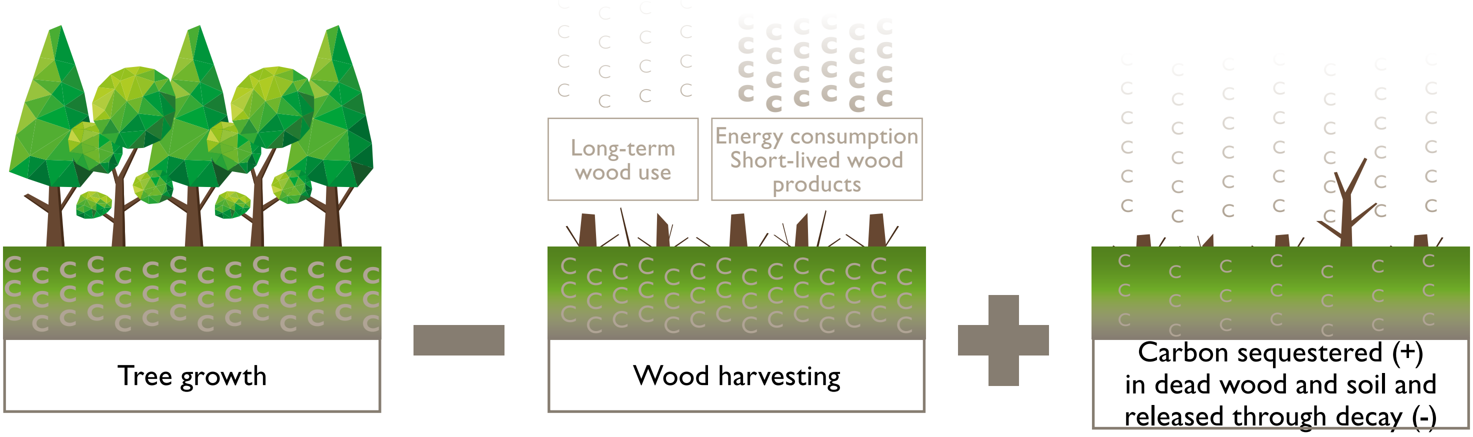
Forest carbon sinks
must be included in bioeconomy sustainability assessments

Forest carbon sinks reduce the atmosphere's carbon dioxide content.

The utilisation of wood and forests inevitably affects carbon sinks, which is an issue that must be considered when seeking cost-effective means for mitigating climate change.

Increasing carbon sinks is important for achieving the goals of the Paris climate agreement.

THE FOREST'S CARBON BALANCE I.E. THE ANNUAL CHANGE OF THE CARBON STOCK =



IF THE CARBON BALANCE IS NEGATIVE

The forest's carbon stock has decreased.
Carbon dioxide has been released into the atmosphere.

