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A SYSTEMS APPROACH TO FOREST CARBON ACCOUNTING

This May 2017 blog is written by Marina Melanidis from the PICS [Forest Carbon Management Project](), a multi-year collaborative effort created by the Pacific Institute for Climate Solutions, involving scientists from Natural Resources Canada (NRCan), the University of British Columbia (UBC) and other agencies.

When discussing climate change, forests are an important factor. Second only to oceans, they are the one of the world's largest natural storehouses of carbon, containing more carbon than is currently in the atmosphere [1]. Globally, the amount of carbon accumulated by forests from 1990 to 2007 was equivalent to 34% of emissions released from fossil fuels, removing approximately 8.8 billion tonnes of carbon dioxide (CO_2) from the atmosphere each year [2]. The forest sector has been recognized globally for its ability to reduce Greenhouse Gas (GHG) emissions [3], and with nearly 10% of the world's forested land [4] Canada's interest in climate change mitigation opportunities within its forest sector has been steadily increasing.

B.C. is home to 55 million hectares of forest [5], and the amount of carbon contained in wood harvested from these forests each year is roughly equal to the annual carbon emitted from all other sectors in the province [6]. In its 2016 Climate Leadership Plan, B.C. has pledged to use forests to help reach the GHG reduction target of 80% below 2007 levels by 2050 [7].

Forests, however, are not a self-contained system, and in order to fully understand the trade-offs of any mitigation strategy for B.C.'s forest sector, it is important to take into consideration the flow of carbon between forest ecosystems, wood products, and the manufacturing and energy sectors [8]. This approach is called a systems perspective, and it is necessary to account for the carbon stored and released by B.C's forest sector as a whole.

There are three core elements involved when using a systems perspective to assess forest mitigation strategies: carbon emissions and removals from forests, carbon that is stored in wood products, and the substitution effect that occurs when wood products replace more emission-intensive products, such as concrete or coal.

EMISSIONS AND REMOVALS FROM FORESTS

Carbon is continuously released from and taken in by forest ecosystems. Forests release carbon through respiration (a process where sugars are converted into energy to fuel living cells) the decay of dead organic matter, and when biomass is burned during wildfires. Carbon sequestration (the uptake of atmospheric carbon) occurs through photosynthesis as trees grow. Through this process carbon is absorbed and used to create plant biomass, such as wood, where it is then stored. About half of the dry weight of wood is carbon.

A forest can act as a net source or net sink of carbon, depending on whether it releases or sequesters more carbon in a given year. From 1900 to 2002, B.C.'s forest sector was a net carbon sink: this means forests removed more carbon from the atmosphere then was released by decomposition, wildfires, and the decay and burning of harvested wood products. Since 2003 however, the forest sector has usually been a net carbon source, meaning it released more carbon than it removed, due largely to an increase in tree death from the mountain pine beetle outbreak and an increase in wildfires [6]. **To learn more about carbon in forest ecosystems, turn to the second blog in our series.**

CARBON STORAGE IN WOOD PRODUCTS

Harvesting a tree does not result in an immediate release of carbon into the atmosphere. Instead, carbon remains stored within the wood, and therefore within the wood product. Harvested wood products (HWPs) like wood furniture, lumber, and pulp and paper continue to store the carbon taken in by trees throughout the length of the product's life [9]. When a product is disposed of via landfill, or burned as a source of energy (which is referred to as bioenergy), the carbon is released back into the atmosphere. Therefore, wood products with longer useable lifespans, such as wood used for construction, store carbon for longer periods of time than products with a short usable lifespan, like most paper or wood used for energy. Recycling and repurposing wood products at the end of their lifespan can prolong the length of time carbon is stored.

The flow of carbon from forest ecosystems to HWPs can significantly influence mitigation strategies; carbon stored in wood products can remain stored for decades and sometimes even centuries within the product (for example, lumber in a house) or in landfills, and therefore is kept out of the atmosphere [5]. **The third blog in our series looks at harvested wood products in greater detail.**

THE SUBSTITUTION EFFECT

When using wood products in place of products or energy sources that are more emissions-intensive, a net reduction of GHG emissions often occurs [10]. This is called the substitution effect. There are two types of substitution. Material substitution refers to the emission reduction that occurs when wood products are used to replace materials whose production causes more GHG emissions on a life-cycle basis, such as cement or steel. Measuring carbon intensity on a life-cycle basis results in all emissions that are released from material extraction to disposal to be included. Energy substitution refers to the emission reduction that occurs when wood biomass is used as fuel to produce energy (electricity or heat) that replaces fossil fuels, such as coal, whose production and use may cause more GHG emissions on a life-cycle basis. If the wood used as fuel comes from residues from harvest or from waste wood, a net GHG reduction is possible.

Since wood can have a relatively low carbon footprint compared to many of its alternatives, whether they are materials like cement or energy sources like coal, substituting wood as a material or fuel can result in less carbon being released into the atmosphere. These avoided emissions increase the benefits of using wood from a climate change mitigation standpoint [11]. **For more information about the substitution effect, see the fourth blog in our series.**

Thoroughly assessing the impacts of climate change mitigation strategies for the forest sector is complex because there are multiple elements to consider: the carbon that can be stored in living forest ecosystems, the carbon that can be stored in HWPs, and the carbon emissions that can be avoided through substituting wood for emission-intensive products. Developing mitigation strategies with a systems perspective allows for all these elements to be taken into account, and enables the design of climate-effective mitigation strategies [12]. Ultimately, every climate change mitigation strategy utilizing B.C.'s forests will feature trade-offs, often between increasing carbon storage in living trees and harnessing the mitigation benefits available through the use of wood products. The systems perspective helps us examine these trade-offs more accurately and better estimate how changes in forest sector activities can be used to mitigate the rate of carbon increase in the atmosphere and the future impacts of climate change.

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