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# Forest Carbon Reporting: Interactions Between Stocks, Fluxes and Pools

CANADIAN FOREST SERVICE SCIENCE-POLICY NOTE

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Forests are complex ecosystems that sequester carbon as trees grow and release carbon when trees and soil decay or burn. They are also affected by both natural processes and human activities. These factors make estimating forest carbon a complex task.

The forest carbon cycle is described using several different concepts: emissions and removals, pools, stocks, and fluxes. In line with the guidance of the International Panel on Climate Change (IPCC), Canada's National Greenhouse Gas (GHG) Inventory focuses forest carbon reporting on carbon fluxes. Forest carbon fluxes are reported in terms of their annual net GHG flux, or the sum of all GHG fluxes across pools each year.

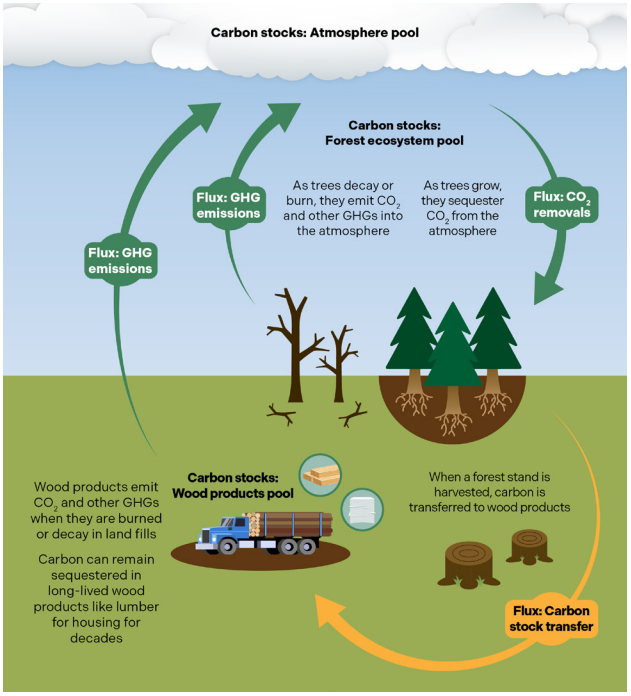


**Figure 1.** The forest carbon cycle.

## Forest Carbon Terminology

**Emissions/removals:** Emissions and removals happen when carbon is released to or sequestered from the **atmosphere,** respectively. As trees grow, carbon dioxide ($CO_2$) is sequestered from the atmosphere during photosynthesis, resulting in a **carbon removal.** As trees decay or burn due to wildland fires, insect attacks or other disturbances, they release $CO_2$ and other GHGs to the atmosphere, resulting in a **carbon emission.**

**Pools:** A carbon pool is a **system** that has capacity to store or release carbon. Oceans, soils, atmosphere and forest ecosystems are examples of carbon pools. Forest ecosystems can be broken down into several different pools: above- and belowground biomass, deadwood, litter, and soil, as well as pools external to the system—namely, wood products.

**Stocks:** A carbon stock is the **amount** of carbon stored within a **pool.** Within a forest ecosystem, carbon stocks are the amount of carbon that has been sequestered from the atmosphere and is now stored in its pools.

**Fluxes:** Carbon fluxes are **transfers** of carbon from one pool to another over a **specified time.** In other words, carbon fluxes measure gains or losses in carbon stocks. In terms of forests, carbon fluxes can take several forms:

- **Emissions** of GHGs from a forest carbon pool to the atmosphere.
- **Removal** of $CO_2$ from the atmosphere by a forest ecosystem pool.
- **Transfer** of carbon stocks within forest carbon pools.

## What is the carbon flux from Canada's managed forest?[1]

Canada reports the managed forest's carbon balance as the net flux resulting from the sum of its (1) $CO_2$ removals from the atmosphere, (2) GHG emissions from forest management activities and decomposition, and (3) transfers of carbon to the wood products pool. The transfer of carbon to the wood products pool reduces the carbon stocks in the managed forest pool as it increases the carbon stocks in the wood products pool.

