



Frequently Asked Questions about the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3)

The [Carbon Budget Model of the Canadian Forest Sector \(CBM-CFS3\)](#) was developed by Natural Resources Canada's Canadian Forest Service (CFS) to meet the operational-scale, forest carbon accounting needs of forest managers and analysts across Canada. The CBM-CFS3 is a stand and landscape-level modelling framework that can be used to simulate the dynamics of all forest carbon stocks required under the United Nations Framework Convention on Climate Change (UNFCCC). It is compliant with the carbon estimation methods outlined in the 2003 Intergovernmental Panel on Climate Change (IPCC) [Good Practice Guidance for Land Use, Land-Use Change and Forestry](#), and [2006 IPCC Guidelines for National Greenhouse Gas Inventories](#).

Many individuals in research organizations, forest industry, governments, academia, and non-government organizations use the CBM-CFS3 to calculate:

- how much carbon is stored in their forest stand biomass and soils
- how much carbon is released to the atmosphere through decay and disturbance
- how much biomass carbon is transferred to the forest products sector from their forests every year

As the domain of forest carbon accounting expands, interest continues to grow in forest ecosystem models like the CBM-CFS3. This document provides a list of frequently asked questions and answers about the CBM-CFS3. While intended for those new to the model, this document may also be helpful to those who already have experience with it.

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For more detailed information about the CBM-CFS3, consult the science publication on the model ([Kurz et al., 2009](#)), the user's guide ([Kull et al., 2019](#)), or contact [Stephen Kull](#), Carbon Modeling Extension Forester at the Canadian Forest Service, Natural Resources Canada.

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Is the CBM-CFS3 a spatial or an aspatial model?

The CBM-CFS3 is an aspatial model, meaning forest stands are not spatially referenced. Users can track and report results for specific stands in their CBM-CFS3 project by attaching a unique classifier to each of their stands when they create their data import files or when entering stand information into the model.

What are the system requirements to run the CBM-CFS3?

To run the CBM-CFS3, you will need:

- a monitor capable of 1024 X 768 resolution (small fonts are highly recommended)
- Windows operating system
- Windows operating system language set to “English (Canada)” for the English version of the CBM-CFS3 and “French (Canada)” for the French version of the CBM-CFS3
- display DPI setting set to “Normal size (96DPI)”

Is the model source code open and available to users and software developers?

No.

In what languages are the CBM-CFS3 and its user’s guide available?

The CBM-CFS3 and its user’s guide are currently available in Canada’s two official languages, English and French. Spanish, Polish and Russian versions of the model interface have also been developed. The design of the CBM-CFS3 has facilitated conversion of the graphic user interface to other languages. If you are interested in having the CBM-CFS3 and its user’s guide translated to another language, please [contact the carbon accounting team](#) at the Canadian Forest Service to discuss potential collaboration.

How is the CBM-CFS3 maintained, updated, and developed?

The carbon accounting team at the Canadian Forest Service maintains, updates, and continues to develop the

CBM-CFS3 software. The team maintains connections with the international science community to ensure that the science of forest carbon accounting is kept up to date in the model. The team is also connected to the international policy community to ensure that the model continues to meet international forest carbon reporting requirements. Additionally, the carbon accounting team is connected to the international forestry community – those using the CBM-CFS3 – and continues to refine and develop the model to meet their needs.

Do I need to use a timber supply model to use the CBM-CFS3?

No. For stand-level projects, the user can enter their data using the Stand-Level Project Creator. For landscape-level projects, they can put their data into import files formatted for the CBM Standard Import Tool. Consult the [Operational-Scale Carbon Budget Model of the Canadian Forest Sector \(CBM-CFS3\) Version 1.2: User’s Guide](#) for more information.

Is training in the use of the CBM-CFS3 available?

Yes, a self-guided training package is available for download on Canada’s National Forest Information System (<https://carbon.nfis.org/cbm>). The training consists of 20 training videos, 4 tutorials and 2 exams. It takes approximately 12 hours from start to finish. All software documentation is included in the training package.

