BRITISH COLUMBIA

Ministry of
Forests, Lands and
Natural Resource Operations

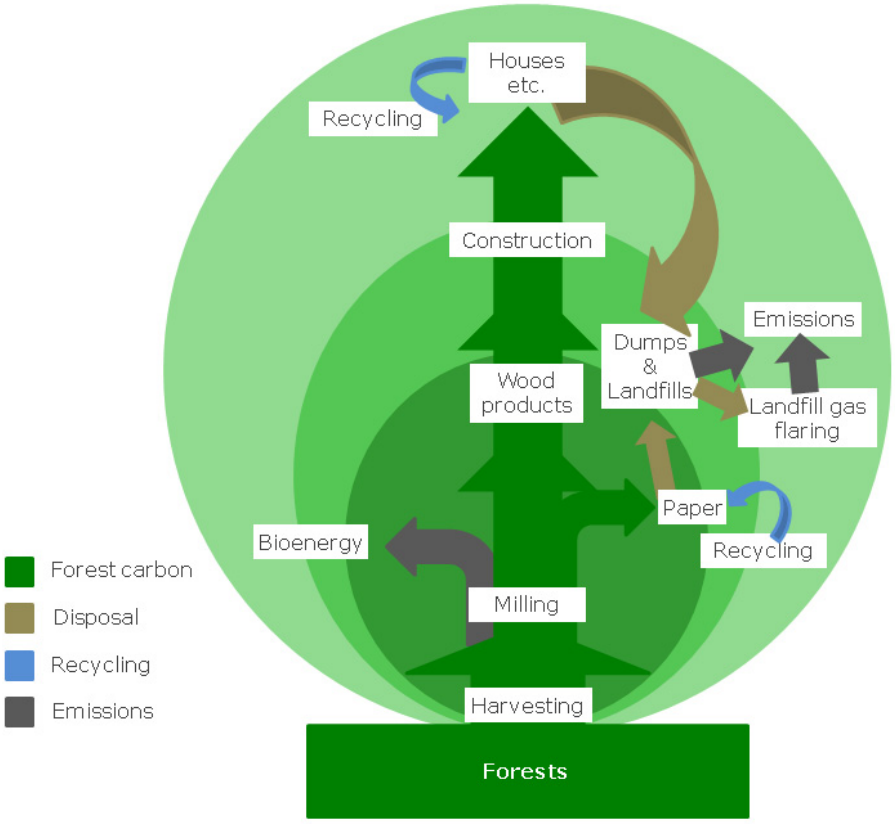
A Carbon Calculator For Harvested Wood Products

User's Manual

Caren Dymond and Larry McCulloch

This user's manual describes a spreadsheet tool that can be used by resource professionals, architects, designers, and people interested in carbon offset projects to determine carbon emissions generated from harvested wood products.

August 19, 2013



MITIGATING CLIMATE CHANGE

TABLE OF CONTENTS

INTRODUCTION

WHAT IS A CARBON CALCULATOR FOR HARVESTED WOOD PRODUCTS?

Since 2010, when it became mandatory for the public sector in British Columbia to be carbon-neutral, interest in determining emission levels from the use of various commodities, including wood products, has been growing. The B.C. government regulates carbon management through the Greenhouse Gas Reductions Targets Act, the BC Emissions Offset Regulation, and the Forest Carbon Offset Protocol.

This carbon calculator is simple spreadsheet that you can use to determine the carbon footprint of your wood products - logs, lumber, plywood, panels, or paper. In addition to the emissions of carbon, you can see the storage of carbon in different products over time.

The tool uses data generated by the BC Harvested Wood Products, Version 1 model. The model was developed by Caren Dymond of the B.C. Ministry of Forests, Lands, and Natural Resource Operations in collaboration with Werner Kurz, Michael Magnan, and Mark Hafer of the Canadian Forest Service.

INTENDED USES

We expect that the calculator spreadsheet will be used by resource professionals, architects, designers, and people interested in carbon offset projects to estimate the carbon footprint associated with the wood products they use in North America[1]. It automatically converts a variety of input parameters to tonnes of carbon dioxide equivalent, and will provide you with information on total carbon storage and emissions based on how wood is used (e.g. single family homes), and how carbon levels change over time. Graphs are automatically generated for key values to visually portray carbon storage and emissions over a 100 year period.

The calculator is meant to help you quickly estimate carbon emissions with minimal input on your part. This user's manual provides detailed instructions on how to use the calculator and interpret results. We have also provided definitions and explanatory notes within the calculator to help minimize the need to refer back to the manual.

The calculator will work best with larger projects such as those using more than 10 m^3 roundwood, 1000 bf of lumber, 50 sheets of plywood, or panels.

