

Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) experiences in implementing a Tier 3 approach

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Outline

- Background
- Benefits of Using Tier 3 Models of Forest Carbon Dynamics
- Validation of Tier 3 Models
- Increasing Transparency of Tier 3 Models: A proposal
- Conclusions



Background

- IPCC Meeting on National Forest GHG Inventories - a Stock Taking (Yokohama)
- UNFCCC Experts Meeting (Bonn)
- Feedback from UNFCCC review process
- Primary concerns centered around incomplete documentation and lack of transparency of Tier 3 models used in GHG inventory reporting in LULUCF sector.
- Perception of Tier 3 models as “black boxes”



Canada's **National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)**

Reporting of GHG balance to EC for National GHG Inventory Reporting.

Analyses in support of policy development and international negotiations.

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
 - Core model of NFCMARS
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- Builds on 20 years of CFS Science
 - Available at:
carbon.cfs.nrcan.gc.ca



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Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

- Compliant with IPCC 2003 GPG and 2006 Guidelines
- Relies on forest inventories, empirical yield data and activity data (incl. management, disturbances and LUC)
- Links DOM (including soils) dynamics directly to biomass dynamics by simulating stand growth and mortality, biomass inputs, decomposition and disturbance impacts.
- Sophisticated book-keeping tool, with some process simulation where data are incomplete.

Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

- Long history of testing, calibration and improvements.
- Applied at the stand and landscape level for estimation of past and projected future GHG emissions and removals
- Over 40 peer-reviewed publications describing the model, the underlying data (and studies from which data were derived), and the application of the model to case studies.
- Uncertainty analyses, and sensitivity analyses conducted.
- Several ongoing projects to further improve the model.
- Comparisons of the model against several other process models (publication in review) and timber supply models.

Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

- Used by academics, government scientists, and consultants in Canada and internationally.
- Growing body of expertise: users provide feedback on model performance and potential issues of concern.
- ... and yet the perception among reviewers remains that a Tier 3 model is a “black box”.
- More of the same (i.e. publications, conventional documentation) is not likely to overcome this perception.

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Benefits of Tier 3 Models of Forest C Dynamics

- Accommodate best available, country-specific data
- Represent main processes affecting forest GHG E&R
- Stratify growth rates by species, region, forest type, age, disturbance history, some account for climate variability.
- Fill data gaps (e.g. dead organic matter and soil C)
- Represent impacts of human activities (management, LUC) and natural disturbances in year of event and subsequent years (delayed emissions, recovery).
- Provide detailed annual output about stocks, component fluxes, stock changes, and other relevant indicators.

Benefits of Tier 3 Models of Forest C Dynamics

- Tier 3 models for the estimation of greenhouse gas emissions and removals are demonstrable improvements over Tier 1 and Tier 2 approaches.
- Countries are expected to use Tier 3 models where advanced methods and detailed data.
- Model developers and users want to work with UNFCCC expert reviewers to address and overcome perceptions of lack of transparency.

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Validating Tier 3 Models of Forest C Dynamics

