User's Manual for FSC Forest Carbon Monitoring Tool

FSC-MAN-30-006 V1-0 EN

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The Forest Stewardship Council (FSC) is an independent, not for profit, non-government organization established to promote environmentally appropriate, socially beneficial, and economically viable management of the world's forests.

FSC's vision is that the world's forests meet the social, ecological, and economic rights and needs of the present generation without compromising those of future generations.

Foreword

This document explains how to use the **FSC Forest Carbon Monitoring Tool**. The FSC Forest Carbon Monitoring Tool can be used by FSC forest management certificate holders to monitor the carbon in their forests and, if desired, demonstrate the positive impacts of responsible forest management on carbon sequestration and storage via the FSC Ecosystem Services Procedure (FSC-PRO-30-006). The Forest Carbon Monitoring Tool was developed by UNIQUE forestry and land use GmbH on behalf of FSC International. It is an Excel workbook comprising several spreadsheets.

Software requirements

The tool was designed to run on Microsoft® Office Excel 2010. FSC declines all responsibility for inconsistent results or components that do not run properly when the tool is applied on older Excel versions.

Macros

For correct functioning of the tool, it is necessary to allow the utilization of macros. To enable macros to run on your computer, you will need to set the security level to allow macros to be run (see section 3.2). FSC declines all responsibility for any errors or deficiencies in the Forest Carbon Monitoring Tool, or in the documentation accompanying it; for program maintenance and upgrading; and for any damage that may arise from use of the Forest Carbon Monitoring Tool and its associated macros.

Acknowledgements

The Forest Carbon Monitoring Tool has been developed by UNIQUE forestry and land use GmbH on behalf of FSC International.

For any enquiries for UNIQUE, please write to: unique@unique-landuse.de

Contents

A. Objective

The objective of the Forest Carbon Monitoring Tool is to assist FSC forest management certificate holders to assess, monitor, and simulate carbon stocks, carbon stock changes, and related greenhouse gas emissions of their certified forests and management operations. The tool was developed to integrate existing forest inventory data and carry out assessments of carbon stocks and management-related carbon stock changes. When inventory data is not available, default values can be used.

B. Scope

This manual is to be used primarily by FSC forest management certificate holders who are interested in using the FSC Forest Carbon Monitoring Tool.

This document may also be used by certification bodies that have to evaluate the use of certificate holders of the FSC Forest Carbon Monitoring Tool.

C. Effective and validity date

Approval date	6 August 2020
Publication date	14 August 2020
Effective date	14 August 2020
Period of validity	until replaced or withdrawn

D. References

The following referenced documents are relevant for the application of this document. For undated references, the latest edition of the referenced document (including any amendments) applies.

FSC-PRO-30-006 Ecosystem Services Procedure: Impact demonstration and market tools

E. Terms and definitions

Aboveground tree biomass: Living biomass of trees above the soil, including the stem, stump, branches, bark, seeds, and foliage.

Belowground tree biomass: Living biomass of trees below the soil, including live roots, sometimes excluding fine roots of less than 2 mm diameter because these often cannot be distinguished empirically from soil organic matter or litter.

Biomass expansion factor: A multiplication factor that expands growing stock, or commercial round-wood harvest volume, or growing stock volume increment data, to account for non-merchantable biomass components such as branches, foliage, and non-commercial trees.

Carbon dioxide (CO_2): According to the Glossary of the Intergovernmental Panel on Climate Change (IPCC),[1] a naturally occurring gas fixed by photosynthesis into organic matter. A by-product of fossil fuel combustion and biomass burning, it is also emitted from land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured, thus having a global warming potential of 1.

Carbon pool: A reservoir of carbon that has the potential to accumulate (or lose) carbon over time, which for land-use projects or programmes encompasses aboveground biomass, belowground biomass, litter, dead wood, soil, and wood products.

Carbon stock: The quantity of carbon held within a pool, measured in tons of CO_2.

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[1] IPCC (2013) Glossary. In: Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., and Midgley, P.M. (eds) *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK and New York, USA. (Also available at https://www.ipcc.ch/ipccreports/tar/wg1/518.htm, accessed 6 January 2017.)

Dead wood: Non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. It includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the host country for its *United Nations Framework Convention on Climate Change* (UNFCCC) national inventory accounting.

Default factor/value: A parameter value that is specified in a methodology with the intention of standardizing the calculation of net GHG emission reductions and/or removals, and providing greater consistency of calculations across projects.

Dry biomass (or dry matter): Biomass that has been dried to an oven-dry state, often at 70°C.

Forest: Land with woody vegetation that meets an internationally accepted definition (e.g. by the UNFCCC, IPCC, or Food and Agriculture Organization of the United Nations) of what constitutes a forest, which includes threshold parameters such as minimum forest area, tree height, and level of crown cover, and may include mature, secondary, degraded, and wetland forests.

Forest management enterprise (FME): Company or operation responsible for forest management (FSC-STD-20-012 V1-1 *Standard for Evaluation of FSC Controlled Wood in Forest Management Enterprises*).

Forest management unit (FMU): A clearly defined forest area with mapped boundaries, managed by a single managerial body to a set of explicit objectives that are expressed in a self-contained multi-year management plan (FSC-STD-20-011 V1-1 *Accreditation Standard for Chain of Custody Evaluations*).

Form factor: The ratio of the volume of a tree or its part to the volume of a cylinder having the same length and cross-section as the tree. Within this tool, the default tree form factor that should be applied is 0.5.

Growth model: A model is a formula or set of formulae that uses parameters and input values to establish the value of one or more output variables. Within this tool, a growth model refers to the growth function of a particular and homogenous forest cluster, referred to as a forest stratum. It reflects the development over time of certain forest management-specific parameters (e.g. number of trees per hectare, mean height, mean diameter, basal area [in m^2] per hectare, and standing volume [in m^3] per hectare) considering natural growth, as well as both positive and negative effects on these parameters due to human interventions such as thinning and tending. This tool allows flexible entry of data into the growth model from various sources, such as growth and yield tables, and scientific models. In addition, if local information is missing, users can create their own growth model by entering minimal information on the development of a certain forest. A detailed explanation on application of the growth model is provided in section 6.2.

Greenhouse gas: Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary GHGs in the Earth's atmosphere. There are a number of entirely human-made GHGs in the atmosphere, including the halocarbons, and other chlorine- and bromine-containing substances dealt with under the Montreal Protocol. In addition to CO_2, N_2O, and CH_4, the Kyoto Protocol deals with the GHGs sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Intergovernmental Panel on Climate Change (IPCC): The leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge on climate change and its potential environmental and socio-economic impacts. The IPCC is a scientific body under the auspices of the United Nations. It reviews and assesses the most recent scientific, technical, and socio-economic information produced worldwide that is relevant to the understanding of climate change.

Litter: Non-living biomass, with a size less than a minimum threshold diameter (e.g. 10 cm), chosen by the host country for its UNFCCC national inventory accounting, lying dead and in various states of decomposition above the mineral or organic soil, including litter, fumic, and humic layers. Live fine roots (of less than the threshold diameter for belowground biomass) are included in litter where they cannot be distinguished from it empirically.

Loss method: A method to assess the impact of selective logging operations in tropical natural forests in terms of carbon emissions, considering three factors: emissions relative to extracted volume; damaged

biomass in the process of logging; and damaged biomass resulting from infrastructure necessary for logging. This method is very simple and uses default factors for nine key timber-producing countries in the tropics.

Project: Within this tool, the term 'project' can be used synonymously with forest management unit (FMU).

Project area: A spatial area or areas submitted for certification with clearly defined boundaries managed to a set of explicit long-term management objectives.[2]

Root-to-shoot ratio: The quotient of the dry weight of the shoots produced during a given growth period divided by the dry weight of the roots, especially for crop plants.

Species: Within this tool, a tree species or a species group for which specific biometric parameters (e.g. biomass expansion factor, wood density) or models (e.g. growth model, yield table) are selected and applied to assess carbon stocks or carbon stock changes.

Stratum: To increase the accuracy of forest information from inventories, it is good practice to divide the forest area of a particular FMU or project into subpopulations or strata that form relatively homogenous units in terms of forest parameters such as species composition, volume, growth, carbon stocks, and carbon stock changes.

Tool: In the case of this FSC tool, a type of module that provides a procedure for performing a specific analysis.

Wood density: The mass of wood per unit volume, an important trait for understanding the function and ecology of woody species, as well as for estimating stored biomass and carbon content.

Wood products: Products derived from wood harvested from a forest, including fuelwood and logs, and the products derived from them such as sawn timber, plywood, wood pulp, and paper.