Definitions For Some Terms in This Document

Carbon Pools – Categories where wood-sourced carbon is stored for years: homes, commercial buildings, furniture, shipping pallets, repairs to homes and paper (these are collectively referred to as end-use products)

CO_2e - equivalent tonnes of carbon dioxide (e.g. 1 tonne of C is = to 3.667 tonnes of CO_2)

Decay rate – the rate of conversion from storage in a carbon pool to an emission

Emission – the amount of carbon converted from wood fibers to a gas and released to the atmosphere because of decay or combustion

Roundwood - Harvested logs that have been delivered to a milling facility

Secondary Wood Products - Lumber, plywood, oriented strand board (OSB), medium density fiberboard (MDF), and pulp produced from roundwood

Storage – the retention in a carbon pool

Retirement rate – the rate of loss from a end-use carbon pool to disposal based on a products life-expectancy.

tC - metric tonnes of elemental carbon, in wood this may be within cellulose, lignin, carbohydrates or other complex molecules

More detailed information on the model and data supporting the calculator, including life cycle processes, wood product distribution, retirement statistics, and data sources, can be found in: Dymond, 2012. Forest

[1] Disclaimer: The tool is meant to provide an estimate of carbon retention and emissions based on published research available in 2010. The user is cautioned to consider that data relationships and calculations may be different than when the tool was developed.

carbon in North America: annual storage and emissions from British Columbia's harvest, 1965-2065. Carbon Balance and Management 7/8.

INTRODUCTION TO THE WOOD PRODUCT LIFE CYCLE

The flow of wood in the calculator starts with logs delivered to a mill, or with secondary wood products such as lumber and plywood that have been produced in a mill. If you input secondary wood products, the emissions associated with creating those products from whole logs are estimated and added onto the carbon footprint calculation. Based on statistics on wood use and retirement for North America, it tracks which carbon pools the wood ends up in, how long it persists until retirement, and how carbon contained in the wood is emitted back to the atmosphere through decay or combustion (see figure one).

For example, in 2010, 84% of logs harvested went to a sawmill and of this, 47% was actually turned into lumber, of which 25% went into single family homes. As time passes, these single family homes are renovated, and some of the original material is sent to a landfill where it decays returning some of the wood in the atmosphere as carbon dioxide.

The option of including or not including storage of wood and paper in landfills and dumps is provided because there are differences about how this material is treated in some carbon offset protocols. In some cases it is considered to be a valid from of carbon storage, and in other cases it isn't.

