StandsSIM.md Simulator Handbook

Forest Models course

2017-2018

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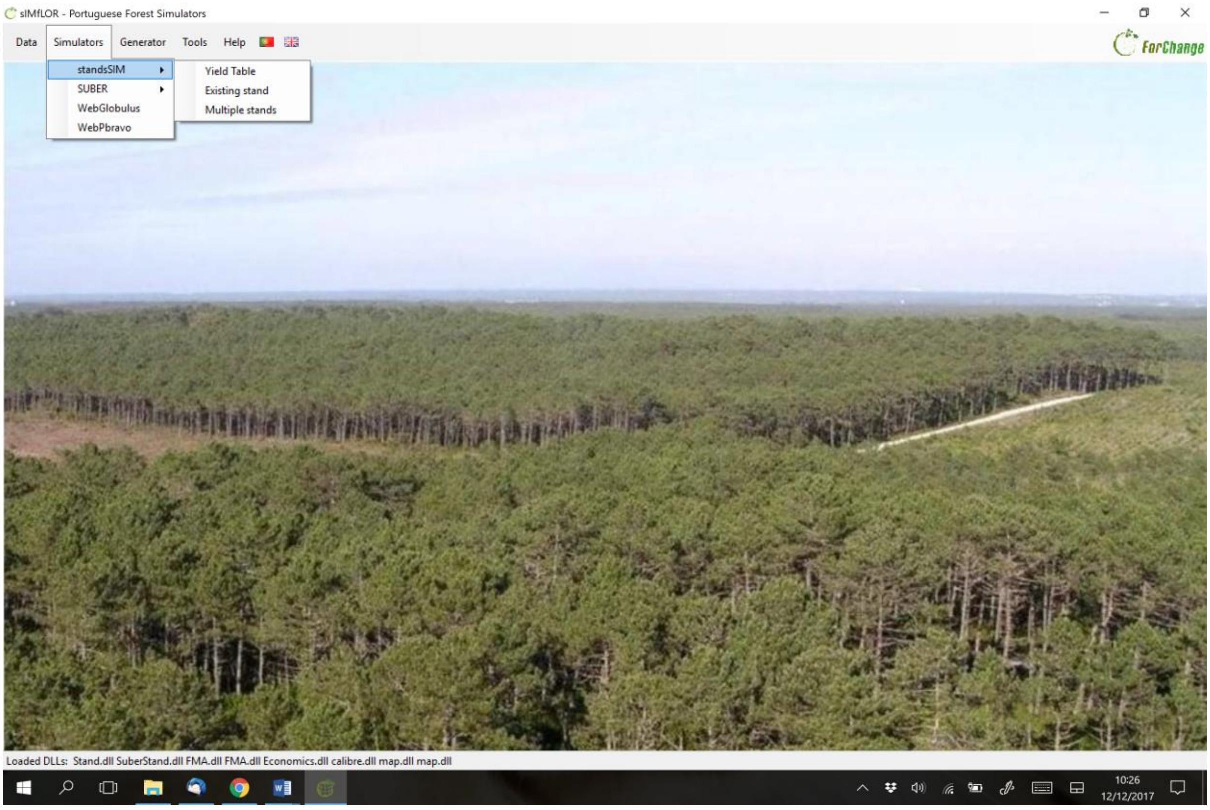

Work-in-progress

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StandsSIM.md handbook organization

The objective of StandsSIM.md handbook is to present a description of the version of the **StandsSIM.md** currently integrated in the **sIMfLOR** platform illustrating its potential for simulating and assessing forest management alternatives.

The handbook is organized in 5 chapters. The first chapter provides a brief description of the **sIMfLOR** simulators platform, after which a brief description of models and simulators is provided. The third chapter describes **StandsSIM.md** structure and functioning and it is followed by a chapter where the inputs needed to run the simulations are described making a link between the csv input files and the information provided through the interface. The last chapter presents a compilation of solved hands-on-examples with print screens to illustrate the process for simulations runs for Yield Tables, Existing Stands and Multiple stands including a section where the consistency between different inputs is addressed. Finally, two appendices containing the list of variables and in the input and output files their descriptions are presented.

sIMfLOR download and installation instructions

sIMflor is freely available on the FCTools website. The user must register to have access to the download. The sIMfLOR_2017 zipped folder should be saved and unzipped in a location other than the *desktop* or the *downloads* folder. Make sure you don't leave blank spaces in the name of the folder where you save sIMfLOR_2017. Please note that sometimes the applications graphs.exe and Graphs_DD.exe (within STANDsSIM folder) have to be unzipped in a next step. The latest JAVA version is advisable; otherwise, the graphs functionality will not be available.

The software has no specific requirements, but the user must set the regional settings to English and make sure the *decimal symbol* is set to "." (not ",") and the *list separator* is set to "," (not to ";"). In case the tool still does not run, it might be possible that you opened one of the input csv files in excel and saved it. Open all the inputs that you visited using Notepad to make sure you don't have any ";". If you do, within Word go to: Home \ Editing \ Replace \ Find What: ";" \ Replace with "," \ Replace All.

Acknowledgements

The development of **sIMfLOR**, the simulators and partly the growth and yield models has been developed under the scope of several national and European research projects:

EFORWOOD: Tools for Sustainability Impact Assessment of the Forestry-Wood Chain (FP6-2004-518128-2);

MOTIVE: Models for Adaptive Forest Management (FP7-ENV-2008-1-226544);

AFORE: Forest biorefineries: Added-value from chemicals and polymers by new integrated separation, fractionation and upgrading Technologies (CP-IP 228589-2);

SIMWOOD: Sustainable Innovative Mobilisation of Wood – Regional forest governance dialogues fostering conscious forest ownership and sustainable wood mobilisation in Europe (EU FP7-KBBE-2013.1.2-07);

StarTree: Multipurpose trees and non-wood forest products: a challenge and opportunity (FP7-ENV-2012-311919);

Agforward: AGroFORestry that Will Advance Rural Development (FP7-KBBE-2013-7-613520).

SADRI: Models and Decision Support Systems for Addressing Risk and Uncertainty in Forest Planning (SADRI) - PTDC/AGR-FOR/4526/2012 - funded by the Portuguese Science Foundation (FCT);

ForEAdapt: Knowledge exchange between Europe and America on forest growth models and optimization for adaptive forestry. Funded by the 7th European Community Framework Programme (project under grant agreement PIRSES-GA-2010-269257).

1 Introduction to sIMfLOR

ForChange team is one of the 4 research groups at the Forest Research Centre (CEF) one of the 3 research centres at School of Agriculture (ISA). CEF was created in 1976 and was initially oriented towards the research of the eucalypt ecosystem. Presently, it embraces wider research topics covering multifunctionality of ecosystems, sustainable management under climatic, social and economic changes, with a full resource use in a bioeconomy context.

ForChange group focuses on the management of Southern European Atlantic and Mediterranean forests, encompassing a variety of ecosystems ranging from intensive forest plantations for timber production to coastal dunes stabilization forests, and agroforestry systems. Because of ForChange's collaboration in several national and international research projects, the group dedicates to forest inventory and monitoring activities gathering valuable data on the impact of silviculture on ecosystems. The development of growth and yield models is one of the core research topics of the group that has been involved in the development of a wide range of forest growth and yield models. However, models are as valuable as the number of practitioners that can use them in decision-making processes. For this reason, this research team has dedicated to the integration of forest growth models into computer programs, commonly called forest simulators, and to the development of a user-friendly interface - sIMfLOR.

1.1 sIMfLOR platform structure

sIMfLOR platform, a simulators platform, was created to harmonize the interfaces of the different growth models and simulators developed within ForChange. This interface was created to assist users in the preparation of the input files required to run the simulators. The platform aims to encourage users from different research fields, forest managers and forest owners to make use of the forest simulators in an easy way.

Different stand and regional level simulators, including **StandsSIM** and **SUBER**, have been integrated in a common environment where the user can find other tools developed, such as the "Generator" that helps creating the management related inputs for the simulators (**Figure 1**).

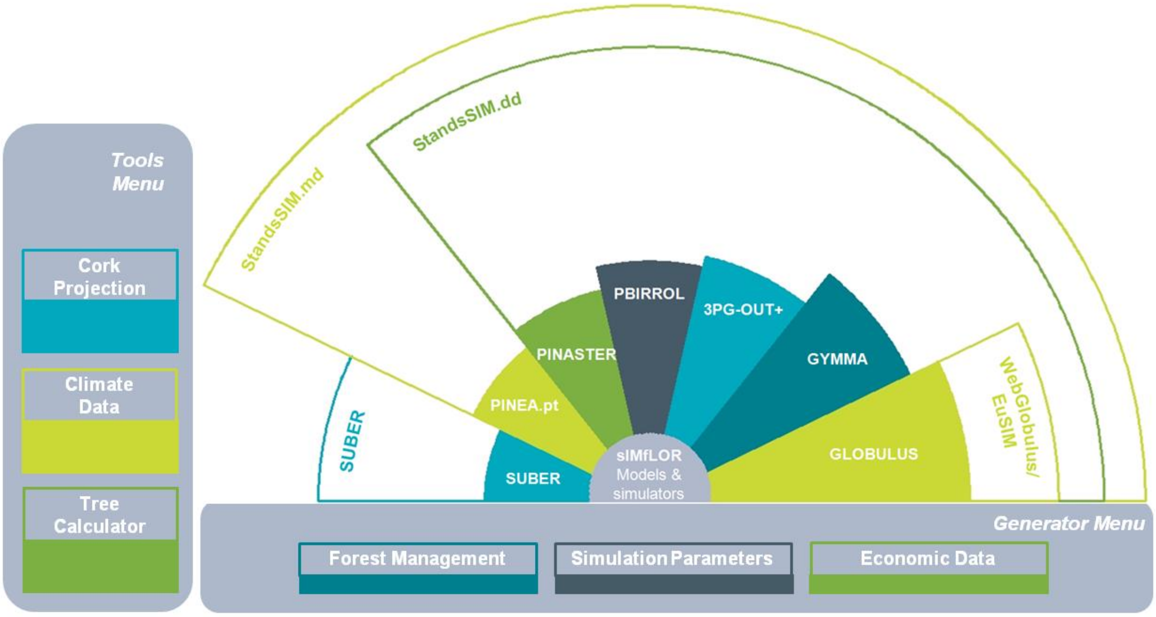


Figure 1. Simplified overview of the sIMfLOR structure.

Forchange Tools website, ***FCTools*** *(http://www.isa.ulisboa.pt/cef/forchange/fctools/en)* was created to facilitate the access of all users to the existing tools allowing the free download of its latest versions (registration on FCTools required prior to download). In this website the user will find the descriptions of the growth models and simulators developed for the main tree species in Portugal as well as supporting bibliography.

2 Brief description of forest models and simulators

A forest model can be defined as a dynamic quantitative representation of the forest based on a set of (sub-)models or modules that together predict the dynamics of the forest. For practical, applications, forest models should be implemented in computer programs with user-friendly interfaces – usually designated as forest simulators. A forest simulator is a computer tool that is based on a set of forest models and makes long-term predictions of the status of the forests under different scenarios of climate, forest policy and/or forest management. Forest simulators usually predict, for each point in time, wood and non-wood products from the forest.

The core of any forest simulator is the growth module responsible for updating the values of state variables. This module comprises the suite of fitted growth functions/sub-models, in the case of empirical models, or algorithms representing processes, in the case of process-based models. The value of each state variable in the following instant in time is dynamically predicted based on the present characteristics of the stand and environment. The calculation module contains fitted functions/sub-models and other components that permit the estimation of other tree and stand variables. This module is static which means that all variables refer to the same instant in time. For simplicity reasons, sub-models will be referred to as models. Silvicultural practices influence stand development and long-term site properties. Besides management, simulations are usually driven by additional external drivers such as disturbances, demand, or landuse changes, all of which are usually implemented in individual modules (**Figure 2**).

