The DIFENs project

An overview of methods, assumptions, results and conclusions

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The DIFENs project

Extreme events such as droughts and storms have caused considerable damage to our forests in recent years. Forests with low resilience, which find it difficult to adapt to environmental changes, are particularly affected.

At the same time, the demands placed on forests are increasing: national and international regulations focus on their role as a source of raw materials, carbon sinks and as a valuable habitat for many species. In order to meet these demands, forests must be managed specifically to provide these services.

It is to be expected that extreme events will occur more frequently in the future and have an ever greater impact on the forestry sector. This also poses new challenges for the use of wood, as the available supply of wood will be subject to strong fluctuations in the future.

New forms of forest management and a targeted conversion of forests are required in order to secure the diverse services provided by them in the long term. This will also lead to changes in the composition of tree species.

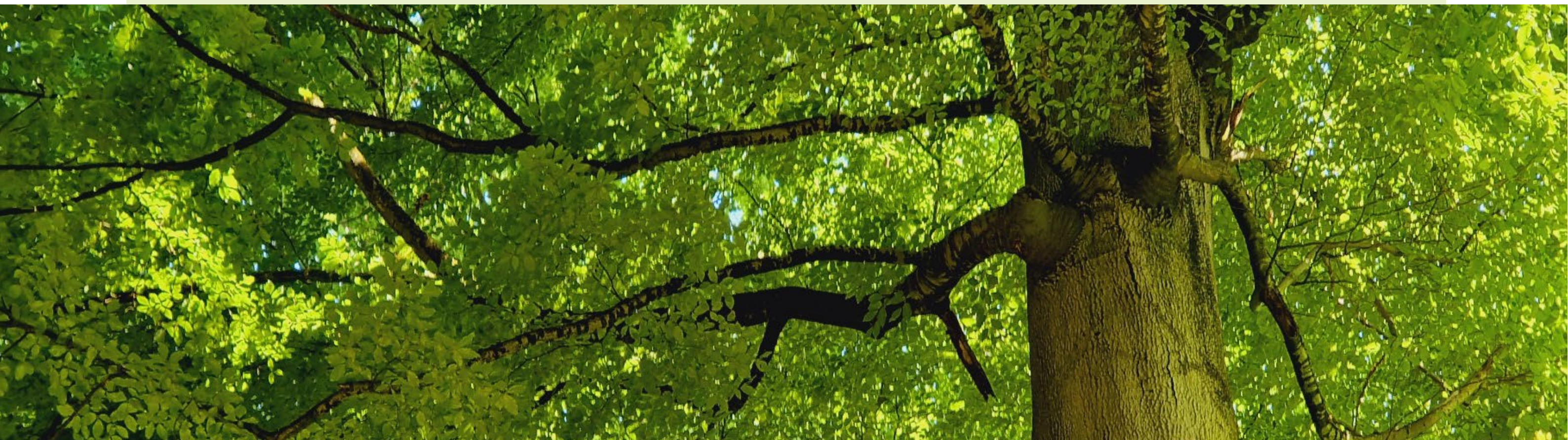
Numerous studies have already analysed the development of forest stands, wood production and carbon storage under different management scenarios - mostly based on national forest inventories. Until now, however, there has been a lack of an integrated approach that considers wood demand, climate change impacts and forest management together.

The DIFENs project closes this research gap by developing detailed scenarios that link end-product sectors, semi-finished goods and raw materials:

- The TRAW model is used to determine future **wood demand**. Long-term indicators on demand and a Delphi survey steer the demand for end products. Semi-finished goods and raw materials are then derived from the proportion of wood in timber goods.
- The calculated wood demand is fed into the **forest development model** FABio-Forest, which can react to climatic changes by linking it to the 4C forest growth model.
- Finally, the HoLCA model derives **greenhouse gas emissions** and **life cycle assessments** along the value chain from data on wood use.

DIFENs thus offers new approaches for the sustainable adaptation of the forestry and timber sector to climate change and market changes. The focus is on the following central questions:

- How much wood will be needed in Germany in the future?
- How will the forests in Germany develop in the course of climate change?
- Can the forests meet future requirements under the changed conditions?
- What consequences does this have, in particular for the balance of greenhouse gas emissions and other environmental impacts?



Modelling of wood use

Development of wood demand in Germany

Projections of wood use

The modelling of wood use shows that the demand for wood for material use, including sawn timber products, pulp and new bio-based semi-finished products, is continuously increasing. While 64 million m^3_{swe} (solid wood equivalent, use of raw materials to produce semi-finished goods) are currently used annually, a demand of 76 million m^3_{swe} is expected in 2050. In contrast, the demand for wood for energy use will decrease significantly over the next few years and eventually continue to fall steadily until it stabilises at around 46 million m^3_{swe} in 2050.