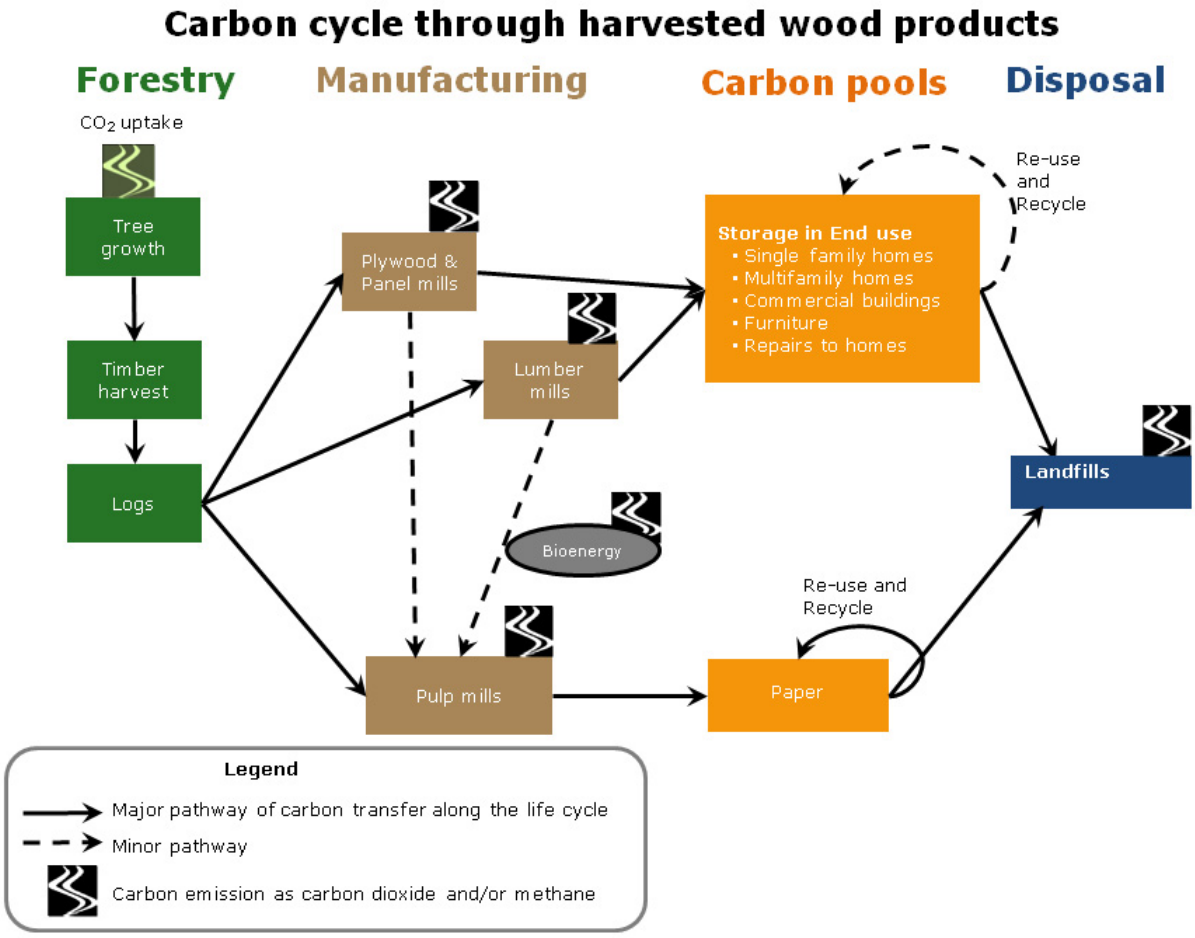


Figure 1. The wood product life cycle.

USING THE SPREADSHEET TOOL

The calculator comprises two main sheets in a Microsoft Excel workbook; plus some additional sheets for more information and some Visual Basic for Applications that helps with formatting. The two main sheets in the workbook are:

- the Calculator sheet
- a Graphs sheet

You will need to allow macros for the calculator to work.

Except for the data entry cells (indicated by yellow fill) on the Calculator sheet, the spreadsheets are locked and protected so the results remain consistent with the published model. To obtain additional access please contact us.

THE INSTRUCTION SHEET

We provided an instruction sheet in the workbook to help make the tool more user-friendly. The instruction sheet contains information on the origin and purpose of the tool, basic information on how to use it, and a User's Agreement which specifies the terms and conditions under which you can use the tool. It also contains a copy of the wood product life cycle (shown above in figure 1) which is intended to help you visualize how the whole process fits together.

User Agreement

We also included a User Agreement in the calculator, reproduced here, to make sure you understand the limitations of liability associated with its use.

1. Copyright for the Spreadsheet Tool and User's Manual Reside with the Crown. The copyright permits unrestricted use, distribution, and reproduction, provided that the original work is cited as: Dymond, C.C. 2012. Forest carbon in North America: annual storage and emissions from British Columbia's harvest, 1965-2065. *Carbon Balance and Management 7/8*.

2. Any changes to the default parameters and relationships must be clearly listed in any communication of results. Furthermore, the results cannot be said to have come from the model BC-HWPv1 or BC Harvested Wood Products, Version 1.

3. While this workbook and associated User's Manual have been developed carefully and with the best information available at the time, the individuals and organizations involved in their development do not, either collectively or individually, warrant their use for any purpose nor make any representations regarding their fitness for any use or purpose whatsoever. Each user agrees to use them at their own risk and under no circumstances will the individuals or organizations involved in their development be liable for any damages whatsoever arising from the use of these materials, or from an inability to use them.

How to Use This Calculator

The instruction sheet in the calculator also includes an abbreviated description of basic steps you need to know to use the calculator. You can quickly refer to this while you have the workbook open, or can review the more detailed information in this User's Manual.

CALCULATOR SHEET

The calculator sheet is where you enter your information about the roundwood or secondary wood products you are using. You enter data in cells with yellow fill (see the example below). Cells with green fill are provided as examples and cells with blue fill are the headings or descriptive text meant to help you enter the data correctly. All cells except the cells with yellow fill are protected and cannot be changed.

Project Description

In the Project description section, enter text to help describe the project. Information you include in this section will serve as a header for the Results sheet. If you enter more than about 90 characters (including blanks) in the User Identification or Project Identification sections, you will not be able to see them all. In the project description section you can use up to about 400 characters. It is also OK to leave this section blank.

Project Description	
User Identification:	Jane Doe, Carbon Management Inc
	User name and affiliation
Project Identification:	Building material sales by Green Buildings Corp
	Short name/title for the project
Project Description:	An analysis of the carbon implications generated from sales of building materials by Green Buildings Corporation's Vancouver outlets
	Provide a description of the project (e.g. location, size, purpose)

Input Data

This section of the Calculator sheet is where you enter data on the type and amount of product that is being used in your project. The first step is to simply click on the **check boxes** below each wood product used in your project. Storage and emissions will be reported for each product you select as well as all products combined. Note that engineered wood products will need to be entered as ft^3 or m^3 of lumber (or bf for I-joists).