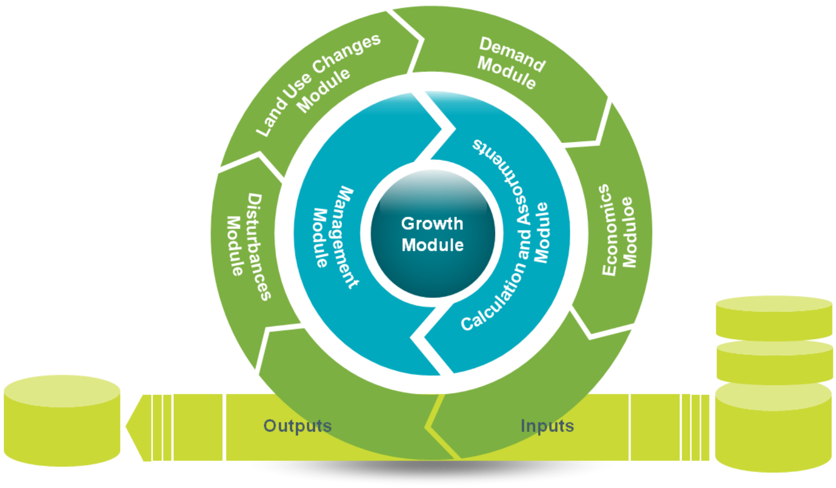


Figure 2. Simplified overview of a simulator.

3 StandsSIM.md simulator

StandsSIM simulator has a management driven version **StandsSIM.md** and a demand driven version **StandsSIM.dd**. Because the demand driven version is meant for regional applications requiring national level inputs it has not been made available in sIMfLOR and all the descriptions within the handbook will refer to the management driven version.

StandsSIM.md is a management driven simulator developed to assist sustainable management of forest landscapes for different stakeholders allowing comparing the evolution of forest dynamics for alternative management approaches. **StandsSIM.md** is a wide-range simulator that allows the user to simulate the growth of a new stand (yield table), an existing stand or multiple stands by filling in the information required in the corresponding forms in **sIMfLOR'**s platform (see chapter 3). Being driven by management, the simulator relies on two core concepts:

a) The FMA describes the set of silvicultural operations that the user desires to carry out from stand regeneration until final harvest (**Figure 3**). Therefore, FMAs must be defined up to the maximum harvest age considered (even-aged stands) or up to the rotation time (uneven-aged stands). For each FMA, even- or uneven-aged, several management options, characterized by different sets of silvicultural operations, and how they are distributed over time, can be considered.

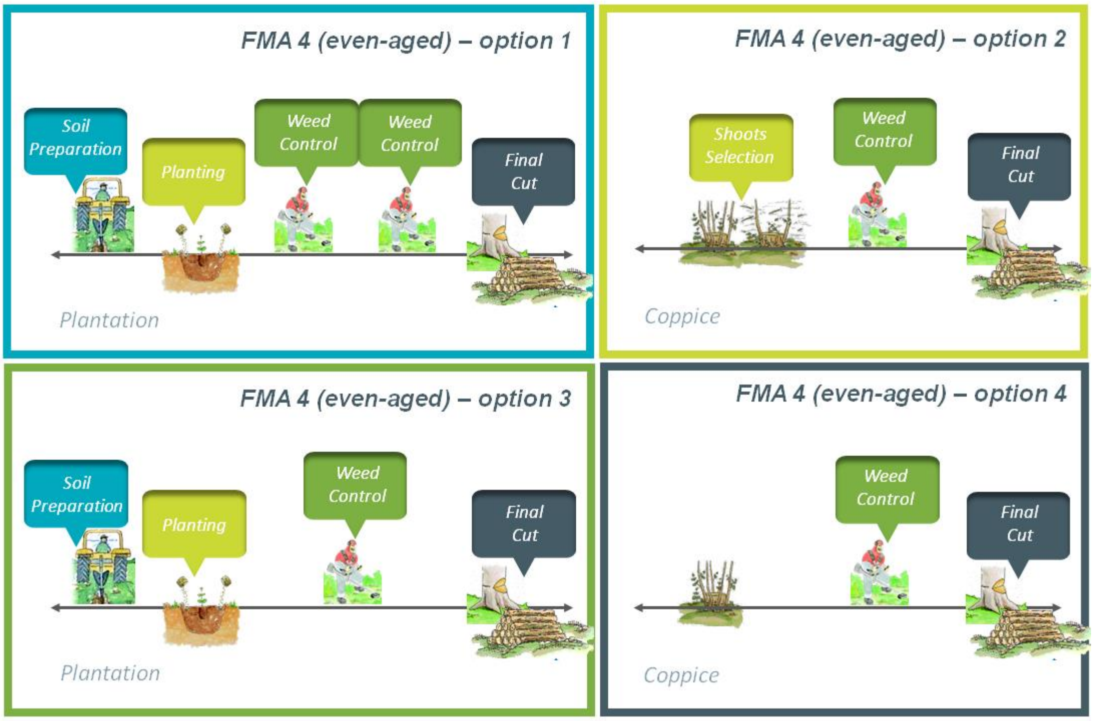


Figure 3. Illustration of different alternative ways to manage even-aged stands.

b) The management prescription corresponds to a sequence of FMAs to be applied to a stand over a given planning horizon (**Figure 4**). The set of cycles, from stand regeneration until final harvest, can be made up of

- different FMAs/options (Prescriptions A and B)
- the same FMA repeatedly (Prescription C).
- a single FMA (Prescription D)

In the process of building the prescriptions, you have to guarantee that each prescription is defined in a way that will permit covering the whole period considered by the planning horizon. For this reason, it is preferable to have prescriptions defined with a number of cycles that exceed the planning horizon and not the other way around (prescription B)

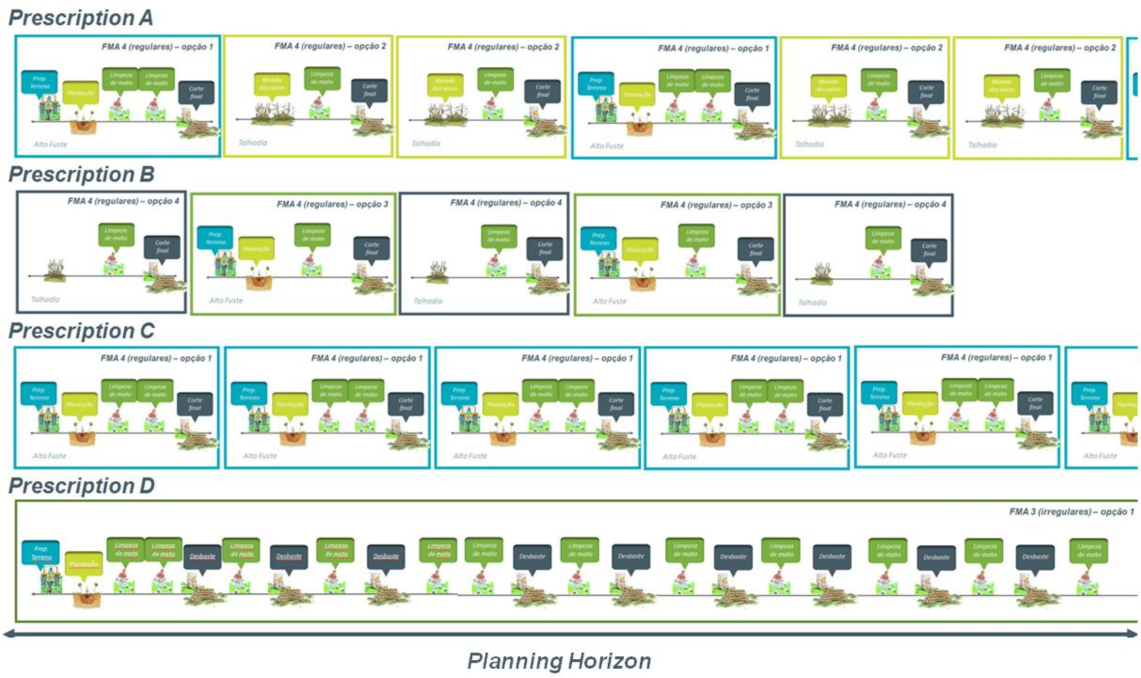


Figure 4. Illustration of different prescriptions.

The simulator allows predicting the evolution of forest stands under different management alternatives producing a wide range of environmental and economic indicators. **StandsSIM.md** integrates a set of growth models organized in modules responsible for initializing new stands or simulating thinning:

a) <u>Stands initialization module</u>: simulates the diameter distribution of trees when the stands reaches a dominant height of 5 m. The distribution is based on data from trials monitored by ForChange group.

b) Thinning module: consideres several types of thinning: from below or according to user defined probabilities depending on tree size and based on different criteria such as the Wilson factor, the residual basal area or the percent thinned basal area.

Additional inputs have to be provided to characterize forest resources in the starting point of simulation, the cost of silviculture operations, the assortments to be consider for each species and climate. The simulator runs on an.

StandsSIM.md starts with forest inventory information at plot/stand level to characterize the forest resources in a region. Once forest resources are characterized for the first year of simulation, it uses the growth and yield models to predict the development of forest resources in the region taking into account the influence of external variables – commonly called drivers – such as forest management (**Figure 5**). The simulator runs for as many years as defined by the user (the planning horizon) with an annual time-step.

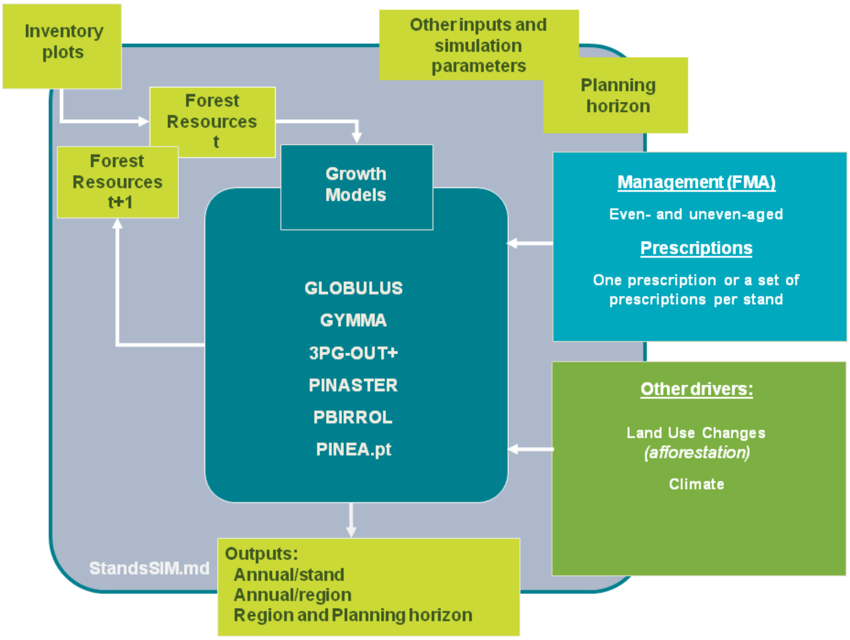


Figure 5. StandsSIM.md structure.

The simulator integrates different forest growth and yield models for the main tree species in Portugal: Eucalypt (*Eucalyptus globulus)*, maritime pine (*Pinus pinaster) and stone pine (Pinus pinea).* Growth and Yield projections are either based on single-tree or stand level growth models depending on the tree species and /or stand structure (**Table 1**). When you define the species and the stand structure for **StandsSIM.md** to select the proper model to be used in the simulation. At present, the simulator only considers the simulation of pure (even and uneven-aged) stands.