F. Introduction

The Forest Carbon Monitoring Tool is a flexible Excel workbook comprising several spreadsheets. It is intended for use by FSC's forest management certificate holders as well as by forest management projects that intend to monitor and/or simulate forest carbon stocks of the most important forest carbon pools of their forest management units (FMUs), or parts of them.

The tool provides a flexible framework that allows forest carbon monitoring in tropical, temperate, and boreal forest ecosystems. Its application is broad: it can be used for rough carbon stock assessment and simulations even if no forest inventory data exist, as well as for FMUs. However, it works best, and is most accurate, if forest inventory data for an FMU are available; such data will be converted to CO_2-equivalents (CO_2e) within the tool. The smallest unit of assessment, 1 ha, can be scaled up to a full FMU.

The reliability of results is highly dependent on the information entered into the spreadsheets. The more detailed the information provided from existing forest inventory data for an FMU, the higher the reliability of the carbon stock assessment. The more pre-set default factors/values used, the more uncertain the carbon stock assessment and/or simulation.

The workbook has three components (Figure 1):

1. General Information
2. Monitoring Tool
3. Simulation Tool.

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[2] FSC-STD-01-002 *FSC Glossary of Terms*: 'management unit'. (Also available at https://ca.fsc.org/preview.fsc-glossary-of-terms-fsc-std-01-002.a-833.pdf, accessed 6 January 2017.)

Figure 1: The FSC Forest Carbon Monitoring Tool
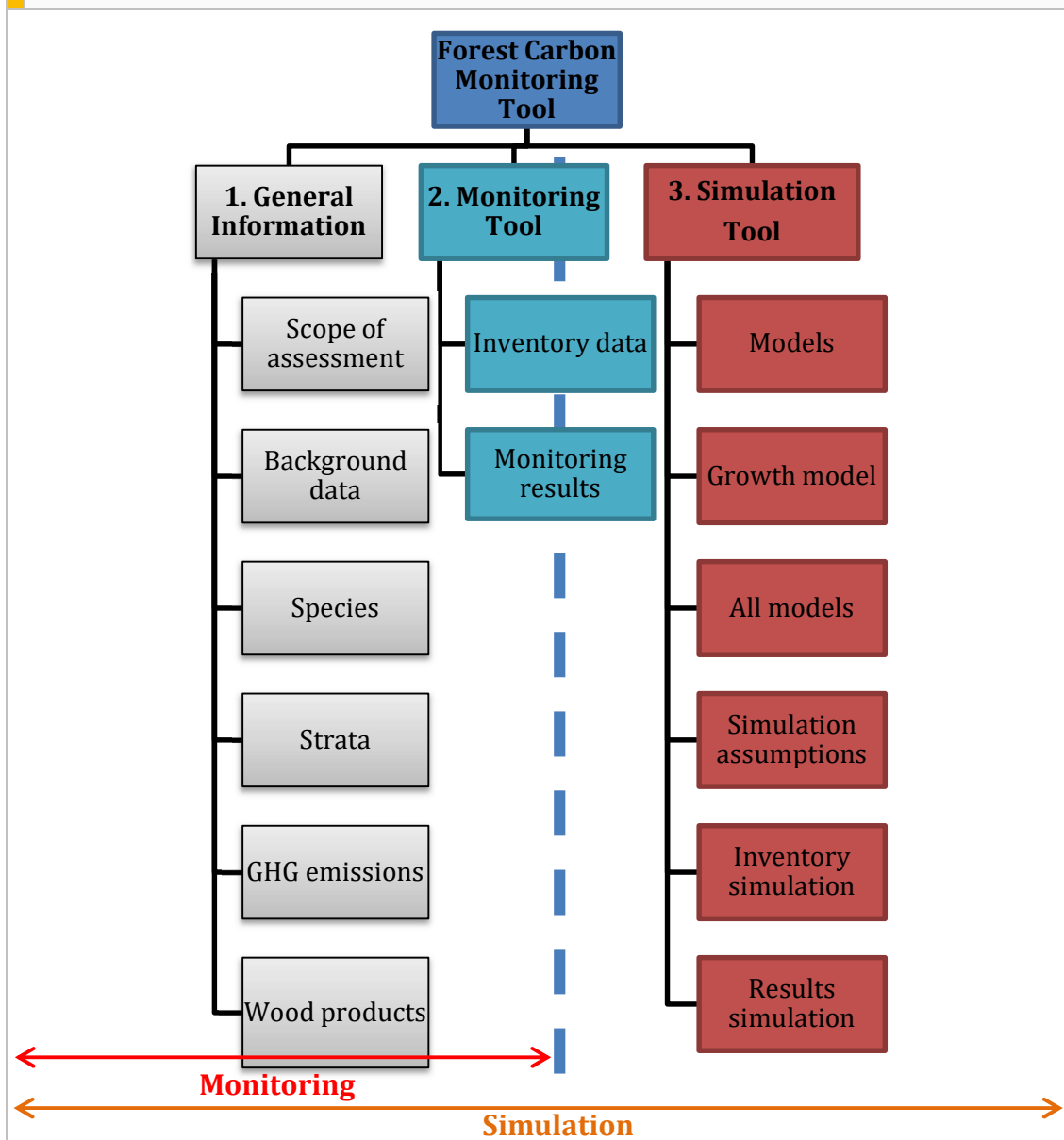
1. General Information. This lays the foundation for subsequent components of the tool. It is necessary to complete at least part of this component to calculate a result (see section 4).

2. Monitoring Tool. This monitors carbon stocks and carbon stock changes of forests within an FMU, based on existing information. It can be used to assess carbon stocks in a particular year, or changes that have occurred between two different years (defined as ex-post or after-the-fact monitoring according to the carbon accounting definition of the IPCC).[3] For users aiming for this type of assessment, only the first two components of the tool are relevant. As part of the Scope of assessment at the start of the first component, users can choose to exclude the simulation option. In this case, the Monitoring results tab will be the final sheet, showing the results of this monitoring option.

3. Simulation Tool. This component is for users aiming not only to monitor carbon from existing FMU information, but also to simulate the development of carbon stocks for a defined future simulation period (e.g. 50 years). By defining Growth models for the respective forest inventory data entered

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[3] IPCC (2000) Carbon Accounting. In: Watson, R.T., Noble, I.R., Bolin, B., Ravindranath, N.H., Verardo, D.J., and Dokken, D.J. (eds) *Land Use, Land-Use Change and Forestry*. Cambridge University Press, Cambridge UK. (Also available at http://www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=6, accessed 6 January 2017.)

into the Monitoring Tool, this component performs a future simulation. The Simulation Tool component is optional, and works successfully only if the information for the Monitoring Tool is complete.

The tab About this tool at the top of the navigation panel displays background information regarding disclaimers and protection for use of the tool. This tab is displayed throughout the Excel workbook.

Mandatory and optional data

The following tabs are mandatory for both the Monitoring Tool and the Simulation Tool:

General Information:	Scope of assessment
	Background data
	Species
	Strata
Monitoring Tool:	Inventory data

General Information

The first tab, Scope of assessment, allows users to define which analyses they wish to perform, including the choice of additional carbon pools (apart from the tree biomass).

As a precondition for *both* assessment options, the user needs to define a minimum set of parameters.

- Under Background data, describe conditions specific to the FMU: Total area, Country/continent, and Biome (Boreal, Temperate, Tropical).

- Under Species, define the main species or group of species within the FMU along with the corresponding parameters that convert tree volumes into biomass and carbon, respectively.

- Under Strata, define each stratum with unique biological characteristics for which separate carbon monitoring/simulation should be performed, giving minimum descriptors (Area, Elevation, Precipitation).

The GHG emissions tab allows the user to enter information on fossil fuel consumption and fertilizer applications in the FMU. The Wood products tab allows classifications of wood products for use if emissions from these sources and the carbon stored in long-lived wood products are to be assessed. These two tabs are optional and do not affect any other calculations; they are also excluded from the future simulation.

Monitoring Tool

Under the Inventory data tab, the user provides key information about the FMU forest resources from existing forest inventories. The data need to be entered according to the Strata defined in the previous component.

Simulation Tool

To carry out simulations of carbon stock changes, both the model and simulation components of the tool have to be applied. For models, the user either develops a simple volume growth model within the tool, or enters existing volume growth models relevant for growth projections and future carbon simulations. Under the simulation tabs, simulations are actually defined and carried out.

The Forest Carbon Monitoring Tool is designed for use by those without significant forest carbon expertise. It offers support to the user in compiling all relevant carbon-related information using default factors and

values, following the hierarchical tiers (1–3) of the IPCC guidelines for estimating GHG emissions and removals.[4] These three tiers are a function of methodological complexity, regional specificity of emission factors, and the extent and spatial resolution of the activity data. They progress from least (Tier 1) to greatest (Tier 3) level of certainty. When applying this tool, moving from lower to higher tiers will usually require more locally specific, site- and species-specific, or forest type-specific forest inventory data and default values. Many cells contain help notes on the use of default values if local project data are not available. The notes appear as you click on the respective cells of the parameter descriptions. Once users become more familiar with carbon stock assessment, the default factors and values may be changed from uncertain international default factors and values to more site-specific information. The tool provides a database of the IPCC default values.

