunting community and the municipalities and districts of Gmunden and Vöcklabruck are involved too.

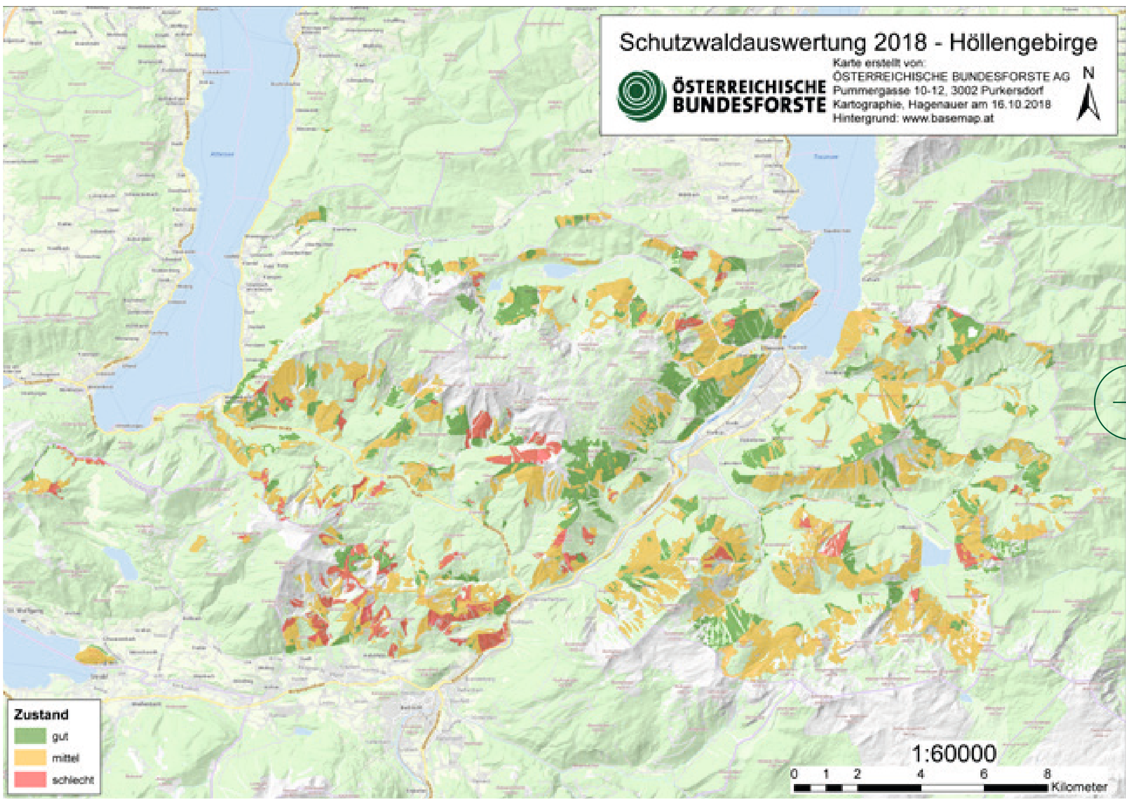

Figure. 4: Cartographic image showing the condition of the protection forest in the H llengebirge. Source: Internal ÖBf evaluation

Höllengebirge integrated protection forest project

From the project area spanning around 10,500 ha, about 6,125 ha are identified as forest, 3,000 ha of which are commercial forest and 2,900 ha are protection forest; 210 ha are categorised as non-woodland and 4,300 ha are unproductive land (wasteland). Of the area identified as unproductive, at least 2,000 ha (more than 50 %) are covered with mountain pines and thus form part of the non-productive protection forest. The natural growing conditions, forest use in centuries past and the current condition of the forest in the Höllengebirge are representative of ÖBf forests, so this territory is the ideal sample region with a special focus on establishing a balanced relationship between forest and game.

A major improvement was achieved on the land by implementing targeted silvicultural measures and a holistic concept that takes into account soil conditions, climatic changes, new technological opportunities and wildlife ecology. The stability of protection forests in the project area is to be guaranteed in the long term through the continuation and ongoing adaptation of silvicultural and, above all else, hunting measures.

