From Carbon Source to Carbon Sink: How Forestry can Help Mitigate Climate Change

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A document informing the Discussion Item 4a: Carbon emissions associated with forest operations

Key Points

- Reducing the amount of carbon in the atmosphere helps mitigate climate change.
- Forests can act as carbon sink or carbon source, depending on the balance between photosynthesis and respiration.
- Forest operations affect the carbon balance of forests and contribute to carbon emissions through the burning of fossil fuels.
- Various management strategies can be used to increase carbon storage and reduce emissions from forest operations.

Introduction

Climate change is increasingly recognized as a serious threat to people, economies, and ecosystems. Carbon dioxide is recognized as a contributing factor. Reducing the amount of carbon emissions into the atmosphere could slow the effects of climate change. Canadian forests can play a key role in this process.

Understanding the role that forests play in the carbon cycle is of particular importance. Trees remove carbon dioxide (CO_2) from the atmosphere by absorbing it through their leaves and converting it into sugar, in a process called photosynthesis. Some of this sugar is used for new tree growth, and the carbon becomes stored in wood or ends up on the forest floor when leaves and dead branches fall off. Some of the sugar is used by the tree for energy, and is returned to the atmosphere as CO_2 in a process called respiration. Animals and micro-organisms that use plants and other organic material also give off CO_2 through respiration, returning carbon to the atmosphere. The difference between forest uptake of CO_2 (by photosynthesis) and release of CO_2 (by respiration) is the carbon balance of the forest.

The carbon balance determines whether the forest acts as a carbon source or a carbon sink. If the rate of carbon storage exceeds the rate of release, then the forest is considered a carbon sink. Natural disturbances (such as fires and insect outbreaks) can cause the amount of carbon released into the atmosphere to exceed that taken up by photosynthesis. The forest then becomes a carbon source, at least temporarily. Other factors such as forest age, structure and past history can also alter the carbon balance of a forest.

Forest operations affect the carbon balance of forests and contribute to carbon emissions. Although a part of the carbon will remain stored in long life products such as lumber in a house, when loggers remove trees and burn leftover material (slash), carbon is lost from forest systems. The fossil fuels used in forest operations also add to overall carbon emissions. Foresters can use many strategies to increase carbon storage and reduce emissions from forest operations. These can be broadly divided into four categories: *Afforestation, Stand Management, Harvesting* and *Processing.*

Afforestation

One strategy for increasing the amount of carbon stored in trees is to establish new forests on non-forested land (afforestation). Landowners can plant trees on degraded agricultural fields or other marginal land, contributing to increase carbon storage. However, the long-term benefits of carbon storage depend on the permanence of the forest or plantation. If the trees are harvested or burn in a

wildfire, most of the carbon they had accumulated may be released back into the atmosphere. Afforestation is usually only of interest to forest companies with access to private marginal land.

Stand Management

After harvesting, forested sites can remain a carbon source for up to ten years. This is due to increased respiration of CO_2 by soil microorganisms and decreased photosynthesis. Ensuring prompt regeneration on cut sites is vital to minimize the amount of time a forest remains in a carbon source state.

Lengthening the rotation age (age at which forests are cut) is a simple strategy that can be used to increase carbon storage on forest lands. By extending harvest cycles, the trees accumulate greater amounts of carbon as woody biomass. However, this may not always be economically feasible for forest companies. Protecting forests against fire, disease, and insect pests also helps to preserve the carbon stored in trees. However, suppression of natural disturbances comes with its own set of complications.

Another important factor to consider is the carbon accumulation rate. In general, younger forests have faster growth rates, and thus accumulate more carbon annually than a mature forest of similar species. Mature forests have more carbon stored on site, but young forests build up carbon more rapidly. Forest managers must find a balance between the amount of carbon stored and its rate of accumulation.

Forest managers can use tools to increase the rate at which forests accumulate carbon. They can favour culture method such as density management and brush control that promote faster growth and thus help collect carbon more rapidly. They can also use fertilizers to increase tree growth rates. However, inefficient use of nitrogen fertilizers can increase emissions of another more potent greenhouse gas, nitrous oxide (N_20). Until the trade-off between carbon accumulation and N_2O release is quantified, nitrogen fertilization should be treated cautiously.