Table 1 - . Summary of the Growth and Yield models available for the main tree species in Portugal.

Tree Species	Stand Structure	Model Name	Model Type	Model Input level	Model Time-step
Eucalyptus globulus	Even-aged	Globulus3.0	Empirical	Stand	Year
		3PG-out+	Process-based (hybrid)	Stand	Month
	Uneven-aged	GYMMA	Empirical	Stand	Year
Pinus pinaster	Even-aged	PINASTER	Empirical	Tree	Year
	Uneven-aged	PBirrol	Empirical	Stand	Year
Pinus pinea	Even-aged	PINEA.pt	Empirical	Tree	Year

For additional details on the growth and yield models visit FCTools website where all the bibliography is listed.

4 StandsSIM.md within sIMfLOR- sIMfLOR_2017 folder structure

If you don't have any default input files, the first step, is generating the forest management approaches (FMAs) inputs and the Economic inputs. But before that let us take a look at the structure of the downloaded sIMfLOR_2017 folder (**Figure 6**).

Name	Date modified	Type
CALIBRE	12/07/2017 10:38	File folder
en	12/07/2017 10:38	File folder
EXAMPLES	12/07/2017 10:38	File folder
files	12/07/2017 10:38	File folder
GENERATOR	12/07/2017 10:38	File folder
INPUTS	25/06/2017 23:45	File folder
pt	12/07/2017 10:38	File folder
STANDSSIM	12/07/2017 10:38	File folder
SUBER	12/07/2017 10:38	File folder
Calibre.dll	07/11/2016 11:39	Application extension
Economics.dll	11/07/2017 00:14	Application extension
…		
README	06/06/2017 16:42	Text Document
simflor	10/07/2017 22:46	Application Manifest
simflor	10/07/2017 22:46	Application
simflor.exe.config	27/10/2009 22:46	CONFIG File
simflor.exe.manifest	10/07/2017 22:46	MANIFEST File
simflor.pdb	10/07/2017 22:46	PDB File
…		

Figure 6. sIMfLOR_2017 folder structure.

The most important sub-folder is the EXAMPLES containing default input files, some of them specific for each tree species, (**Figure 7**). The species name is identified by a two-letters code, where Ec stands for Eucalyptus, Pb for maritime pine and Pm for stone pine. Inside the folders "FMA", "inventario" and "prescricao" the user will find species-specific csv files for the FMA, the plot/stand characterization and the prescription, respectively. The names of the files in the FMA sub-folder begin with *FMA_31*.csv* and *FMA_41*.csv*, where the number 3 stands for uneven-aged stand structure, whereas 4 for even-aged stand structure. In turn, the following number indicates the different options of FMA3 or FMA4 that have been defined (e.g.

FMA_42.csv* corresponds to the second forest management option for even-aged stands that was generated by the interface).

- EXAMPLES
  - Ec
    - FMA
      - FMA_31_Ec_*.csv
      - FMA_41_Ec_*.csv
    - Inventario
      - inv_Ec_R_7234.csv
      - inv_Ec_several.csv
      - inv_Ec_I_8031.csv
      - inv_Ec_J_7234.csv
    - prescricao
      - prescription_Ec_R_7234.csv
      - prescription_Ec_several.csv
      - prescription_Ec_yieldtable.csv
      - prescription_Ec_I_8031.csv
    - Assortment_ec.csv
  - Pb
    - FMA
      - FMA31_Pb_Fw_IRReg.csv
      - FMA31_Pb_Gres_IRReg.csv
      - FMA41_Pb_SelfThin_REGular.csv
      - FMA41_Pb_025_Reg.csv
      - FMA41_Pb_025_REGular.csv
      - FMA41_Pb_G25_REGular.csv
      - FMA41_Pb_SelfThin_Reg.csv
    - Inventario
      - inv_Pb_several.csv / inv_Pb_several_arv.csv
      - inv_Pb_SSB101.csv / inv_Pb_SSB101_arv.csv
      - inv_Pb_J_6888.csv / inv_Pb_J_6888_arv.csv
      - inv_Pb_R_7595.csv / inv_Pb_R_7595_arv.csv
    - prescricao
      - presc_Pb_yt.csv
      - presc_Pb.csv
      - presc_Pb_Existente.csv
      - presc_Pb_several.csv
    - Assortment_pb.csv
  - Pm
    - FMA
      - FMA4_Pm_15_REGular.csv
    - Inventario
      - inv_Pm_arv_n136.csv / inv_Pm_n136.csv
      - inv_Pm_new.csv / inv_Pm_new_arv.csv
      - inv_Pm_reg.csv / inv_Pm_reg_arv.csv
    - prescricao
      - prescr_Pm.csv
      - prescr_Pm_yt.csv
      - presc_1_Pm_reg.csv
    - Assortment_Pm.csv
  - AvgClimate.csv
  - Consumables.csv
  - Operations.csv

Figure 7. Structure of the folders within the EXAMPLES folder of sIMfLOR_2017

The files generated using the interface are be saved in STANDSSIM folder, inside the corresponding tree species folder or in the OUTPUT folder (**Figure 8**), *file names marked in green*). Inside each of the species folders you will find the complete set of input files required to run StandsSIM.md simulator for each of the species (*the ones in grey were not created using the interface*).

STANDSSIM	3PG		*inicia_StandSimulator CSV* *weather CSV* *weather_average CSV* *weather_average_P CSV* *AvgClimate CSV*
	GLOBULUS	input_stand CSV input_clima CSV input_prescr.CSV	*FMA41_Ec_Regular.CSV* *ini_standsSIM.CSV* *Operations.CSV* *prescription_Ec_yieldtable.CSV* *Assortments_Ec.CSV* *AvgClimate.CSV* *Consumables.CSV*
	OUTPUT	output_YieldTable.CSV output_annual.CSV output_dd.CSV output_NPV.CSV output_TotalAnnual.CSV	
	PINASTER	input_stand CSV input_clima CSV input_prescr.CSV input_stand CSV	*FMA41_Pb_025_Reg.CSV* *ini_standsSIM.CSV* *input_tree.CSV* *assortments_Pb.CSV* *AvgClimate.CSV* *Existente_inv_arv_Pb_n10.CSV*
	PINEA	input_stand CSV input_clima CSV input_prescr.CSV input_stand.CSV	*ini_standsSIM.CSV* *Pm_FMA4_15_Reg.CSV* *assortments_Pm.CSV* *AvgClimate.CSV* *Existente_inv_arv_Pm_n136.CSV*
	Graphs Graphs_DD ini_standsSIM.CSV ini_standsSIM_Ec.CSV ini_standsSIM_JR.CSV standsimulator		

Figure 8. Structure of the sub-folders within the STANDSSIM folder of sIMfLOR_2017.

4.1 StandsSIM.md input files created with the Generator

In general terms, one can say that **StandsSIM.md** requires 3 different types of inputs: the forest inventory inputs (stand and/or tree level), the forest management inputs (describing the

FMA and prescription) and the economic inputs (setting the prices for the silvicultural operations in the FMA, consumables, definition of assortments and its prices).

All inputs can be prepared in excel files and converted to csv files. However, to facilitate the use of **StandsSIM.md**, sIMfLOR was created and interfaces developed to facilitate the preparation of inputs. The input files related to silvicultural operations, their costs and the definition of assortments and their prices can be prepared in the Generator. The inputs characterizing trees and stands and the site (e.g. climate, topography), can be created by filling in the required information in the forms. The number and type of files that can be generated through **sIMfLOR** depend on what you want to simulate: a new plantation (Yield Table), an Existing Stand or Multiple Stands (**Figure 9**). The latest option will require most of the inputs to be prepared outside **sIMfLOR**. Please note that when creating a yield table for a tree species simulated using a tree level growth model, the *input_tree.csv* file is generated containing a single tree with all its variables set to zero.

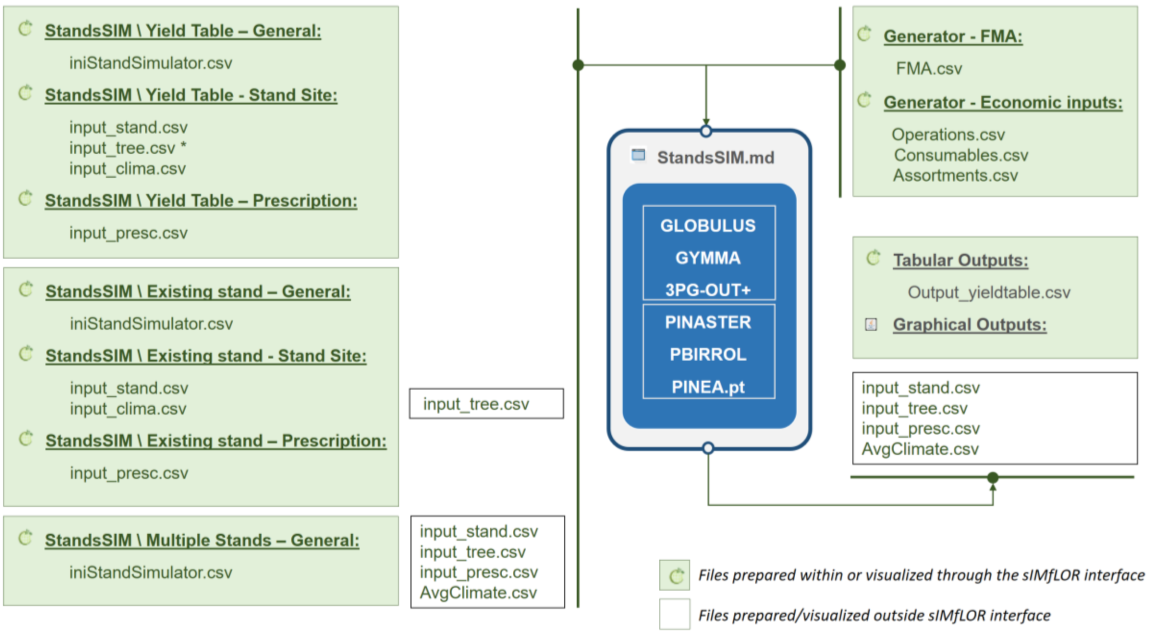


Figure 9. StandsSIM.md input and output files and their relation with sIMfLOR interface

It is important to know how the information provided through the interface is saved in the different input files. In **Appendix 1**, you can find the list of all the variables contained in each input file and the corresponding description.

4.1.1 Forest Management Data

A forest management alternative (FMA) is characterized by a set of user-defined silvicultural operations selected out of a vast list (CAOF 2016) grouped according to the mechanization level (e.g. manual, mixed, mechanical and infrastructures).

When an FMA file other than the default is desired, a new one can be created using the Generator. In this menu you will be asked to select the tree species for which you want to describe the forest management (FMA) - let us take eucalypt as an example (**Figure 10**). You will be asked to provide details about the silvicultural model you desire to follow (even-aged, uneven-aged or even-aged for energy). You will also have to define the type of regeneration and in the case of eucalypt if you want to consider coppice management you must choose “coppice”. Under “planting” the tool will assume the stands will never reach the second rotation. Before you select the silvicultural operations, you have to define the number of years for which you want to define management. This number can coincide with the period from stand regeneration until harvest or exceed. The number of years for which management is defined is the same for the planted and coppiced rotations.