Summary

Nowhere else are management measures more important and more recognised as a necessity than in the protection forest. The first guiding principle of the Austrian Protection Forest Policy formulated in 2019 in the Protection Forest Action Programme states that "intact protection forests are the most sustainable and the cheapest contribution to the security of Alpine habitats." (www.schutzwald.at).

Active management is absolutely vital if the best possible forest protective performance is to be ensured at a reasonable financial cost. If forests are left to their natural dynamics, which are still being accelerated by climate change, this disuse would temporarily and regionally lead to stocks collapsing

and thus to the protective performance being lost. Forests in particular that are not adapted to the local conditions and are subject to high pressure from game require special observation and care. So managing protection forests is a key task for forest managers.

The question of funding measures that cannot be covered by wood harvesting revenue has been the topic of discussions for decades now, and has only led to little progress despite numerous initiatives – be it protection forest platforms at federal and state level or the Austrian Forest Dialogue. This question would have to be solved by involving all the stakeholders at a political level.

The major economic importance of the protection forest was emphasised using ÖBf as an example in the audit reports published by the Austrian Court of Audit. Specific silvicultural and hunting measures that have to be implemented to maintain, restore and safeguard the protection that the forest provides can be found, among other things, in an internal ÖBf protection forest strategy and in the strategic long-term "Ecology & Economy" project.

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⑥ Recreation *and* health

Viewpoint

Increasing urbanisation has resulted in the clearly noticeable trend of people spending their leisure time in forests for recreational purposes – and this development has only been reinforced by the restrictions on freedom of movement implemented due to the Covid-19 pandemic. Forests offer people a wide range of opportunities and services that help them improve their personal wellbeing and benefit their health. Most of them are linked to forest development with tracks, paths and trails. Forest owners are responsible in two respects (they are liable as the owners of the paths, and they have to balance various people's interests) and do not receive any payment for this role.

Scientific statements

The needs and wants that visitors to forests have in relation to the natural surroundings are very clear to see in a recent study of literature that was a collaborative endeavour undertaken by the Medical University of Vienna, the University of Natural Resources and Life Sciences in Vienna and the Federal Research and Training Centre for Forests, Natural Hazards and Landscape. A total of 149 scientifically reviewed articles and 31 publications with relevant topics were evaluated and summarised in an interpretive manner. The following are regularly identified as reasons why people visit forests: to escape the crowds, the hustle and bustle and the density of the city, to get away from their everyday working lives, and to enjoy peace and quiet and fresh air. Privacy and the feeling of solitude are also important recreational aspects. While having the company of someone they know does indeed make people feel safer, if their safety is guaranteed they prefer being alone to recover from mental exhaustion in nature (Cervinka et al., 2014).

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Mountain biker
in the Wienerwald
biosphere reserve

Suda et al. (2021) also observe that people are keen to enjoy recreation in the forest and – as another aspect – discover nature. It's even possible to measure the benefit of visiting the forest, particularly for people affected by high levels of stress. The salivary cortisol level used as a stress index decreased significantly over a period of days in test subjects who spent time in a forest landscape. This tended to result in lower blood pressure and an adjusted pulse rate (Cervinka et al., 2014).

In addition to the visual and acoustic surroundings having a positive impact, it has also been scientifically proven that forests produce fresh air by filtering pollutants like soot and particulate matter and releasing fragrances. A large deciduous tree can bind up to one tonne of soot and particulate matter per year. Together with the increased humidity below the leaf canopy, these conditions are particularly beneficial to human respiration.

Heat-related stress is reduced thanks to the cooler, more humid climate inside the forest (Lackner et al., 2021). This is where the forest's wellbeing and recreational benefits are interlinked with one another. A handbook for forest-related education and teaching about nature deals with the partial aspect of biodiversity under the motto "Forest biodiversity is good for you". The introduction states that the species, habitat and genetic diversity found in the forest all lead to us benefiting from the health-promoting effects of spending time there (Lackner et al., 2021). The topic is being raised to a political/strategic and European level in a publication by Forest Europe. The "Human Health and Wellbeing" group of experts puts forward an additional perspective, among other things, by calling on the sustainable forestry stakeholders to include visitors to the forest as stakeholders in forestry planning processes using the key words and phrases "involvement", "inclusion" and "cross-sectoral cooperation":

> Modern forest management planning, however, has to consider more objectives including societal demands of local communities and stakeholders. Management of forests near urban areas is, in particular, under pressure from citizens who feel they should have a right to influence the management of their favourite places in surrounding forests. These aspects should, therefore, be integrated into forest management planning which represents, in the majority of cases, a participatory process involving various stakeholders, citizens, businesses, organisations and other interested parties in and around the forest being managed (Marušáková et al., 2019).