The CBM-CFS3 does not have a data import tool for the timber supply model that I use; can one be developed?

The carbon accounting team at the Canadian Forest Service may develop new import tools for the CBM-CFS3 based on user requests and subject to funding and programmer resources. The team is open to collaborative model development and model development suggestions. If you want to request the development of a new import tool or collaborate to develop a new import tool, please [contact the carbon accounting team](#). In the meantime, those who do not use the Remsoft® Spatial Planning System can use the CBM Standard Import Tool for operational-scale data imports, or the Stand-Level Project Creator for creating individual stands.

What are the current limitations of the CBM-CFS3?

Peatland and moss carbon dynamics:

Despite the CBM-CFS3 having a placeholder for carbon in peat, it is disabled. Due to the complexity of peatland dynamics, they will not be implemented into the framework of the CBM-CFS3. However, they have been implemented in the spatially explicit Generic Carbon Budget Model (GCBM) as a component model called the Canadian Model for Peatlands (CaMP). A moss carbon module (Moss-C) has been implemented in a research version of the CBM-CFS3, but has not yet been included in the version released to the public.

The impacts of climate change on forest growth:

The CBM-CFS3 can simulate the effects of temperature changes on decomposition rates (Kurz and Apps, 1999), but it does not address the impacts of changes in precipitation on decomposition. While it also does not explicitly address the impacts of climate change on forest growth, users can implement transitions from one growth curve to a new curve that reflects their presumed changes in growth associated with any temperature changes during their project simulation. Most applications of the CBM-CFS3 focus on the recent past or the next few decades. Refining the representation of climate change impacts is the subject of ongoing research.

The impacts of climate change on disturbance regimes:

These impacts are not predicted through process simulation. However, users can implement them by providing scenarios with changes in disturbance regimes without explicit attribution to possible causes such as fire suppression or climate change.

Insect disturbances that cause reductions in growth rates:

Similar to the lack of explicit impacts on growth caused by climate change, insect disturbances also do not explicitly cause reductions in growth rates in the CBM-CFS3. However, just as with a changing climate, the user can implement transitions from one growth curve to a new curve following insect disturbances to reflect any expected changes in volume increment.

Forest structure:

The CBM-CFS3 treats all stands as even-aged (one age or age class associated with each stand, regardless of whether the stand contains trees of multiple ages or age classes). However, there are ways for the user to implement the growth of stand components of multiple ages in a single stand, each being represented by the actual volumes of those components at their respective ages. For example, the user could transition a 50-year old aspen stand classifier set represented by one aspen growth curve, to a stand classifier set represented by two growth curves (one identical to the original aspen curve, and one representing assumed new undergrowth of white spruce). This could be done using a non stand-replacing disturbance event with no associated carbon impacts or change in stand age. The disturbance event would occur and the stand would switch from the original growth curve at age 50 to the new growth curves at age 50. The volume increments for the white spruce component (although read by the model as being age 50) would only actually be representative of white spruce growing from age 0.

Volume-to-biomass conversion:

Due to the original structural design of the CBM-CFS3, the volumes of a stand with multiple hardwood or multiple softwood components can only be converted to biomass using the volume-to-biomass conversion coefficients for one of the hardwood or softwood component species (each age over volume curve is not converted to biomass using its specific volume-to-biomass conversion coefficients, unless it happens to be the curve containing the highest summed volume). For example, if a stand is represented by a white spruce growth curve and a balsam fir growth curve, and the white spruce curve contains the higher summed volume, the model will combine the two curves and convert them to biomass using the volume-to-biomass conversion coefficients for white spruce. This is not the case in a stand with mixed softwood and hardwood species. The curves for each species will be converted with the appropriate user-selected species volume-to-biomass conversion coefficients.