Input Data					
Input Product:	Roundwood ☑	Lumber ☑	Plywood ☑	OSB/MDF ☑	Paper ☑
	Click the check boxes for the types of input product used in your project. Choosing more than one product is permissible.				
Input Metric:	ft3	bf	sf	sm	tonnes
	Select the correct input metric from the drop down list				
Input Type	SPF	Cedar	SPF	Hardwood	Newsprint
	Select the correct input type (species or product mix) from the drop down list				
Thickness			1/2	5/8	
	Select the correct panel thickness from the drop down list				
Input Quantity:	1000	1000	1000	1000	1000
	Enter the quantity of input product being used in the project				

The next step is to select the correct **input metric** (unit of measurement) for each input product you have selected. Definitions for each unit of measurement are included in the cells with blue fill adjacent to the Project Description section.

Definitions and Acronyms	
Roundwood	Harvested sawlogs or pulplogs that have been delivered to a milling facility.
Secondary Wood Product	Lumber, plywood, oriented strand board (OSB), medium density fibreboard (MDF), and paper produced from roundwood.
End Use Product	Homes, commercial buildings, manufactured products like furniture, shipping products, repairs. Also referred to as a carbon pool.
Paper	Includes all paper products. Paper is both a secondary wood product and a separate carbon pool.
tC	Mass of elemental carbon in metric tonnes.
CO_2e	Equivalent tonnes of carbon dioxide (e.g. 1 tonne of C is equivalent to 3.667 tonnes of CO_2).

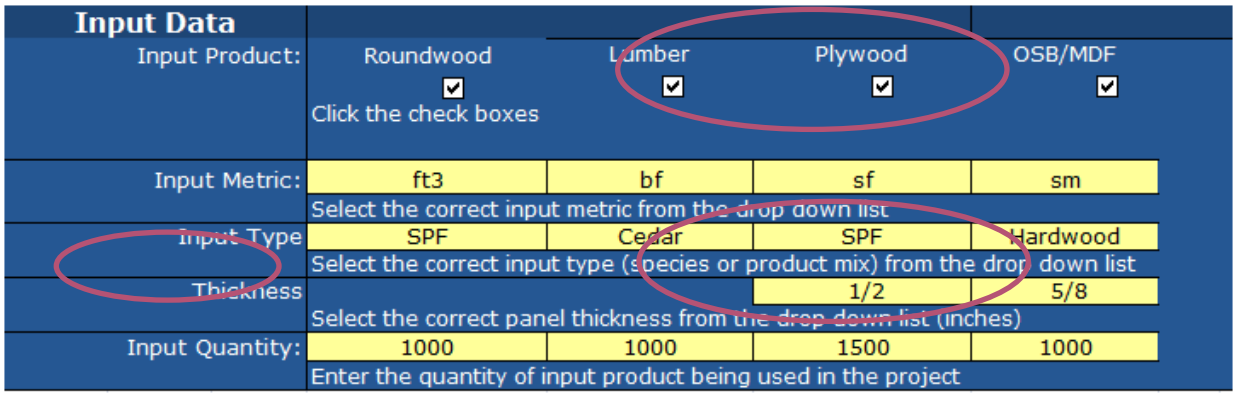
The calculator allows you to choose between tC (tonnes of carbon) or another unit of measure that is commonly used for that product (e.g. for lumber its bf or m^3). To select the correct unit, just click under the chosen product and a drop down box will appear. Click on the correct unit within the drop down box. A warning message will pop up reminding you to ensure that you have selected correctly. Very different results will be obtained with different **input metrics**. The calculator automatically converts the unit of measure you have chosen to tonnes of carbon dioxide equivalent and this is what is reported in the Results sheet.

If you know how much wood product you have, but the information is in an input metric that is not available in the drop down boxes, you will need to convert it to one of those available. A good source for such information is Briggs, D.G. 1994. Forest products measurements and conversion factors : with special emphasis on the U.S. Pacific Northwest. Institute of Forest Resources. available at http://www.ruraltech.org/projects/conversions/briggs_conversions/briggs_book.asp.

After clicking on the correct metric either press the Enter key on your keyboard or click on a new cell. If you want to change your selection, just click on the correct input cell again and choose a different metric.

The next step is to choose the **input type** that you are using. For roundwood, lumber, plywood, and OSB or MDF this will involve selecting the appropriate species of wood. With roundwood and lumber you have a choice of SPF (spruce pine fir mix), cedar, or hardwood. In B.C., spruce, pine, and true fir lumber are normally not separated. Because cedar has such a different density, and is usually sold as a separate product, the calculator provides it as a separate choice. The same is true of hardwoods[2]. If your product is primarily hemlock or hembol you should select SPF. For plywood the only option for input type is SPF. For OSB or MDF you can choose SPF or Hardwood.

With plywood and OSB/MDF, before you enter information on the quantity of product you are using, you will need to specify the **thickness** that you are using, in inches.