[4] IPCC (2006) *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Intergovernmental Panel on Climate Change. (Also available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html, accessed 28 July 2016).

1. Getting started

1.1   Master copy

Always keep a master blank version of the tool, since some cells contain formulae that may be overwritten with your own data. Some worksheets are protected by default to prevent users from accidentally overwriting calculations. The password to unlock them is 'Carbon'.

1.2   Macros

For the FSC Forest Carbon Monitoring Tool to function, it is necessary to enable the utilization of macros. Usually a warning message appears when opening the Excel file for the first time. To allow macros, click on **Enable this content** in the **Security Options** window (Figure 2).


Figure 2: How to enable macros
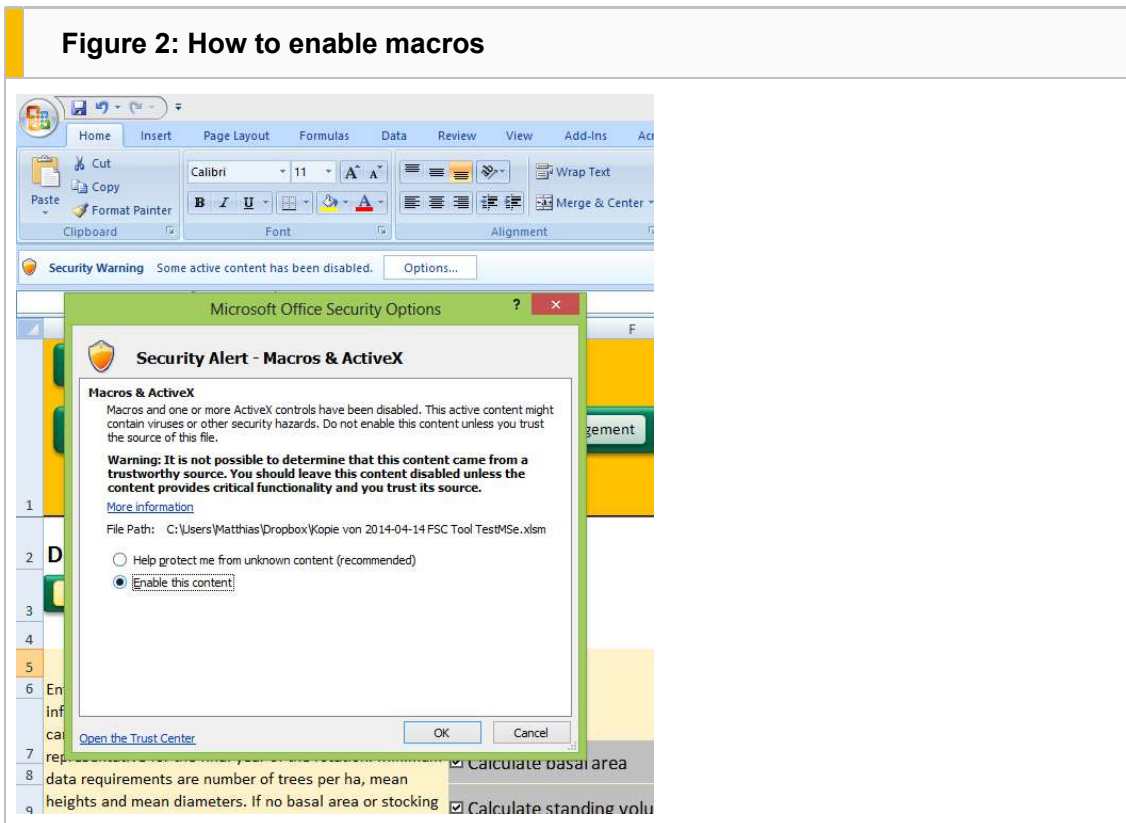
Where macros are being used for the first time in Excel, the warning message on opening the file may not appear. In this case it is necessary to enable the use of macros for correct functioning of the tool (Figure 3).

- In Excel 2010, click on **File**, **Options**, then select **Trust Center**, **Trust Center Settings**, **Macro Settings**).
- In versions earlier than Excel 2010, click on the **Microsoft Office** button and go to **Excel Options**.
- Select **Enable all macros** and save changes.

It is recommended that you reverse this process and disable macros when not working with the Forest Carbon Monitoring Tool. FSC accepts no responsibility for users' individual use of macros.

Figure 3: How to enable macros for Excel
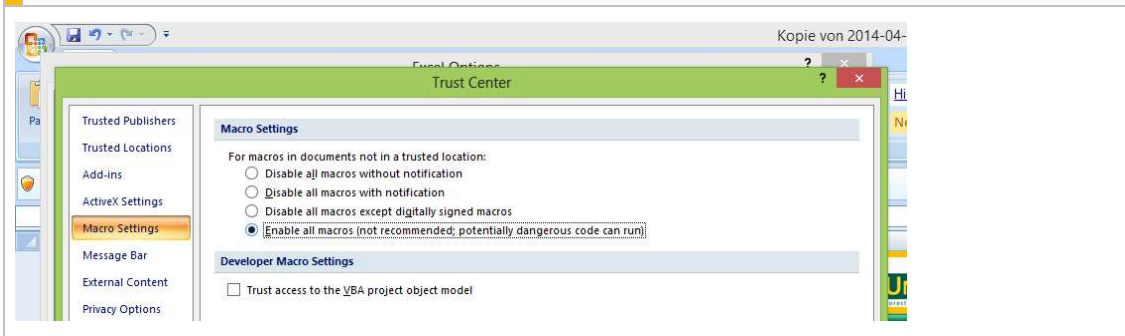
1.3 Navigation across worksheets

The FSC Forest Carbon Monitoring Tool requests users to specify information concerning different forest strata, and a set of inventory information and management practices. Different tabs, displayed on the navigation bar at the top of the tool, represent different information to be entered. Figure 4 shows the navigation bar that appears at the top of each sheet. Click on the headers to navigate through the tool. Generally it is recommended to start on the left and move iteratively through the tabs, as the individual worksheets build upon each other from left to right.

Figure 4: The navigation bar
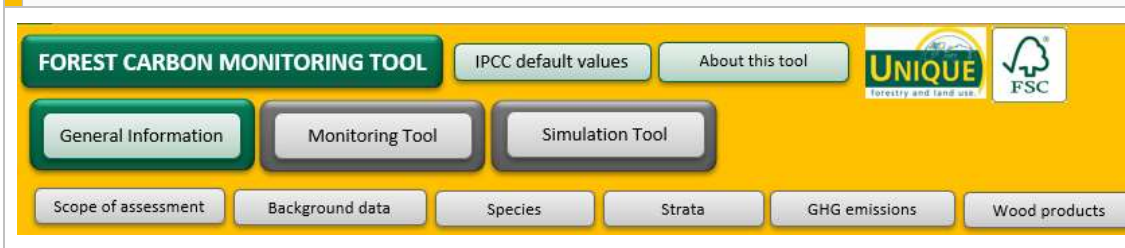
1.4 Types of data entry cells

The tool differentiates between data entry fields that must be entered manually and those that have a dropdown list. Most of the data have to be entered manually. Cells to be entered manually normally have a green column header (Figure 5)

Figure 5: Example of column header for manually entered data
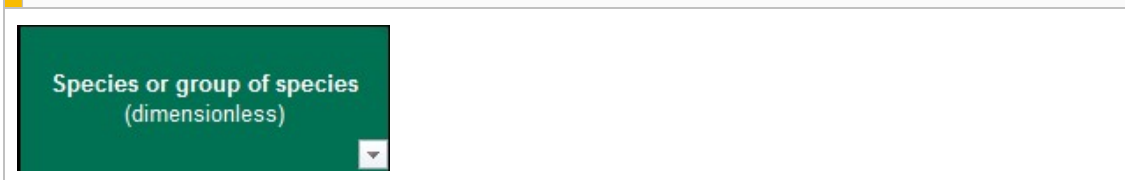
Dropdown entry fields require users to select one value from a predefined list (Figure 6).

Figure 6: Example of column header for dropdown list entry
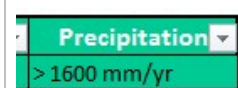
Some entry parameters offer default values based on existing IPCC data (e.g. Figure 7). These values need to be entered manually. Clicking on the column header takes the user to the default value database.

Note that to increase the accuracy of carbon monitoring it is always preferable, where possible, to use local or regional data rather than the internationally accepted default values.