Mangrove forest:

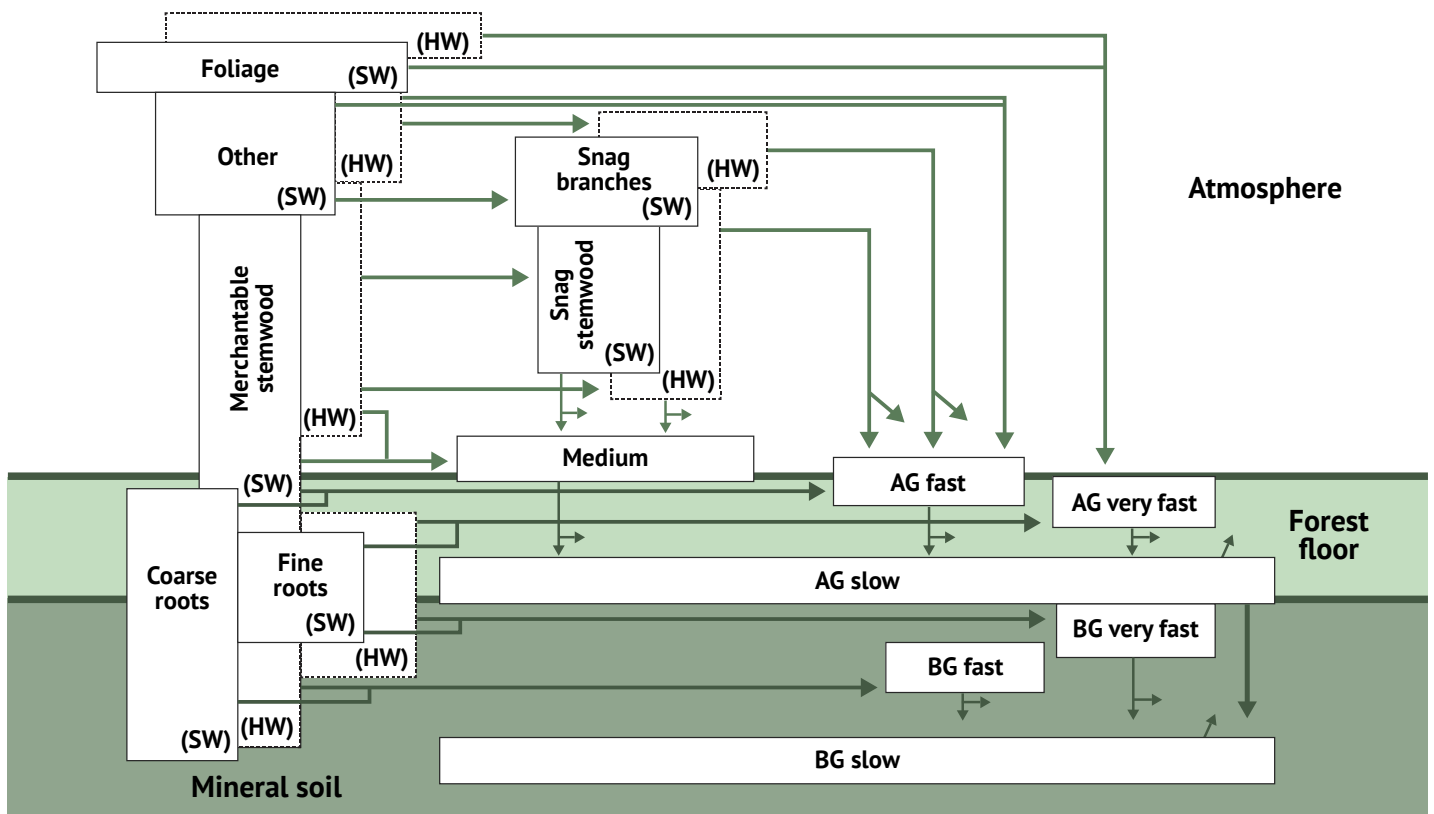
The CBM-CFS3 should not be used to model mangrove forest ecosystems, as the soil carbon dynamics emulated by the model were not designed for marine ecosystems or coastal wetlands.

What disturbances are represented in the CBM-CFS3 and how are they represented?