Management measures for forest landscapes

While it is indeed easy to call for participatory processes, doing so certainly won't lead to clear "mandates to act" for forest owners. As Schulz & Meyer (2021) explain, there is no such thing as an "average visitor to the forest", so therefore there is no ideal sample forest that satisfies all visitors equally. Rather, it appears that the type of activity (e.g. walking, cycling or jogging) and demographic factors (e.g. age, gender, origin, tradition, wealth or education) have a very different and diverse impact on people's needs.

For example, younger and more educated individuals rate deadwood in forests more positively, while older people tend to prefer "tidy" impressions of the forest. But despite how diverse people's needs are, several studies show that there are specific forest structures that most visitors tend to prefer and that have a positive impact on recreation (Cervinka et al., 2014; Schulz & Meyer, 2021). The following requirements are the result of merging all the different formulations expressed in the references:

- Sparse forests
- Visibility in the stock
- Older, richly structured stocks
- Natural biodiversity
- Diversity not just within one stock, but variety within the stocks too
- Formed roadsides
- Sweeping treetops
- Mixtures of deciduous and coniferous trees
- Seasons are easily recognisable, e.g. fresh greenery, autumn colours
- Rather small amounts of deadwood – preferably standing as opposed to fallen
- Open spaces within the forest, e.g. clearings, meadows
- A tidy, but still natural impression

Most visitors to the forest have additional needs too:

- Good accessibility; parking spaces
- Easy access thanks to a well-developed network of paths
- Guidance, e.g. by means of signposts, maps and markers
- Seating facilities made from natural materials
- Absence of health and safety risks

Aspects that have a negative impact on the recreational effect:

- Dark forests filled with extremely dense stocks
- Noise caused by forest machinery or felling work
- Closed paths (due to forestry work)
- Fresh, large-scale clear-cutting; large amounts of wood harvesting residue
- Litter left lying around in the forest and on the paths
- Crowds; overcrowded forests
- Conflicts between visitors, e.g. cyclists cycling too fast, dogs running around off their leads

In addition to the specific forest features, special structures like bodies of water, open space or sports equipment have a positive effect on the recreational value. After spending time in a well-kept and managed forest, most visitors are more relaxed, calmer and in a better mood than they are after being in a "wild" one. Wild forests tend to make people feel insecure, in danger and thus fearful too. During the day-to-day management of forests near urban areas, it is particularly important to avoid or reduce negative factors like felled trees, closed paths and noise caused by forestry machinery (Cervinka et al., 2014).

Most forest visitors' requirements usually contrast with those formulated for strict protected areas like core areas of biosphere parks and wildernesses (e.g. a well-developed network of paths with different routes vs. a small amount of fragmentation, an unobstructed view into the forest vs. a "thicket" created by natural succession, seats vs. no infrastructure whatsoever).

From the scientific illustrations, it can be concluded that the demands placed on forest owners increase the closer forest areas are to metropolitan areas and the more pressure they place on forest use. In this context, the distinct liability that the owners of the paths have, which is formulated in Section 1319a of the Austrian Civil Code, and communication of the forest code of conduct are particularly important. Not only does this code relate to compliance with forestry regulations like the ban on staying overnight in forests and the ban on open fires; it also applies to understanding the legitimacy of other forms of forest use within the meaning of fair play.