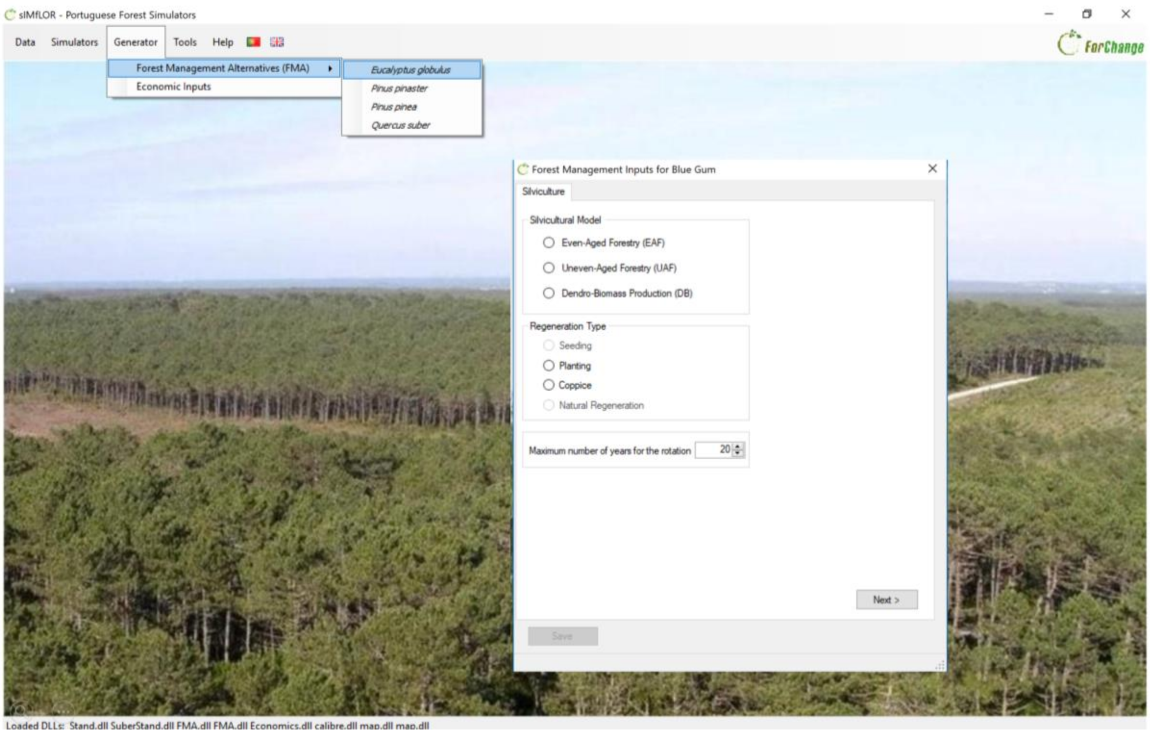


Figure 10. Print screen of the form Silviculture under the Generator\FMA\Eucalyptus globulus

In the “Operations” tab, the definition of the FMA involves selecting the operations from the list. After selected, operations will show on the table below and you will have to define when and how often these will take place (**Figure 11**). In the case of coppice, you should not forget to select the operations for the coppice rotation before moving to the next tab. Please note that all coppices will be managed in the same way under the same FMA.

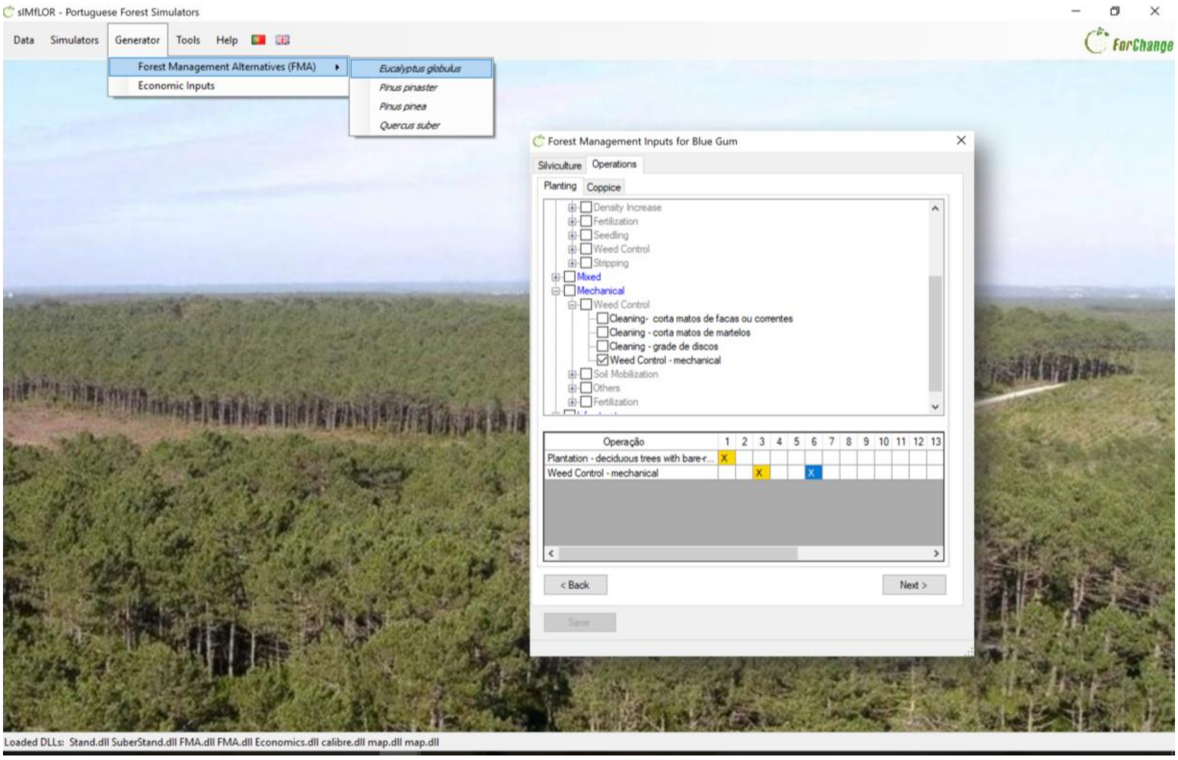


Figure 11. PrintScreen of the form Operations under the Generator\FMA\Eucalyptus globulus

As you move to the next tab, you might be asked to provide additional information for some of the operations you selected (e.g. planting requires information on the number of trees to plant; shoots selection requires information on how many shoots to leave per stool) (**Figure 11**).

After the details have been provided and saved you can take a look at the FMA file structure by opening it using the link in blue in the bottom of the window. The FMA file generated through the interface consists of matrix of 68 silvicultural operations (columns) over time (rows) with some additional information for some specific operations (the silvicultural details). The operations selected to take place are marked with 1 whereas the ones which haven't been selected will show the value zero. Thus, the X_{ij} matrix of 0/1 values, where i is the silvicultural operation whereas j represents the simulation year. For example, X(13,3)=1, means that the operation 13 is carried out at year/age 1. The top rows of the FMA file describe: 1) the silvicultural model (4 - even-aged or 3 - uneven-aged); 2) the regeneration type (planting or coppice); and 3) the number of years for which you want to define management (**Figure 12**).

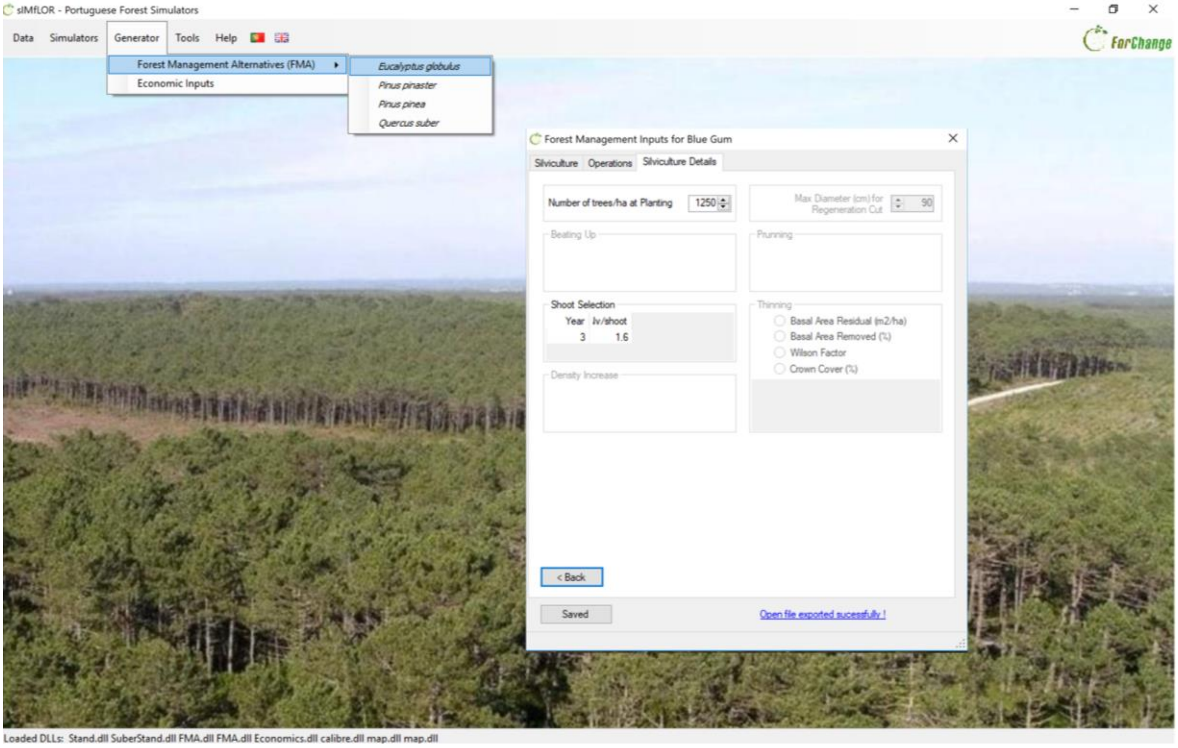


Figure 11. PrintScreen of the form Silviculture Details under the Generator\FMA\Eucalyptus globulus