The CBM-CFS3 contains over 200 pre-defined disturbance types that represent the transfers of ecosystem carbon stocks that occur at the time of disturbance. Users are able to create custom disturbance types to represent the ecosystem carbon transfers if an existing default is not sufficient. Examples of pre-defined disturbance types include:

- Wildfire
- Insect disturbance
- Clear-cut with slash-burn
- Clear-cut harvesting with salvage
- Fire combined with salvage logging
- Insects combined with salvage logging
- Deforestation (various types corresponding to converted land use)
- Afforestation
- Natural nonforest rehabilitation
- Partial cutting (50% removal)
- Western jack pine budworm
- Aspen defoliators
- Spruce budworm
- Salvage logging after fire
- Salvage logging after insects
- Eastern hemlock looper (various degrees of defoliation)
- Mountain pine beetle (various defoliation and mortality impact levels)
- Spruce beetle (various defoliation and mortality impact levels)
- Generic mortality (ranging from 5% to 95% mortality for creating custom disturbance types)
- Commercial thinning (ranging from 10% to 85% volume removal)
- Stand replacing natural succession
- Clear-cut harvesting without salvage

What does the carbon pool structure of the CBM-CFS3 look like?



The carbon pool structure of the CBM-CFS3
AG=Aboveground BG=Belowground SW=Softwood HW=Hardwood

The carbon pool structure of the CBM-CFS3 displaying carbon flow through a forest ecosystem. Beginning with the biomass pools, (Foliage, Other, Merchantable stemwood, Coarse roots, Fine roots), carbon flows to the above and belowground dead organic matter (DOM) pools, (Snag branches, Snag stemwood, Medium, Aboveground fast, Aboveground very fast, Aboveground slow, Belowground fast, Belowground very fast, Belowground slow), and then flows from the DOM pools to other DOM pools and the atmosphere.

How were the volume-to-biomass equations used for each tree species in the CBM-CFS3 developed and where can I obtain them?

The conversion factors and methods used by the CBM-CFS3 are based on the results of an ongoing Canadian Forest Service project at the Pacific and the Laurentian Forestry Centres. This project focuses on developing such conversion factors for application to the [Canadian Forest Inventory](#) (CanFI2001). A published report of the methods is available from the [CFS Publications Database](#). The volume-to-biomass coefficients in the CBM-CFS3 were updated in early 2015. Details about these and any other updates are available at https://nfi.nfis.org/en/biomass_models.

What is the difference between the aboveground and belowground slow DOM pools?

The belowground slow DOM pool consists of carbon (C) from the very fast belowground DOM pool (from a proportion of the fine root turnover), the fast belowground DOM pool (from a proportion of the coarse root turnover), and the slow aboveground DOM pool (from a biomixing rate).

The aboveground slow DOM pool consists of C from the very fast aboveground DOM pool (from a proportion of the fine root turnover). Carbon in the aboveground slow DOM pool also comes from the fast aboveground DOM pool (from (a) a proportion of the coarse root turnover, (b) a proportion of branch snag decay, and (c) branch snag fall down), and the medium DOM pool (from (a) a proportion of the stem snag decay and (b) stem snag fall down).

Is a list of CBM-CFS3 research publications available?

Yes. The Canadian Forest Service's Publication Database has a summary of CBM-CFS3 research publications from around the world available for download.

What kind of data inputs does the CBM-CFS3 require?

In general, the CBM-CFS3 requires the following data inputs from users to create a project:

- Volume-over-age curves for all trees species under all management regimes
- Detailed forest inventory, including stand records that identify leading species, area, age, and historic and last disturbance type
- Disturbance information (optional): disturbance types, a list of events identifying stand types, ages, and amounts affected by each specific disturbance type, and the year in which the events will occur
- Land-use change information (optional): inventory of stands to be afforested or expected to be deforested or converted to land uses other than forest
- Harvest schedule (optional): harvest and silviculture types, a list of events identifying stand types, ages, and amounts affected by each specific type, and the year in which the events will occur

The CBM-CFS3 also generates the following data inputs to a user's project based on administrative (province or territory) and ecological boundaries (terrestrial ecozone of Canada):

- Litter fall and decomposition rates
- Volume-to-biomass conversion coefficients
- Disturbance matrices (if disturbances are applied)
- Mean annual temperature data

What is the bare minimum of information required for a detailed forest inventory for input into the CBM-CFS3?