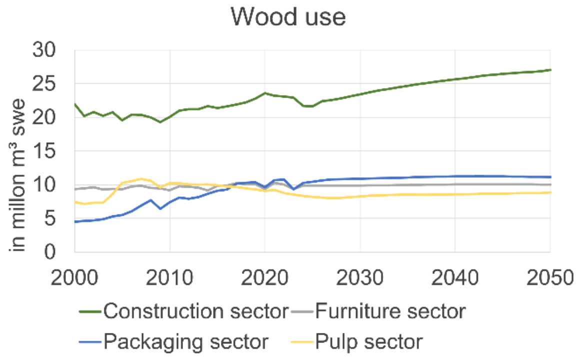


Figure 1: **Wood use by sector**

Development by sector of use

Substantial growth is expected in the **construction sector** by 2050, primarily through modernisation and civil engineering. With a use of 27 million m^3_{swe} of wood, the construction sector clearly outstrips the other sectors. The use of raw materials in the **furniture and packaging sector** remains largely constant at 10 million m^3_{swe}. The use of raw materials in **pulp production** will also stabilise at around 9 million m^3_{swe}.

In 2050, 49.1 % of the wood used as a raw material will be softwood and 12.1 % hardwood. The extraction shares are as follows:

- Stem wood (39.5 %)
- Other solid wood (21.7 %)
- Industrial waste wood (19 %)
- Recycled wood (10.7 %)
- Other primary biomass (9.2 %).

Of the solid wood removed, 80 % is softwood and 20 % is hardwood.

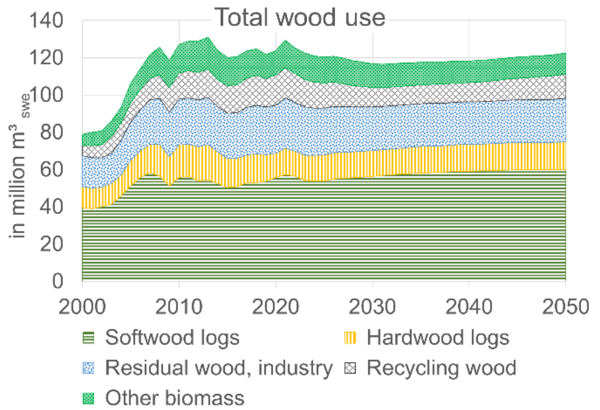


Figure 2: **Total wood use by raw material category**

Simulations

The effect of an increased **timber construction** quota was examined in a simulation. Despite a 35% linear increase in the timber construction quota between 2024 and 2050, the overall increase in wood use in the construction sector will be only 3.5%. This is due to the proportion of new buildings (29.2% in 2050), the proportion of wood used in non-timber buildings (50%), and the substitution of non-timber buildings with timber construction. If the target is fulfilled in 2050, an additional 0.9 million m^3 of raw materials will be used.

Another **adaptation scenario** analysed the effects of measures to save softwood. By reducing waste, increasing the use of waste wood and the use of hardwood, the necessary softwood felling could be reduced by an average of approx. 5.7 million m^3_{swe} per year between 2026 and 2050. At the same time, hardwood felling would increase by 2.3 million m^3swe. This could temporarily counteract a shortage of softwood.

Forest growth model

Effects of forest management, climate and changes in wood use in Germany

Forest development in a changing climate

The model showed that more frequent extreme events such as droughts and storms can **substantially reduce growth** particularly that of conifers, by 2083 (Fig. 3). Often occurring extreme weather events could reduce growth by 35% compared to less frequent droughts and other disturbances. This would also significantly reduce the stock. Consequently, frequent extreme weather events would transform the forest from a **CO_2 sink** into a **CO_2 source** (Fig. 3b).

Based on the assumptions of the baseline scenario, the domestic softwood supply is not expected to meet demand from 2040 onwards (Fig. 3c). The gap persists throughout the simulation period.

Optimised use of wood that reduces wood residues, increases the use of waste wood as a material, and substitutes softwood with hardwood mitigates the effects of the reduced conifer supply. Compared to the baseline scenario, the supply deficit in the 'Optimised wood use' scenario is delayed by around ten years (Fig. 3d).

