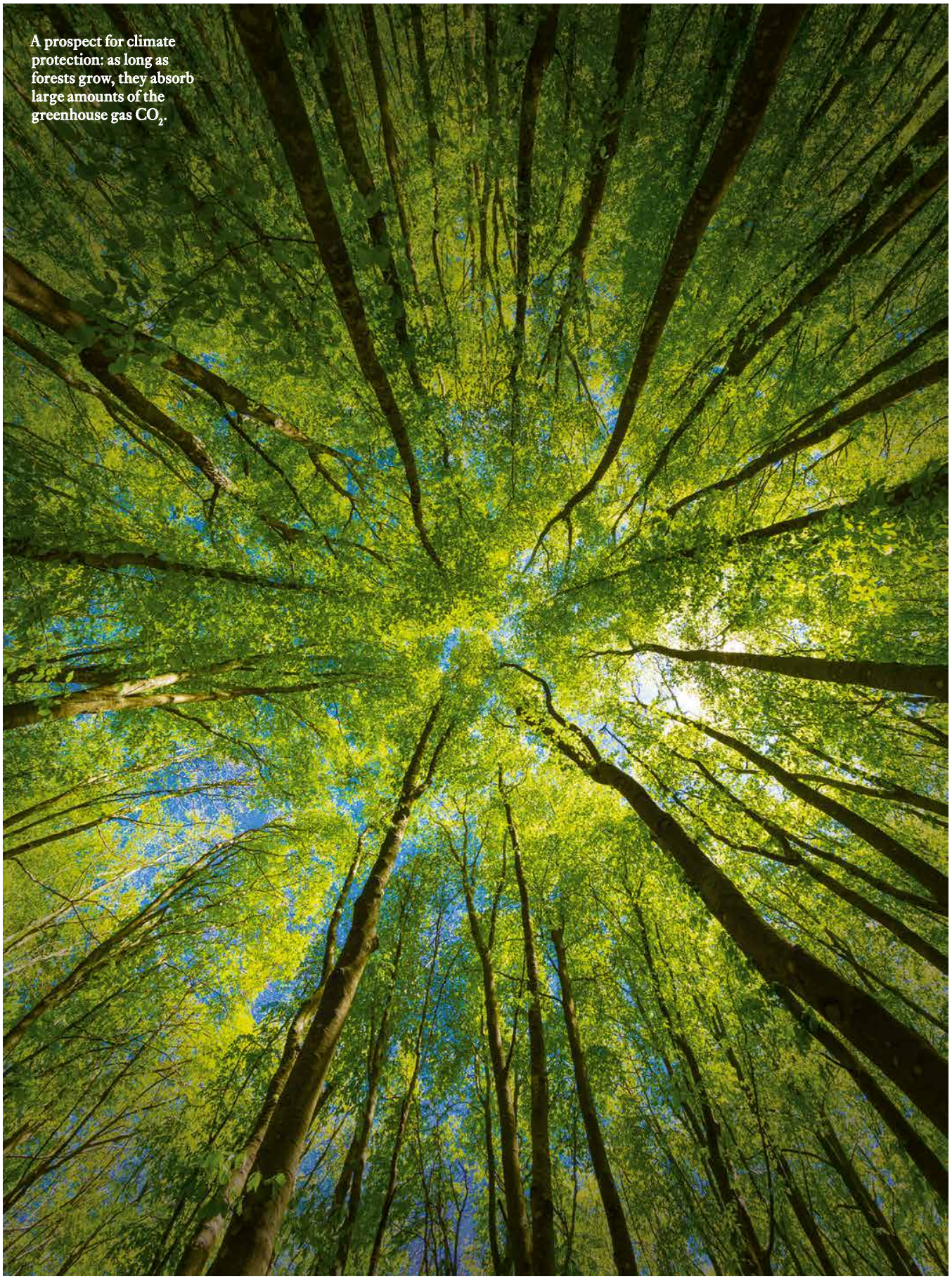

A prospect for climate protection: as long as forests grow, they absorb large amounts of the greenhouse gas CO_2.