▶ THE FOREST HAS BECOME AN EMISSION SOURCE

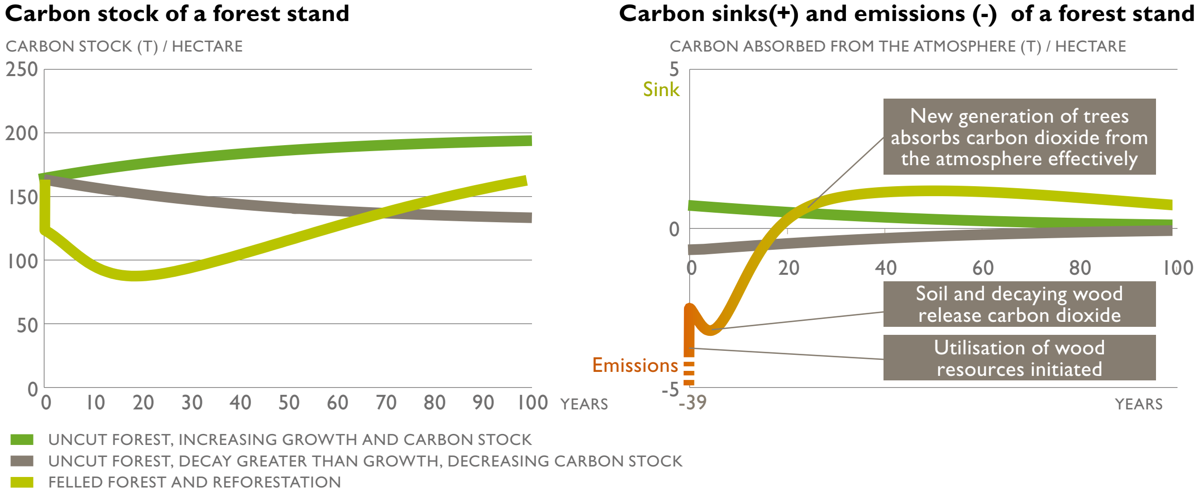
IF THE CARBON BALANCE IS POSITIVE

The forest's carbon stock has increased.

▶ THE FOREST HAS SERVED AS A CARBON SINK

A CARBON SINK EQUALS AN INCREASE IN THE CARBON STOCK

Harvesting wood reduces immediately the carbon sink. The use of wood in, for example, long-lived wood constructions, may also partially maintain the carbon stock. Currently, however, the carbon in wood harvested from forests is mostly released into the atmosphere fairly quickly through the direct use of wood as an energy source or through short-lived wood products, such as paper.



After felling the carbon stock is drastically reduced and the forest stand turns into an emission source. The annual carbon sink of the new forest exceeds that of an old forests after 15-20 years (right figure), but it nevertheless takes decades before the total amount of sequestered carbon exceeds that of the uncut forest (left figure).

Felling and using wood releases carbon dioxide from the carbon stock

One of the key questions is how wood harvesting affects the carbon stocks of forests and, by extension, carbon sinks and emissions. In the case of an individual forest stand, the situation can be easily outlined. In the final felling of a stand, the majority of its carbon stock is tapped. **This temporarily transforms the forest stand into a source of emissions**, as most of the carbon harvested along with the wood is released rapidly into the atmosphere from shortlived products or energy use. After the felling, the carbon stock is also initially reduced as a result of the felling residues decaying in the forest.

Gradually, the new generation of trees begins to restore the carbon stock to the level preceding the harvesting. In Finnish conditions, **it takes decades for a forest stand's carbon sink to accumulate a carbon quantity equivalent to that released through final felling and wood use**. In forests where no felling is conducted, tree growth gradually dwindles and the amount of dead wood increases as the trees age. As a result, the annual carbon sink of old forests is normally smaller than that of young rapidly-growing forests, even though the total carbon stock in the trees and soil of old forests is substantially larger than in young forests. If left unharvested, the forest stand could have continued sequestering carbon, the carbon stock could have remained fairly stable or the carbon stock could have begun to decrease as a result of decay or pest outbreaks killing trees.

A carbon sink is formed by a mosaic of forest stands

In large areas or entire countries, sustainably managed forests contain stands in a variety of developmental phases. On an annual level, trees are only felled in some forest stands. **When the sum of the annual harvesting, decay of residues and natural loss is smaller than the total growth, the whole area serves as a carbon sink.**

The annual carbon sink capacity of Finnish forests has strengthened significantly since the 1980s despite the fact that annual roundwood removals have increased from less than 50 million to nearly 70 million cubic metres. Thanks to the increasing growing stock volume due to the relatively young age structure of Finnish forests, climate change, the rise in carbon dioxide content and the increased growth of trees resulting from nitrogen deposition, **Finland can continue to increase wood removals to a degree without the annual total carbon sink decreasing in the coming years or decades**. However, this does not mean that the effects of wood harvesting on the carbon sink of forests would be insignificant.