The model scenarios also explored the effects of **converting forests** to increase hardwood and Douglas fir. Further scenarios show the extent to which changes in the **use of dead trees** affect the forests (these results are available (in German only) at https://fabio-model.de/difens).

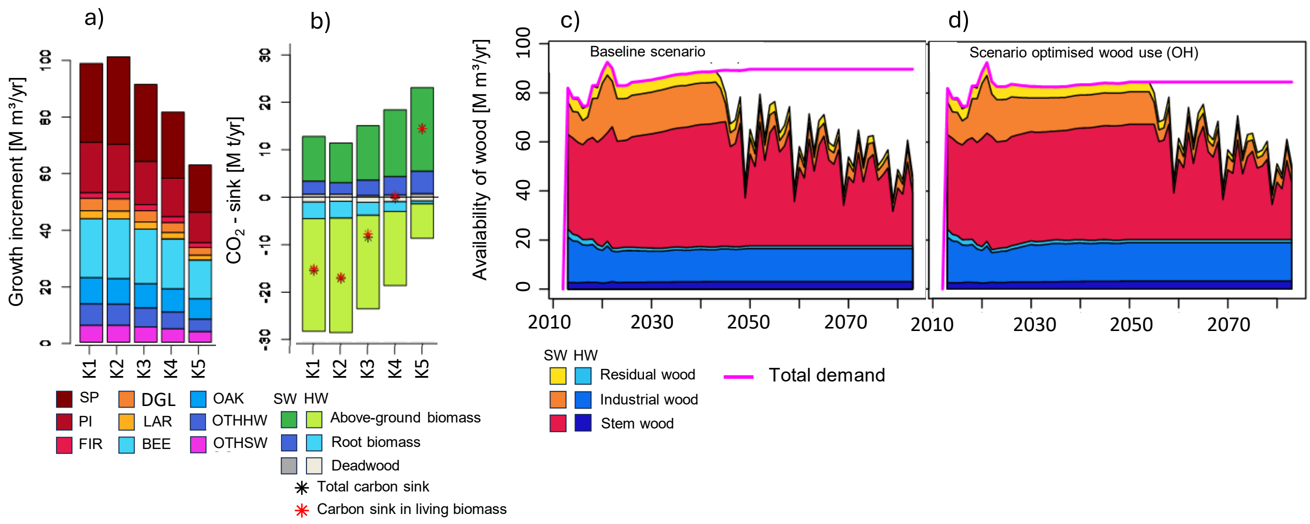


Figure 3: **Mean a) growth increment and b) CO_2 sink capacity of living biomass under different assumptions of climate development (negative values = carbon sink, positive values = carbon source). It was assumed that the climate conditions will continue as observed in the following periods: K1=2013-2017, K2=2003-2017, K3=2003-2023, K4=2013-2022, K5=2018-2022. Development of wood extraction in the c) baseline scenario and d) an adaptation scenario in which optimised wood use (less offcuts, waste wood longer in the cycle, increased use of hardwood instead of softwood) is assumed. SP: spruce, PI: pine; DGL: Douglas fir, LAR: larch, BEE: beech, OTHHW: other hardwood, OTHSW: other softwood, SW: softwood, HW: hardwood**

Wood material flow and life cycle assessment model

Greenhouse gas emissions from wood use in Germany

Development of emissions in the timber market system

According to the assessment carried out, a total of 23 million tons of CO_2-equivalents (CO_2-eq) of greenhouse gases are produced in the timber market system examined. This corresponds to around 3.5% of total greenhouse gas emissions in Germany.

Greenhouse gas emissions by sector

The paper and pulp industry is responsible for the largest share of emissions, accounting for 62% of the total. Although the paper and pulp industry is an emissions-intensive sector, it only contributes to deforestation to a small extent due to very high recycling rates. The second largest source of emissions is the production of wood-based materials, primarily due to the use of glue.

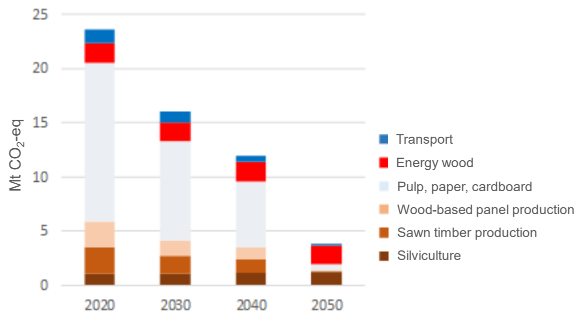


Fig. 4: Greenhouse gas emissions of Germany's wood industry

Prognosis up to 2050

If the energy transition is successfully implemented and fossil fuels are largely phased out, Germany's total emissions will fall to around a tenth of today's level by 2050.