PHOTO: ADOBE STOCK

FORESTS CHANGE THE CLIMATE

TEXT: KLAUS JACOB

Forests can remove large amounts of CO_2 from the atmosphere. So far, there is consensus about this throughout the scientific community. However, there is some dispute about how forests can best protect the climate – whether they should be managed sustainably or left undisturbed. Right in the middle of this dispute is Ernst-Detlef Schulze, Director Emeritus at the Max Planck Institute for Biogeochemistry in Jena.

The fight against climate change can be won only with allies – and forests can be one of them. They are a natural counterpart to oil and coal because trees assimilate CO_2 from the atmosphere, convert it into sugars with the help of sunlight, and use it to produce wood, among other things. On average, one cubic meter of wood contains about 0.3 tons of carbon, which corresponds to about 1 ton of CO_2. Thus, forests remove huge quantities of greenhouse gases from the atmosphere. Along with the oceans, forests are one of the world's major "carbon sinks" (to use the experts' terminology) – and for Germany, forests are the nation's largest sink.

Researchers at ETH Zurich led by Jean-François Bastin have even calculated that large-scale afforestation could solve the climate problem – at least for the next few decades. However, many experts doubt that this is realistic – partly because an area of the size of the U.S. would have to be planted with additional trees, at a time when suitable areas for afforestation are becoming increasingly scarce as a result of climate change and of intensified competition with food production in many places. Development is currently pointing in a different direction. According to the UN Forest Status Report for 2020, around 10 million hectares of forest are lost every year – an of area the size of Bavaria and Baden-Wuerttemberg combined. In Brazil, plantation owners are burning the Amazon rain forest. They are encouraged by a president who believes that the export of agricultural products – not least to Europe – is more important than climate and environment. In the U.S., increasingly devastating wildfires are blazing; these are exacerbated by climate change. And in Europe, heat, drought, and storms are damaging the forest, making it easy for bark beetles and harmful fungi to take hold.

Many experts are deliberating the question of how the world's forests must be transformed in order to resist climate change. In this context, they also disagree about what kind of forest is the most favorable for climate mitigation. Is it better to leave a forest alone – as is the case in some nature reserves? Or can a forest benefit the climate more if it is managed sustainably? Ernst-Detlef Schulze, Director Emeritus at the Max Planck Institute for Biogeochemistry in Jena, has studied the forests in Central Europe together with other scientists – and has come to a conclusion that may sound surprising at first. Schulze calculates that a sustainably managed forest makes a much greater contribution to climate mitigation than one that is left undisturbed.

The reason is that a natural forest helps the climate only if it is growing (i.e., if the mass of its wood – and thus of sequestered carbon – is increasing). In older forests, where the wood increment is reduced, the carbon balance has largely reached equilibrium. And as soon as trees die and their wood rots, the stored carbon is released as CO_2. What's more: the forest can even become a source of carbon, for exam-

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ple when drought, windthrow, or pests, such as the bark beetle, attack the vegetation – as can currently be seen in the Harz Mountains. A study by the University of Leeds confirms: the capacity of undisturbed tropical forests to absorb CO_2 has been declining since the 1990s. Scientists warn that the Amazon could even become a source of CO_2 by the mid-2030s.

However, different rules apply to managed forests. There is no natural state of equilibrium here because logs are constantly being removed. According to data from the Federal Ministry of Food and Agriculture from 2014, about 11 m^3 of wood per hectare grow each year in German forests. Most of this is used commercially. Only a small proportion of this wood decays on the forest floor, and roughly two-thirds of the annual growth serves humans in many ways. The wood is processed into durable products (such as wooden houses or furniture), used in consumer goods (including paper, cardboard, or tissues), or provides cozy warmth in the form of firewood or pellets. Wood that is burned replaces fossil fuels. Without firewood, many homeowners would turn to oil or coal. However, many durable products are also incinerated after use and thus serve to generate energy. In an article published in early 2020 in the journal Global Change Biology – Bioenergy (GCBB), a team led by Schulze assessed the CO_2 flows for German commercial forests (as far as the data allowed) and concluded that replacing fossil fuels with wood alone saves 1.9–2.2 tons of CO_2 per hectare of commercial forest per year. However, this applies only if the wood actually replaces oil or coal. If Germany were to begin generating 100% of its energy from wind and solar resources, this calculation would no longer add up, even though wood is also a renewable resource.

