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Forests are carbon stores
Burning wood is not climate-neutral

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Overview

The assumption that the use of the forest and the consumption of wood represents a contribution to climate protection is widespread. At the same time some argue against protected forest areas, even in the name of climate protection. Natural forests are downright presented as a climate problem. Such positions are not covered by facts or scientific studies. Rather, they ignore even extremely clear findings. This background paper summarises the relevant scientific results against these named assumptions.

- **The forest is an effective carbon store**: this is particularly true for old, functioning forest ecosystems with significant stores in living tree stands, dead wood and soil. Intensive wood use has also reduced carbon reservoirs and carbon sink capacity in Germany. Leaving the living and dead wood in combination with 'regrowth' (stock accumulation) would be the most effective form of climate protection in forests in the short term.
- **Burning wood is not climate-neutral:** the use of wood for energy purposes contributes to the greenhouse gas effect, especially in the short term. In Germany it contributes to the deterioration of the condition of broadleaved forests.
- **More wood use does not automatically mean more carbon storage in wood products**: The idea that replacing energy-intensive materials with wood could contribute to climate protection (substitution effect through wood product storage) is highly questionable in the light of complex material flows (imports, exports, etc.) and the entire life cycle of wood products (harvest, transport, service life).
- **Poor adaptation to climate change and over-utilisation:** There is a risk that forestry, through inappropriate silvicultural strategies and over-utilisation of wood, will contribute to forests becoming a source of greenhouse gases in the future.

Conclusions

In the course of the energy transition funding policy is on the wrong track in Germany. Wood harvested in the forest must never be used as a supposedly climate-neutral fuel. At most, waste wood in the course of cascade use should be used for energy purposes and potentially trimmed timber from cities or wood from landscape conservation. Wood-fired power stations contribute to the greenhouse effect in the short term and promote the overexploitation of broadleaved forests in Germany. It must not be an option to fire coal-fired power stations with wood. Wood is a valuable material that must be used in durable and precious wood products. If wood use continues to weaken forests in the context of climate change, it is not a contribution to sustainable development and certainly not to climate protection.

The forest is an effective carbon store

Forests are among the most important carbon reservoirs on the planet. The climate protection effect of forests is a function of forest area and biomass. Worldwide, the forest-bound carbon sinks and reservoirs have been considerably reduced, and this also applies to Germany. The simplest option is to accumulate biomass in forests in order to build up a long-term carbon store. Forestry use is a relevant variable here: less fellings results in more biomass accumulation in the forest and thus a greater climate protection effect. Due to the intensive use, the cultivation of alien species, simple forest structures such as monocultures, and the reduction of tree age, forests are, particular in Germany, far from being nature forest ecosystems.

Reduced harvesting would not only make existing trees older and let them continue to store carbon, but also lead to significant biomass gains in the forest, not least because there would be fewer forest roads or less/no logging trails (which can easily represent a 20% loss of the area available for wood cultivation).

The current wood reserves in Germany (biomass on average approx. 350 solid cubic metres/ha) can be classified as low in comparison with European primary forests. These reserves can reach levels of stock volume between 478 and 918 cubic metres/ha (Schnell 2004, Commarmot 2013; Hobi et al. 2015, Knapp & Spangenberg 2007, Meyer et al. 2003, Commarmot et al. 2005, Drössler & Lüpke 2007). Germany's forests have not fully exploited their natural potential for biomass enrichment, or have by no means reached it. Erb et al. (2018) also came to the same conclusion, calculating an additional biomass potential of up to 34 % for the temperate zone.

Moreover, it is a frequently propagated myth that in older forests there would be a balance between carbon dioxide uptake and release. This has not been proven to be tenable. On the contrary, old forest ecosystems in particular are long-term carbon reservoirs, and they continue to bind CO_2 continuously for 200 years, on average 2.4 tC/ha/a (Luyssaert et al. 2008). The forests in Germany are on average only 77 years old. Even if the carbon uptake were to decrease with age, there would still be a long time to exploit their carbon sequestration potential.