The bare minimum needed is an area stratified by age classes and forest type (where forest type is a set of user-defined classifiers, one of which must identify the leading species). Growth curves need to be identifiable by the same forest types that define the inventory.

What is the smallest area the CBM-CFS3 can model?

The smallest area that can be modeled using the CBM-CFS3 is 0.1 ha.

What is the minimum and maximum number of classifiers that I can use in the model to describe my stands?

Classifiers are user defined and you can describe your stand with your own stand characteristics terminology. The maximum number of classifiers is ten and the minimum number is one. If you only use one, it must define the leading species.

Do the volume/age curves used as input for the CBM-CFS3 have to represent merchantable volume, and which should I use, total, gross, or net merchantable volume curves?

The CBM-CFS3 calculates biomass components from merchantable volume. Calculations use a national system of volume-to-biomass estimation models developed as part of Canada's national forest inventory (Boudewyn et al., 2007; nfi.nfis.org/en/biomass_models). Users should employ gross merchantable volume curves (i.e., volume inside the bark of the main stem, excluding tops and stumps, but including defective and decayed wood of trees or stands). The volume-to-biomass estimation models that are built into conversion coefficients in the CBM-CFS3 assume standard provincial and territorial merchantability criteria.

Can a project I create with the CBM-CFS3 contain more than one management area/unit, and how do I identify this in my data?

Yes. Simply add a classifier to your data that identifies management area/unit. Once you have created and simulated your project, you can filter results by the management area/unit classifier you created. If you have management areas/units in different administrative (province or territory) or ecological (terrestrial ecozone of Canada) boundaries, you should also consult the answer to the following question: "My project will have more than one ecological or administrative boundary. Which import tool(s) can I use, and how do I prepare my input data to account for this?"

My project will have more than one ecological or administrative boundary; which import tool(s) can I use, and how do I prepare my input data to account for this?

The CBM Standard Import Tool should be used. When preparing your import files, you must include a classifier for ecological boundary (terrestrial ecozone of Canada) and administrative boundary (province or territory) in the description of each of your stands. During the CBM-CFS3 data import process, in addition to mapping each of your disturbance types, species, and nonforest types (if any) to those defined in the CBM-CFS3, you will need to identify your administrative boundary and ecological boundary classifiers. You will also need to map each of their classifier values to administrative and ecological boundaries defined in the CBM-CFS3.

How many records can the CBM-CFS3 process?

Successful simulations containing approximately 1.4 million records distributed across some 100 disturbance groups (administrative management units), each of which comprised several ecological spatial units (nearly 800 spatial units), have been completed using the CBM-CFS3.

Which CBM-CFS3 import tool should I use?

The ideal CBM-CFS3 import tool for each user will depend mainly on where their input data and information are coming from. Users whose input data are coming from the Remsoft® Spatial Planning System software, other timber supply models or other sources can use either the CBM Standard Import Tool or the Stand-Level Project Creator. The CBM Standard Import Tool requires the user to create standardized import files containing their data and information. The Stand-Level Project Creator requires the user to enter data and information manually for their project. Projects created using the Stand-Level Project Creator cannot contain more than 100 stands.

I want to test the impact of a new harvest or disturbance plan on my forest carbon stocks and stock changes. Is there a simple way to get an idea of what kind of impact it will have?

Using the Stand-Level Project Creator, create a project with a 1 ha stand of your most common forest type and apply the new harvest or disturbance plan. Following simulation of the project, examine the impacts on your ecosystem carbon stocks and stock changes. To get an idea of the potential impacts, multiply the results by the number of actual hectares covered by the forest type you selected. Compare these results to those you obtained for that same area under your original harvest or disturbance plan. Keep in mind that a reliable comparison can only be made by simulating the complete inventory under the new scenario.