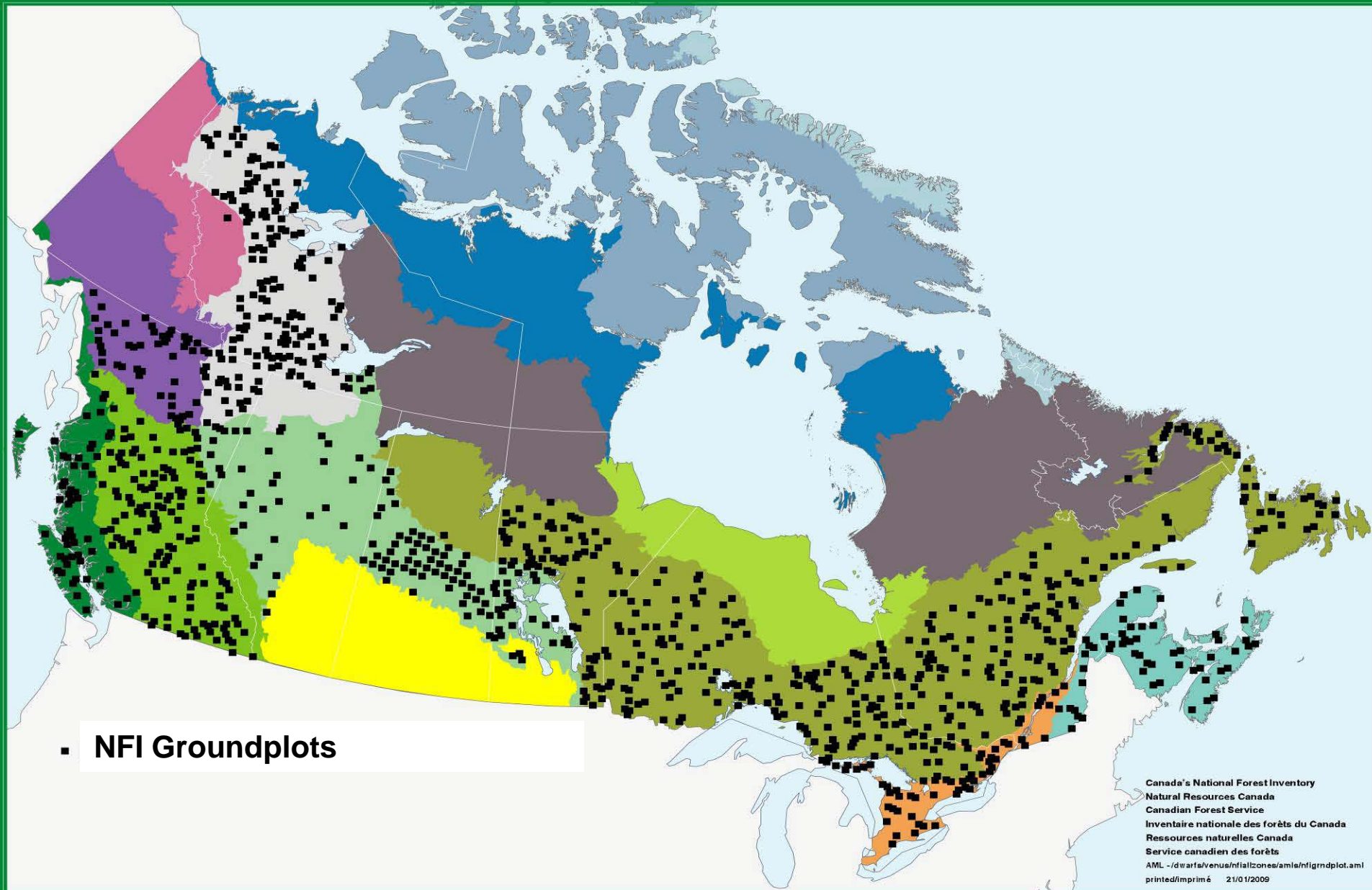
- Statistical approaches described in the literature
- Plot and stand-level validation
- Small landscapes
- Regional validation

Validating Tier 3 Models of Forest C Dynamics

Plot and stand-level validation

- Ecological studies provide component flux estimates (litter fall, turnover rates, growth and mortality rates, fire emissions, etc.) that can be compared to model predictions
- Long-term ecological studies, e.g. decomposition experiments for model calibration and testing
- Comparison of Tier 3 model predictions of ecosystem C stocks against field measurements (sample plots, national inventories).

National Forest Inventory Ground Plots



Validating Tier 3 Models of Forest C Dynamics

Small landscapes

- Comparison of Tier 3 models against other independent process models (stocks, fluxes, NPP, NEP, NBP, etc.) or timber supply models (growing stock, harvest rates).
- Repeated measurements (inventories, sample plots, tree rings) – reconstruct time dynamics of C stock changes
- Direct measurements of fluxes using eddy-covariance towers
 - define the tower footprint that is represented by model
 - Integration of high frequency flux measurements to Tier 3 model time steps (monthly, annual)

Validating Tier 3 Models of Forest C Dynamics

Regional validation

- Validation of GHG emissions and removals through independent flux measurements at regional or national scale currently not feasible (but advances are being made on several fronts).
- UNFCCC reporting limited to fluxes from anthropogenic activities – thus unmanaged lands that contribute to regional fluxes currently not included in reporting.
- Uncertainty of regional source and sink estimates from inversion models increase with increasing spatial resolution.