The options available in the drop down boxes include thicknesses that are commonly used for these products (e.g. 1/2"). If your project involves more than one thickness you will need to first convert the

[2] When hardwood is selected as input type for roundwood, the calculator uses trembling aspen density in converting m^3 to tonnes of CO_2e. When hardwood is selected as input type for lumber or OSB/MDF, the calculator uses paper birch density in converting m^3 to tonnes of CO_2e.

different thicknesses to a 3/8" basis (a standard thickness used in specifying quantities of plywood and panels), and then choose 3/8" in the drop down box. You can do this by dividing the thickness of your product (expressed as decimal) by 0.375, or you can look the value up in the thickness tables in the Conversions and Parameters sheet. Once you have converted different thicknesses to the 3/8" basis you will need to add the quantities for those products together and enter this value in the input quantity cell. Here is an example of how the unit conversion calculation works:

Original Dimension	Plywood ½"	Plywood ¾"
3/8" Basis	0.5/0.375 = 1.333	0.75/0.375 = 2.666
Quantity	1500 sf	1000 sf
Input Quantity Used In The Calculator	(1.333*1500)+(2.666*1000) = 4665 sf	

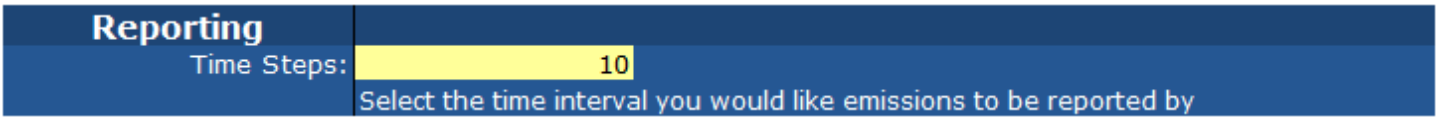
No option has been provided to enter metric thicknesses since these products are not normally sold in metric dimensions. If you only have quantities in metric dimensions, you can use the conversion factors in the Conversions and Parameters sheet. Note also that, although there are different thicknesses for lumber, an option to enter lumber in different thicknesses has not been provided. You must convert different thickness and width dimensions to board feet, m^3, or tC.

The last step under Input Data is to specify the **quantity of material** being used in the project. A quantity must be provided for each type of input product selected. Ensure that the correct input metric and type have been selected. If data is missing for any of the input parameters, an error message will prompt you to include the missing information.

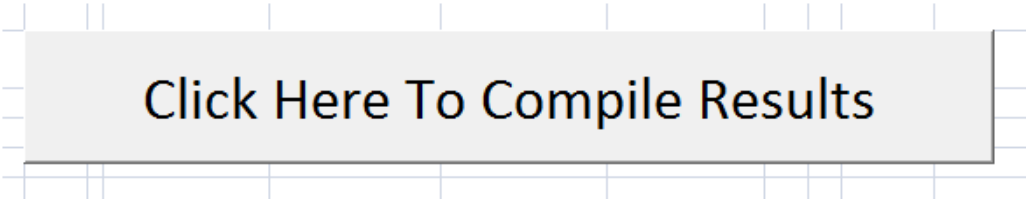
If you decide to **remove** the product from the project, just click again on the check box for the product you want to remove and all data associated with it will be erased.

Reporting

In the section of the Calculator sheet entitled Reporting, you choose the **time interval** you would like retention and emissions to be reported by. Click on the time steps cell and select 1, 5, or 10 years. If, for example, five is selected, carbon remaining in the project, and cumulative emissions, will be reported every five years from project commencement.



Finally click on the button to generate the results. If nothing appears to happen, try clicking on an empty cell, and then on the button again.



Quick Results

Finally, in the Calculator sheet, we have included a Quick Results section. This simply summarizes total carbon emissions and storage (including storage in landfills) at the end of 100 years. It was provided to allow you to quickly get the carbon footprint (emissions) without having to go to another sheet.

You can make a change to any input and immediately see how the 100-year carbon storage and emissions change. It is important to note that you must click on the Click-Here-To-Compile-Results button after you make your changes before the Quick Results section (and Results sheet) will be updated.

Quick Results (tonnes of CO_2e)		
Carbon Used In Your Project		52
Carbon Storage After 100 Years Including Landfill Storage		22
Carbon Emissions (Footprint) Over 100 Years		30
Uncertainty (tonnes of CO2e)	Minimum	Maximum
Carbon Emissions (Footprint) Over 100 Years	25	38

GRAPHS SHEET

In this section of the calculator, data on yearly change in carbon stocks are used to create some charts that portray carbon the decline in wood storage and increasing emissions over time. Charts generated in this version of the calculator include:

- Carbon retention by pool (single family homes, multi-family homes, etc) as shown in the example below.
- Cumulative emissions for all selected wood products combined (roundwood, lumber, plywood, OSB/MDF, paper) with and without storage in landfills and dumps.
- Carbon remaining for all selected wood products combined, with and without storage in landfills and dumps.