Bench at Lake Toplitz

The forest – a health and therapy-promoting oasis

Countless initiatives, activities and experience-based or recreational products and services around the world deal with the topic of forests and health; there are also in-depth publications on this matter. In Japan, for example, the "in trend" is climbing trees with the aim of having direct and sensory contact with them. There are even facilities that allow disabled people to get involved too. Shinrin-yoku ("forest bathing") is better known in Europe (Green Care Wald, 2016). The Austrian concept of Waldness® (bathing in forest air) is similar to this – people go to the forest to recharge their batteries (waldness.info/). The idea of forest school nurseries, where most activities take place in the forest, comes from Scandinavia. Children who attend nurseries like these are healthier than ones who attend conventional care facilities. They develop good physical awareness and a strong sense of balance (Häfner, 2002).

In Austria, the Green Care project was initiated by the Vienna Chamber of Agriculture and established at the Federal Research and Training Centre for Forests, Natural Hazards and Landscape. Green Care refers to nature-based measures that are designed to promote health, wellbeing and quality of life. In detail, they are educational, advisory, social and therapeutic interventions in natural landscapes. As demand is rising, so too are the products and services on offer relating to forest – health – therapy as a subject matter. Qualified training courses are therefore an essential prerequisite too, and offered in large numbers. ÖBf is also holding a forest and health course at the Wissen Ist Für Immer (Knowledge is Forever) institution in Lower Austria.

Monetary Assessment

Cost/benefit analyses of forest therapy measures could not be found in the context of the project entitled "Health benefits of forest landscapes". There are numerous studies on forests' recreational value that outline different assessment approaches and results. Two statements can be derived here: On the one hand, forests provide non-tradeable environmental goods (like recreation and health benefits) that are highly valuable and beneficial to humans. On the other, these benefits that the forest offers the population appear to be greater than the timber production losses, not to mention the maintenance and management costs. But, in many cases, this is still problematic – especially for private forest owners – because it is generally impossible to charge for the losses and the work that somehow or other helps encourage people to visit the forest and is often done "on the side" (Cervinka et al., 2014).

ÖBf's activities

ÖBf is maintaining and expanding the range of recreational facilities available through a multitude of usage contracts, not to mention cooperative relationships with stakeholders in the tourism and leisure industry, to develop the forest as a recreational area in the best possible way taking all the other benefits into account. The recreational value of ÖBf's land is currently EUR 1.3 billion/year according to the "Value of Nature" study (Getzner et al., 2020). Reference is made in this respect to 3,863.22 km of hiking and walking trails, 432.24 km of cross-country ski trails, 2,101.68 km of cycling and mountain biking trails, and 662.44 km of bridle paths.

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Summary

People visiting forests for recreational purposes benefit from the welfare it offers in the form of fresh air, coolness and tranquillity. Whether the general population can also rest, relax and recuperate in the forest due to guaranteed accessibility and available guidance largely depends on the degree of development. The likelihood of most demands being met increases if forests are managed actively – particularly if stakeholders are involved in developing the products and services on offer.

Promoting mental and physical health also goes hand in hand with a certain level of infrastructure, which would be impossible to build in areas under strict protection. Forest disuse is not an option in this case either.

⑦ The forest of the future – *climate-fit forests*

Viewpoint

Our forests are hugely affected by the consequences of climate change. Frequent extreme weather conditions (like long drought periods and extreme occurrences such as storms and heavy rainfall) weaken forests and make them more vulnerable to insect disasters. The results of such conditions are large amounts of damaged timber and cleared areas. Forward-looking forest management immediately restores the stock in accidentally cleared areas through afforestation. It focuses on tree species, mixtures and origins that are best adapted to both the site and the climate conditions to be expected in the future.

Natural regeneration is actively promoted by means of planting additional vegetation and introducing appropriate maintenance and hunting measures. This allows forests to adapt to climate change more quickly and ensures that forest services are continuously provided.

Scientific statements

"Climate-fit forests" is a catchphrase used not only in forestry PR activities, but also in scientific publications. The aim is to have stocks that are healthy, stable, structurally rich, biodiverse and adapted to the site with a time horizon of 2100 in most cases. The forest of the future should be able to withstand negative influences like storms, drought periods, extreme rainfall events and the associated higher pressure that pests cause as best as possible. They should also be highly resilient (i.e. they should be able to recover quickly after damaging events). In this context, structural diversity primarily means the presence of different tree species that are of different ages, along with the herbaceous and shrub layer typical of the forest community. But in a broader sense, it also means the presence of natural forest elements like pockets of old wood, deadwood and microhabitats.