Especially in the temperate mixed broadleaved forests of Germany (and comparable regions), the accumulation of humus and deadwood leads to the creation of considerable carbon, nutrient and water reservoirs. A large-scale study of the temperature and boreal forests of North America (with over 18,500 study plots) shows that old forests are not only effective carbon reservoirs and sinks, but that sensitivity to climate change also decreases with biomass wealth (Thom et al. 2019). A remarkable result is that the total ecosystem carbon content increased with forest age, especially beyond 130 years. The highest forest growth rate was found in the oldest forests. The biomass in the forest plays a key role, especially for resistance. This means that the carbon remaining in the forest makes a functional contribution to forest conservation. Herefrom follows a strong argument for leaving 'carbon' in the ecosystem beyond direct climate protection effects: In the ecosystem, positive feedbacks can set in; biomass-rich forests with high humus and deadwood stocks not only have a favourable effect on soil moisture and tree growth, but also on microorganisms, which in turn can become part of a stable carbon pool in the forest floor (Magnússon et al. 2016).

Deadwood in the forest is not a short-term source of carbon in the forest, as the decomposition of the trunk wood is a lengthy process that takes decades and is greenhouse gas neutral in interaction with the regrowth of young trees (Suzuki et al. 2019). In direct comparison, wood products may not have a longer, but rather a shorter retention time than deadwood in the forest (Beudert and Leibl 2020).

An important and recently published paper from the US points out that for a proper assessment of forestry, all emissions must be considered very carefully, and that in forests that have been more heavily used in the past, under certain circumstances restricting logging can have a positive climate change mitigation effect. Past wood utilisation may have significantly reduced current sink capacity (Hudiburg et al. 2019).

Burning wood is not climate-neutral

One third of the wood harvested in Germany (fresh wood) is burned. If not burned, this proportion could easily remain in the forest as biomass and serve as a carbon store. The assessment that firewood or, in general, the burning of biomass is climate-neutral is based on a number of false assumptions (see, among others, articles by Ter-Mikaelian et al. 2015, Booth 2018 and Agostini et al. 2014). It ignores a large number of facts. The fossil energy alone, which is consumed in forest management, timber harvesting and the transport and processing (shredding, drying etc.) of firewood, makes wood a clearly non-CO_2-neutral energy source (Lower Saxony Ministry for the Environment, Energy, Building and Climate Protection o.D.).

Energy production from wood under the EEG directive means that emission savings which would otherwise have been achieved by generating energy from solar or wind power are transformed into an increase in CO_2 that is effective in the atmosphere for at least decades and is even higher than if the corresponding amount of energy had been produced from fossil fuels (Ståhls et al. 2011, Smyth et al. 2017, Soimakallio et al. 2016).

Wood has a much lower energy content compared to fossil fuels (1 kg firewood ≙ 0.5 SKE[1] (Beitz & Küttner 2013, Searchinger et al. 2018), 1 kg lignite briquettes ≙0.7 SKE, 1 m^3 natural gas ≙1.1 SKE, 1 kg domestic fuel oil ≙1.5 SKE (BMWi 2019, Beitz & Küttner 1995, Agostini et al. 2014). The combustion of wood is sometimes significantly less favourable for the climate than the combustion of coal (Matthews et al. 2014, Duffy et al. 2016, Beddington et al. 2018, Searchinger et al. 2018). Energy

1 Hard coal unit (HCU): 1 kg HCU corresponds to the amount of energy released when burning 1 kg of a hypothetical hard coal with a calorific value of exactly 7,000 kcal/kg. 1 kg SKE = 0.7 kg ÖE (oil unit).

substitution therefore clearly counteracts the climate target of 2050 and contributes to an immediate increase in CO_2 in the atmosphere and thus to irreversible climate damage (Beddington et al. 2018).

The team of authors around Searchinger warned very clearly in Nature Communications in 2018 against the energetic use of wood in Europe. Booth (2018) also came to the conclusion for the USA that the combustion of so-called wood waste is not climate-neutral. Norton et al (2019) summarised another clear criticism of energy wood use in their study: "*Serious mismatches continue between science and policy in forest bioenergy*". Politics clearly does not follow the current state of science.

The time that forests take to recover carbon emissions from energy use is called *payback time* or *carbon debt payment time* and it can require decades or even a century before a balance is reached. Only then could there be a net climate protection effect at all. The 'payback time' is influenced not only by the type of wood being burned (moist fresh wood, saw waste wood, etc.), but also by how the forest reacts after the wood is removed. This depends, among other things, on the type of use (e.g. large clearcuts or the removal of individual trees) and also increasingly on the climate (change). If reforestation or regrowth is delayed or even severely impaired in extremely dry and hot years, a negative effect results.