Figure 7: Default value for wood density
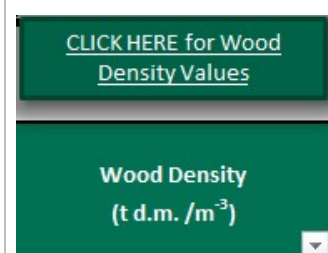
In some cases, not all cells will be required for data entry, depending on the Scope of assessment selected under the **General Information** component. Cells that are not required are displayed in grey, and may be ignored (Figure 8)

Figure 8: Tool options selected/not selected
The **Precipitation** cell under Strata is disabled by answering 'No' to questions 3 and 4 under Scope of assessment.

1.5 Sequence of data entry

It is recommended to work through the Forest Carbon Monitoring Tool from the beginning (from general data to inventory data, models, and simulation). Some sheets will not work properly if previous sheets have not been completed.

1.6 How to delete data

Under the Species, Strata, GHG emissions, and Wood products tabs (General Information) and the Inventory data tab (Monitoring Tool), the user will input data into the model. Please note that to avoid damaging the structure of the spreadsheet, data should be deleted from the table *only* by using the **Delete selected** button that will appear to the right on the navigation bar (Figure 9). If you inadvertently delete data in another way, the row will highlight red and can be restored by using 'Undo' (**Ctrl-Z**).

Figure 9: "Delete selected" button
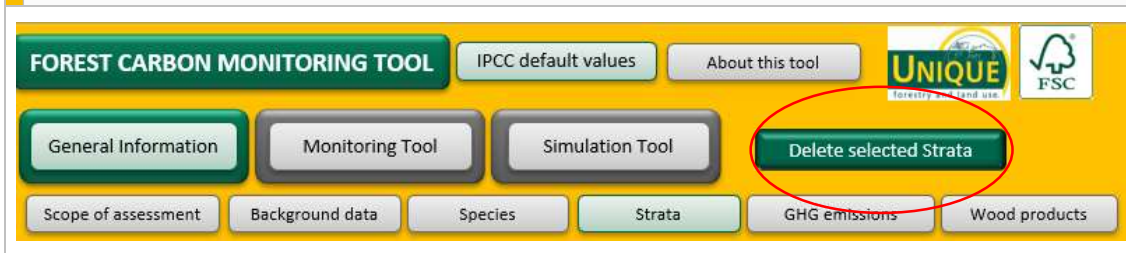
To delete data (Figure 10):

1. Click on the row (or rows) you want to delete
2. Click **Delete selected**
3. Answer **Yes** to the question 'Do you want to delete selected rows?'
4. Note that you cannot delete the first row, only the subsequent rows

Figure 10: Example of deleting selected species (rows)

Species or group of species (dimensionless)	Wood density (t d.m. /m^{-3})	Carbon fraction Default value = 0.47 (dimensionless)	Biomass expansion factor (dimensionless)
Andira parviflora	0.59	0.47	2
Andira retusa	0.67	0.47	3.4

2. General Information

2.1 Scope of assessment

Here you need to answer up to eight questions with **Yes** or **No** (Figure 11). Based on your answers, certain fields within the relevant worksheets that become irrelevant will be greyed out. Clicking on the **Information** button to the right of each question displays the relevant decision support information in the central panel.

To the right of the central panel, there is the option to calculate only emissions from logging in tropical areas (Figure 11).

Figure 11: Scope of assessment

Do you have forest inventory data to estimate carbon stocks of your forest area?	Yes
Do you want to include carbon from shrubs in your carbon assessment?	Yes
Do you want to include carbon from dead wood in your assessment?	Yes
Do you want to include carbon from litter in your assessment?	Yes
Do you want to include carbon sequestered in wood products in your assessment?	Yes
Do you want to simulate future carbon stock changes of your forest resources?	Yes
Do you have growth models available to simulate future carbon stock changes of your forest resources?	Yes

Alternatively, if you are *only* interested in calculating carbon emissions from logging activities, select Yes on the dropdown menu below and proceed to the Loss methods cell under Background data.

Do you want to calculate only carbon emissions from tropical forests caused by logging activities?	Yes

2.2 Background data

Under this tab, all fields are required. The information relates to the location and area of the project, and the timeframe in which comparisons of carbon stock changes are envisioned to be carried out (Figure 12).

Figure 12: Background data entry fields

Name of project/FMU	Brazil FMU Project	Total area in ha	537 ha
Country	Guatemala	Biome	Tropical
Continent	America	Aboveground tree biomass (t d.m./ha)	300 — Click here for IPCC Default values
Loss method: Reference country	Brazil		
Loss method: Annual extraction rate tropical forest	200 m³/year		

Data required

- **Name of the project/FMU**: This helps to identify different files for carbon stock assessments, for example if a forest management enterprise (FME) owns different forests and wants to analyse them separately.

- **Country**: This dropdown entry field is used to link IPCC default values to the information entered.

- **Continent**: Automatically inserted when the country is selected.

- **Total area in ha**: The total area of assessment (FMU/project area) should be entered in hectares.

- **Biome**: Select the IPCC climate zone of the FMU location from the dropdown list. This is needed to specify default values used to convert biomass to carbon.

- **Aboveground tree biomass**: The IPCC has defined specific aboveground biomass values for countries, regions, biomes, and ecosystems. Note that these values are very broad and may not accurately reflect the aboveground biomass of your specific forests. You can search the IPCC database within this tool to define the most representative value; or, if available, more specific values for the FMU may be entered here from any other source. Values should be entered in tons aboveground biomass (dry matter) per hectare (t d.m./ha).

- **Loss Method: Reference country**: A reference country must be selected from the dropdown list; if your country is not listed, choose a country that is similar in terms of tropical forest conditions.

- **Loss Method: Annual extraction rate tropical forest**: To assess the loss of carbon emissions as a result of selective logging in tropical natural forests (indicated by **Yes** in the right-hand area under Scope of assessment), the annual timber extraction rate in total m^3 per year needs to be entered here. Default values are available only for selected tropical timber-producing countries.

Loss method:

For some tropical forest enterprises, no inventory information is collected on total standing stocks and forest resources. Instead, information is collected on quantities of timber to be extracted prior to harvesting operations. With this default loss method you can assess the impact of selective logging operations in terms of carbon emissions considering three factors: emissions relative to extracted volume; damaged biomass in the process of logging; and damaged biomass resulting from infrastructure necessary for logging. This method is based on a recent study[5] and is applied as a very simple method using default factors for nine key timber-producing countries in the tropics. If you have only information on timber extraction volumes rather than inventory data on standing forest stocks, you can indicate **Yes** under Scope of assessment (Question: 'Do you want to calculate only carbon emissions from tropical forests caused by logging activities?') and calculate the emissions lost.

2.3   Species

Here you need to define tree species' specific conversion parameters. These conversion factors are used in the tool to convert typical forest inventory data to biomass data and to carbon dioxide equivalents. The default factors can be defined for individual species, or for groups of tree species with similar characteristics. Default values are available from the IPCC database.

Note that it is necessary to provide this information only for the most dominant species or species groups on which each Stratum is based. The carbon monitoring results are then calculated on the basis of the stratum entered. For each stratum, a representative tree species or group of species needs to be assigned, either from the **IPCC default values** table within the worksheet, or from another source. If a forest has mixed strata, and there are not sufficient data per species, it is highly recommended to enter a group name for the combination of species and treat them as if they were only one species, or to add the values of just the principal species in the stratum. This will increase the variability of the data.

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[5] Pearson, T.R.H., Brown, S., and Casarim, F.M. (2014) Carbon emissions from tropical forest degradation caused by logging. *Environmental Research Letters* 9(3). doi: 10.1088/1748-9326/9/3/034017. (Also available at http://iopscience.iop.org/1748-9326/9/3/034017, accessed 28 July 2016.)

Figure 13: Tree species parameter definition

Data required

- **Species or group of species**: Enter the name of the species or group of tree species to link this information to the forest strata and inventory data to be provided in subsequent worksheets. All the calculations in the tool will refer to these names and corresponding conversion factors.

- **Wood density** and **Biomass expansion factor (BEF)**: These fields are mandatory for carbon calculations. Wood density should be given in tons dry matter per m^3; BEF is dimensionless. If you do not have data for your species, in each case 'click here' to go to the **IPCC default values** table, from which values can be sourced. Once you have chosen a value, click the yellow **Return to specie**s button and enter the value manually (Figure 14).

- **Root-to-shoot ratio:** The FSC tool uses an IPCC Clean Development Mechanism equation from the *Afforestation and Reforestation of Lands except Wetlands* [6] and a default value as an intermediate calculation for standing volume. The equation and default value are calculated automatically within the tool and do not need to be selected from the IPCC default values.

