Canada’s National Forest Carbon Monitoring, Accounting and Reporting System: Applications in Reporting and Policy Support

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Forestry and Agriculture GHG Modeling Forum, Workshop #4: Modeling Ag-Forest Offsets and Biofuels in U.S. and Canadian Regional and National Mitigation

March 5-8, 2007 – Shepherdstown, West Virginia
Outline

- Methods: NFCMARS
- Managed Forest GHG Balance (1990 – 2005)
- Projected Future GHG Balance
- Conclusions
Requirements for Forest Carbon Accounting

- Contribution of Canada’s forests to the global C cycle
- Support policy analyses (projections):
  - decision to include forest management in Kyoto reporting,
  - assess land-use change policy options (ARD),
  - assess implications of forest management strategies.
- Monitoring and reporting of forest C stock changes.
Canada’s National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)
LULUCF in the National GHG Inventory

Canada’s National Greenhouse Gas Inventory (Environment Canada)

- Land-use Change and Forestry
- Agriculture

Energy
Industrial Processes
Solvents
Waste

Forest C Accounting System
NRCan/CFS

LUC - ARD

Agriculture C Accounting System
AAFC
Key Elements of Approach

• Science-based conceptual framework is the foundation for the design, and for data synthesis and integration
• Build on forest management knowledge – data driven!
• Modeling is consistent across spatial scales.
• Initially, combine one inventory with change information.
• Develop models, databases and infrastructure for projective analyses using best-available data
• Conduct scenario and sensitivity analyses
• Improve available data for use in monitoring and reporting
• System evolves with better data and new science
Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

- An operational-scale model of forest C dynamics.
- Allows forest managers to assess carbon implications of forest management: increase sinks, reduce sources
- Builds on >15 years of CFS science
- Available at: carbon.cfs.nrcan.gc.ca
Canada; 18 Reporting Zones

Hierarchy of Spatial Scales

60 Reconciliation Units

>1,400 Spatial Units

> 2.5 Million Stands
Managed and Unmanaged Forest

~238 Mha of Managed Forest
Analyses of Forest C Stock Changes for over 1,400 Spatial Units

Spatial units are forest management areas. Analysts can use CBM-CFS3 to assess their forest’s contribution to the C budget.
CBM-CFS3 uses spatially-referenced information about forest conditions within Spatial Units.
CBM-CFS3 reports ...

5 Carbon Pools:

Biomass
1. Aboveground Biomass
2. Belowground Biomass

Dead Organic Matter
3. Dead Wood
4. Litter
5. Soil Organic Carbon

Net Carbon Balance
Emissions by CO$_2$, CH$_4$, CO (and N$_2$O)
Area changes for forest-related land categories
Annually by spatial unit, reconciliation unit and reporting zone
CBM-CFS3 uses Data from Forest Management Planning

- Volume/age curve(s)
- Detailed forest inventory
- Litter fall and decomposition

- Volume to biomass conversion
- Disturbance(s)
- Land-use change(s)

- Harvest scheduling tool

- Harvest schedule

- CBM-CFS3

Results database
Growth and Yield Data Sources
Stand-level Volume to Biomass Conversion

- CFS project developed conversion factors for CanFI 2001 to convert merchantable volume into biomass (Boudewyn et al., in preparation)
  - Over 1,100 biomass component equations applied to
  - 7.1 million tree measurements from
  - 174,000 Permanent/Temporary sample plot measurements
- Root Biomass (Kurz et al. 1996, Li et al. 2003)
Disturbances

- Direct emissions of CO$_2$, CH$_4$, N$_2$O
- Transfer biomass C to forest product sector
- Transfer biomass C to dead organic matter
- Affect subsequent C dynamics
- Affect age-class structure
Area annually burned

- Base data from CFS Large Fires Database
- Area burned in fires (> 200 ha) from 1959 to 2004.
- Canadian Wildland Fire Information System for 2004 - 2005
- Map shows 1980 – 2003
Canadian Wildland Fire Information System

Monitors Daily Fire Activity

Annual Area Burned Analysis
CWFIS and CBM-CFS3

Calculate fire emission based on fuel and fire conditions

Image: R. Landry, NRCan, CCRS
Insect Impacts simulated in CBM-CFS3

DEFOLIATORS
• Growth reduction
• Tree Mortality
• Defoliation can be directed to target stands defoliated in prior years
• Multi-year impact sequence

BARK BEETLES
• Tree Mortality

Credit: T. Hogg

“White” tree rings formed during severe insect defoliation
Tracking Land-use Change Events

Agricultural Expansion
Settlements
Industrial Infrastructure
Deforestation Monitoring

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Area Mapped (Mha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975-1990</td>
<td>15.0</td>
</tr>
<tr>
<td>1990-2000</td>
<td>38.1</td>
</tr>
<tr>
<td>Northern Full Area</td>
<td>55.6</td>
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</tbody>
</table>

Mapped area sampled from: ~204 Mha

Source: D. Leckie, NRCan, CFS
Carbon Budget Model of Canadian Forest Sector

- Forest inventory and growth & yield data
- Natural disturbance monitoring data
- Forest management activity data
- Land-use change data
- Ecological modelling parameters