In Canada's National GHG Inventory, the managed forest's net flux shows carbon losses throughout the entire reported time series (Figure 2, green bars). This is because losses of carbon stocks within the managed forest resulting from the transfer of carbon to wood products, combined with emissions stemming from forest management activities and decomposition, have been greater than the managed forest's carbon sequestration. However, the managed forest's carbon losses have been decreasing in recent decades, from 140 $MtCO_2e$ in 2004 to 24 $MtCO_2e$ in 2023. This decrease since 2004 is tied to a reduction and subsequent levelling-off of wood harvest rates, among other factors.

[1]From here on, references to the "managed forest" concern the managed forest's anthropogenic component as defined in Canada's National GHG Inventory, thus exclude emissions from natural disturbances that are beyond human control.

### HUMAN ACTIONS IN CANADA'S FORESTS

Canada's forests cover 367 million hectares (ha), and 226 million ha of this is the managed forest, where human activities affect forest carbon. The managed forest includes land managed for timber harvest, protected areas, and areas under intensive protection against natural disturbances.

While emissions from natural disturbances play an important role in Canada's forest carbon balance, the United Nations Framework Convention on Climate Change (UNFCCC) requires that countries' GHG reporting focus on human-caused GHG emissions and removals. For this reason, Canada separates forest emissions and removals in the managed forest due to human activities (anthropogenic component) from those due to wildland fire, forest insect outbreaks and other natural disturbances beyond human control (natural disturbance component).

## What about the carbon flux from wood products?

While timber harvesting does result in some emissions to the atmosphere, the majority of carbon is transferred to the wood products pool, where it is stored for varying amounts of time depending on the product. Bioenergy and short-lived products, such as paper, release GHGs quickly, while long-lived products, such as lumber for housing, can store carbon for decades.

In Canada's National GHG Inventory, wood products' net flux shows carbon gains throughout most of the reported time series (Figure 2, brown bars). This is because, generally, more carbon stock is harvested, transferred and stored into the wood products pool than is emitted by the burning or disposal of wood products. In Figure 2, the minimum flux value (-61 $MtCO_2e$) was recorded in 2004, corresponding with peak harvest rates, while the maximum value (+1 $MtCO_2e$) occurred in 2009, when harvest rates were at their minimum.

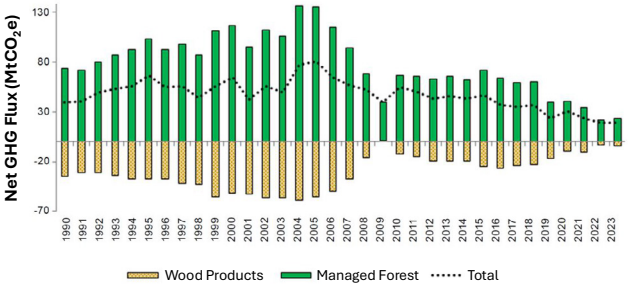


**Figure 2.** Net GHG flux ($MtCO_2e$) of the anthropogenic component of the managed forest, associated wood products, and their total from 1990 to 2023. Positive GHG flux values indicate carbon losses while negative GHG flux values indicate carbon gains.

## How can understanding forest carbon fluxes inform climate change policy?

Canada's forests play an important role in the global carbon cycle due to their large area and high carbon stocks. Having a clear understanding of how the amount of carbon stored in forests is changing is important for informing climate change policy.

For example, while a forest area might have high carbon stocks, its annual flux could show net carbon losses. This can happen when a forest area is losing more carbon through harvest or other processes than it is gaining back in growth each year. Understanding such phenomena can inform management efforts that enhance carbon sequestration while promoting ecological sustainability and economic growth.

Decision makers with a grasp of carbon fluxes of wood products can also promote the efficient use of harvested wood in ways that encourage long-term carbon storage. For example, buildings made with wood can store substantial amounts of carbon for decades, contributing to a larger global stock of carbon in long-lived wood products.


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