When I map my disturbance types to those modelled in the CBM-CFS3 during the data import process, I do not see one similar to my disturbance type. Can I set up a new default disturbance type in the CBM-CFS3, and what does this involve?

Yes. Users can add a new default disturbance type using the Default Input Data Editor. In this editor, it is recommended that users copy and rename an existing disturbance type (as opposed to adding a new one) that may have somewhat similar impacts on ecosystem carbon transfers. This will result in the creation of linked disturbance matrices for each ecozone type, containing carbon matrix transfers identical to the original disturbance type selected. Users can then make minor edits to their new disturbance matrices that they plan to use to reflect how carbon will transfer in the forest ecosystem because of their new disturbance type. Users can also add a new disturbance type and set up the disturbance matrices for it from scratch.

What is a disturbance matrix?

A disturbance matrix defines how carbon is transferred in the forest ecosystem from carbon pool to carbon pool (or to the atmosphere or forest products) for each terrestrial ecozone of Canada following a specific natural or anthropogenic disturbance event. A disturbance matrix can be edited and new ones can be created.

What is an assumption in the CBM-CFS3 and how is it used?

There are fifteen assumption types in the CBM-CFS3:

- Simulation
- Stand Initialization
- CBM Run
- Biomass Turnover
- Climate
- DOM Turnover
- Disturbance Matrix
- Disturbance and Management
- Growth
- Volume-to-biomass
- Growth multipliers
- Disturbance multipliers
- Nonforest initialization
- Historic growth curves
- Historic disturbance types assumptions

When users create a project, a default assumption is created for each of these assumption types. The default assumptions created are essentially names linked to the user's imported data or data assigned to the user's project based on the administrative and ecological zone they select during data import. For example, imported growth and yield curves would be linked to the default growth assumption. Users can also create their own assumptions and link them to new data that they enter into their project in the CBM-CFS3.

A project must have at least one assumption of each type to be run in a simulation. As discussed, one assumption of each type is created by default whenever users create a project. This allows users to proceed immediately to execute a simulation and review results.

How many projects can I open at once in the CBM-CFS3?

One, but results from multiple projects can be compared while having only one project open.

Can I run more than one simulation at a time in the CBM-CFS3?

Yes. In the Simulation Scheduler, you can add more than one simulation at a time, and they will run sequentially. Python scripts are also available from the carbon accounting team at the CFS. These scripts permit users to run projects outside of the model's graphical user interface and run multiple projects concurrently.

How long does it take to process a simulation?

Processing time for a CBM-CFS3 simulation will depend on the size and complexity of the user's project and their computer hardware. Having a good computer processor and lots of RAM will help speed up processing.

A small project (<5000 stands, 4 classifiers, 10 disturbance events per time step for 100 years) will take approximately 5 to 10 minutes to simulate.

A large project (>200,000 stands, 10 classifiers, 1,000 disturbance events per time step for 100 years) will take approximately 4-8 hours.

Some users may run into issues with large simulations when using the CBM-CFS3 graphical user interface. In these instances, it may be possible to circumvent the issue by running the model using Python scripts. Users can contact the [carbon accounting team at the CFS](#) for more information about these scripts.

What results categories are included in the CBM-CFS3, how many variables can be graphed in each, and what are some examples?

CBM-CFS3 results categories include:

- Stocks: 10 variables including Total ecosystem, Biomass, and Dead organic matter carbon
- Stock Changes: 3 variables including Delta total ecosystem, Delta total biomass, and Delta dead organic matter
- Ecosystem indicators: 11 variables including Net Primary Productivity, Net Ecosystem Productivity, and Net growth
- Ecosystem transfers: 28 variables including Total harvest (biomass + snags), Litter, Soil C
- Emissions: 12 variables including Total biomass, Total dead organic matter, and Total CH4
- Disturbed Area: 2 variables including Area disturbed and Area (ha)
- Age Classes: 4 variables including Area (ha), Biomass (t), and Dead organic matter (t)
- Age Classes by Timestep: 4 variables including Area (ha), Biomass (t), and Dead organic matter (t)
- Disturbance Transfers: 3 variables including Disturbance losses, Biomass to soil from disturbances, and Net Biome Productivity
- Unrealized Disturbance: Unrealized disturbed area

Does the CBM-CFS3 account for carbon in shrubs and mosses?