Research into climate change issues started in Austria around two decades ago and has been conducted at full speed ever since. It is continuously revealing new findings that can be implemented in practice. The StartClim research programme that forest topics are also represented in was launched in 2002. Sped up by 2003, a year filled with extreme climate events including a Europe-wide heatwave that had never been seen before since climate records began, and by the awareness that the temperature could increase particularly severely in the Alps, forest-specific research activities were not long in revealing the urgent need for action on the part of forest owners. The spruce (Austria's main species of tree) was the focal point. Planted on unsuitable sites in the east of the country, which is dry in the summer, it was expected to fail on a large scale – and has done so since.

Lighthouse projects of relevance to ÖBf in this context are Adapt (assessment of forests' vulnerability with respect to climate change and adaptive management strategies, 2006 to 2008) and its follow-up projects, Manfred (management strategies for adapting Alpine forests to the risks of climate change, 2009 to 2012), SicAlp (site protection in the Limestone Alps, 2010 to 2012), the follow-up project StratAlp (forest management in the northern Limestone Alps, 2013 to 2014) and Sustree (protecting and sustainably managing our forests to preserve diversity in the face of climate change, 2016 to 2019).

The results of the projects listed above, supplemented by additional research findings, can be summed up in the following recommendations for adapting forests to climate change and pursuing a major common goal: the promotion of vitality, stability and diversity (Buchacher et al., 2020; Klemmt et al., 2020; Perny et al., 2020; Ruhm, 2017):

- Extreme thinning, especially when trees are young, to increase the stability of individual trees, shorten the production and therefore risk periods, and relieve the pressure on the water balance
- Minimising risk by promoting tree species diversity, mixing tree species and ensuring rich structures at stock level (motto: "Trees that scatter don't slip", better risk distribution, easier to compensate for disruptive events, prevention of total failure)
- Taking new pests and damage patterns into account (motto: "Nothing's certain", see ash dieback, beech bark disease and Phytophthora alni)
- Selecting suitable tree species origins
- Introducing or promoting native tree species (e.g. Norway maple, field maple, wild fruit species) that were previously less widespread and are capable of adapting to an increase in temperature
- Leaving, promoting and introducing pioneer tree species like birch, willow and aspen, which can adapt more quickly to climatic changes due to their rapid generation sequence with earlier, more frequent and more productive fructification
- Combining natural regeneration and planting
- Using the benefits of natural regeneration: genetic diversity, undisturbed root development, less risk of biting and lower costs
- When planting, using the room for manoeuvre for assisted migration (i.e. using more suitable origins, for the use of different mixture methods and for introducing non-existent native and non-native tree species)
- Adapting hunting strategies for cloven-hoofed game, with the aim of preserving mixed tree species
- Investing in maintenance measures (e.g. regulating mixtures, reducing trunk numbers and thinning)
- Preventing humus loss, especially on chalky soils in mountain regions, by means of advance regeneration or rapid reforestation

Reforestation zone following windfall in the Grossarl Valley

© ÖBf / Wolfgang Simlinger

ÖBf's activities

ÖBf has been working at a strategic and operational level on forest restructuring for a long time now, using scientific findings as a basis and accompanied by intense PR work – see www.wald-der-zukunft.at. This project is being implemented throughout the entire company under the title "Forest of the Future", and is designed to last for decades.

Focus – Forest of the future

Adjustment of the growing targets in the long term was tackled in 2015 as part of the "Ecology & Economy" project. This involved the idea that near-natural forests are more resistant to pest infestations and climate stress than non-natural ones. So the potential natural forest community (PNFC) that would establish itself on this site without any human intervention forms the guiding principle for the composition of tree species. Climate change scenarios were another element incorporated into this adaptive management strategy. The course was primarily set by taking even greater account of site differences (such as altitude, soil type and rainfall conditions) and by expanding the range of tree species.