- **Carbon fraction**: This is a mandatory value for estimating carbon stocks in trees, including belowground biomass. A general IPCC default value (0.47) independent of the species is widely accepted and used in most compliance (Clean Development Mechanism) and voluntary (e.g. Verified Carbon Standard) project calculations and national GHG inventories.

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[6] UNFCCC (2016) *Afforestation and Reforestation of Lands except Wetlands* version 2.0. AR-ACM0003. United Nations Framework Convention on Climate Change. (Also available at https://cdm.unfccc.int/methodologies/DB/C9QS5G3CS8FW04MYYXDFOQDPXWM4OE, accessed 28 July 2016.)

Figure 14: Using the IPCC default values table

Deleting data

Data should be deleted from the table *only* by using the button **Delete selected** to the right on the navigation bar; see section 3.6.

2.4 Strata

In this tool, the most important classification system is strata, which represent different subpopulations of the FMU. The tool analyses the particular carbon stocks and carbon stock changes of these subpopulations. Generally, each line entered into the tool represents one unique stratum, which the user needs to define via the Species tab by inputting the most representative default values (wood density, biomass expansion factor, root-to-shoot ratio, etc.). The tool applies these to assess stratum-specific carbon stocks/stock changes. Forest stands (a commonly used term and management unit in many FMUs) may be grouped into homogenous strata in terms of species, growth conditions, and carbon stocks; or each stand could be considered a single stratum.

Under this tab, define these homogenous forest strata by assigning a name and inputting the total area of each stratum, in hectares. In addition, very simple climatic information is required from dropdown lists if you choose to include carbon assessment of dead wood and litter.

Figure 15: Defining strata

Stratum	Area within FMU (ha)	Elevation	Precipitation
Dense forest	1119,797852	< 2000m	> 1600 mm/yr
Open forest	1649,062735	< 2000m	> 1600 mm/yr
Shrubland	34,98773051	< 2000m	> 1600 mm/yr
Juvenile forest	212,9149069	< 2000m	> 1600 mm/yr
Non-forest	468,797671	< 2000m	> 1600 mm/yr

Data required

- **Stratum**: Manually enter your chosen stratum name and the results will be shown based on this nomenclature.
- **Area within FMU**: Enter the total area of this particular forest stratum, in hectares.
- **Elevation** and **Precipitation**: These fields are required only if assessment of carbon in dead wood and litter pools has been selected (by answering **Yes** under Scope of assessment). Select the most suitable geographic and biophysical characteristics from the dropdown list. Based on this, a default calculation for dead wood and litter is derived and included in the results, based on IPCC guidance.

Deleting data

Data should be deleted from the table *only* by using the button **Delete selected**; see section 1.6.

2.5   GHG emissions

This tab is not mandatory for monitoring carbon stocks and changes. It provides default IPCC-based quantification approaches to accounting of GHG emissions due to forest operations, harvesting, and management. Use this worksheet to analyse GHG emissions occurring in the project area as a result of fossil fuel burning and application of fertilizers, following IPCC guidance.

For GHG emissions due to combustion of fossil fuels, the total annual consumption of diesel and gasoline for the entire assessment area is entered. The GHG emissions from synthetic and organic fertilizer use in forest management are calculated based on defined strata and fertilizer application rates per hectare, averaged over the stratum-specific rotation period. In addition, the percentage nitrogen content is required. It is not possible to compare different management scenarios or different years.

Figure 16: GHG emissions from forest management

Annual fossil fuel consumption

Fossil fuel types	Total annual consumption (liters)
Diesel	
Gasoline	

Application of fertilizers

Do you apply fertilizers in forest management?	Yes

Please complete the green tables below for each type of fertilizer and application rates per stratum

Stratum	Name of the fertilizer	Organic or Inorganic	Nitrogen content in percent	Total application rate of fertilizer per stratum per h	Units - select
Shrubland	A	Organic	0,1	15	pounds
Open forest	B	Organic	0,1058	20	kg
Dense forest	C	Inorganic	0,05	20	pounds

Data required

- **Annual fossil fuel consumption**: Enter the annual fuel consumption in litres, separately for diesel and gasoline, for the entire FMU/project assessment area.

Figure 17: Annual fossil fuel consumption – data entry fields

Fossil fuel type	Total annual consumption (litres)
Diesel	3000
Gasoline	4000

•
•

Application of fertilizers: For each previously defined stratum where fertilizers are applied, first insert the name of the fertilizer. Then confirm the use of organic/inorganic fertilizer; the average percentage nitrogen content; and the fertilizer application rate per hectare averaged over the stratum-specific rotation period.

Figure 18: Fertilizer application data entry fields

Stratum	Name of the fertilizer	Organic or Inorganic	Nitrogen content in percent	Total application rate of fertilizer per stratum per h	Units - select
Plantation forest	A	Organic	0.1	5	kg

Deleting data

Data should be deleted from the table *only* by using the button **Delete selected**; see section 1.6.

2.6   Wood products

This tab is not mandatory for monitoring carbon stocks and changes. It provides a simplified approach to accounting for the carbon sequestered and stored in wood products derived from the forest. The methodological approach is based on that of the IPCC.[7]

Data required

If you decided to assess carbon stored in wood products (by answering **Yes** under Scope of assessment), you need to define the species-specific wood product classes (from the dropdown list) and the annual timber extraction rates (in m^3) for these categories, based on the tree species/species group previously defined under Species.

Note that harvested timber is always related to losses starting during harvesting, transport, and processing, thus only wood products and respective volumes that take these losses into account should be entered.

---

[7] IPCC (2006) Harvested Wood Products. In: Eggleston, H.S., Buendia, L., Miwa, K., Ngara, T., and Tanabe, K. (eds) *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use*. Prepared by the National Greenhouse Gas Inventories Programme. Institute for Global Environmental Strategies, Japan. (Also available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP.pdf, accessed 6 January 2017.)

Figure 19: Wood product data entry fields

Species	Wood product classification	Volume of timber extracted annually (m^3)
Mixed Oak	Wood-based panels	20

Deleting data

Data should be deleted from the table *only* by using the button **Delete selected**; see section 1.6.

3. Monitoring Tool

The following tabs are mandatory for both the Monitoring Tool and the Simulation Tool:

General Information:	Scope of assessment
	Background data
	Species
	Strata
Monitoring Tool:	Inventory data

Once the **General Information** is complete, limited quantitative information on the forest resources within the strata is required, normally generated from forest inventories. This information can be entered for one specific year (e.g. the current year) to monitor current forest carbon stocks; or for two years to assess changes of carbon stocks between these years.

3.1   Inventory data

Some limited inventory parameters are entered under this tab. You may enter up to two different years of inventory data for each stratum, but they should correspond to the two years entered in General Information (if you enter a year that does not correspond, it will be highlighted in blue).

The Strata and Species you have previously entered will be available via dropdown lists.

The tool allows the use of more than one defined tree species. You may also split one stratum (same stratum name) into different rows if there are different dominant tree species data for which you have defined species-specific parameters.

Data required

Two types of quantitative data entry can be distinguished in this sheet, depending on the Scope of assessment.

- If you only want to **monitor** carbon stocks or carbon stock changes, you should enter standing volumes (in m^3/ha) for the different years of inventory.
- If you also want to **simulate** carbon stock information based on age, then age classes representative for the year of inventory are required.

Figure 20: Inventory data entry

Data entry fields *if you do not want* to simulate future scenarios:

Required for monitoring carbon stocks/ stock changes				Required for the simulation
Year	Stratum	Species	Standing Volume (m³/ha)	Age at year of inventory
2014	Private forest	Andira retusa	55.0	10
2015	Industrial Forest	Andira parviflora	75.0	15
2016	Plantation forest	Aniba amazonica		

Data entry fields *if you want* to simulate future scenarios:

Required for monitoring carbon stocks/ stock changes				Required for the simulation
Year	Stratum	Species	Standing Volume (m³/ha)	Age at year of inventory
2014	Private forest	Andira retusa	55.0	10
2015	Industrial Forest	Andira parviflora	75.0	15
2016	Plantation forest	Aniba amazonica		

Deleting data

Data should be deleted from the table *only* by using the button **Delete selected**; see section 1.6.

3.2 Monitoring results

Based on Inventory data inputs, the tool performs the carbon stock and carbon stock change monitoring calculations and the results are shown in this summary sheet. **Note that this sheet remains unprotected, and care should be taken not to delete or change any formulae.**

Whenever data are entered or changed, you need to click the light green **Refresh Results** button. The results are organized into two main parts.

3.2.1 Carbon stocks

This part shows the results for one particular year (please select the year based on the results you wish to see); results are shown for all carbon pools, including wood products and GHG emissions as a result of forest management.