The climate balances of different forests

Not all wood that grows back is harvested. Schulze assumes that only about two thirds of the growth is removed. About one third remains in the forest. Among other things, the wood volumes of forests grow. According to the calculations made by Schulze and his team, each hectare removes 1–2 tons of CO_2 from the atmosphere every year stored in biomass. On average, the replacement of fossil fuels and the increase in wood compensates the CO_2 emissions or CO_2 concentration of around 3.5 tons per hectare of forest. In the meantime, a group led by Schulze has also quantified how much greenhouse gas the atmosphere would be spared if products were made out of wood requiring relatively low energy input instead of using materials that require more energy input or from fossil raw materials, such as a house constructed of wood instead of concrete or bricks. "We estimate this contribution of the forest to reducing CO_2 emissions to be about 2.8 to 4.9 tons per hectare per year," says Schulze. This contribution is in addition to the replacement of fossil fuels and the increment of wood volumes. Schulze and his colleagues have published their results in the journal "Biologie in unserer Zeit". But does a managed forest really contribute more to climate protection than a natural one? Schulze has also calculated that it does. But we must also bear in mind that true primeval forests have not existed in Germany since time immemorial. German forests have been used and cultivated in one way or another since ancient times.

Today's nature reserves, in which the forests are left undisturbed, are all relatively young. They have by no means reached the stage where the carbon dioxide balance has reached equilibrium. They are therefore capable of sequestering additional CO_2 for years or decades to come. These years are particularly important for climate mitigation while restructuring of the energy industry is being driven forward. In Germany, about one-third of the land area is forested, of which around 3% goes unused. But which nature conservation area provides meaningful figures for comparison? There are very different kinds of forests: deciduous, coniferous, and mixed forests: young and old forests, forests growing on sandy soil, limestone, or clay; forests in mountainous or flat terrain, forests interspersed with large and small clearings. We should be ascertaining the growth in each forest and calculating its average value. However, we don't have enough data to accomplish this. In his article in GCBB, Schulze cited forest inventories in Hainich National Park in Thuringia from 2000 and 2010 for comparative calculation. At the turn of the millennium, the survey documented a timber inventory

A passion for forests: after his retirement, the forest scientist and biologist Ernst-Detlef Schulze acquired tracts of forest, which he manages with great care.

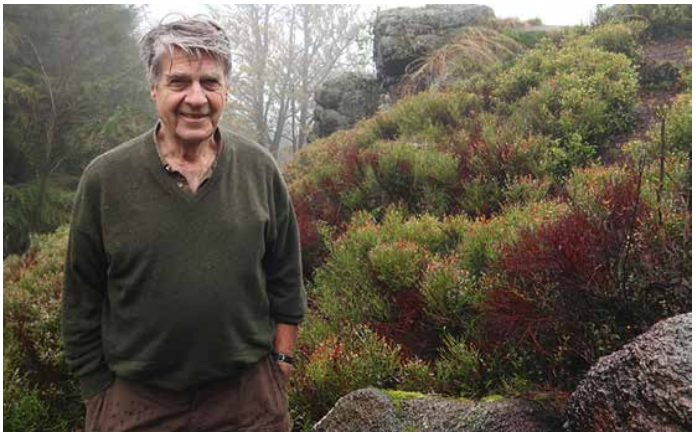

PHOTO: KLAUS JACOB

TIMBER GROWTH IN THE HAINICH

GRAPHIC: GCO

Different perspectives: Schulze's team considers the Hainich as an operational unit (A). The fact that the forested area sampled (shaded area) has increased in size between 2000 and 2010 is irrelevant here. The young, thin trees on the new forest plots only lead to a slight reduction in the 2010 timber stock inventory. This results in an increase of only 0.4 m^3/ha/yr. In the 2010 inventory, researchers led by Manfred Grossmann therefore consider either only the areas that were already forested in 2000 (B), for which they determine a wood increment of 9 m^3/ha/yr. Or they factor the areas that were newly forested in 2010 into the 2000 inventory as areas without wood supply (C) and arrive at a wood increment of 6 m^3/ha/yr.