ÖBf is specifically striving to make the following changes: Spruce, the main tree species in Austria's forests, covering a surface area of 57.4 % according to the 2018 Austrian Forest Inventory, is also the most strongly represented in the federal forests. Its current share of 59 % (as of 2018) is to be reduced to 41 % in the long term. Larch, which is resistant to storms and snow breakage, is to replace beech as the second most important tree species. Its surface area is to rise from 9 to 24 %. Expansion is also on the cards for fir, pine and Douglas fir. Swiss stone pine, a high-altitude species, is appreciated just as it was before. Deciduous trees are promising prospects in regions that are prone to heatwaves and drought (like Burgenland and Waldviertel). Oak in particular is to be more noticeable, covering 2 % of ÖBf's forest land. Other species of deciduous tree are to be found on 4 % of the surface area. The comparatively small increase in deciduous tree species is due to the fact that purely deciduous forest stocks are also to be turned into mixed deciduous / coniferous forests on suitable sites. Figure 6 presents a summary of the surface areas that the most common tree species cover at present and will cover in the future.

Natural regeneration due to tree species typical of the local area

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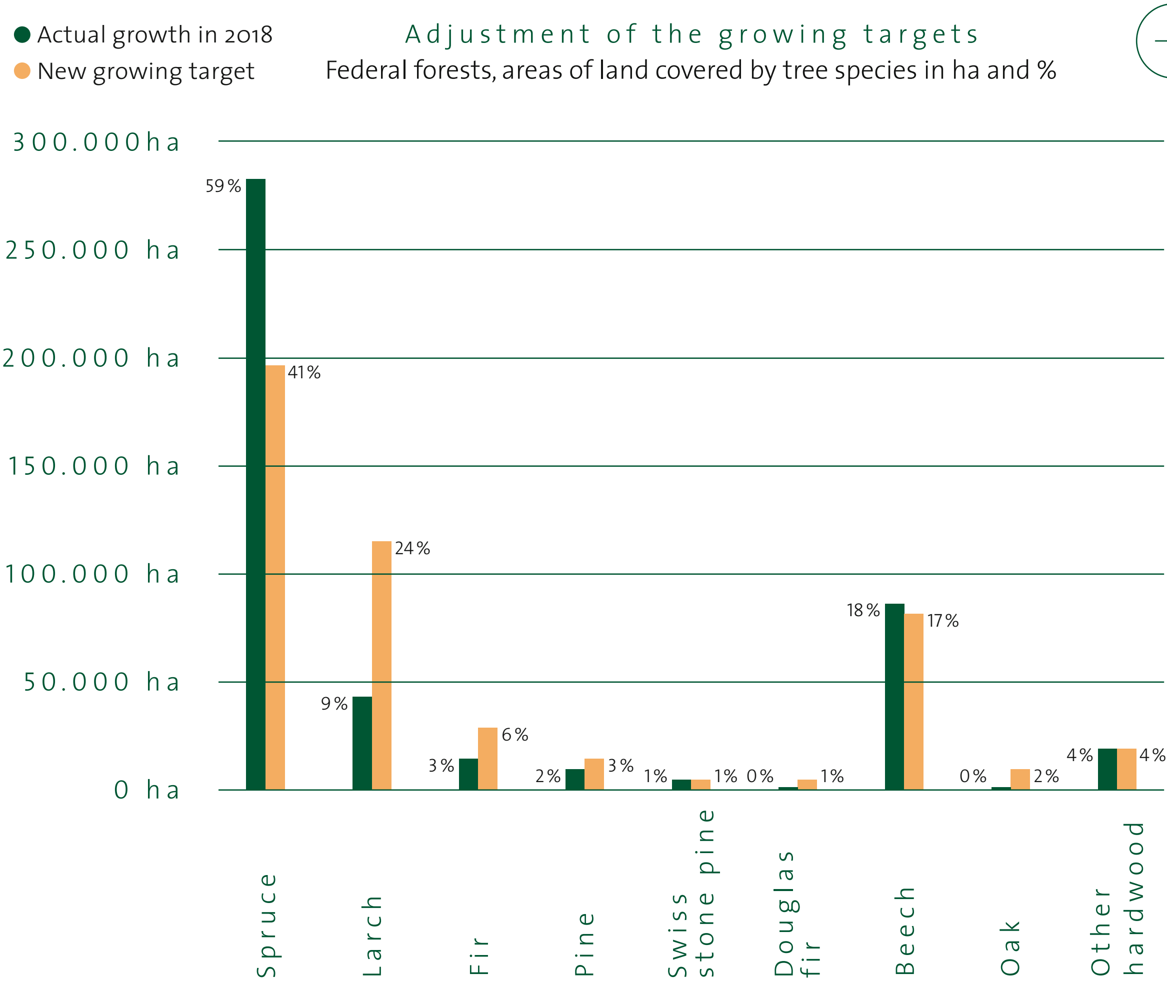