Figure 21: Project summary and Refresh Results button

Whenever data is entered or changed, the 'Refresh results' button needs to be clicked. [Refresh Results]

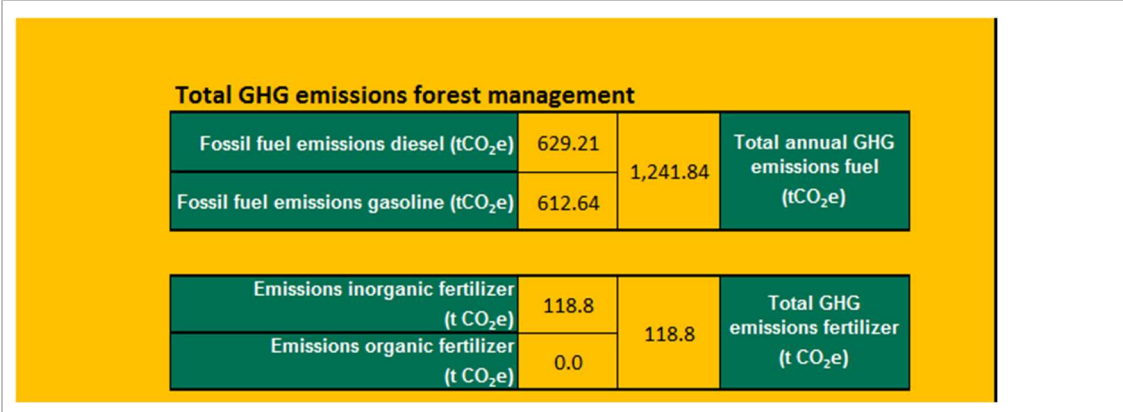Brazil FMU Project located in Brazil; size 500 ha; Tropical conditions

Figure 22: Results – carbon stocks and project emissions for one (current) year (1)

Data required

- **Year**: Select the year for which you want to show results.
- **Total area of the project** and **Total area inventory tab**: These compare the initial total area of the project/FMU (previously entered under **General Information**: Background data) with the sum of areas defined for each stratum (in hectares). This is to cross-check aerial information.
- **Total carbon balance**: This value represents the total balance of tCO_2e within the FMU or project at a current year minus any project GHG emissions such as fossil fuel burning or emissions from fertilizer use. GHG emissions from the Loss Method are not included.
- **Loss Method selective logging in tropical forests**: If annual extraction rates for the entire project area have been entered as part of the simple loss method of GHG emissions as a result of selective logging in tropical forests (see the right-hand area under Scope of assessment), the total annual emissions are shown here.
- **Carbon stock results**: **Forest carbon stock density** and **Total forest carbon stocks FMU** show the weighted average carbon stocks per hectare for the entire assessment area, and the total sum of all carbon pools, respectively.
- **Carbon pools**: This section includes average carbon densities per hectare for all carbon pools in the assessment area (trees, shrubs, dead wood, and litter, in tCO_2/ha), including harvested wood products (shown in total CO_2e per year), depending on the selection previously made under Scope of assessment.
- **Total GHG emissions forest management**: Project/FMU GHG emission totals are shown separately for each GHG source (diesel, gasoline, inorganic and organic fertilizer, in tCO_2e).

Figure 23: Results – carbon stocks and project emissions for one (current) year (2)

Total GHG emissions forest management			
Fossil fuel emissions diesel (tCO₂e)	629.21	1,241.84	Total annual GHG emissions fuel (tCO₂e)
Fossil fuel emissions gasoline (tCO₂e)	612.64		
Emissions inorganic fertilizer (t CO₂e)	118.8	118.8	Total GHG emissions fertilizer (t CO₂e)
Emissions organic fertilizer (t CO₂e)	0.0		

3.2.2 Carbon stock changes

Scroll down to this second section, which refers to the change in the forest carbon pools between two years (select the two years). The first table (Figure 24) displays the total carbon stock changes; the second interactive pivot table (Figure 25) allows you to compare the results for the different strata entered.

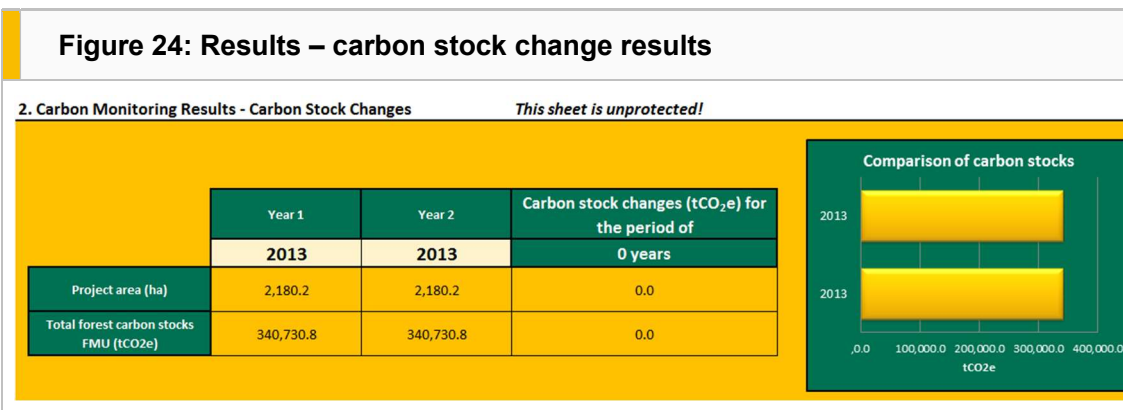**Figure 24: Results – carbon stock change results**

2. Carbon Monitoring Results - Carbon Stock Changes   *This sheet is unprotected!*

	Year 1	Year 2	Carbon stock changes (tCO₂e) for the period of
	2013	**2013**	**0 years**
Project area (ha)	2,180.2	2,180.2	0.0
Total forest carbon stocks FMU (tCO2e)	340,730.8	340,730.8	0.0

Comparison of carbon stocks

2013

2013

,0.0   100,000.0 200,000.0 300,000.0 400,000.0
tCO2e

Figure 25: Results – details of carbon stock per stratum

Year	2015					
Stratum	Carbon stocks density of trees (tCO₂e/ha)	Carbon stocks density of shrubs (tCO₂e/ha)	Carbon stocks density of dead wood (tCO₂e/ha)	Carbon stocks density of litter (tCO₂e/ha)	Area per stratum (ha)	Total carbon stocks (tCO₂e)
Plantation forest						
Private forest						
Industrial Forest	373.0	25.9	3.7	3.7	100.0	40627.1
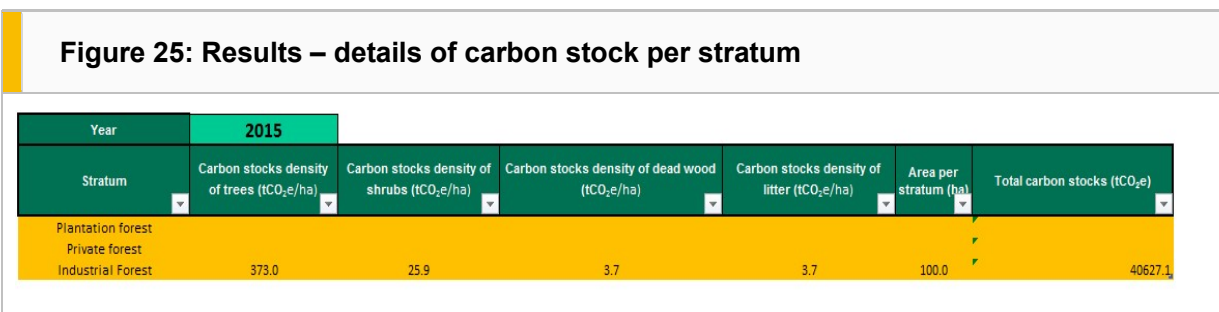
4. Simulation Tool

The following tabs are mandatory for both the **Monitoring Tool** and the **Simulation Tool**:

General Information:	Scope of assessment
	Background data
	Species
	Strata
Monitoring Tool:	Inventory data

4.1 Models

The modelling and simulation worksheets are relevant if you want to carry out a simulation of future carbon stock flows. To simulate the future growth of the forest and the respective carbon stocks over time, the model uses stratum-specific standing volume growth models. You can either input your own volume models sourced from yield tables, scientific models, etc.; or if local information is missing, you can develop a very simple new growth model by entering minimal information on the development of a certain forest stratum. Preferably a model should be defined for each stratum.

Please note that if you divided the inventory data into separate species in one stratum, you need to do the same for the models, that is, create a model for each stratum and species/species group.

Enter the number of models

You need to define how many growth models will be used for the simulation by entering the number into the worksheet. You may create as many models as you wish – preferably as many as the strata defined under Scope of assessment.