CBM-CFS3
System compliant with IPCC Reporting Guidelines

Good Practice Guidance for Land use, Land-use Change and Forestry
GHG Balance in Canada’s Managed Forest (1990 - 2005)
Acknowledgements

CFS-Carbon Accounting Team at PFC and NoFC:
Werner Kurz, Thomas White, Graham Stinson, Caren Dymond, Eric Neilson, Brian Simpson, Cindy Shaw, Ed Banfield, Greg Rampley, Michael Magnan, Gary Zhang, Kevin Belanger, Scott Morken, Sarah Davies

CFS Deforestation Monitoring Team:
Don Leckie, Dennis Paradine, Sally Tinis, Will Burt, Dean Hardman, Frank Eichel, Dave Tammadge,

CFS Policy: Tony Lemprière, Darcie Booth, Peter Graham

SOILS: Tony Trofymow,, Carolyn Smyth


NFI project office: Mark Gillis, Katja Power, Paul Boudewyn and Alex Song
Acknowledgements

BC: M. Boyce, G. Lawrence, D. Spittlehouse, J. Parminter, D. Draper, Stephen Davis
AB: Dave Morgan, Daryl Price, Evelynne Wrangler
SK: Mark Johnston, Bob Wynes
MN: Greg Carlson, Jianwei Liu, Wenli Xu, S. Warrington
ON: Michael Termikaelian, Steve Colombo, Joe Bovin, V. Scott and P. Gray
PQ: Michel Campagna, Marc DeBlois, Bruno Levesque
NS: Ken Snow, Robert O’Keefe, Jorg Beyeler
NL: Boyd Pittman, Ivan Downton
PEI: Jon Hutchinson, Glen Williams
YT: Aynslie Ogden, Jesse Devost
NWT: Tom Lakusta, Susan Corey, Lisa Smith
NB: Robert Dick, Doug Mason
Managed Forest Ecosystem Stock Changes

Stock Change (Mt C / yr)

Year


Sink

Source

Total
Area burned affects annual C balance

![Graph showing C Stock Change (Mt C / yr) vs. Area Burned (Mha) from 1990 to 2005. The graph indicates periods of Source and Sink, with C Stock Change values ranging from -50 to 2.4 and Area Burned values ranging from 0.0 to 2.4.](graph.png)
Risk Assessment of the Decision on Article 3.4 of the Kyoto Protocol: Should Canada elect Forest Management for inclusion in Kyoto reporting?
Countries that have ratified the Kyoto Protocol must decide by 2006 whether or not to elect forest management activities under Article 3.4.

If yes, then account for annual C stock changes in area of forest subject to forest management during the first commitment period (2008 – 2012).

All stock changes in the managed forest – human induced or natural causes.
Background

• Potential to off-set emissions from ARD and from fossil fuels, but also a risk that FM will contribute a net source.

• What is the probability distribution of the net C balance of the area subject to forest management in the first Kyoto commitment period (2008 – 2012)?

• Studies were conducted in 1999 to develop preliminary scenarios (Kurz et al. 2000) and in 2000 to assess 32 scenarios (Kurz and Beukema 2001). These used National Biomass Inventory (Bonnor 1985) as only inventory data source.
Annual change in ecosystem C stocks 2008-12
Results for 15 scenarios

Base run is not the only possible outcome. What is the probability of each outcome?

Source: Kurz and Beukema, 2001
Predicting future forest dynamics using a stochastic approach

100 Monte Carlo Runs for all of Canada
Assumptions used in Risk Analyses

- **Harvest**: Used timber supply model or AAC projections, some adjusted based on provincial inputs.
- **Fire**: Annual area burned randomly drawn from regionally parameterized probability distributions of area burned.
- **Insects**: Regional projections of area and impact based on historic data and current forest conditions for eastern spruce budworm, aspen defoliators, mountain pine beetle, spruce beetle, eastern hemlock looper, and Jack pine budworm.
Probability Distribution for the 1st CP Including Non-CO$_2$ Greenhouse Gas Emissions

Preliminary results: 1 in 10 probability of FM sink on average during 2008-2012
What Contributes Most to the Risk?

• In 1990-2005 the managed forest was a sink in most years - why do these results say 2008-12 likely will be different?

• A high risk of a source in 2008-12 can be explained:
  – Harvest/salvage have a large C impact – in increases with projected harvest levels (a predictable contribution to the risk)
  – Insects contribute to the risk at an increasing rate due to an anticipated increase in infestations (natural outbreak cycles)
  – Fires are a wild card – unpredictable and highly variable, they make the largest contribution to the risk
  – Legacy of age-class structure
Conclusions

- Canada’s managed forest was a net C sink of 16.6 Mt C / yr from 1990 – 2005; it was a sink in 12 of 16 years.
- Canada’s managed forest has an estimated 91% probability of being a net source of greenhouse gases in the first commitment period (2008 – 2012).
- Future negotiations should seek to address current shortcomings of the KP accounting rules for forests.
- Forest mitigation options are available: assessment of their benefits is in progress