of 363.5 m^3/ha; 10 years later, the figure was 367.5 m^3/ha. Using these figures, as published by the National Park, as a basis, Schulze arrived at an increase of 0.4 m3/ha/yr for the unmanaged natural forest. This corresponds to a CO_2 equivalent of 0.37 tons – compared with 3.2–3.5 tons in the commercial forest. Schulze's conclusion: a sustainably managed forest is about 10 times more beneficial to climate protection than a natural one. The use of wood in durable products was not even considered here.

This calculation sparked fierce criticism, which led to weeks of heated exchange in specialist journals and the media. The bone of contention was that the size of the forest area in the Hainich had increased between the first and the second inventory. Thus, the number of sample points increased from 1,200 to 1,421. Where before there had been only bushes, 10 years later, arm-thick saplings had grown. This young forest reduced the average timber stock because the figures always referred only to the forested area of the National Park as a management unit. Schulze justifies his approach with the fact that the Hainich is an operational unit that must always be considered as a whole – even if partial areas grow and shrink in size and the number of sample points changes. "The national forest inventory follows the same procedure. Only then can we compare the results," Schulze explains.

However, Forest Torsten Welle from the Natural Forest Academy in Luebeck thinks this kind of calculation is wrong: "This is cherry-pi-

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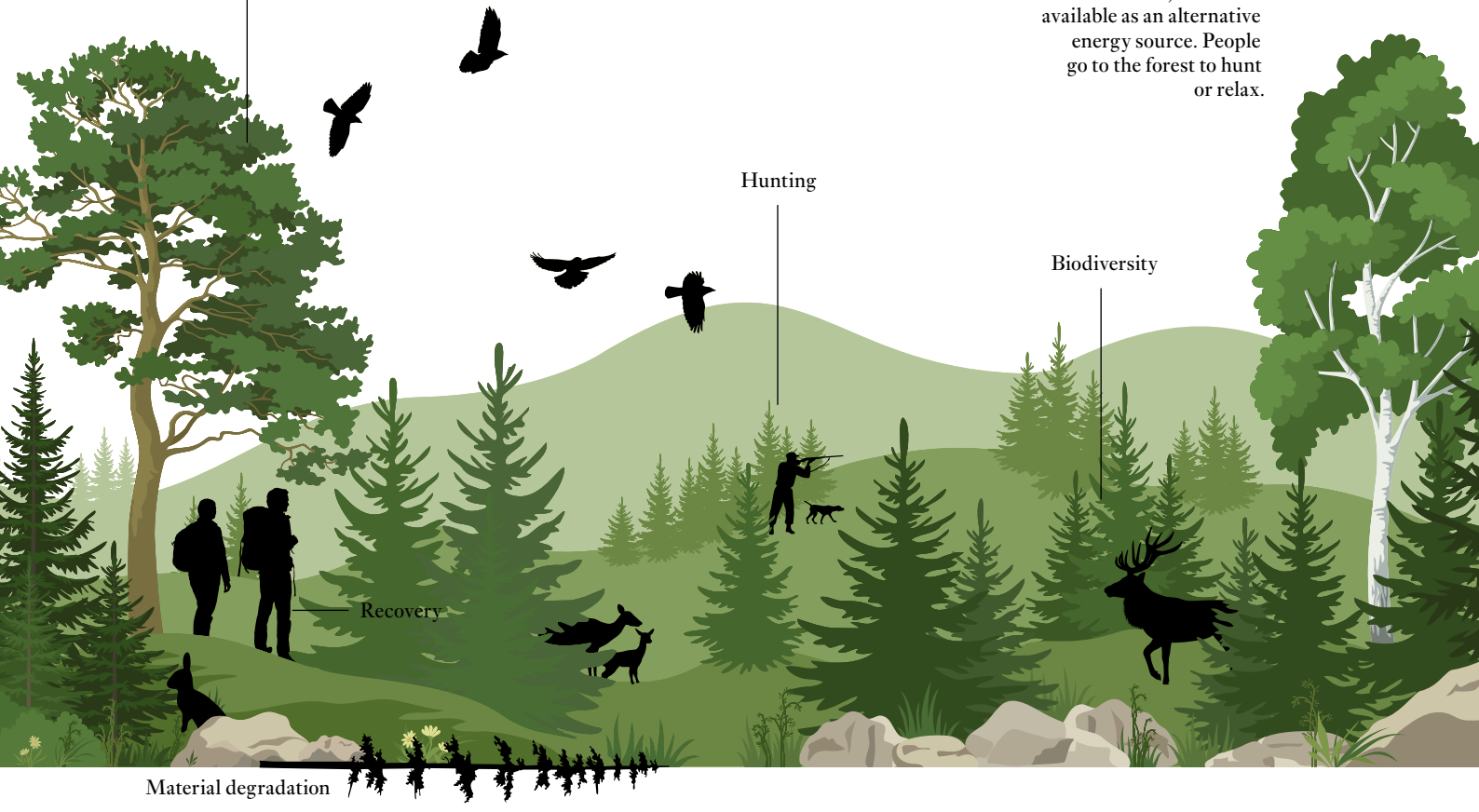
cking!". The head of the Hainich National Park, Manfred Grossmann, also criticizes the approach. He suggests a different calculation: if you consider only the 5,015 ha with 1,200 measuring points from the second inventory that were recorded in the first, you get an annual increase of just under 9 m^3; this corresponds to about 9 t of CO_2 absorbed from the atmosphere. And for a reference area of 5,287 ha with 1,421 measurement points (i.e., if part of the area is included in the calculation as unforested in 2000), it comes to 6 m^3/ha. In terms of climate protection, both values mean that the natural forest rates better than the commercial forest – but only as long as the former is still growing and the CO_2 savings