Ressources naturelles Canada
Natural Resources Canada

Is Canada's managed forest a carbon sink or source?

CANADIAN FOREST SERVICE SCIENCE POLICY NOTE

SEPTEMBER 2025

Forests are a vital part of the global carbon cycle—the movement of carbon between the atmosphere, lands, oceans, and human sources. Forests sequester carbon dioxide (CO_2) from the atmosphere through photosynthesis (**Figure 1**). Carbon then becomes a part of forest biomass (i.e., tree trunks, branches, roots, and leaves) and is stored in dead organic matter (litter and dead wood), as well as in soils as leaves, branches, and trees fall to the forest floor. Forest carbon is emitted when trees burn or when they decay after dying (through natural processes, fire, insect attack, or other disturbances).

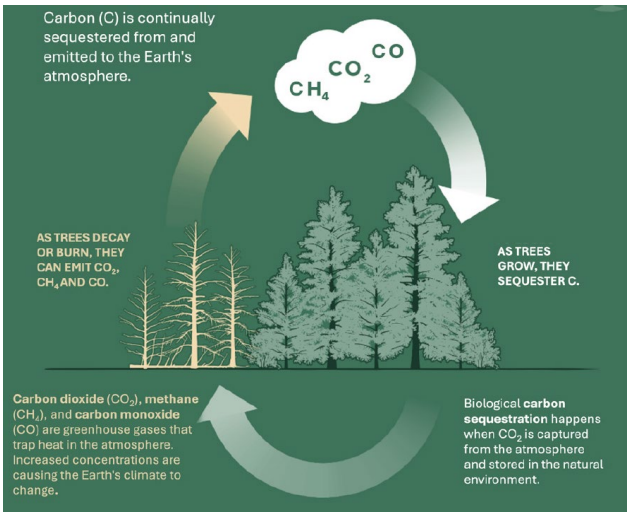


Figure 1. The forest carbon cycle.

The forest carbon cycle is also influenced by human actions. When a forest is harvested, carbon is transferred out of the forest and stored in wood products. Long-lived wood products, such as lumber for housing, store carbon for decades. Short-lived products, such as paper or tissue, emit carbon quickly. Human actions, such as planting trees or improving tree growth, can help increase carbon sequestration.

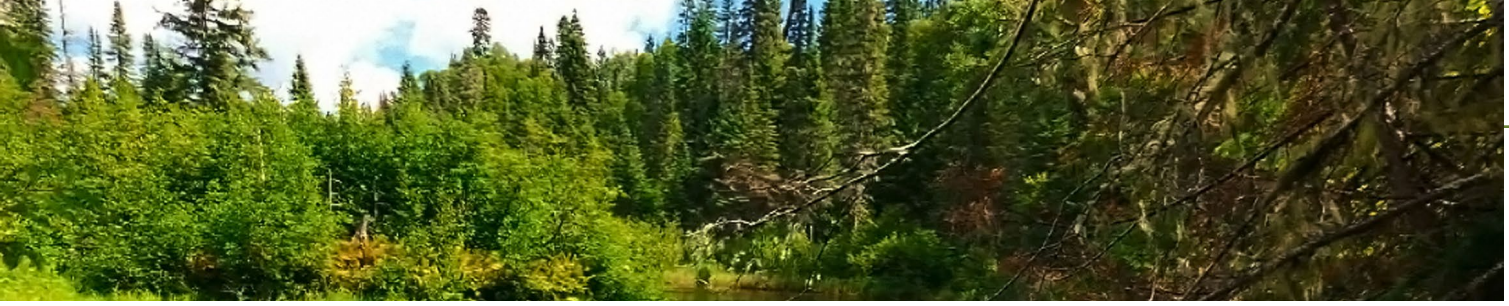
Forests can act as either carbon sources or carbon sinks. A forest is a carbon source if it emits more carbon than it sequesters. A forest is a carbon sink if it sequesters more carbon from the atmosphere than it emits.

How does Canada estimate the amount of carbon in its forests?