Harvesting

Harvesting can be very energy intensive, and may lead to unnecessary emissions of carbon dioxide. Increasing the fuel efficiency of harvesting and transport equipment helps to reduce carbon emissions. Proper training of operators and preventive machine maintenance also helps to improve fuel efficiency.

Implementing a structured harvesting plan also helps reduce avoidable carbon emissions. The construction and maintenance of forest roads and landing sites requires much energy and fossil fuel burning. Foresters can design in advance plans that minimize road networks, thus contributing to reduce carbon emissions. To minimize road networks, harvests should be concentrated in intensively managed areas, ideally located close to a central mill site. It is important to note, however, that harvesting systems using more extensive road networks can also have ecological benefits (see Discussion Item 1b).

Lastly, the common practice of piling up and burning slash after harvest causes important amounts of carbon to be loss through combustion. Saving some slash for biomass energy production can potentially help displace the burning of fossil fuels (See Discussion Item 2d).

Processing

Sawmills and pulp and paper mills use energy to process timber into merchantable products. To reduce carbon emissions, mills can obtain more energy from renewable sources and reduce their use of fossil fuels. They can also improve their energy efficiency and minimize waste. Over the past few years, the Canadian forest industry has made great strides toward reducing fossil fuel use in mills.

Summary

The forestry sector can play a major role in helping to halt climate change. A wide range of strategies can be implemented to increase the amount of carbon stored in trees and decrease carbon emissions from forest operations. The appendix provides a table that summarizes the main strategies discussed.

Discussion questions

1) What are the strategies used by the company to increase carbon storage and reduce emissions?
2) Is the company engaged in afforestation activities?
3) How is carbon storage taken into account in stand management decisions?
4) Are steps taken to maximize fuel efficiency during harvest and processing?
5) Does the company implement structured harvesting plans to minimize road networks?
6) What is the company's policy concerning the burning of slash after harvest?

Further reading

- Canadian Forest Service; Carbon cycle [Internet]. Ottawa, ON: Natural Resources Canada; 2007 Oct [Cited 2009 May 11]. Available from: http://ecosys.cfl.scf.rncan.gc.ca/dynamique-dynamic/carbone-carbon-eng.asp
- Canadian Forest Service; Is Canada's forest a carbon sink or source? [Internet]. Ottawa, ON: Natural Resources Canada; 2007 Oct [Cited 2009 May 11]. Available from: http://cfs.nrcan.gc.ca/news/544
- United States Department of Agriculture (US) [USDA]. Climate Change, Carbon, and Forestry in Northwestern North America: Proceedings of a Workshop. Portland, OR: Pacific Northwest Research Station; 2004 Apr. 119 p. Available from: www.fs.fed.us/pnw/pubs/pnw_gtr614.pdf
- Rotherham, T. A Short Explanation of the Role of Forests in the Kyoto Protocol. S&W Report. 2003; 33: 1-5. Available from: http://www.ontariowoodlot.com/pdf_older/Kyotoprotocol_exp.pdf
- LiveSmart BC; Pacific Carbon Trust [Internet]. Victoria, BC: Province of British Columbia; 2007 [Cited 2009 May 11]. Available from: http://www.livesmartbc.ca/government/trust.html

Appendix

Strategy to Increase Carbon Storage/ Reduce Emissions	**Issues/limitations**	**Uncertainty Involved**
Rapid replanting of cut sites	Cost/coordination	Low
Increased afforestation	Increased plantations, cost, negative public image of uniform forests	Low
Improved fuel efficiency	Cost of new technology, training of operators	Low
Structured harvesting plan	More intense harvesting on connected areas, reduced roads, reduced costs, increased clearcuts, negative public image, increased impacts over smaller areas	Low
Sawmills and pulp and paper mills	Waste minimization, Energy efficiency, increased use of renewables	Low
Use slash for biomass energy production	Transportation distance to processing plant	Moderate
Lengthening of rotation age	Loss of revenue to forest companies, increased habitat diversity , site storage of carbon vs off-site storage	Moderate
Long Lasting Products	Hard to keep track of	Moderate
Maximizing carbon accumulation rate	Encourage younger forests, fertilization, Negative public image of cutting down old growth, Loss of Carbon Storage, Loss of habitat diversity	High