Validating Tier 3 Models of Forest C Dynamics

- Validation of Tier 3 models is possible at various spatial scales, over different time scales with various approaches.
- Validation can occur against measured stocks, stock changes or component fluxes.
- Validation of emissions and removals estimates at the regional or national level using inverse modelling of atmospheric CO₂ sources and sinks currently constrained by high uncertainties in flux estimates from inverse models.
- Although validation of Tier 3 models can at times be difficult, detailed information about component fluxes, strata, etc. provided by Tier 3 models enables validation steps that are not possible with Tier 1 or 2 approaches.¹⁸

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Increasing Transparency of Tier 3 Models of Forest C Dynamics

Short-term

Reviewers and developers could identify:

- Common list of key information items (e.g. metrics, assumptions, descriptive information) that could enhance the comparability of CRF data produced by Tier 3 models and facilitate comparison with T1 and T2 approaches.
- Standardized format to present information to enhance the comparability and the transparency of T 3 models.

Long-term

- A more substantial effort may be required ...

Increasing Transparency of Tier 3 Models of Forest C Dynamics: A proposal

- Analytical laboratories routinely use standard (reference) samples to test and compare equipment performance.
- Tier 3 models of forest C dynamics could similarly be assessed against standard tests using agreed-upon indicators and performance measures.
- Documenting the outcome of such tests could help reviewers understand the performance of Tier 3 models by demonstrating what estimates of emissions and removals models produce for a series of standardised tests.
- Implementation would require several steps ...

Proposal to increase Transparency of Tier 3 Models

1. Agree on Indicators *(could include)*

- Annual per ha and total C amounts in 5 C pools (and possibly more pools if this enhances comparability);
- information on area and area changes in each of the six UNFCCC land categories;
- estimates of Net Primary Production, Net Ecosystem Production and Net Biome Production;
- emissions and removals of CO₂ and non-CO₂ greenhouse gases by land category and year, and
- other relevant indicators e.g., litterfall, annual transfers of harvested C out of forest, fire emissions per ha burned.

Proposal to increase Transparency of Tier 3 Models

2. Develop series of standard tests *(from stand to complex landscapes)*

- Forest management activities in single stand of different forest types, biomes, species, stand ages etc.
- Natural disturbance representation – single stands,
- Progressively more complex scenarios, 10s of stands
- Land-use change scenarios
- Landscape simulations with 100s or 1,000s of stands

Proposal to increase Transparency of Tier 3 Models

3. Agree on Performance Measures

- Could be combinations of qualitative measures, rules, and possibly even “pass/fail” criteria
- Examples of (seemingly simple) rules could include
 - Conservation of area: during a landscape-simulation the area included in the project must not change.
 - Conservation of mass: sum of reported C fluxes must be consistent with the combined differences in C stocks.
 - No transitions in and out of land-use categories unless specified by LUC activity data or by other rules

Proposal to increase Transparency of Tier 3 Models

4. Conduct Analyses – Document Results

- Perform series of progressively more complex simulations.
- Document the results in standardised reporting tables (possibly a database to facilitate comparisons across models) and archive input data and model version used.
- Provide information to expert reviewers and evaluate utility of approach in achieving increased transparency.

Proposal to increase Transparency of Tier 3 Models

5. Iterative Process with Feedback from Reviewers and Model Developers

- Developing and implementing such tests and procedures will require time and cooperation among model developers.
- Likely an iterative process that requires feedback from reviewers and model developers for design of tests
- Will require leadership role of coordinator(s) and/or a secretariat.
- Outcome of model comparisons also of scientific interest as developers expect to benefit from comparisons with other models.

Conclusions

- Tier 3 models for the estimation of GHG emissions & removals are demonstrable improvements over Tier 1 or 2.
- Developers want to address concerns of reviewers and increase transparency.
- Model documentation can be improved; necessary but not sufficient.
- Proposal for model developers and reviewers to design jointly a series of standardised performance tests to facilitate comparison of Tier 3 model estimates.
- See background paper for further information and references.



Thank you very much!



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Forest Carbon Accounting Comptabilisation du Carbone Forestier



Canadian Forest Service
Service canadien des forêts



<http://carbon.cfs.nrcan.gc.ca>
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