With more than 200 million ha of managed forest, it is not possible to directly measure carbon in every inch of Canada's forests. Instead, the Canadian Forest Service (CFS) uses its Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) to simulate carbon dynamics in Canada's managed forest. The model estimates greenhouse gas (GHG) fluxes—including carbon released to and removed from the atmosphere and carbon transfers among forest carbon pools. The model relies on millions of forest measurements across the country to produce Canada-wide estimates.

What is the carbon balance of Canada's entire managed forests?

Canada's forest covers 360 million ha and 230 million ha of this is the managed forest where human activities affect forest carbon (**Figure 2**). The managed forest includes land managed for timber harvest, protected areas, and areas under intensive protection against natural disturbances. By considering the carbon balance of managed forests and associated harvested wood products in a single sector-wide estimate, Canada accounts for both human activities and natural disturbances.



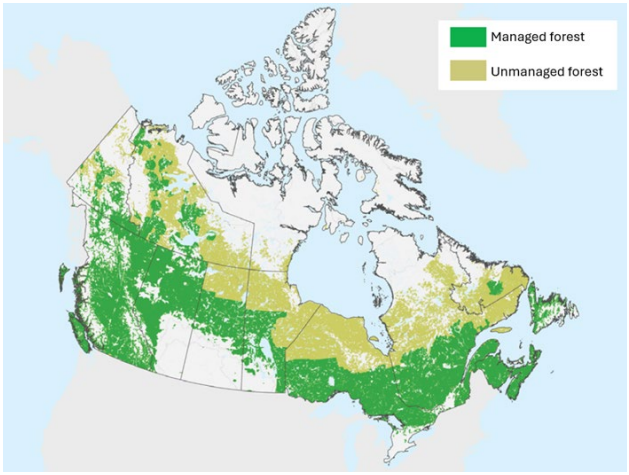


Figure 2. Canada's managed and unmanaged forest area. Sourced from Canada's 2025 National Inventory Report to the UNFCCC.

Each year, Canada's managed forest acts as a carbon sink or a source, depending mainly on the area affected by fire and insects. **Figure 3** shows that in recent decades, Canada's entire managed forest, including the wood products harvested from it, has become a carbon source, emitting more carbon into the atmosphere than it is sequestering. Natural disturbances have contributed to this shift because the area burned by wildland fires and damaged by insect outbreaks in Canada has increased substantially over the past 20 years. Canada's managed forest emissions were exceptional in 2023 due to the unprecedented wildland fires that burned 7.9 million hectares.

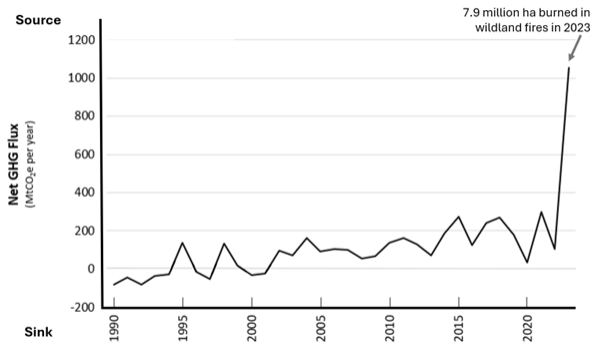


Figure 3. The total net GHG flux from Canada's managed forests and associated harvested wood products, 1990–2023. Data include both anthropogenic and natural disturbances. GHG indicates greenhouse gas; $MtCO_2e$, metric tons of carbon dioxide equivalent. GHG flux is the net balance of emissions, removals, and carbon transfers.

With the carbon balance of Canada's entire managed forest largely being determined by natural disturbances, how do we know what impact humans are having?

Understanding the impact that humans are having on the GHG flux of the managed forest is important. It helps us evaluate how the actions we can control, such as forest management activities, affect the carbon balance. Canada separates GHG flux reporting for the managed forest area into two categories: natural disturbances and anthropogenic (affected by human actions) disturbances.

When looking at the managed forest anthropogenic category and the wood products derived from those lands, Canada's managed forest has been a net carbon source in recent decades (**Figure 4**). This is because transfers of carbon stocks from the managed forest to the harvested wood products pool, combined with emissions stemming from forest management activities and decomposition within the managed forest pool, have been greater than the managed forest's carbon sequestration (green bars). The harvested wood products pool shows carbon gains throughout most of the reported time series (1990–2023). These gains are generally due to more carbon being harvested, transferred, and stored in the wood products pool than is emitted by the burning or disposal of wood products. This includes emissions from wood products derived from Canada's forests that are used both domestically and worldwide.