from wood products are not taken into account. Forestry scientist and ecologist Henrik Hartmann, a colleague of Schulze's at the Max Planck Institute in Jena, also believes Schulze has left himself open to criticism with his comparison with the corrected reference area. Moreover, he thinks Schulze should have looked at additional nature reserves, including ones outside Germany. Corresponding figures for natural parks in Slovakia are even listed in the paper. When they are factored in, the average increase in the wood supply of unmanaged forests totals approximately 3 m^3/ha/yr. When this calculation is applied, sustainably managed forests do not contribute 10 times more to CO_2 storage than unmanaged ones. However, they are at least as beneficial to climate protection. "That, too, would be a good argument," says Hartmann. However, Schulze and his co-authors use only the Hainich National Park in Thuringia for a direct comparison with commercial forests. Schulze justifies this by saying that they wanted to draw up a balance for Germany and that no further inventory data of National Parks in Germany were available for this purpose.

The data from the Slovakian nature reserves were from relatively small ex-

FUNCTIONS AND BENEFITS OF THE FOREST



Versatile green: forests not only absorb CO_2 and counteract climate change, they also store water and provide a habitat for many plants and animals. Furthermore, they provide wood that is processed into paper and furniture, used in construction, and made available as an alternative energy source. People go to the forest to hunt or relax.

perimental plots, not comparable to National Inventories. Therefore, they did not take into account all of the changes found in a contiguous forest area, such as losses resulting from storm or beetle damage. "The only way to do that is to conduct inventories at the landscape level," says Schulze. The Thuenen Institute of Forest Ecosystems, which reports to the Ministry of Agriculture and publishes the annual forest condition survey, supports Schulze and his team – albeit with reservations. They believe that the Hainich is not representative of a typical German forest because it is on limestone terrain. Based on these figures alone, it is impossible to judge whether protecting forests is better for protecting the climate than using wood for energy.