These graphs are generated automatically and use the entire 100 year data set. They are password protected and cannot be changed. If you want to create your own graphs you will need to create a new sheet and then copy data for it from the results sheet.

You can export the graphs to a .png format. Click on a graph to select it, then click on the menu Add-Ins, and select Export Chart. It should open a dialogue box where you can choose a directory and provide a name for the file. This graphic can then be imported to a presentation or document.

RESULTS SHEET

In the Results sheet there are 3 sections: Project Description, Explanatory Notes, and tabular results. The first section is simply a copy of the data from the input sheet and serves as header if you want to print the results. If you want to change any of the information in this section you need only click in the cell and edit it. If you rerun the calculator from the Calculator sheet, however, the edits will be lost.

Results are produced by the calculator for each carbon pool as well as for all carbon pools combined, including and excluding landfill/dump storage. A separate table is generated for each input product (e.g. roundwood, lumber, plywood, etc.). If you have not clicked one of the check boxes in the Calculator sheet, no results will be produced for that product. You can also select how many rows are produced in each results table by specifying the reporting interval in the Calculator sheet. If, for example, 5 years is chosen, there will be 20 rows (100/5).

The results tables show cumulative change in CO_2e over time (reported as equivalent tonnes of CO_2). For example, in the table below, the amount of carbon stored in oriented strand board or medium density fibre in manufactured products, dropped from 5 to 1 tonnes over a 100 year period. During this same period, cumulative emissions from **all** carbon pools increased from 9 to 14 tonnes.

OSB/MDF Retention and Emissions (in Tonnes of CO_2e)												
Year No.	Single Family Homes	Multi-Family Homes	Comm Buildings	Manuf. Prod.s	Shipping	Repairs	Other	Landfill	Total CO2e Retention Excl Landfill and Dumps	Total CO2e Retention Incl Landfill and Dumps	Total CO2e Emissions Exclud storage in Landfill	Total CO2e Emissions Includ storage Landfill
10	2	0	1	5	0	2	3	2	14	16	12	9
20	2	0	1	4	0	2	3	4	12	16	14	10
30	2	0	1	4	0	1	2	5	10	15	15	11
40	2	0	1	3	0	1	2	6	9	15	17	11
50	2	0	1	2	0	1	2	6	8	14	18	12
60	2	0	1	2	0	1	2	7	7	14	19	12
70	1	0	1	2	0	1	1	7	6	13	20	13
80	1	0	0	1	0	0	1	8	5	13	21	13
90	1	0	0	1	0	0	1	8	5	13	21	14
100	1	0	0	1	0	0	1	8	4	12	22	14

It is important to note that these results are based on regional statistics from Canadian and U.S. sources regarding the distribution, retention, and retirement of wood products and may not exactly reflect retention or emissions in your project.

CONVERSIONS AND PARAMETERS

The Conversions and Parameters sheet is provided so that you can see what factors have been used in generating the results and to assist you with making any conversions that are not made automatically by the calculator. It summarizes user options, provides conversion tables to convert imperial thickness to metric equivalents and to convert thickness to 3/8" basis, and lists all the conversion factors used by the calculator to convert data you provide into tonnes of carbon dioxide equivalent.

References are also provided so you can delve into the conversions more thoroughly to better understand the impact these variables might have on carbon flux estimates. The last section of this sheet provides information on the retirement and decay rates that were used in the BC Harvested Wood Products Model v1.0 to produce the data tables upon which the calculator is based.

VIEWING AND PRINTING

Information contained on each individual sheet can be viewed and printed using standard Microsoft Excel page layout formatting. We recommend you use "Print Preview" and make adjustments using the Page Setup and Scaling tools to configure printing to suit your needs. Selecting a group of cells and choosing "Print Selected" before going to "Print Preview can also be a useful approach. Clicking on a chart will allow you to print only the chart, not the whole page.

While we have endeavored to format the document so it is easy to view and is pleasing to the eye, different monitors will portray colours differently and people have their own preferences with respect to fonts and text size. It is not possible to change the fonts or colours on protected sheets. However, you can copy the sections you want and paste them onto a new sheet to make the changes there.

INTERPRETING THE RESULTS

INTERPRETING THE QUICK RESULTS SECTION

The calculator starts by determining the mass of carbon stored in the wood molecules of the products you are using in your project. Adjustments are made to convert area or volume measurements to mass, and to account for water content, adhesives, additives, and the losses during initial manufacturing for everything except logs. Once these adjustments are made, the mass is converted into an equivalent amount of carbon dioxide (CO_2e). This value is the amount of greenhouse gases (primarily carbon dioxide) that was removed from the atmosphere by growing trees and makes up most of what we report in the first line of Quick Results section - Carbon Used In Your Project.