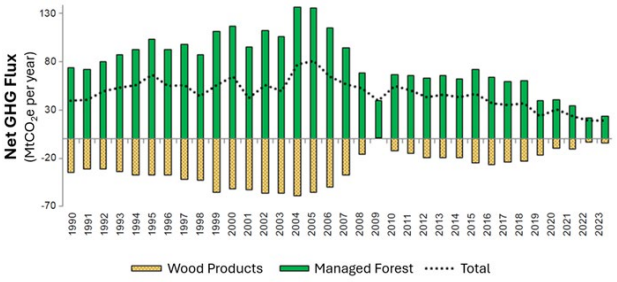


Figure 4. Annual net GHG flux of Canada's managed forest and associated wood products, 1990–2023. GHG indicates greenhouse gas; $MtCO_2e$, metric tons of carbon dioxide equivalent. Data include only the anthropogenic component. GHG flux is the net balance of emissions, removals, and carbon transfers. Positive GHG flux values indicate carbon losses whereas negative GHG flux values indicate carbon gains. When the GHG fluxes for the managed forest and wood products components are added together, carbon transfers between the two categories are cancelled out and the resulting value (black dotted line) is representative of the total net emissions to the atmosphere.

Although the GHG flux from the anthropogenic category of Canada's managed forest and harvested wood products has been consistently positive, it has been decreasing since around 2005. In the decades prior to 2005, the rate of harvested area in Canada increased in response to economic demand and forest management actions related to the mountain pine beetle epidemic in western Canada. This caused the proportion of land emitting carbon to also increase. As a result of the global economic recession in the late 2000s, followed by a decade of steady harvest rates, the proportion of land acting as a carbon sink is now increasing. At the same time, carbon is being transferred to an increasing global pool of long-lived wood products.

How uncertain are Canada's forest carbon estimates?

Estimating forest carbon is a complex undertaking, and there is uncertainty involved in the modelling process. This includes uncertainties in tree growth and decay processes, in the forest age and species composition, and in the area affected by wildland fire and insect outbreaks.

The uncertainties associated with forest carbon estimates are reported in an uncertainty range (the interval within which we expect the true estimate to be). For the managed forest (anthropogenic category) and the harvested wood products derived from it, the average uncertainty range is 70 million metric tons of carbon dioxide equivalent ($MtCO_2e$) for each year from 1990 to 2023.

Natural Resources Canada's CFS and Environment and Climate Change Canada collaborate with external partners to continuously improve Canada's forest carbon estimates. Canada's planned forest carbon improvements are tracked in an Improvement Plan. Many updates are anticipated over the next 10 years, including expanding the forest carbon modelling to Canada's entire forest area (managed and unmanaged). In addition, CFS is in the early stages of developing a new forest carbon monitoring system that improves the use of remote sensing data, allowing for spatially explicit modelling of forest carbon in the future.

Can Canada's forests still contribute to a climate change solution?

Yes. Forests in Canada still serve as crucial carbon reservoirs by sequestering and storing large amounts of carbon from the atmosphere. Beyond their importance as carbon reservoirs, Canada's forests also support rich biodiversity. They are a key source of economic prosperity, supporting industries such as forestry, tourism, and recreation, and providing livelihoods for many communities across the country.

Even if Canada's managed forest is a source of carbon, we can still take action to reduce emissions and increase sequestration. Management activities that increase forest resilience to fire and insect outbreaks can help reduce emissions. We can increase carbon sequestration through activities such as afforestation (the creation of new forests). We can also ensure fast regeneration of the forest after harvesting or natural disturbances through natural regrowth or replanting efforts. Carefully selecting which tree species to plant can also improve the resilience of these new forests to the impacts of climate change. The measures that we take to decrease emissions or increase carbon sequestration from forests can provide important co-benefits for people and nature.

We can also use harvested wood efficiently and in ways that encourage long-term carbon storage. For example, buildings made with wood store substantial amounts of carbon for decades, contributing to a larger global pool of long-lived wood products. Wood products can replace emissions-intensive products and materials. For example, bioenergy can replace fossil fuels such as coal and diesel to reduce net emissions.