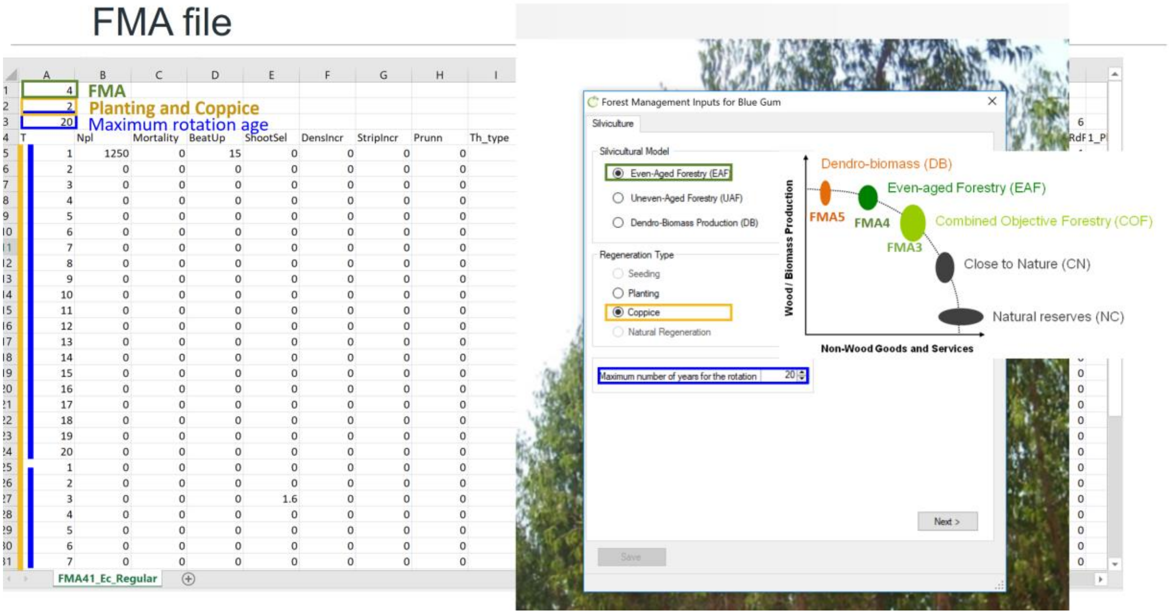
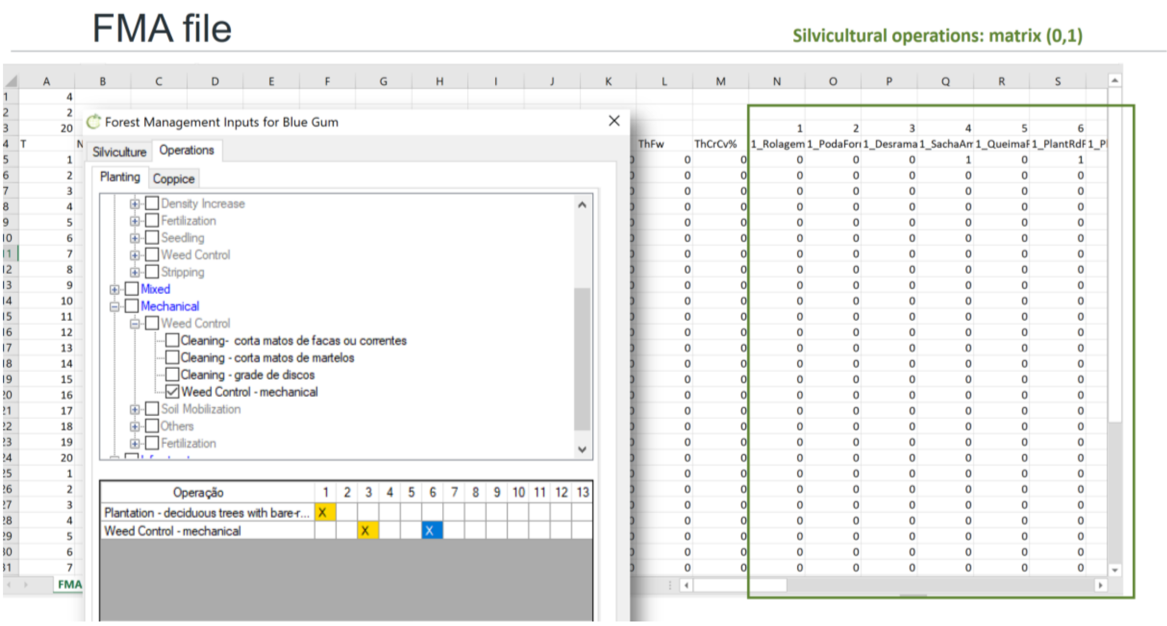


Figure 12. Side by side comparison of the transcription of the information provided in the Silviculture form and the content of the FMA file.

In the FMA file you will find a numeric identifier from 1 up to 68 is assigned to each silvicultural operation that allows you to locate the 0/1 Matrix within the file (**Figure 13** , marked in green), while the details show in the initial columns (Figure xxxx.1 , marked in yellow). The FMA file is saved in the EXAMPLES folder (see Table 2 for the structure of the folder).



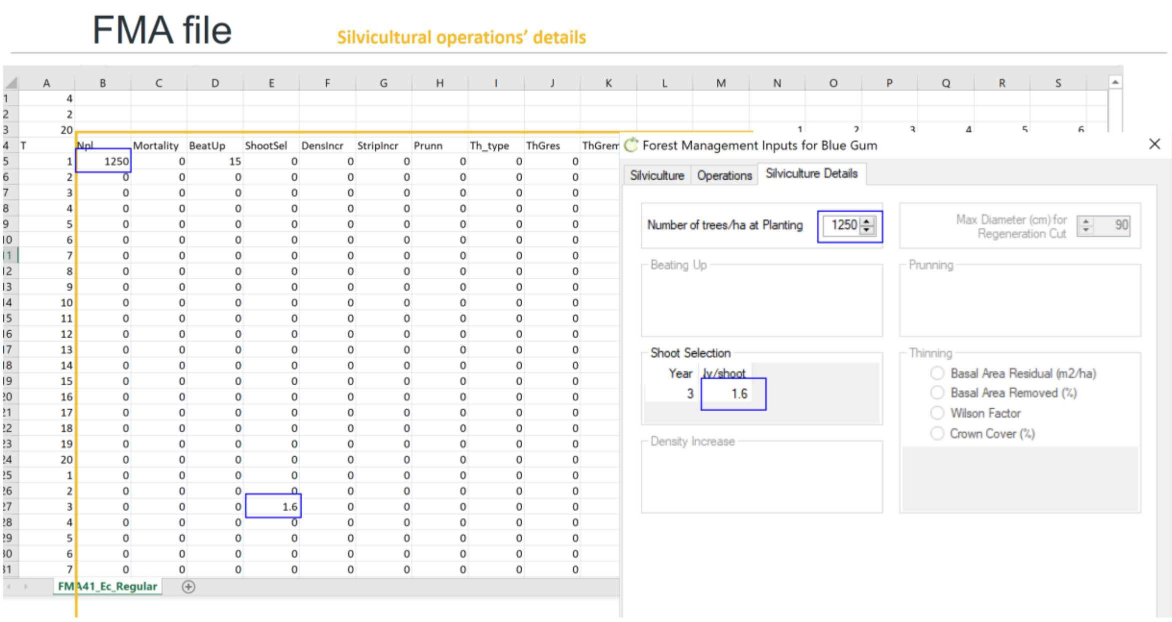


Figure 13. Side by side comparison of the transcription of the information provided in the forms for Operations and Silviculture Details and the content of the FMA file.

4.1.2 Economic Data

The costs for the operations listed under the FMA tab have been made available since 2002 and are updated every 2 years (CAOF 2016). The economic data comprises the costs for the 68 silvicultural operations (Operations Values tab), the costs for the products used in management such as plants or fertilizers (Other Values tab), the price of woody (Wood Products tab) and non-wood products (Non-wood Products tab).

In the Opreations Values tab, after uploading the default costs file, the labour costs for the 68 silvicultural operations are displayed by operation type: Manual, Mixed, Mechanical and Infrastructures (**Figure 14**). Costs vary with the working conditions (e.g.: steepness, stoniness of the terrain and presence of shrubs) with the minimum costs linked to easy working conditions. You can edit the average cost and save the changes. In this tab, you will also have to define the discount rate that will be used in the calculus of the net present value.

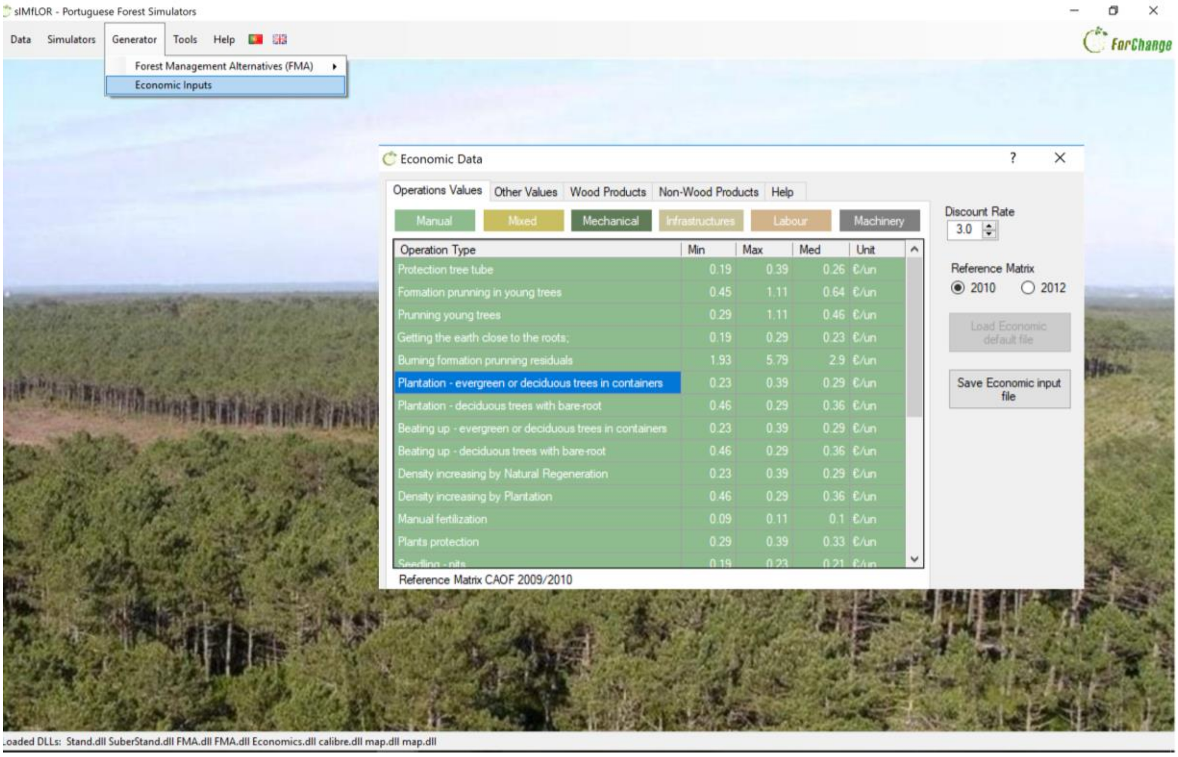


Figure 14. Print screen of the form Operations Values under the Generator\Economic Inputs.

If you open the file (INPUTS folder) you will find the 68 operations listed by row and the costs distributed by 4 different columns depending on the unit of the cost (e.g €/tree, €/km, €/m^3 and €/ha) (Figure xxxx.3 - in olive green). On the top row, you have the discount rate, followed by the number of additional discount rates and the additional discount rates you would like to have use for computing the EEA (Figure xxx).

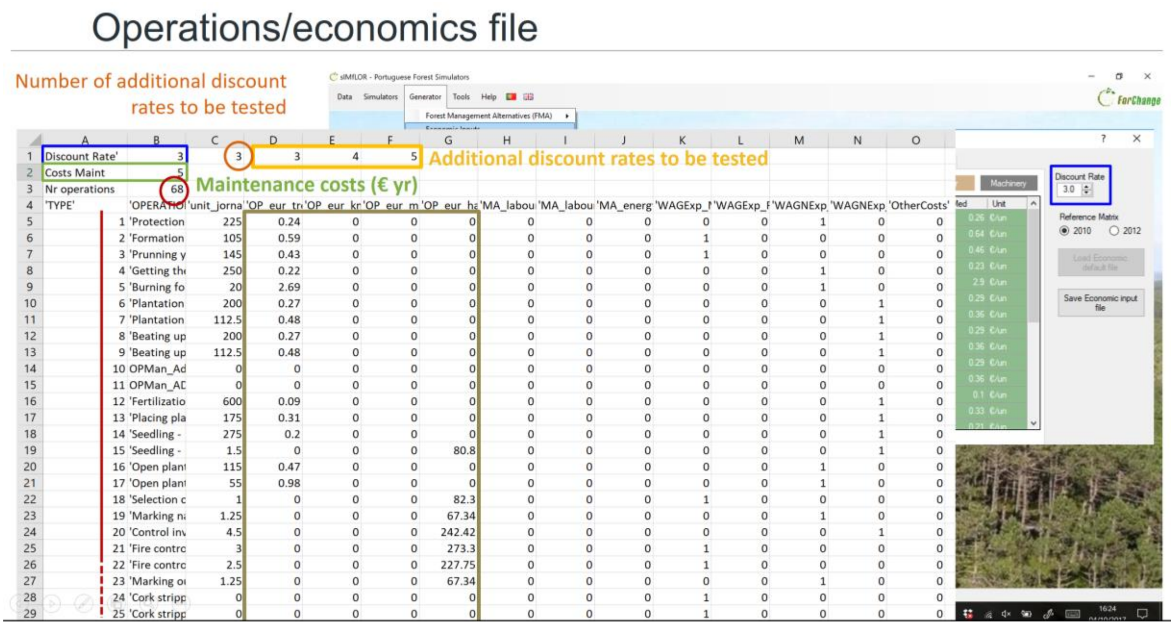


Figure 15. Side by side comparison of the transcription of the information provided in the form for Operations Values and the content of the Operations file.