The discussion shows that forest inventories and plot studies have their limitations. Timber inventories take only the trunk wood into account – and only from trees that are thicker than seven centimeters in diameter at breast height (DBH). But carbon is also in the soil: in the roots, in the soil litter, in the mineral soil, and in the underground biomass. Critics of the climate balance drawn by Schulze and his colleagues also argue that the side effects of logging are not taken into account: to get to the logs, heavy machinery must work its way through the undergrowth; this can alter the soil structure. Pierre Ibisch, a professor at the Eberswalde University for Sustainable Development, also points out that complete clearance leads to a significant increase in temperature because the sun's rays can then reach the ground. He says that even thinning, which creates more space for usable trees through selective interventions, leads to warming. German foresters therefore describe it as "hot cutting". The consequences: the ground heats up, carbon dioxide escapes, and the trees at the edge of the new clearing come under stress.

Comparing a natural forest with a managed forest is always risky from a scientific point of view. This is because many assumptions have to be made because not all details have been researched yet. In addition, a forest not only protects the climate – it also performs a variety of tasks and has environmental advantages. People therefore seek forests for recreation, hiking, cycling, and jogging. Forests also store water and thus prevent flooding. At the height of summer, they lower temperatures through evaporation. Finally, forests provide a habitat for many plant and animal species, including deer, which like to eat the shoots off young trees in particular.

Schulze, who owns several tracts of forest, knows all this from experience. "I bought the forest because I wanted to manage it in my retirement," says the Director Emeritus, who at the beginning of his career was on a path to taking a high-up position in the Forest Service. As a forest owner, he has learned not only about the ecological but also the economic and social aspects of forest management. One of his forests surrounds a long-extinct volcanic cone, and the terrain is fairly steep. The 79-year-old clambers up the 400-meter elevation difference with the vigor of someone half his age. When you ride along the breakneck paths with Schulze in his off-road vehicle, you get the impression that he is talking about a garden that he lovingly tends. In one place, he bemoans the loss of some hundred-year-old beeches that were damaged by a late frost and will probably die sometime in the next year. In another, he has planted a few rowan trees. But these do not seem to be thriving. Apart from individual spruce monocultures, the forest, with its abundance of bushes and undergrowth, appears wild and rich in biodiversity. No wonder it is popular with hikers, especially because the ancient volcano is the highest elevation in the area. The rocks at its summit are an attractive destination. But these visitors are giving Schulze cause for concern. He has painstakingly built paths in order to be able to harvest wood. But the hikers leave their trash behind, and mountain bikers recklessly race down to the valley, frightening the wildlife. He bears the costs, while others are benefiting from his investment and dedication.

GRAPHIC: GCO, ILLUSTRATIONS: ISTOCK

Too many deer

Schulze shows me a photo of a stag in a clearing on his phone. What would delight any city dweller presents another problem for Schulze. There are simply too many deer. Large predators like bears or wolves, which could help to decimate the population, were wiped out centuries ago. Even though wolves are gradually returning and lynx are back in some forests – including Schulze's – there are too few natural enemies of the deer. Moreover, when forest owners are primarily concerned with hunting, they feed the animals throughout the winter. The

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animals then continue to gnaw away at the young trees during the rest of the year. Schulze prevents this by putting up fences – a lot of them. But even intensive hunting does not limit the game population – because animals keep migrating into his relatively small forest. But the problem under consideration goes beyond gnawing dear and reckless mountain bikers. The challenge is ultimately how to manage forests in Germany and Europe in the future. Forests are about to reach a turning point. On the one hand, the trees are supposed to have effects on climate change. On the other, climate change is increasingly affecting trees. According to the 2019 German Forest Survey, the crown condition "has never been as bad as in 2019." Not even a quarter of the trees had a healthy crown. The dry summers are increasingly leaving their mark – with long-term consequences. Pierre Ibisch speaks of the "physiological memory" of trees. And there is no sign of climate change letting up; in fact, temperatures are continuing to rise. Ibisch warns that in the long term, a forest steppe with a high proportion of grass could even develop in many places. Even today, storms, bark beetles and fungi are already destroying entire forests. In turn, the large amount of damaged timber causes timber prices to fall. Forest owners are extremely concerned about this – according to Ibisch, there is even a sense of panic. Many of them sell off the damaged spruce wood to China in order to at least partially mitigate their losses. And they're cutting down their beech trees while they are still relatively healthy. According to the Thuenen Institute, in 2018, felling increased by 10% compared with the previous year because of the removal of damaged timber. However, it stabilized again to some extent last year – albeit at a high level.