There will continue to be non-CO_2 emissions from energy use (methane, nitrous oxide) up to 2050, meaning that energy use will account for the highest proportion of emissions in future.

Other environmental impacts such as particulate matter emissions and acidification will also be significantly reduced by 2050. The amount of acidifying and particle-forming emissions could be reduced by 40 % by 2050 from around 110,000 tons in 2020.

Potential substitution effects

The assessment was also used to analyze the potential of alternative materials to replace wood. A complete substitution of all wood-based products with other materials would lead to **additional emissions of almost 80 million tons of CO_2-eq**. However, this is a rather theoretical assumption.

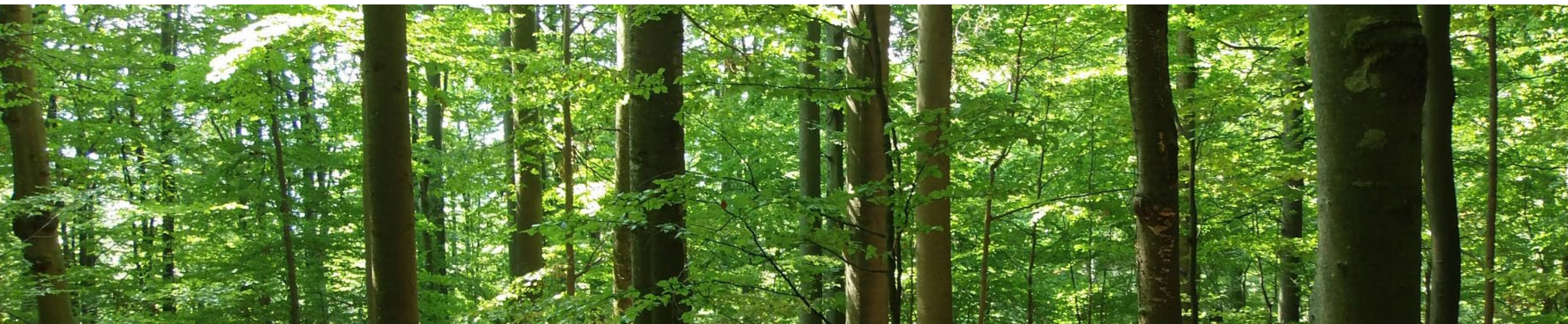
Influence of an improved circular economy

The annual **CO_2 storage in wood products** shows a growing potential. Rising material use can increase this from 8.5 million tons to over 15 million tons of CO_2-eq per year.

In contrast, the energy use of wood emits a total of over 40 million tons of CO_2.

Important premises for this study:

If the transformation to achieve the climate targets is not successful, emissions from the wood industry will remain high. At the same time, the substitution effects would also be greater in this case.



Response options

Conclusions for various stakeholder groups

Scientific research

The results show that linking the modelling of wood demand with both empirical and process-based forest growth models is a promising approach for future scenario analyses.

Model comparisons contribute significantly to a better understanding of the underlying processes. By comparing different model approaches, valuable insights into their behaviour and informative value can be gained.

Instead of individual scenarios, science-based **corridors** should be used to better show the uncertainties and ranges of future developments. However, these are often more difficult to communicate to decision-makers. Effective **communication** of research should therefore rely on the presentation of corridors and probabilities.

Wood industry

The assumptions made show that, depending on the scenario, the demand for softwood may no longer be fully met between 2040 and 2050.

Optimising the use of wood - for example by reducing offcuts, increasing the use of waste wood and of hardwood - can mitigate the reduced supply of softwood over several years.

The results of a qualitative expert survey were largely converted into quantitative results through the modelling.

In terms of climate impact, the question arises as to whether carbon is better stored in long-lasting wood products or in forests. The decisive factor is above all the lifespan of the respective method of storage.

Forest management

The **effects of climate change on wood production and carbon storage** in forests are considerable and constitute a key challenge for future forest management.

Climate-sensitive projections of forest development are required to adequately address these developments. The growth and mortality of trees should both be modelled as a function of climate.

Particular attention should be paid to the **interactions between wood supply and nature conservation aspects**, especially the tensions between the use of deciduous and coniferous wood. The relative decline of old deciduous trees could have both ecological and economic consequences.

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Further brochures: Das Projekt DIFENs, DIFENs – Holzverwendung, DIFENs – Waldmodellierung und DIFENs - Ökobilanzierung,

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