Unless the user provides a volume-over-age curve for a shrub component, it is not modelled in the CBM-CFS3. The public version of the model currently disregards both shrubs and mosses, and operates under the assumption that their carbon content is neutral (as much carbon is lost annually through decay from this pool as is gained through new growth). However, in terms of mosses, it may not be. A moss carbon module (Moss-C) has been incorporated into a research version of the CBM-CFS3. This module may be made available in future public versions of the model.

Does the CBM-CFS3 track carbon in forest products?

The CBM-CFS3 accounts for forest ecosystem carbon dynamics. The transfer of carbon can be made to a "Forest Products" pool and users can track how much carbon is harvested from their land base. However, only inputs to this pool are tracked (the carbon dynamics of the forest products sector are not explicitly modeled).

Can the global warming potential (GWP) values used to generate CO2e result graphs in the model be modified by the user?

Yes, but not in the graphical user interface.

Can I export my project results, and if so, in what formats?

Yes. While you can display your project results in graphs in the model, you can also export them in .txt or Microsoft Excel file format for editing and graphing in other software.

Is this model endorsed by any organization(s) for forest carbon accounting?

The Government of Canada uses the CBM-CFS3 for reporting to the United Nations Framework Convention on Climate Change (UNFCCC) on greenhouse gas contributions from Canada's forests. This is done under Natural Resources Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS). Ireland also uses the CBM-CFS3 for their reporting to the UNFCCC. Other countries are in the process of implementing use of the model for this purpose as well.

Is use of the CBM-CFS3 for forest carbon accounting a legal or regulatory requirement for any specific greenhouse gas agreements, forest certification, or sustainable forest management programs?

No. In Canada, some forest carbon offsets protocols, under development federally and provincially, may either recommend or require use of the CBM-CFS3 for aspects of submitted projects.

Can the CBM-CFS3 be applied outside of Canada?

Yes. Although developed for use in Canada, the CBM-CFS3 can be applied in other countries. The model contains climate, decay, ecological, and timber merchantability parameters and data specific to Canadian terrestrial ecological zones and species, making it most easily adaptable to countries with similar climates and species.

The Archive Index Database that houses the Canadian default parameters in the CBM-CFS3 can be re-parameterized for forest ecosystems outside of Canada. To date, the CBM-CFS3 has been applied in over 26 countries. For more information about adapting the model for use in your country, [contact the carbon accounting team at the Canadian Forest Service](#).

Can I use the CBM-CFS3 for forest certification reporting?

Yes, but users should review the reporting requirements for any certification program to determine whether the CBM-CFS3 is an approved tool for reporting forest ecosystem carbon stocks and stock changes under that program.

I have encountered an error while installing or using the CBM-CFS3 and I have been unable to resolve it; what should I do?

Document the actions you were attempting when the error occurred and obtain a screen capture of the error (or document what the error message stated). Send this information to the [carbon accounting team at the Canadian Forest Service](#). Our team will attempt to diagnose the problem and will contact you with the solution or follow-up questions to resolve the problem.

When I use the model, some of the buttons and/or boxes in particular windows are missing when compared to figures of those windows in the CBM-CFS3 user's guide or tutorials; what should I do?

First, make sure you are using the latest version of the model and user's guide. One of the user's display settings on their Windows operating system usually causes this issue.

For proper display of CBM-CFS3 graphical user interface (GUI) contents, screen resolution should be set to 1024 X 768 (small fonts recommended). The DPI (dots per inch) setting should be set to "Normal size (96DPI)". On some rare occasions, the user's selected Windows theme has sometimes affected the display of the CBM-CFS3 GUI.