In the Other values tab you will find the prices of some products used in some of the operations (e.g. the labour cost for planting can be found under the Operations Values tab, while the price for plants is here). These values can also be edited and saved (**Figure 16**).

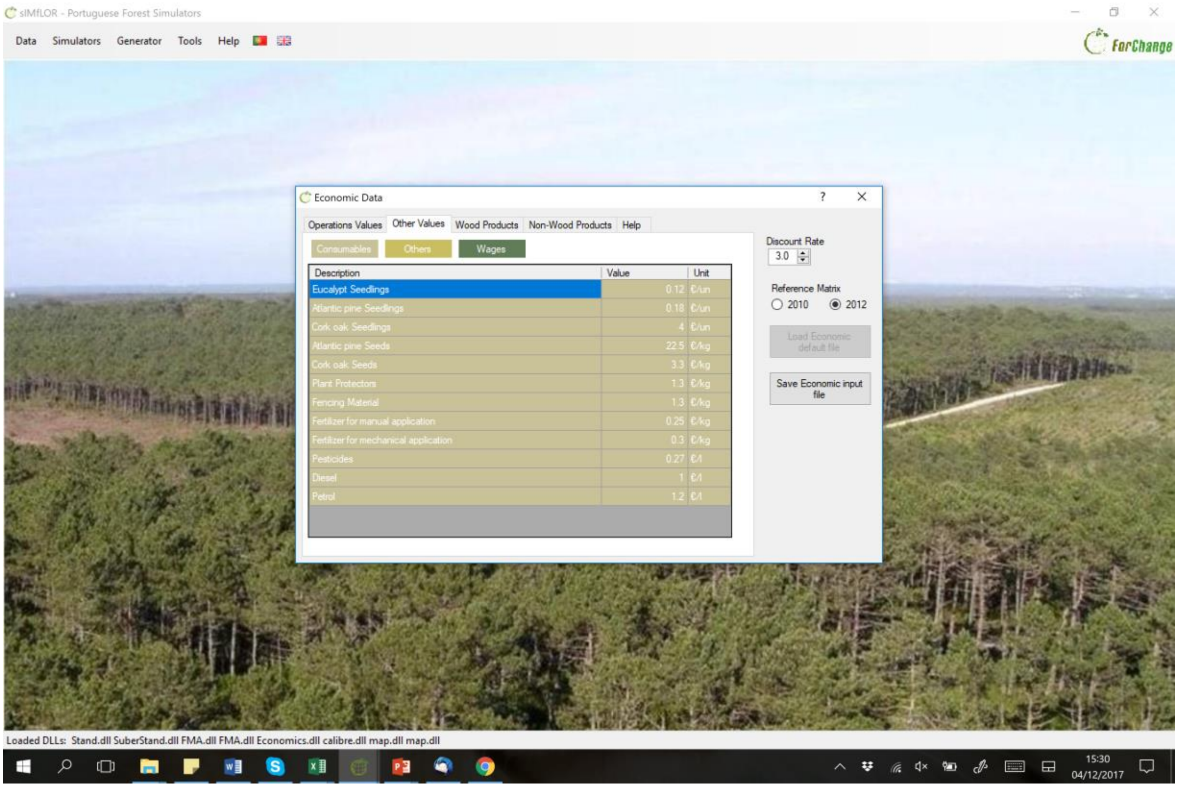


Figure 16. Print screen of the form Other Values under the Generator\Economic Inputs.

4.1.3 Assortments

Under the Wood Products tab, after selecting the tree species, the number of assortments has to be set and characterized by defining the log threshold diameters (cm), the log length (m), whether you want to consider assortments with (1) or without bark (0), and finally the value of each assortment (€/m^3). In the case of eucalypt, because the wood is used for pulp there is only the need to define the top diameter. You can name the assortments and decide whether you want to run the simulation considering the removal of harvest residues by ticking the corresponding boxes (**Figure 17**, marked in blue). So far, the Non-wood Products tab is only active for cork oak. After filling in the information required under the economic data tab you must click the button "save economic data", and 3 inputs files are generated (*operations.csv*, *consumables.csv* and *assortments.csv*) and saved in the folder INPUTS.

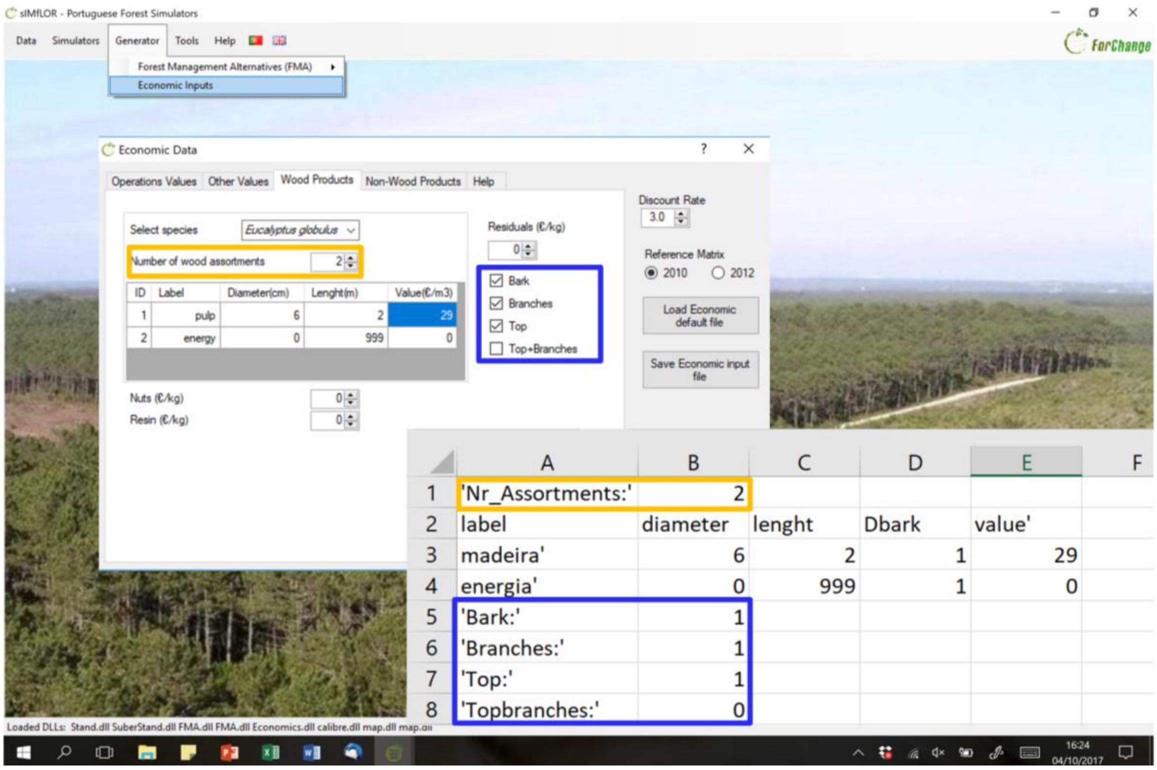


Figure 17. Side by side comparison of the transcription of the information provided in the form for Wood Products and the content of the Assortments file.

4.2 StandsSIM.md input files – Prescriptions and Stands

A prescription is the sequence of forest management approaches (FMA) that are used along the planning horizon for a given stand or group of stands. Therefore, a prescription is composed of k cycles, each one corresponding to an FMA. When running the tool under the FMA MODE, each cycle is characterized by 4 variables: the tree species, stand structure, rotation and the FMA id. You have to make sure that for the 1st cycle these 4 variables match the characteristics of the stand or stands to each the prescription is assigned. For example, if you want to simulate the growth of an eucalyptus even-aged stand in the second rotation, the 1st cycle of the prescription must have the rotation (rot) set to 2 (**Figure 18**).

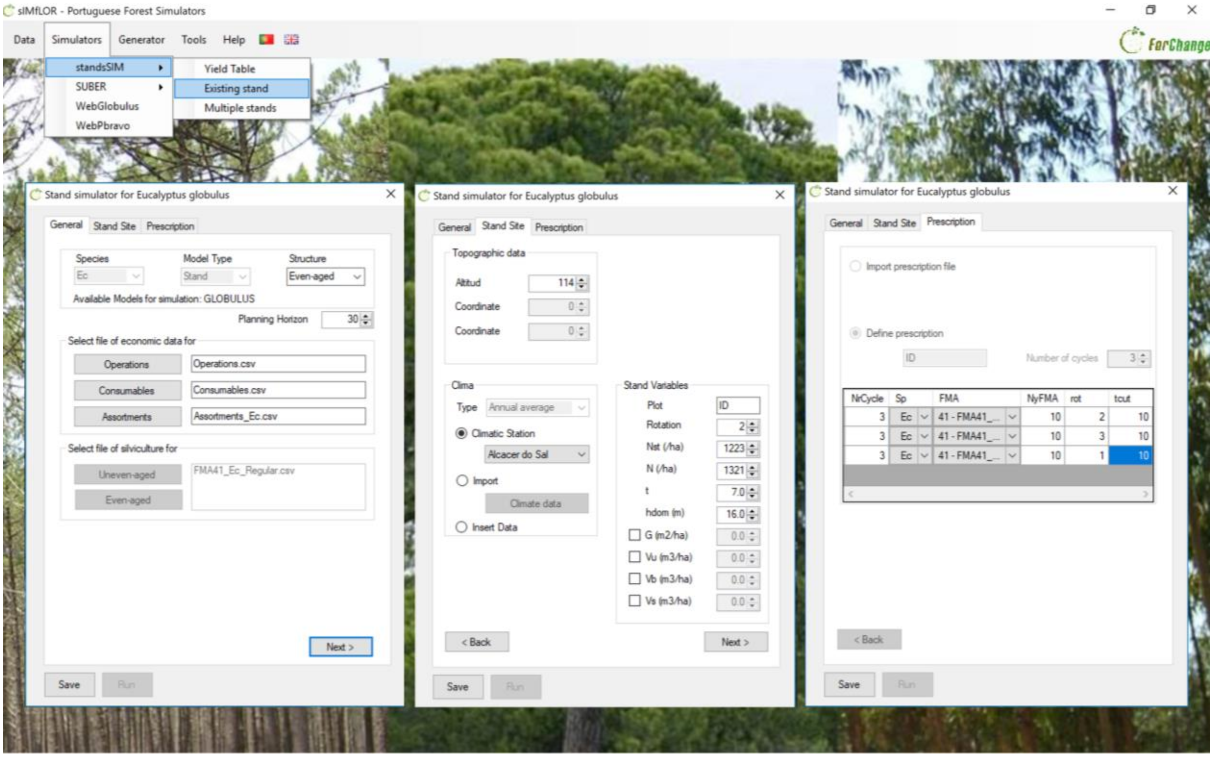


Figure 18. Print screen of the filled in forms for an existing eucalyptus stand in the second rotation considering a prescription composed of repetitions of the same FMA.