A major problem with burning wood is that there is a considerable time urgency on the reduction of CO_2 in the atmosphere. However, the wood energy option can inherently not achieve a rapid reduction, because the carbon can only be bound again after decades at the earliest.

Intensive wood use: Boom in wood combustion since 2008 - Broadleaved forests in Germany particularly hard hit

The rapid growth in energy use is particularly significant. Since 2008, approx. 50% of the total volume of wood has been used for energy purposes. The "incipient subsidy programmes brought about a strong revival at the beginning of the new millennium. (...) The demand for energy wood in 2016 was 59.5 million m³, which corresponded to an increase of +219 % compared to 1990 or about +8.4 % per year" (Mantau 2019).

Energy use has a clear influence on felling in Germany: in 2016, the proportion of merchantable wood in energy wood came to 70.2 % or 16.9 million m³ (Mantau 2019). The energy wood use amounts tp 66.7 % hardwood and 33.3 % softwood. As a consequence, this means that the rapid growth in energy use has primarily and disproportionately affected the more natural broadleaved forests through increased timber harvesting.

It is important to discuss and investigate whether this intensification of use has weakened the corresponding forest ecosystems to such an extent that they now suffer more from extreme weather conditions than could have been expected (see below).

More wood use does not automatically mean more carbon storage in wood products

The development of new, durable hardwood products could be the right way to make appropriate use of wood as a resource. However, no such trend can be deduced from current wood use. Germany produces higher proportions of short-lived wood products than long-lived wood products in the 5-year average between 2013-2017 (FAO 2019). Softwood is much more relevant than hardwood for the material substitution effects and the supposedly associated climate protection effect. But there is currently a great deal of "damaged softwood" from corresponding monocultures due to their susceptibility with respect to climate change effects. Especially in view of congested sales markets, it cannot be transferred to long-lasting product stores to the same extent as in the times before the conifer dying. At best a higher proportion of "damages softwood" should be left in the woods for carbon storage, cooling effects and for biodiversity reasons.

It is often pointed out that the use of wood products instead of energy-intensive materials such as steel or cement has considerable climate protection potential due to a corresponding substitution effect. However, this carbon storage in wood products as a climate protection measure is subject to great uncertainty, as the impacts of the entire life cycle of wood products (harvesting, drying, transport, proportion of roundwood in the wood product) must be assessed (Ingerson 2011). A new study by Harmon (2019) shows that substitution effects in wood use have been overestimated by 2 to 100 times.

Furthermore, it is often assumed that there is no link between the life span of a product (e.g. a building) and the duration of the substitution effect, which is usually assumed to be unlimited. Losses in material substitution are also not expected, so that the substitution effect appears to increase with increasing timber harvest volumes, which wrongly leads to the conclusion that short harvesting intervals, thus young forests, are beneficial to climate protection (Oliver et al. 2014). The common assumptions that the substitution effect of wood is steadily increasing, i.e. that there are neither losses during substitution nor saturation of the substituted carbon and that the "carbon debt" that arises during wood harvesting is compensated by substitution effects are not sustainable (Lippke et al. 2011, Hennigar et al. 2008, Eriksson et al. 2007; Gustavsson et al. 2006; Perez-Garcia et al. 2005; Glover et al. 2002, Börjesson and Gustavsson 2000, Buchanan and Levine 1999; Schlamadinger and Marland 1996, Bethel and Schreuder 1976).

More and more timber imports to Germany - unclear climate balance against the backdrop of complex flow of material and goods

The balancing of the climate protection potential of forests in Germany does not adequately take account of the complexity of material flows, which are also influenced by the import and export of wood and wood products. The forestry and timber industry moves large quantities of timber and timber products, which considerably exceeds the amount of timber felled on German territory.