If you input secondary products, the losses during manufacturing are added to the Carbon Used In Your Project. Also added are the methane emissions caused by the decay of wood and paper in landfills. These are added on top of what the trees initially stored because trees do not take up methane, and it is a more potent greenhouse gas than carbon dioxide.

Over the next 100 years, some of that material will be retired from use, recycled, or be sent to a landfill. At the landfill, some is burned for energy, some decays, and some is just buried (see Figure 1).

The portion of CO_2e that is stored after 100 years is reported in the second line of the Quick Results section - Carbon Storage After 100 Years Including Landfill Storage.

As paper and wood decay or burn, the carbon is returned to the atmosphere. In the Quick Results section this is reported as "Carbon Emissions (Footprint) Over 100 Years". This value represents the estimate of total cumulative emissions that occurred over the next 100 year period.

There is considerable uncertainty around the exact values for manufacturing efficiency, life expectancy of different wood products, recycle rates of paper and other aspects of the forest product life cycle. The range of potentially reasonable values for the Carbon Emissions (Footprint) is provided as "Minimum" and "Maximum" estimates. There are also uncertainties for the carbon storage, but those have not yet been quantified.

While the calculator is meant to be simple and quick to use, it does have limitations. It can be used to determine the emission associated with roundwood or secondary wood products but does not currently provide you with the option to specify the end use for your products. The calculator will only provide you with information on which end use products these secondary wood products normally end up in, and how they are retired from use over time.

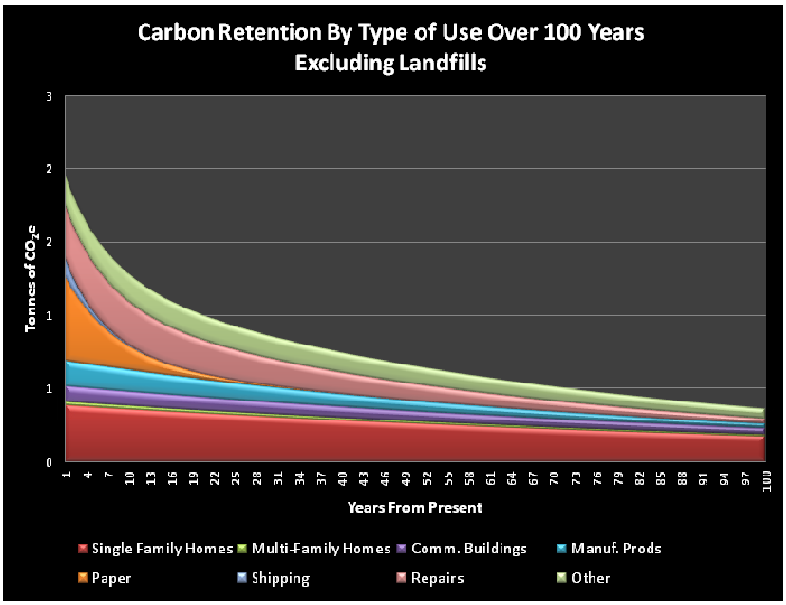
Other aspects worth noting include:

- it doesn't account for fossil fuel emissions used in the production or transportation of the products;
- it doesn't address the substitution benefit of wood compared to other building products;
- the tool counts the burning of wood for energy as creating emissions.

INTERPRETING THE GRAPHS

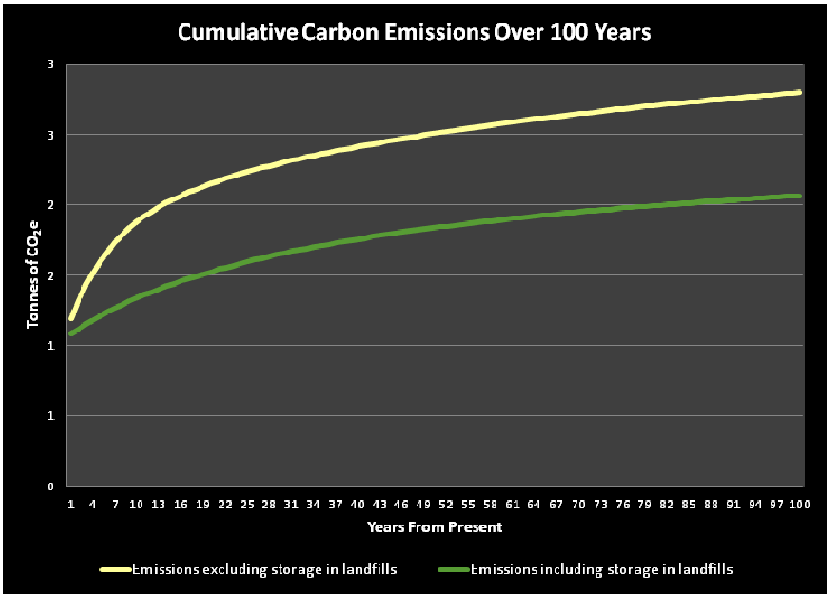
On the Graphs page, the chart entitled "Carbon Retention By Type of Use Over 100 Years, Excluding Landfills" (see example below) provides a visual representation of how the cumulative storage of carbon changes over time.