At a first look, it might seem that the prescription has the correct number of cycles given that the planning horizon was set to 30 and the harvest ages of the 3 cycles were set to 10. However, because the stand has 7 years, only the last 3 years of the 1st cycle will be used, on the other hand a 4th cycle is needed to cover for the last 7 years of simulation (**Figure 19**).

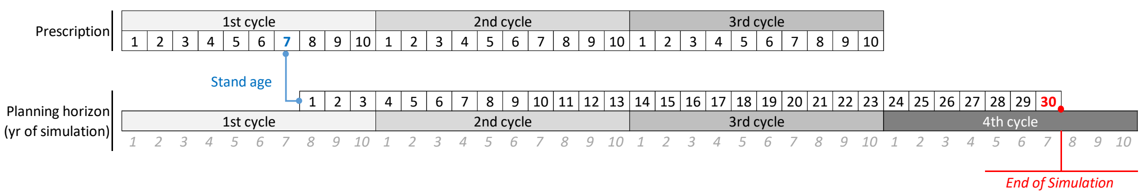
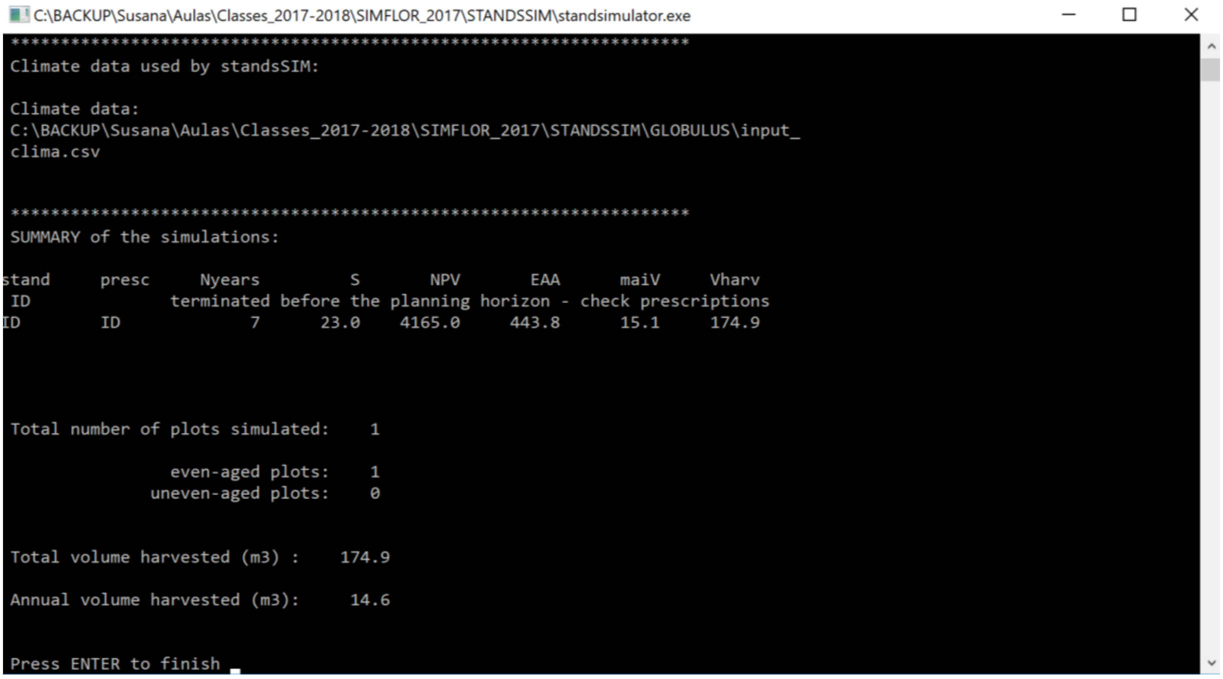


Figure 19. Schematic overview of the application of a prescription to existing stands older than 1.

When the prescription does not cover the entire planning horizon, you get a warning in the black window, advising you to revise the prescription (**Figure 20**). This is the reason why you are always advised to define prescriptions with one cycle more than what it seems required at a first look.



```
C:\BACKUP\Susana\Aulas\Classes_2017-2018\SIMFLOR_2017\STANDSSIM\standsimulator.exe
**********************************************************************
Climate data used by standsSIM:

Climate data:
C:\BACKUP\Susana\Aulas\Classes_2017-2018\SIMFLOR_2017\STANDSSIM\GLOBULUS\input_
clima.csv

**********************************************************************
SUMMARY of the simulations:

stand     presc     Nyears        S       NPV       EAA      maiV     Vharv
 ID              terminated before the planning horizon - check prescriptions
ID        ID              7      23.0    4165.0     443.8      15.1     174.9



 Total number of plots simulated:    1

                even-aged plots:    1
              uneven-aged plots:    0


 Total volume harvested (m3) :    174.9

 Annual volume harvested (m3):     14.6


 Press ENTER to finish
```

Figure 20. Print-screen of the black window showing the summary results of a run containing a warning for a short prescription (not covering the entire planning horizon).

In the example in **Figure 18**, a single FMA was selected over the planning horizon. However, a prescription can be composed of different FMAs (**Figure 21**). These have to be selected in a single step (see section 5.3). The one that shows first in the box (*FMA41_Ec_Regular.csv*) is assigned the FMA/opt id of 41, whereas the second (stp_FMA42_Ec_Regular.csv) the id FMA/opt of 42. These id results of concatenating the information in columns FMA (4) and opt (1 or 2) in the *input_prescr.csv* file (see section 5.3.1).

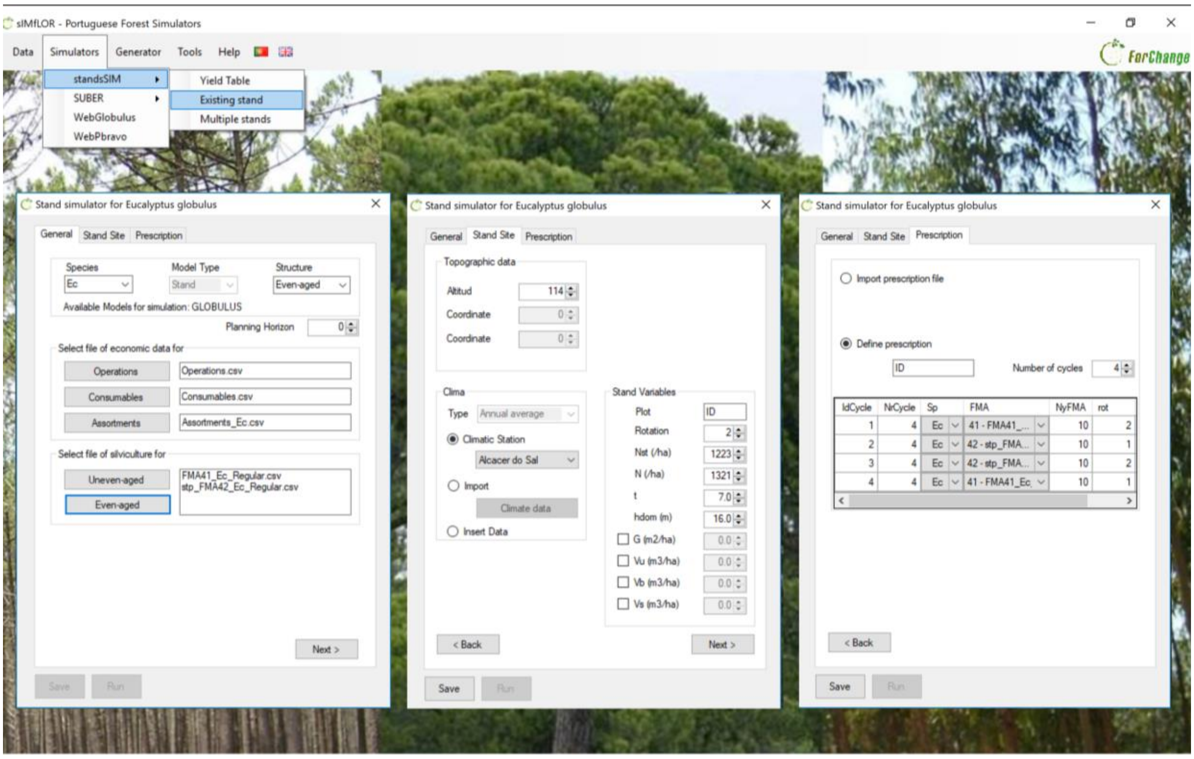


Figure 21. Print-screen of the filled in forms for an existing eucalyptus stand in the second rotation considering a prescription composed of different FMAs.

5 Simulating with StandsSIM.md

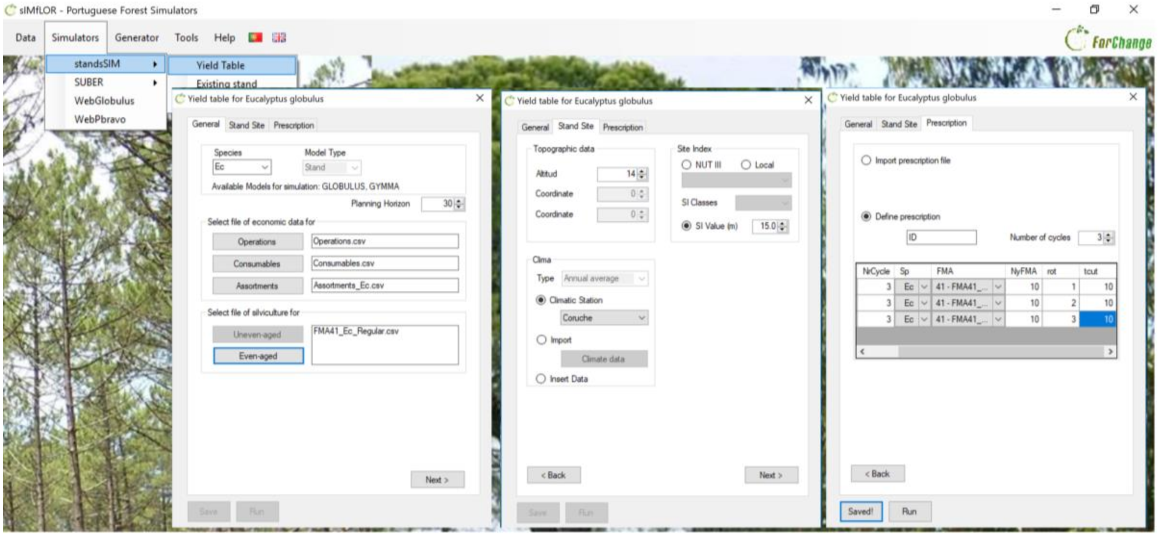
To run a simulation you must go to the Simulators\StandsSIM and choose whether to simulate a yield table (new plantation), an Existing Stand or Multiple Stands. We will now take a look at each of the situations, for which an exercise is presented and solved.

5.1 Simulating a Yield table

The simulation of a yield table is the less demanding in terms of inputs with the possibility of generating all inputs using sIMfLOR interface (Figure y). When you want to simulate a new plantation, you have to characterize the site and the management throughout the planning horizon in the interface forms so that the required inputs are generated. Take the eucalypt plantation described below and see **Figure 22** for the description on how to run the simulation.