Figure 5: Current and future surface areas of the most common tree species, source: Internal ÖBf evaluation

Risk minimisation scheme that aims to optimise softwood stocks

Another ÖBf scheme resulting from the "Ecology & Economy" project addresses risk minimisation through optimising softwood stocks. The risks posed by exclusive monocultures of the same age are becoming increasingly visible under climate change. Costs and financial losses caused by damaging events increase because damaged timber always means that unplanned amounts of timber are harvested, wood harvesting costs are higher, the distribution of wood types is poorer and therefore less revenue is generated, and there is another increase in the risk of beetle infestation. Yet if there is a sufficient number of stable trees in the stock that are suitable for this purpose, regular thinning can keep the stock at an optimum level and thus help to achieve the following goals:

- Maintaining or increasing stock stability
- Reducing the risk of damage
- Bringing about natural regeneration, particularly of fir, at an early stage and over a wide area
- Improving the stock structure and mixture of tree species
- Promoting biodiversity

The decision on implementing the project results should be made at the end of 2021.

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Summary

In light of climate change, continuous forest conservation (which must be in the interest of society and the economy) is only possible if forest owners take action. They must actively promote forest conservation, which science and research offer numerous guidelines for and which politicians provide funding for, no matter how difficult estimating future climatic conditions might be.

Leaving forest areas to their natural dynamics and allowing slow succession and adaptation processes makes sense on a small scale. But things need to be sped up on most of the land through active intervention.

Closing remarks

The forest isn't just an ecosystem; it's also an important part of both the social and economic system. Since climate change is a factor that influences all three of those systems, taking action along the lines of the adaptation and mitigation strategies that the IPCC developed in 2001 is absolutely essential.

If the forest is to remain a source of support in the fight against climate change, it must be supported first of all. The services that most people need and use, too, cannot be provided if nature is simply left to fend for itself. Active, near-natural and sustainable management is critical if the forest is to continuously provide all the services that people expect it to and if the economy's trans-

formation into a bio-economy is to be successful. After all, wood (as a raw material) is Europe's only resource that is available in industrially usable quantities without long transport routes. It is the job of forest owners to integrate nature conservation activities into management practices, and thus promote biodiversity and aim to strike a balance between demands and interests by maintaining the closest possible dialogue with representatives of all stakeholder groups.

The growing demands that society is placing on forests make management absolutely vital – at the level of both larger companies and small forest owners too. Even disused areas cannot do without management entirely.

Annex

Addendum for viewpoint 1

Description of the biodiversity indicators for forests according to Geburek et al. (2015)

Indicators in the Austrian Forest Dialogue's fourth area of activity ("biodiversity in Austrian forests") (Linser, 2020)

State Indicators

- Natural composition of tree species: Tree species of the potential natural forest community, presence of neophytic tree species
- Natural elements of the forest structure: Deadwood, veteran trees
- Safeguarding future, genetically diverse generations of trees: Presence of necessary regeneration, type of regeneration, naturalness of the gene pool
- Forest landscape mosaic (forest fragmentation)

Pressure indicator
Biting and the influence of grazing

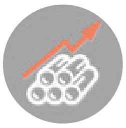
Response indicators
Natural forest reserves, gene pool forests, seed collection stocks – optimised use of existing genetic resources, gene pool plantations The indicators are weighted and aggregated differently. The FBI (forest biodiversity index) is quantified on a scale of 0 (worst condition) to 100 (optimum condition). Please note that a score of 100 points cannot be achieved in a managed forest alone, because the presence of natural forest reserves and specially managed areas like gene pool forests, seed plantations or seed collection stocks are also included in the response indicators. So the full score of 100 can at best be achieved for individual indicators.