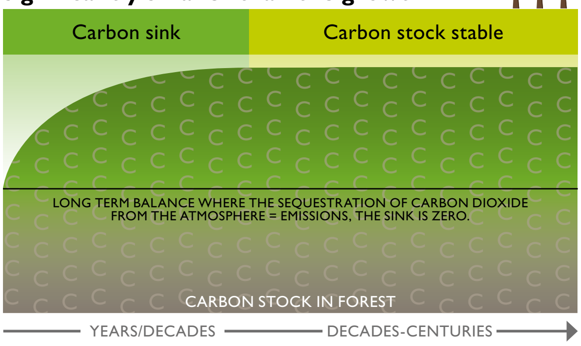
Increased harvesting reduces sink capacity even in wide areas

When transitioning from a fossil fuel-based economy to a bioeconomy by increasing harvesting, we are correspondingly reducing the growth of the forest carbon stock. From the point of view of mitigation of climate change, the issue is that increased harvesting simultaneously constricts the annual sink compared to a situation without increased harvesting. This is due to the fact that **felling results in a loss both of the forest's carbon stock and part of the future carbon sink**. It takes years before the new tree stock emerging after the final felling binds more carbon than trees ripe for felling.

A forest's carbon sink cannot keep growing indefinitely, but as we make the transition from a fossil fuel economy to a sustainable one over the coming decades, any changes in the carbon sinks will have a significant impact on the atmosphere's carbon dioxide content. In this transitional period, **it is important to consider the impacts of wood harvesting on carbon sinks, what is produced from wood and what alternatives for using wood are available**. Even if less fossil fuels are used the atmosphere's carbon dioxide content can continue to grow. This happens if the reduction of fossil emissions is achieved through an increase in the use of biomass which causes a significant reduction in the carbon sink for decades to come.

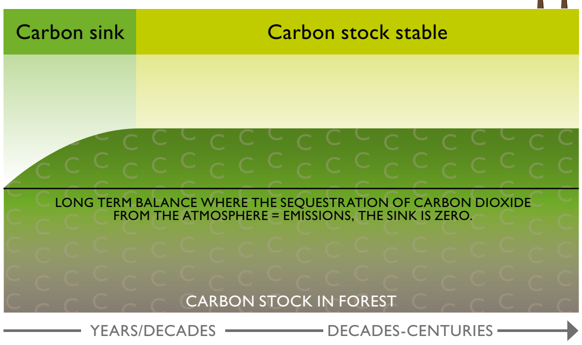
By strengthening carbon sinks and making the right choices in the use of wood we can limit the increase of carbon dioxide content in the atmosphere.

The growth of forest increases, commercial and other removals are significantly smaller than the growth



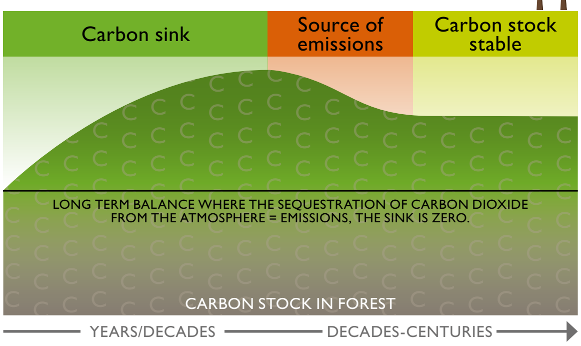
Initially the carbon stock grows rapidly until the ageing and increasing density of forests reduces the growth of the stock. In the long term the carbon sink approaches zero.

Active forest management utilizes a larger proportion of the growth



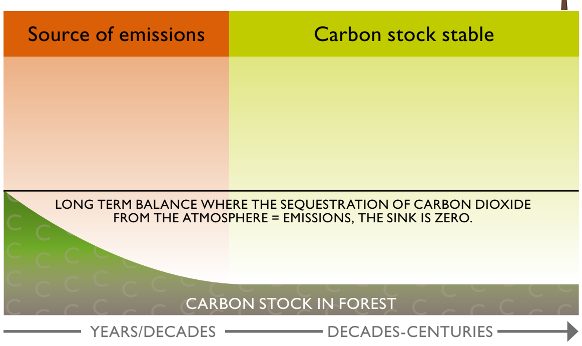
The sink remains smaller and the carbon stock levels off more rapidly when fellings are increased to benefit from the increased growth. Active management may stop the forest from becoming a source of emissions, but in a time perspective of years or some decades the relative diminishing of the sink is the most significant impact.