In the fight against climate change, every effort to reduce emissions or increase carbon sequestration and storage matters (**Figure 5**).

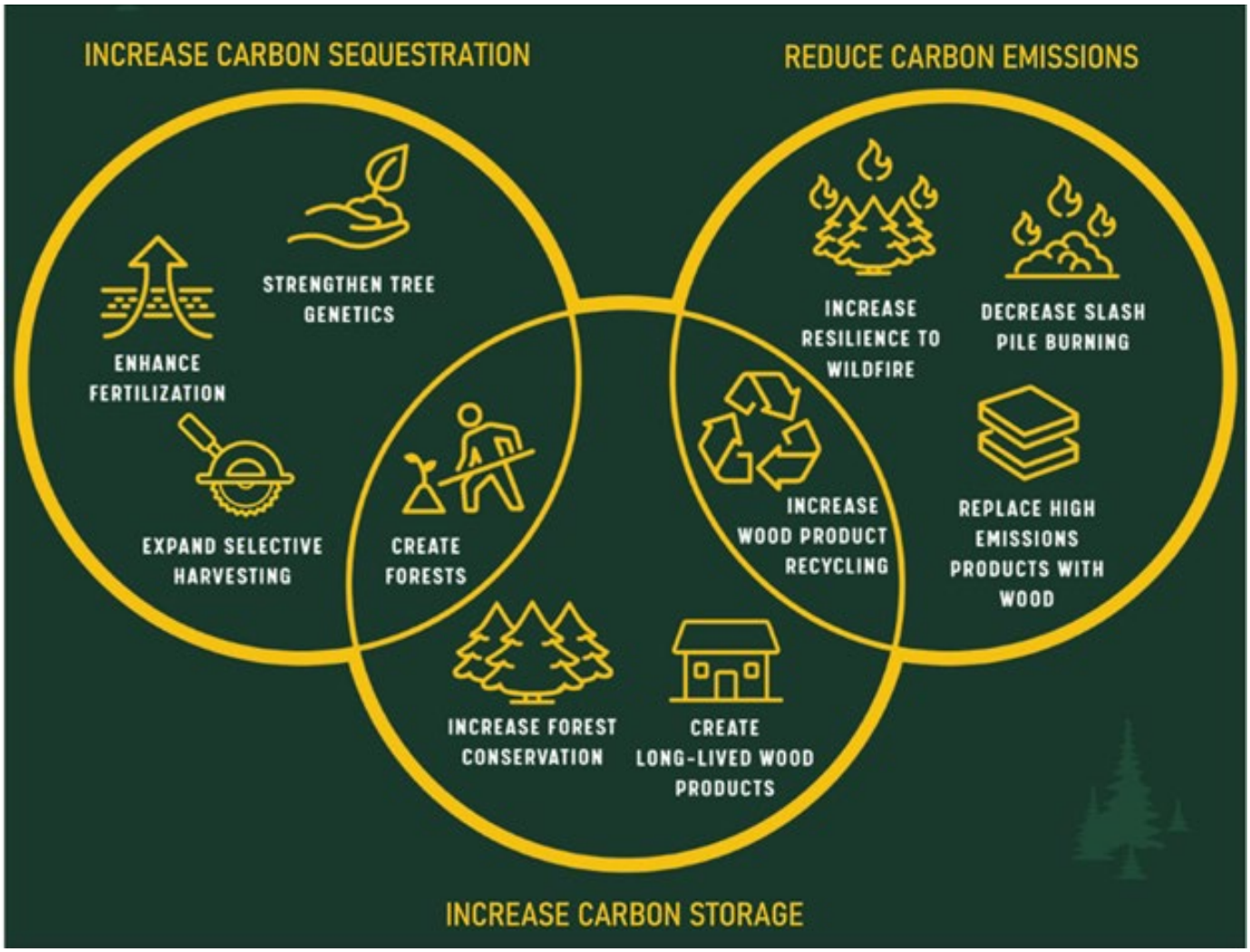


Figure 5. Climate change mitigation actions in the forest sector.

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