1. Enter the desired number of models in the light green box (top right of the table)
2. Click the yellow button **Click to enter rows**
3. Select the predefined stratum and tree species/group from the dropdown lists for each model
4. Enter the length of the rotation period in years
5. Click the yellow button **Click to add to "All models"**.

Figure 26: Stratum-specific definition of models (1)

Define annual volume growth models

The next step is to define annual, one hectare-based volume growth for each of these models for the entire rotation period.

[If you have your own stratum growth model, then go directly to the Models tab, the first tab in the sequence. Once you have selected the number of growth models you would like to simulate, go to the All models tab and enter in specific standing volume (m³/ha) data. If you have no growth model, or only volume

data over longer time intervals (e.g. every 5 or 10 years), go to the Growth Model tab to develop a simple annual volume growth function.]

Figure 27: Stratum-specific definition of models (2)

Note that the first row of the table in Figure 27 cannot be deleted. To delete any model below number 1, select a cell and click on the **Delete selected model** button. In order to delete the content of the first row, either change the data in that row, or go directly to Growth model.

4.2   Growth model

If you do not have your own growth models for the strata selected for simulation, this step will assist you in developing a simple growth model for the simulation.

Please note that this sheet is unprotected; care should be taken not to accidentally change or delete important growth functions.

You may also use this worksheet by integrating differences in forest management and compare these with an existing growth model for the same forest. The construction of annual models is hectare-based and requires only a minimal set of growth information that should be as realistic as possible. There are three main steps, revealed by scrolling horizontally within the worksheet:

1. **Enter forest information**
2. **Examine growth models using the graphs**
3. **Select the most realistic growth model and copy–paste the annual volume data from this model into the next worksheet.**

To aid navigation between these three steps, the buttons illustrated above are repeated several times within the worksheet. Clicking each of buttons 1–3 centres the user over the relevant step.

Step 1: Enter forest information

Here you should enter a minimum of three to four age-dependent, stratum-specific growth information parameters (Figure 28). The first row should always be age 1 with the respective growth information. At a minimum, you need to input:

*   Number of trees per ha

- Height (m)
- Mean diameter at breast height (cm).

If no Basal area or Standing volume data are available, using the green cells directly above the table, select **Yes** to calculate them from the dropdown list. For standing volumes you also need to enter a Form factor in order to reduce cylindrical volumes (the default value is 0.5). All values should be per hectare. If stands to be modelled are older than that in the first row, additional rows with the related three to four information parameters need to be entered accordingly. **The final row must always be for the final year of a rotation**. As you enter these data, the annual models for all parameters entered will appear in the **Growth model** table for the entire rotation period.

Figure 28: Step 1: Enter forest information

For each model to be developed, enter a minimum of three age-dependent growth values in the table below. The first row should always be age 1; the last entry should be the final year of rotation. Minimum data requirements are: **Number of trees per ha**, **Height** and **Mean diameter**. If no **Basal area** or **Standing volume** data are available, select **Yes** on the right to calculate the values. For **Standing volumes**, you need to enter a tree form factor; the default tree form factor value to use is 0.5.

Calculate basal area	Yes
Calculate standing volume	Yes

Age	Number of trees per ha	Height (m)	Mean diameter at breast height (DBH) (cm)	Basal area (m²/ha)	Standing volume (m³/ha)	Form factor
1.0	300	5.0	20.0	9.4	23.6	0.5
5.0	290	5.0	22.0	11.0	27.6	0.5
8.0	295	7.5	21.0	10.2	38.4	0.5
10.0	250	9.2	12.4	3.0	13.9	0.5
15.0	300	10.0	12.5	3.7	18.4	0.5

Step 2: Examine growth models using the graphs

Based on the information entered in Step 1, two different growth models over the entire rotation are constructed. The models are derived from two polynomial functions. (**The functions are below cell A75 of the tool – it is important to not change this part of the worksheet**).

The **Growth models derived** table (columns J–W) is divided into three parts (Figure 29). The first part (dark green) shows the actual values you entered in step 1 ('#N/A' indicates missing actual values). The second (light green) and third (grey) parts show the two different growth models derived from the polynomial functions for the parameters height, diameter at breast height, basal area, and volume. The volume columns, highlighted in yellow, are required for the simulation.

Figure 29: Growth models based on polynomial functions

Growth models derived, to be used in 'All Models'

Select either volume growth model 1 or 2 and copy - paste them into the tab 'all models'

		Actual values				Model 1				Model 2			
Age	Trees per ha	Actual height data (m)	Actual diameter data (cm)	Actual basal area data (m³/ha)	Actual volume data (m³/ha)	Height model 1 (n=2) (m)	Diameter model 1 (n=2) (cm)	Basal area model 1 (n=2) (m²/ha)	Volume model 1 (n=2) (m³/ha)	Height model 2 (n=3) (m)	Diameter model 2 (n=3) (cm)	Basal area model 2 (n=3) (m²/ha)	Volume model 2 (n=3) (m³/ha)
1	100	2.0	3.0	0.1	0.1	1.7	2.1	0.1	0.1	2.0	3.0	0.1	0.2
2	100	#N/A	#N/A	#N/A	#N/A	2.7	3.2	0.0	#N/A	2.3	2.2	#N/A	#N/A
3	100	#N/A	#N/A	#N/A	#N/A	3.6	4.3	0.3	0.6	2.8	2.1	#N/A	#N/A
4	100	#N/A	#N/A	#N/A	#N/A	4.5	5.4	0.5	1.7	3.6	2.8	#N/A	#N/A
5	150	4.4	3.9	0.2	0.4	5.3	6.3	0.8	2.8	4.5	3.9	0.0	0.4
6	150	#N/A	#N/A	#N/A	#N/A	6.1	7.3	1.0	4.0	5.4	5.5	0.5	1.5
7	150	#N/A	#N/A	#N/A	#N/A	6.8	8.1	1.3	5.3	6.4	7.2	1.0	4.0
8	200	7.5	9.1	1.3	4.9	7.4	9.0	1.6	6.7	7.4	9.1	1.6	6.9
9	200	#N/A	#N/A	#N/A	#N/A	8.0	9.7	1.9	8.2	8.4	10.9	2.2	9.8
10	250	9.2	12.4	3.0	13.9	8.5	10.4	2.2	9.8	9.2	12.5	2.8	12.6
11	250	#N/A	#N/A	#N/A	#N/A	9.0	11.1	2.5	11.6	9.9	13.7	3.3	15.2
12	250	#N/A	#N/A	#N/A	#N/A	9.4	11.7	2.9	13.4	10.4	14.5	3.7	17.3
13	250	#N/A	#N/A	#N/A	#N/A	9.7	12.2	3.2	15.3	10.6	14.6	3.9	18.6
14	250	#N/A	#N/A	#N/A	#N/A	10.0	12.7	3.5	17.3	10.5	14.0	3.9	19.1
15	300	10.0	12.5	3.7	18.4	10.2	13.2	3.9	19.4	10.0	12.5	3.7	18.5

Presented with these two growth models, you need to decide which is closest to the reality of each forest stratum. As a decision support tool, the models are shown in an interactive graph to the right of the model table (columns Z–AJ). You can change the graph displayed by selecting different parameter growth models (height, diameter, basal area, and standing volume) from the dropdown list (Figure 30). The timespan and starting year can also be changed to assess the growth curves in more detail (Figure 31). Ultimately, you should come to a conclusion as to whether model 1 or model 2 is more realistic in terms of volume growth.

Figure 30: Growth model interactive chart – dropdown list

Select model type: Standing volume model (m³/ha) ▼
- Height model (m)
- Diameter model (cm)
- Basal area model (m³/ha)
- Standing volume model (m³/ha)

Select timespan

Select starting year: 1

Figure 31: Graphs of the two growth model curves

Step 3: Select the most realistic growth model and copy–paste

Once you have identified the most realistic volume growth model, you need to copy the respective values of the entire rotation from the model table (one of the two yellow columns) and paste them into the All models worksheet, in the **Standing volume** column for each stratum modelled (see section 6.3).

Please ensure you use Excel's 'Paste as values' function to copy and paste the models. As a minimum, the **Standing volume** growth model is required in this version of the tool.

4.3   All models

Here you need to paste either your own stratum-specific, hectare-based volume growth models, or the **Standing volume** values chosen from the Growth model tab. All stratum-specific models defined previously under the Models tab appear in a single composite table with the values Model number, Stratum, Species, Age, and Standing volume for the year of rotation. In order to enter/paste volume values separately for each model number in a cohesive way, it is possible to apply a filter to select only the model you would like to enter (Figure 32).

Figure 32: Structure of the All models tab

If all model numbers are not shown within the table, please go back to the Models tab and ensure that the yellow button **Click to add to "All models"** has been clicked.