The Thuenen Institute, which is subordinate to the Federal Ministry of Agriculture, regularly reports on the use of wood in Germany:

"The average share of imports over the last three years is 54%. The share of fellings is 23%. Domestic volumes of waste paper and waste wood account for 18% and 4% respectively of the total volume" (Weimar 2018). "On average between 2013 and 2015, timber felling has a share of 91 % of the calculated domestic consumption of raw timber" (Weimar 2018). Since 2009 there have been net imports of coniferous raw timber (in 2013 and 2014 this figure was just under 5.8 million m³ and in 2015, according to provisional figures, 5.4 million m³; Weimar 2018), which is particularly relevant for calculating substitution effects. "Imports of wood and wood-based products add up to 133.1 million m³(r) in 2015. This represents an increase of 1.1% compared to 2014. In 2016, imports increase again by 1.0% to 134.3 million m³(r). According to the provisional figures of the foreign trade statistics, imports will increase again significantly in 2017 by 2.1% to 137.2 million m³(r)" (Weimar 2018).

The question arises as to how timber production abroad (under possibly less sustainable circumstances; e.g. in boreal forests) as well as the greenhouse gas emissions resulting from harvesting, transport and processing are represented and how they influence the national balance of the forestry and timber sector.

Even when developing future scenarios through forestry and the timber industry, there is a complete lack of recognition and reflection of current and future growth rates in the timber industry. "From 2003 onwards, the upswing experienced an enormous acceleration. From 65 million m³ (solid cubic metres equivalent) in 1990, its use rose to over 127 million m³ by 2007 (Mantau 2019). The sawmill industry was the biggest consumer: demand grew by 49% from 1990 to 36 million m³ in 2016; demand from the wood-based panel industry even grew by 67% (Mantau 2019).

The growth outlined here is a key driver of attempts to boost softwood production in Germany. However, the volume of coniferous timber will most likely decline in the future, particularly because of the exceptional calamities in the monocultures. An important question is therefore from where the wood in demand is to be procured and how this procurement will affect the carbon balance of the sector. Additional imports from abroad can be expected.

Bad adjustment to climate change and overuse: forestry (in the future) as a source of greenhouse gases?

The weather extremes of recent years can be seen as harbingers of problems that will worsen as climate change progresses. Monocultures are currently dying on large areas. The corresponding silvicultural model or forest treatment of the last three decades is largely co-responsible for the bark beetle, storm and forest fire calamities. Because monocultures were still cultivated here to a large extent and existing coniferous forests were not converted into near-natural mixed broadleaved forests. For example, the conditions for a mass infestation of bark beetles are most favourable if it concerns larger, contiguous forests with uniform mature to old stock of trees of only one dominant tree species (Jakoby and Wermelinger 2018). It is also suspected that the use of heat and drought-damaged forest areas with broadleaved tree species has contributed to an additional weakening of the forest against climate change.

The situation is likely to worsen in the near future as the influence of climate change continues to grow and activism increases to 'clean up' areas with dead trees as quickly as possible and 'restore' them by planting new trees.

There is an urgent need for a new calculation of the climate protection potential of different types of forest or woodland. There is also a need for a quantitative analysis of forest damage, its spatial distribution and its correlation with types of use and ownership.

It is well known that biodiversity and structural diversity increase adaptive capacities and thus ecological resilience. Thus management has a direct impact on the condition of the forest, as it can influence the dose-effect relationship, e.g. susceptibility to windthrow or the consequences of drought (Yousefpour et al. 2012). Yücesan et al. (2019), for example, describe for an oak forest that a reduction in canopy closure as a result of high felling intensity reduces soil carbon stocks.

There is clear evidence of elevated temperatures in more heavily exploited stands (Norris et al. 2012, Ibisch and Blumröder 2018, Blumröder et al. in prep). Higher temperatures result in the risks of lower productivity and the occurrence of abiotic and biotic damage to these stands compared to forests with a more stable microclimate. In many places, drought and bark beetle damage occurred particularly in areas where previous damage had already been recorded either by windthrow, intensive thinning or felling (Six and Bracewell 2015).

There is a concrete fear that the remaining undamaged stocks are the more vulnerable, the more they are surrounded by damaged areas. The clearing of calamity areas, the associated soil damage through driving with heavy harvesters on the forest ground and extensive deforestation leads to increased warming and drying of those forest areas. This potentially increases the stress on neighbouring undamaged stands. As the comparatively young stands on the damaged areas were already dying before the planned use, a reduced carbon fixation will take place here in the near future. This will at least result in lost carbon sequestration, which could have occurred despite the extreme weather conditions if a different silvicultural model had been followed. Local and regional studies show that bark beetle infestation, for example, leads to the affected forests binding less carbon and temporarily turning from a sink into a source (Seidl et al. 2008).

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