Part of the forests are destroyed in, for example, fires or storms



Initially as in the case above, but denser forests experience increased risk of natural disturbances that may reduce the stock and turn the area into a source of emissions. Except for desertification natural disturbances do not lead to complete destruction and a significant carbon stock remains.

Fellings and other removals clearly exceed the growth of forests



The carbon stock diminishes and the use of forest is a significant source of emissions. This is the situation in countries where forests are used unsustainably or where forest land is extensively converted into other uses. When the destruction stops also the emissions diminish towards zero.

Strengthening the carbon sinks could be one of the most affordable ways of limiting the increase of the atmosphere's carbon dioxide content in the coming decades. The sinks will provide us with additional time to develop more efficient and affordable ways of mitigating climate change. Mankind's need to utilise biomass and land limits the opportunities for leveraging sinks to curb climate change. Moreover, the carbon stocks of forests may be partly destroyed by, for example, forest fires or storms, thus causing a loss of the sink benefits..

The long-term challenge is to create economic systems that utilise no fossil fuels and where both commodities and a portion of the energy are based on biomass. In such systems, the annual carbon sink of forests can be close to zero. That said, the size of forest carbon sinks is determined based on other goals: **if the new economy is based on, for example, large logs and ecosystem services yielded by old forests, a larger carbon stock is maintained than if the economy is based on products from young and rapidly growing forests**. Therefore, the development of material and energy technologies has a substantial impact on what kind of forest bioeconomy is most desirable in the future.

The sustainability of the bioeconomy must be judged based on changes in both emissions and sinks

Countries are in very different situations in terms of forest carbon sinks. In some countries, forests have been destructed and sink capacity can be increased considerably by reforesting suitable areas. In other countries, the ageing of forests reduces the tree stock's capacity to absorb atmospheric carbon dioxide, increasing the risk of forests turning into emission sources.

Regardless of the situation, it is important to monitor changes in carbon sinks and utilise this information when assessing the sustainability of the bioeconomy in the short and long term and creating strategies for mitigating climate change.

> In order to achieve the goals of the Paris Agreement, changes in carbon sinks must be considered in national and international climate policy more extensively than before.

Changes in carbon sinks must be considered in national and international climate policy more extensively than before. On the basis of the 2014 assessment report of the Intergovernmental Panel on Climate Change (IPCC), we can conclude that the goals of the Paris Agreement cannot even be achieved without strengthening global carbon sinks.

References:
Michael Köhl et al. 2015. Changes in forest production, biomass and carbon: Results from the 2015 UN FAO Global Forest Resource Assessment. Forest Ecology and Management 352: 21-34.
Robert Matthews et al. 2015. Carbon impacts of biomass consumed in the EU: quantitative assessment DG ENER/C1/427.
Roberto Pilli et al. 2016. Modelling Forest Carbon Stock Changes as Affected by Harvest and Natural Disturbances. I. Comparison with Countries' Estimates for Forest Management. Carbon Balance and Management 11,5.
Risto Sievänen, Sampo Soimakallio & Olli Salminen: Metsät biotalouden raaka-aineena ja hiilinieluna. Metsätieteen aikakauskirja 2/2016:125-127.
Suomen ilmastopaneeli 2015. Metsien hyödyntämisen ilmastovaikutukset ja hiilinielujen kehittyminen. http://www.ilmastopaneeli.fi/fi/selvitykset-ja-materiaalit/valmistuneet-selvitykset/.

Authors: Mikael Hildén, Sampo Soimakallio, Jyri Seppälä and Jari Liski

Figures and layout: Satu Turtiainen and Matti Lindholm | Pictures: Freepik

ISBN 978-952-11-4579-7 (nid.) | ISBN 978-952-11-4580-3 (PDF)