Under the All models tab, for each model selected the corresponding information will appear in the columns. Once the stratum model has been selected, **you must click to show all models in order to run the simulation model**. Once you have clicked the button **Click to show "All models"**, it will disappear from the screen as the filter has been deleted. After selecting a different stratum model, the button for deleting the filter will reappear on the screen. Removing this filter in order to represent all the individual stratum models within the table will also allow all models to be run at the same time.

4.4 Simulation assumptions

After defining the volume growth models for the forest strata to be simulated, the simulation can begin.

Under the Simulation assumptions tab, define the simulation period and the carbon calculation time intervals. Set the starting year of the simulation (**Inventory year**) from the dropdown list of year(s) for which you entered inventory information earlier. Then select the **Simulation period**, and finally define the carbon assessment intervals (Figure 33). This tool allows the simulation of carbon flows annually, and every 5 and 10 years. If information is changed within the individual cells (i.e. simulation period) during the setup, click on the **Refresh** button in order to actualize the input data, which will be reflected in the results

Figure 33: Simulation assumptions data entry

Setting up your simulation

Inventory year for simulation 2016

Simulation period 50 years

Calculate carbon every 10 years

Last year of balance 2066

Refresh

Define the simulation for the strata selected under **Models**. Set the **Inventory year**, the **Simulation period** and the output years for the simulation. The first simulated year will be the first after the inventory.

There may be a time delay as Excel carries out this calculation.

4.5 Inventory simulation

The simulation results under this tab will be displayed according to each stratum specified under the All models tab using the initial stratum-specific inventory information from the Inventory data tab in the Monitoring Tool (Figure 34). This table can be copied into any other analysis tool.

**Figure 34: Inventory simulation results table**

| Year	Year of start	Stratum	Stratum area (ha)	Species	Maximum rotation period	Age at beginning of simulation	Age class	Standing Volume according to growth model (m³/ha)
5	2013	Dense forest	524.9	Eucalyptus	30	20	25	318.6
5	2013	Open forest	559.1	Eucalyptus		30	35	
5	2013	Shrubland	447.5	Eucalyptus		10	15	
5	2013	Juvenile fore	257.3	Eucalyptus		15	20	
5	2013	Non-forest	391.4	Eucalyptus		30	35	
10	2013	Dense forest	524.9	Eucalyptus	30	20	30	446.6
10	2013	Open forest	559.1	Eucalyptus		30	40	
10	2013	Shrubland	447.5	Eucalyptus		10	20	
10	2013	Juvenile fore	257.3	Eucalyptus		15	25	
10	2013	Non-forest	391.4	Eucalyptus		30	40	
15	2013	Dense forest	524.9	Eucalyptus	30	20	5	47.5
15	2013	Open forest	559.1	Eucalyptus		30	45	
15	2013	Shrubland	447.5	Eucalyptus		10	25	
15	2013	Juvenile fore	257.3	Eucalyptus		15	30	
15	2013	Non-forest	391.4	Eucalyptus		30	45	
20	2013	Dense forest	524.9	Eucalyptus	30	20	10	99.5
20	2013	Open forest	559.1	Eucalyptus		30	50	
20	2013	Shrubland	447.5	Eucalyptus		10	30	
20	2013	Juvenile fore	257.3	Eucalyptus		15	35	

4.6 Simulation results

Finally, the simulation results are aggregated and presented under this tab. First, click on **Refresh results tables** to update the simulation. **This sheet is unprotected.** Note that there will be a delay after clicking on the button while Excel performs the simulation and updates all results.

Figure 35: Click to refresh the results tables
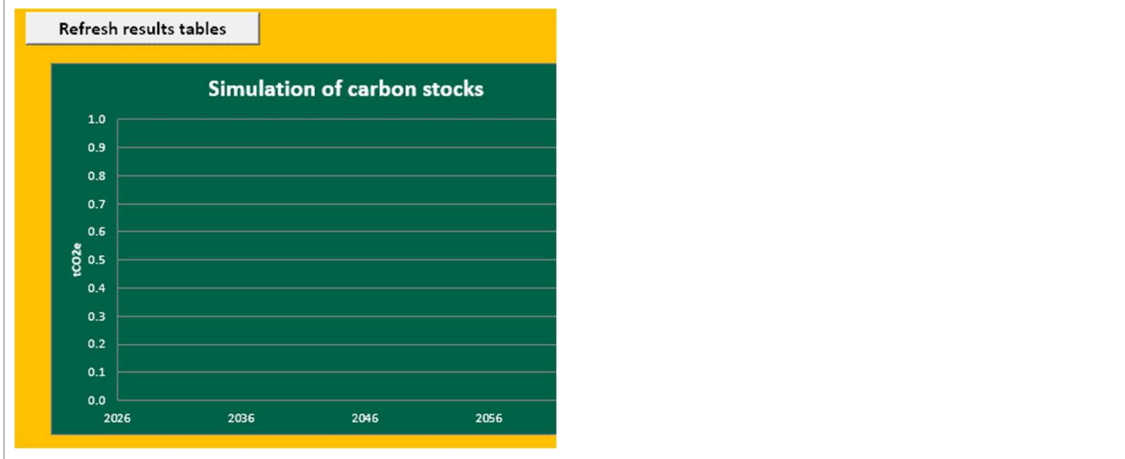
The first table shows the total carbon stocks of all selected strata combined. At the end of the table, the total carbon stocks at the end of the simulation period are shown. You can specify the interval within that period for which the results are displayed. These intermediate years must be multiples of the carbon assessment intervals specified under the Simulation assumptions tab. For example, if the intervals are set to simulate carbon every five years, the intermediate years could be selected as shown in Figure 36.

Figure 36: Results simulation
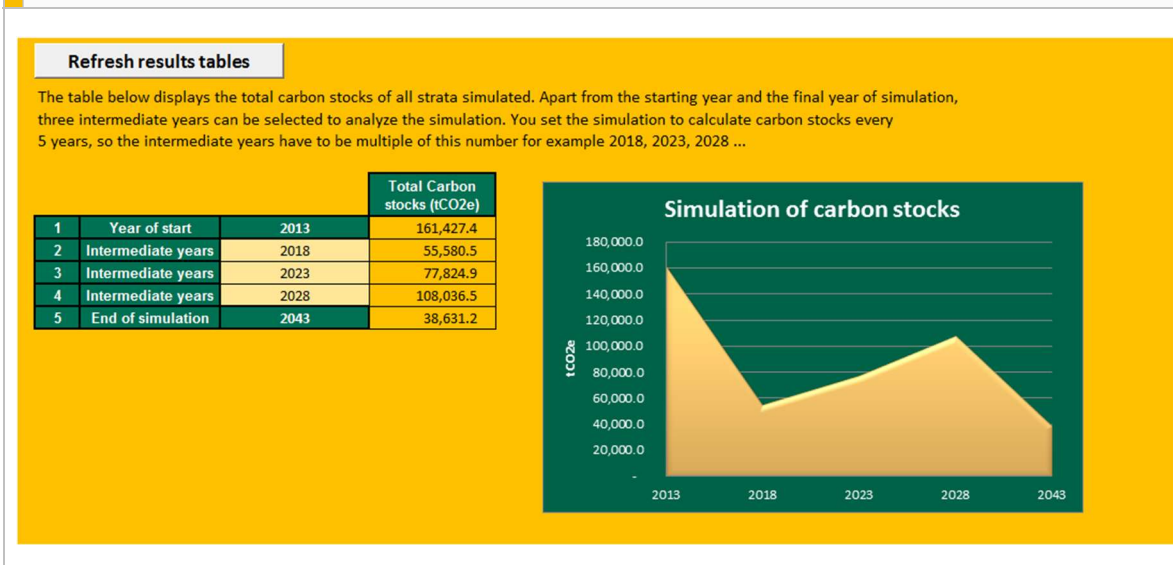
Finally, Figure 37 shows the simulation of average carbon stock density, in tCO_2e per hectare, for all strata selected for the entire simulation period. The different carbon pools are also shown in this table.

Figure 37: Results simulation – average carbon stock densities

Year	Year of simulation	Average carbon stock density of trees (tCO$_2$/ha)	Average carbon stock density of shrubs (tCO$_2$/ha)	Average carbon stock density of dead wood (tCO$_2$/ha)	Average carbon stock density of litter (tCO$_2$/ha)	Average forest carbon stock density (tCO$_2$e/ha)	Total Carbon stocks (tCO$_2$e)
10	2026	68.9	25.9	1.4	2.8	98.9	29659.5
20	2036	0.0	64.6	0.0	0.0	64.6	19387.5
30	2046	0.0	64.6	0.0	0.0	64.6	19387.5
40	2056	0.0	64.6	0.0	0.0	64.6	19387.5
50	2066	0.0	64.6	0.0	0.0	64.6	19387.5

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