The calculator uses the data you provided on quantities of logs, lumber, panels, and paper to determine the storage in the first year. After that, the storage declines based on the life expectancy and recycle rate of different products. For example, the red band in the chart below represents wood within single-family homes. It declines slowly because the life-expectancy of homes in North America is over 100 years partly because our society tends to renovate rather than demolish older homes. Repairs and renovations to our dwellings (pink band) tend to last a shorter period of time - on average, about 30 years.



The chart called "Declining Carbon Storage Over 100 Years" depicts the storage of carbon (i.e. tonnes of CO_2e removed from the atmosphere) for all carbon pools combined. One line on the chart shows how much is stored when landfill and dump material that is no longer in use (but has not yet decayed) is counted as storage, and the other line shows total storage when material in landfills is not counted. The two approaches yield substantially different results. The option of accounting for storage in landfills and dumps is provided here because there are differences about how this material is treated in some carbon offset protocols. In some cases it is considered to be a valid from of carbon storage, and in other cases it is not.

The chart entitled "Cumulative Carbon Emissions Over 100 Years" is the opposite of the Carbon Storage chart (see below). If carbon is not stored, it is emitted and so the shape of the emission curves is like a mirror-image of the storage curves. As was the case with total carbon storage, the trend when landfill and dump material is considered to be an emission is shown, as well as the trend when landfill materials are treated as storage rather than an emission. The year 100 value from the green line on the chart below is reported on the Quick results for the carbon footprint of your project.



GETTING MORE INFORMATION

We hope our carbon calculator tool helps you better understand possible greenhouse gas implications associated with the wood products you use. Please contact us if you have any questions about any aspect of this User's Manual or the associated spreadsheet tool. Let us know what you think at:

Caren Dymond, M.Sc. P.Ag.
Competitiveness and Innovation Branch
Telephone: 250-387-0140,
E-mail: Caren.Dymond@gov.bc.ca
Mailing address: PO Box 9515 Stn Prov. Govt . Victoria BC V8W 9C2

Other Calculators and Models

If you want more control over wood product use, retirement functions, and decay rates you might find the National Council for Air and Stream Improvement (NCASI) model appropriate (available at www.ncasi.org/support/downloads/Detail.aspx?id=30). However, it does not consider the emissions associated with converting logs into lumber, plywood, paper, etc. and it is more difficult to use.

If you are interested in knowing the benefits of using wood instead of fossil fuel intensive products, an on-line calculator is produced by Woodworks (a North American Wood Associations cooperative). However, it does not include the emissions associated with converting logs into secondary wood products such as lumber and panels. http://www.woodworks.org/design-tools/online-calculators/

Further Reading

If you would like to know more about how forest products manufacturing in BC, carbon and greenhouse gas emissions from wood and paper products, try some of the links listed below.

- Dymond, C. 2012. Forest carbon in North America: annual storage and emissions from British Columbia's harvest, 1965-2065. http://www.cbmjournal.com/content/7/1/8
- The Canadian Forest Service Carbon Budget Model Framework for Harvested Wood Products. http://cfs.nrcan.gc.ca/pages/94
- The Woodworks on-line calculator available at http://www.woodworks.org/design-tools/online-calculators/
- The National Council for Air and Stream Improvement (NCASI) model available at www.ncasi.org/support/downloads/Detail.aspx?id=30).
- Sathre R, O'Connor J: A synthesis of research on wood products and greenhouse gas impacts. Vancouver, BC: FPInnovations Technical report TR-19; 2008. http://www.forintek.ca/public/Eng/E5-Pub_Software/5a.fact_sheets.html
- Lippke B, Oneil E, Harrison R, Skog K, Gustavsson L, Sathre R: Life cycle impacts of forest management and wood utilization on carbon mitigation: knowns and unknowns. Carbon Manage 2011, 2(3):303–333 www.corrim.org/pubs/articles/2011/FSG_Review_**Carbon**_Synthesis.pdf
- Briggs,D.G. 1994 Forest Products Measurements And Conversion Factors: With Special Emphasis on the U.S. Pacific Northwest.Institute of Forest Resources, University of Washington, Seattle. http://www.ruraltech.org/projects/conversions/briggs_conversions/briggs_book.asp
- Dymond, C.C. 2012. Our Logs' Story from Truck to Product. BC Forest Science Program Extension Note 107, Victoria, BC. http://www.for.gov.bc.ca/hfd/pubs/docs/En/EN107.pdf