15 indicators

- Indicator 4.1 Composition of tree species
- Indicator 4.2 Regeneration
- Indicator 4.3 Degree of naturalness
- Indicator 4.4 Neobiota
- Indicator 4.5 Deadwood
- Indicator 4.6 Genetic resources
- Indicator 4.7 Forest fragmentation
- Indicator 4.8 Endangered types of forest
- Indicator 4.9 Protected forests
- Indicator 4.10 Naturalness of tree species composition
- Indicator 4.11 Forest biodiversity index
- Indicator 4.12 Natura 2000
- Indicator 4.13 Contractual nature conservation
- Indicator 4.14 Nature forest reserves
- Indicator 4.15 Traditional forest management methods

Addendum for viewpoints 2 und 3

Description of the scenarios used in the CareforParis project



Reference scenario 4.5 – business as usual with moderate climate change (RCP 4.5)
The climate is changing according to regionalised RCP 4.5: 2.0 °C increase in temperature compared to the 1971–2000 period by the 2071–2100 period, and 2.4 °C increase by 2121–2150. The selected RCP 4.5 is slightly above the 2.0 °C maximum target set out in the Paris Agreement. The demand for wood and forest management corresponds to the trend seen in recent years and is influenced by the same general economic conditions as at present. Reforestation with tree species that were previously present on the trial areas.

Reference scenario 8.5 – business as usual with extreme climate change (RCP 8.5)
The climate is changing according to regionalised RCP 8.5: 4.3 °C increase in temperature compared to the 1971–2000 period by the 2071–2100 period, and 7.0 °C increase by 2121–2150. RCP 8.5 is well above the temperature targets set out in the Paris Agreement. The demand for wood and forest management corresponds to the trend seen in recent years and is influenced by the same general economic conditions as at present. Reforestation with tree species that were previously present on the trial areas.

DIS – disaster scenario under RCP 8.5+
In addition to the climate trend under RCP 8.5, lower amounts of rainfall and higher wind speeds are assumed in this scenario. This leads to an increase in drought and windfall events. The estimated mortality rate probabilities are also increased by 20 % to take an increasing risk from forest fire or novel harmful organisms into account. Reforestation with tree species that were previously present on the trial areas.

SFC – shortening of the felling cycle scenario under RCP 8.5
Shortening of the felling cycle as a measure to adapt to climate change. Different studies have shown that the likelihood of disasters increases as the stock itself ages. So, in this scenario, the older, richer forest stocks are prioritised for harvesting, and the average final harvesting age is reduced to 75 years. Reforestation with tree species that were previously present on the trial areas.

TSC – tree species changeover scenario under RCP 8.5
Changeover of the tree species in the forest as a measure to adapt to climate change. Softwood is replaced by different hardwood species (beech, oak and maple) in line with the temperature expected in 50 years. Non-native tree species are not taken into account.

SBU – stock build-up scenario under RCP 8.5
Stock build-up in the forest as a climate protection measure.
Stock is being built up using two measures:

a) The share of disused forest areas is being increased from 1.2 % at present to 5 % by the year 2100.
b) The rate of use calculated in the R 8.5 reference scenario is being gradually reduced.

Reforestation with tree species that were previously present on the trial areas.

Addendum for viewpoint 4
Boundaries in the forestry and timber industry's value chain

The following areas in the value chain were defined in the study conducted by Kleissner (2021):

- Forestry
- Timber industry in the narrowest sense: Sawmills, veneer and wood fibre board production, fibre and paper production
- Timber industry in the narrower sense: Sectors that make goods from wood, e.g. in timber construction, furniture construction, musical instruments, book printing (the sectors are included in the calculations proportionally depending on the amount of wood used)
- Timber industry in the broader sense: Administration, research and education

Sinabell & Streicher (2021) draw the following system boundaries in their publication:

- Core area: Forestry, sawmills, veneer and wood fibre board production
- Segment with closer ties: Sectors that make goods from and with wood. The final products are still clearly recognisable as wood-based.
- Other sectors: Ones that make products from paper and derivative goods.

Three other areas where forestry and timber play an important role are defined (but are not included in the calculations) in addition to the above three segments:

- Wood as a source of fuel
- Wood as a design element
- Administration, research, education

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