PHOTO: PICTURE ALLIANCE/IMAGEBROKER | ANDREAS VITTING

Shaped by humans: in the 15th century, mendicant monks cut a cavity into the oak tree so that travelers could leave alms inside it. Over time, the hole grew, and the landmark of the Hainich National Park gradually took on its current appearance.

The human psyche also plays a role when it comes to forests, and this can hinder objective discussion. Almost everyone instinctively feels at ease and calms down beneath a canopy of oaks and beeches. Germans in particular have an almost romantic relationship with forests. It is the perfect counterpart to a hectic city life. Forest enthusiasts embrace trees to strengthen their souls, and some people even express a desire to be buried under oaks or beeches when they die. However, sometimes the love of forests goes too far: Hartmann learned that environmental activists in Weimar have destroyed forestry workers' machinery in order to prevent logging. Against this background, a calculation like the one Schulze presents also carries considerable political significance. His demands are derived from his calculations. He believes that forest owners should be rewarded for their sustainable management efforts. For example, they could benefit from a CO_2 tax levied on the burning of fossil fuels. But if one assumes that a natural forest protects the climate better than a commercial forest, then demands would be made for a policy that leads to different measures being implemented. Large swathes of the German forests would have to be left undisturbed, and a CO_2 levy would be demanded from the owners of the commercial forests every time they log. However, this would be shortsighted; wood cannot be replaced as a raw material – especially in light of the fact that there are plans to increa-

singly use wood as an alternative to building materials that are manufactured using a great deal of energy. As Hartmann points out, "How are we supposed to do without forest management if we need wood products?" If the logs do not come from Germany, they will have to be imported from Siberia or the tropics. This would most certainly be more harmful to the climate because forestry practices in those regions are usually not sustainable. In the worst case scenario, forests there – which store large amounts of carbon – will be cut down and will be unable to recover and grow back quickly enough.

Of course, financial interests also play an important role, since about half of Germany's forests are privately owned. The list of landowners who want to make money from forests reads like a directory of the old noble families: from Thurn and Taxis to Hohenzollern to Knigge and Guttenberg. So far, their sole source of income is the sale of wood. That is hard enough at the moment. However, according to Hartmann, forcing them to pay a CO_2 levy for each logging operation would not be justifiable. After all, the forests have served the general public in many ways – whether as flood protection or as recreational spaces. However, Ibisch points out that funding programs should not be used to create false incentives that lead to increased felling. Wood should not replace coal, but what else could be used? No matter how the forests are managing to slow down the increasing global warming, this is not a panacea. Even in the largest forest, the capacity for absorbing carbon dioxide is exhausted. In the long run, there is only one way to combat global warming: by drastically reducing greenhouse gas emissions.

SUMMARY

A team led by Ernst-Detlef Schulze has published a study showing that the climate balance of sustainably managed forests is significantly better than that of unmanaged forests.

Other researchers criticize the way in which the climate balance of a natural forest is calculated in this study. They conclude that the benefits to climate protection from these forests are greater.

It is difficult to quantify all the factors that would need to be taken into account in such a comparison. There is still no final verdict on which form of forest is more beneficial to climate protection. Various interests also play a role in the discussion.

In addition to their effect on the climate, forests fulfill many functions (e.g., as sources of raw materials, recreational areas, or water reservoirs). Managed and unmanaged forests are differently suited for this purpose. However, these functions currently have no economic value.