Popular Summary

Operational-scale forest carbon accounting

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Abstract

Forests play an important role in the global carbon budget. How these forests are managed can influence the carbon budget of Canada's forests at local, regional, and national scales. The Canadian Forest Service and the Model Forest Network are developing an operational-scale carbon budget model (Operational Scale Carbon Budget Model of the Canadian Forest Sector–CBM-CFS3) that will allow forest managers to assess forest carbon stocks and stock changes. This presentation briefly examines the role of stand- and landscape-level forest dynamics in the carbon budget and outlines the tools being developed for forest carbon accounting at the operational scale.

KEYWORDS: *biomass, carbon accounting, carbon budgets, carbon budget modelling, organic matter pools.*

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Introduction

Forests play an important role in the global carbon budget. How these forests are managed can influence the carbon budget of Canada's forests at local, regional, and national scales. With the increasing national and international awareness of the role that forests have in the contribution towards carbon sinks and sources, there is growing expectation that forest managers be able to assess the forest carbon stock changes on their land base. Several national and international processes, including forest certification, Criteria and Indicators, and the United Nations Framework Convention on Climate Change, recognize the importance of forests to the global carbon budget. In addition to assessment for reporting, forest managers have the opportunity to contribute to reducing carbon sources and enhancing carbon sinks through their forest management activities.

The Canadian Forest Service (CFS) Carbon Accounting Team and the Model Forest Network (MFN) are working together to develop and provide a tool that forest managers can use to assess forest carbon stocks and stock changes. This tool—the Operational Scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)—builds on over a decade of research and work with the CBM-CFS2 (Kurz *et al.* 1992; Kurz and Apps, 1996, 1999). The model is continually updated to incorporate the best available science and to ensure consistency with international carbon accounting rules. The tool can be used in a monitoring role to account for past and current carbon stock changes, or in a projective role to conduct scenarios of future carbon stock changes.

The Role of Forests in the Carbon Budget

Forests take up carbon from the atmosphere through photosynthesis, and lose it through respiration, decomposition, and through emissions associated with disturbances like fire, insect mortality, and harvesting. The balance between carbon uptake and losses determines whether the forest is a net sink or source for a given period. This balance is influenced by factors at both the stand and landscape level.

Stand-level Dynamics

The net balance between uptake and losses varies over time within an individual forest stand. This is driven mainly by the balance between uptake of carbon through biomass growth, and losses from decay of dead organic matter on the forest floor and in the soil. For a stand to be a net carbon sink, the carbon uptake must be higher than the ongoing losses through decomposition. Since growth rates vary over time, a single stand can change between a source and a sink throughout stand development. In stand initiation (immediately following a disturbance), stands generally act as a carbon source until the carbon uptake exceeds the losses from the decay of dead organic matter, at which point the stand switches from a net carbon source to a net carbon sink. Forest management activities influence stand-level carbon dynamics. Activities that affect biomass growth rates and the timing of growth, such as site preparation, planting, and stand tending, will influence the carbon balance of a stand.

Landscape-level Dynamics

A forest landscape is composed of many stands, and the carbon dynamics of each is affected by the local conditions, stand development stage, and site history. Consequently, at a given point in time, a landscape will generally have a mix of stands that are acting as a source, and others as a carbon sink. The carbon balance of the entire forest can be estimated by summing the exchange in all the stands. At the forest landscape scale, the disturbance regime has a major impact on the carbon balance. Increasing disturbance rates generally result in a carbon source, while reductions in disturbances result in a carbon sink (Kurz *et al.* 1998; Kurz and Apps 1999; Apps *et al.* 2000). Management activities having an effect at the landscape scale, such as suppression of natural disturbances or changing harvest rotation lengths, will have a large impact on the forest carbon balance (Price *et al.* 1997; Kurz *et al.* 1998).

Forest Carbon Accounting at the Operational Scale

Managers who wish to include carbon-related indicators and goals will need tools that help them assess the effect of their activities on forest carbon stocks and stock changes. A carbon accounting tool needs to be applicable across the range of forest management activities and apply to all forests in Canada. The project initiated by the CFS Carbon Accounting Team and the MFN is designed to provide a tool that addresses this need. The objective is to develop, test, and implement a user-friendly forest carbon accounting tool that:

- incorporates our current understanding of ecosystem carbon dynamics,

- is compliant with international guidelines, and
- is available to the forest management community in Canada.

The approach builds on over a decade of research and expertise in the development of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS2), which was primarily a research tool.

The core model (CBM-CFS2) was developed to assess past and future forest carbon stock changes in Canada. It has been used to assess carbon stock changes for all of Canada (Kurz and Apps 1999), both in the managed forests of individual provinces (Kurz *et al.* 1996a) and at the scale of operational units (Price *et al.* 1997; Kurz *et al.* 1998). Currently, the model is used to assess the impact of large-scale natural disturbances across Canada, as well as the effect of the recent mountain pine beetle outbreak in British Columbia.

The approach taken is to provide a model that builds on the existing knowledge base and data normally used by the forest management community. The model makes use of the same type of information that is used in timber supply analysis, augmented with additional data and simulation modelling to cover those aspects of ecosystem carbon dynamics that are not normally included in timber supply modelling. To facilitate the import of data, specific tools have been created. In addition to the standard tool for users to import their data into the model, two specific tools have been added: for Ontario's Strategic Forest Management Model (SFMM) and for the timber supply analysis tool Woodstock.

Biomass Carbon Estimation

A detailed forest inventory provides information on the area, age, and other indicators (such as site class, cover type, etc.) of the forest. Growth and yield information (volume over age) for each strata is used to describe the biomass dynamics over time in each stand. For most operational users, the growth and yield curves can also be empirically derived; however, these curves can also be supplied from yield models or process models. From the volume, conversions are used to obtain biomass and carbon estimates. Regional volume to biomass conversion factors used by the model are being developed to cover the entire country through a CFS project supported by the Federal Panel on Energy Research and Development (PERD). Belowground biomass in coarse and fine roots is estimated using previously developed equations (Kurz *et al.* 1996b; Li *et al.* 2003).

Dead Organic Matter Pools

Most forest inventories do not have information on dead organic matter pools, such as snags, coarse woody debris, litter, and soil carbon. The model uses a simulation approach to estimate the size of the dead organic matter pools (Kurz and Apps 1999). Regional comparisons between independent field observations of soil carbon and estimates by the CBM-CFS2 have yielded reasonable results (Bhatti *et al.* 2002). The CFS is currently using the recently compiled Forest Ecosystem Carbon Database (Shaw *et al.* 2005), and will also examine results from a long-term decomposition experiment (Trofymow and CIDET Working Group 1998) for validation and potential model revisions.

Summary

Forest management activities affect carbon sinks and sources in forests. The CFS and MFN are developing an operational-scale carbon budget model that will empower forest managers to assess and manage the effects of forest management activities. The model is currently in the final stages of Beta testing, with a planned public release in fall 2005. With such a tool, forest managers can begin to determine the effect of current practices, as well as potential practices on forest carbon stocks and stock changes. In addition, model users will benefit from the ongoing scientific and technical improvements to the model. The CBM-CFS3[1] is also at the core of Canada's new National Forest Carbon Monitoring, Accounting and Reporting System, which is being developed to meet international reporting requirements for national greenhouse gas sources and sinks (Kurz and Apps, in press).

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[1] For more information on the CBM-CFS3 see: *http://carbon.cfs.nrcan.gc.ca*

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