Build a yield table for a eucalypt for a planning horizon of 30 years considering: i) a plantation followed by two coppices; ii) final harvest at 10 years for all rotations;	<u>Site Characteristics:</u> Location: *Coruche municipality* *Altitude: 14 m (if you don't know the altitude you can use the webGLOBULUS stand simulator to obtain it)* *Site index: 15 m (base age 10 years)*

iii) managed according to the FMA described in *FMA41_Ec_Regular.csv*



StandSIM input files created:	C:\SIMFLOR_2017\STANDSSIM\ini_standsSIM.csv	C:\SIMFLOR_2017\STANDSSIM\GLOBULUS\input_stand.csv C:\SIMFLOR_2017\STANDSSIM\GLOBULUS\input_clima.csv	C:\SIMFLOR_2017\STANDSSIM\GLOBULUS\input_prescr.csv

Figure 22. Print-screen of the filled in forms for building a Yield Table for eucalypt.

After filling in the information and you press run, usually a black window shows presenting a summary of your simulation run (**Figure 23**).

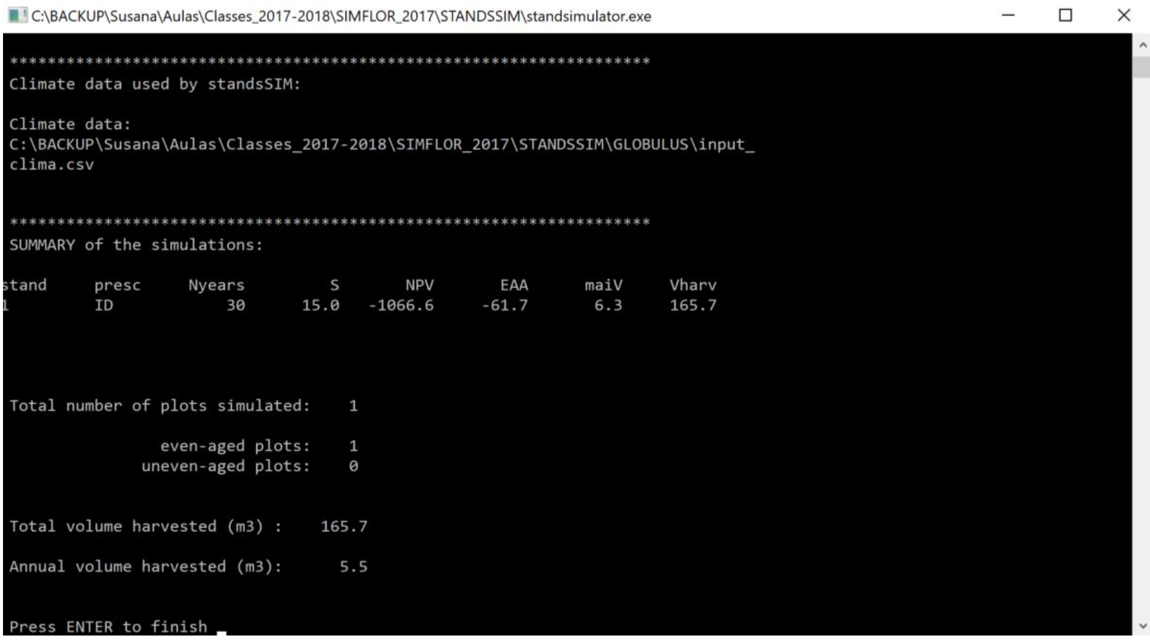
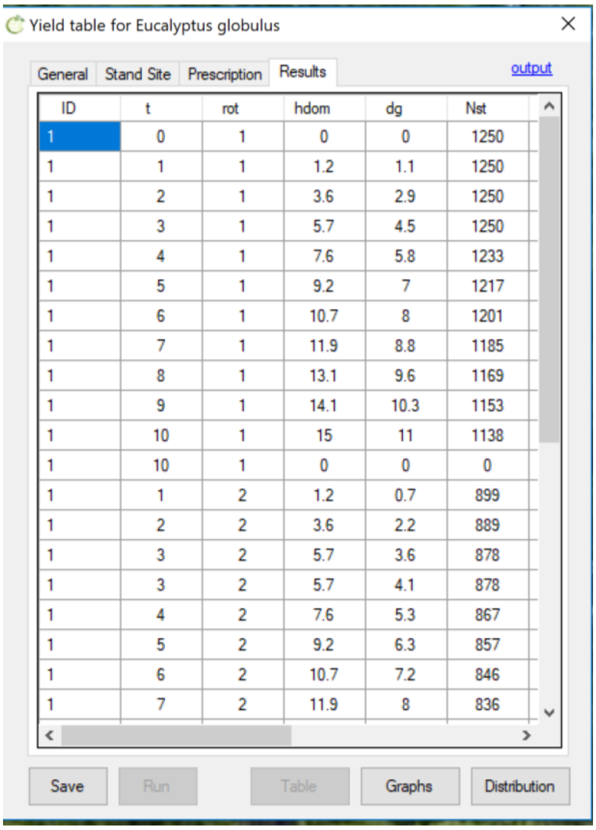


Figure 23. Print-screen of the black window showing the summary results of a successful run.



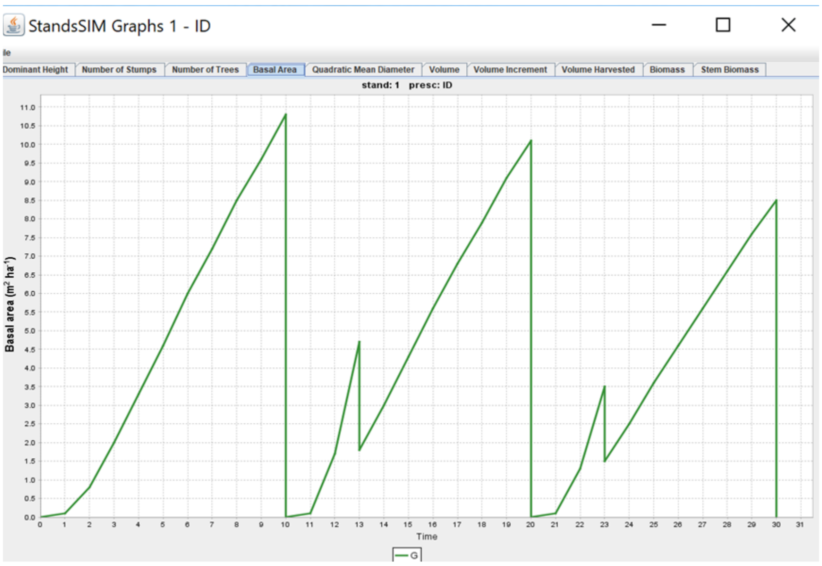
ID	t	rot	hdom	dg	Nst
1	0	1	0	0	1250
1	1	1	1.2	1.1	1250
1	2	1	3.6	2.9	1250
1	3	1	5.7	4.5	1250
1	4	1	7.6	5.8	1233
1	5	1	9.2	7	1217
1	6	1	10.7	8	1201
1	7	1	11.9	8.8	1185
1	8	1	13.1	9.6	1169
1	9	1	14.1	10.3	1153
1	10	1	15	11	1138
1	10	1	0	0	0
1	1	2	1.2	0.7	899
1	2	2	3.6	2.2	889
1	3	2	5.7	3.6	878
1	3	2	5.7	4.1	878
1	4	2	7.6	5.3	867
1	5	2	9.2	6.3	857
1	6	2	10.7	7.2	846
1	7	2	11.9	8	836

This indicates the simulation is completed and by pressing "enter" you return to the interface where by clicking on "Table" you can display a summary of the outputs in tabular form (**Figure 24**). In the upper corner, you will read the word "output", in blue, and by clicking the word you will be allowed to open the complete output file (*output_yieldtable.csv*).

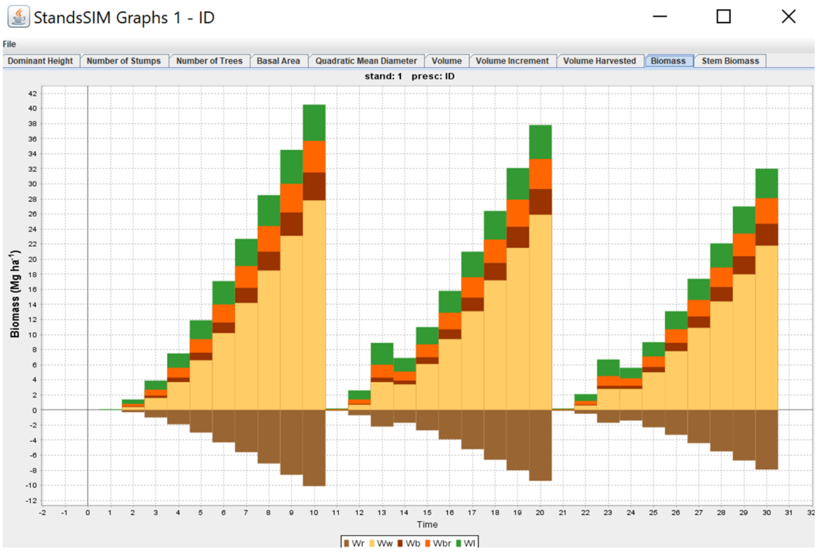
Alternatively, you can opening it directly going to: ***c:\SIMFLOR_2017\STANDSSIM\OUTPUT***. In this file you will find the evolution of a wide range of stand variables over time (see the **Appendix 2** for the description of the output variables).

Figure 24. Print-screen of the table with the summary of the outputs.

Back to the interface, you also have the possibility to visualize the evolution of the most important stand variable in a graphical format using the button "Graphs" (**Figure 25**).



Evolution of stand basal area (G, m^2ha^{-1}) over time for the 3 rotations, where the big decreases observed at years 10, 20 and 30 result of the final cut operation, whereas the smaller reductions in the 2 coppiced rotations are the result of the selection of shoots.



Evolution of stand biomass by tree component (Wi, Mgha^{-1}) over time.

Figure 25. Print-screen of some graphics available automatically generated by the interface.

You will not find significant differences if you choose to build a yield table for maritime pine or stone pine. However, when running StandsSIM.md for these species you will find that after saving the input information provided using the interface an additional input is created at ***C:\SIMFLOR_2017\STANDSSIM\GLOBULUS***: *input_tree.csv*. This file is automatically generated because the growth and yield models for both pines are tree level models, therefore requiring information for trees when simulating existing stands (for plantations tree level information is not required, if you open the file you will see it contains a single tree for which there is no information). Another difference is that for tree level models you have the possibility to seeing the evolution of the diameter distributions over time by clicking on the button “Distribution”, next to the “Graphs”.

To run your simulations smoothly for a yield table you have to make sure that:

1) the sum of harvest ages (or number of years to simulate each cycle) in the prescription is enough to cover the planning horizon. To achieve this you either create enough cycles or increase the harvest ages.

2) the FMA is defined for a number of years greater or equal to any harvest age (or number of years to simulate a cycle) you intent to consider. If you define your FMA using the Generator the “Maximum number of years of the rotation” needs to exceed the harvest ages. On the other hand if you are using an existing FMA file, open it first to make sure management is defined to cover the whole rotations.

5.2 Simulating am Existing stand

The biggest difference between simulating an existing stand and a plantation lies in the fact that you will also have to characterize the existing stand, and its trees in case the tree species are simulated using an individual tree level models beside characterizing the site. Suppose you have the maritime pine existing stand described below. Follow the correct filling in of the forms in **Figure 26**.

Simulate the growth of a maritime pine stand managed as uneven-aged for 35 years after which the stand will be harvested and a plantation of the same species made.

Simulate the growth of these stands applying the suggested FMAs:

FMA31_Pb_Gres_Irreg.csv

FMA41_Pb_025_REGular.csv.

Site Characteristics:

Location: Alcácer do Sal municipality

Altitude: 100 m (if you don't know the altitude you can use the webGLOBULUS stand simulator to obtain it)

Stand Characteristics:

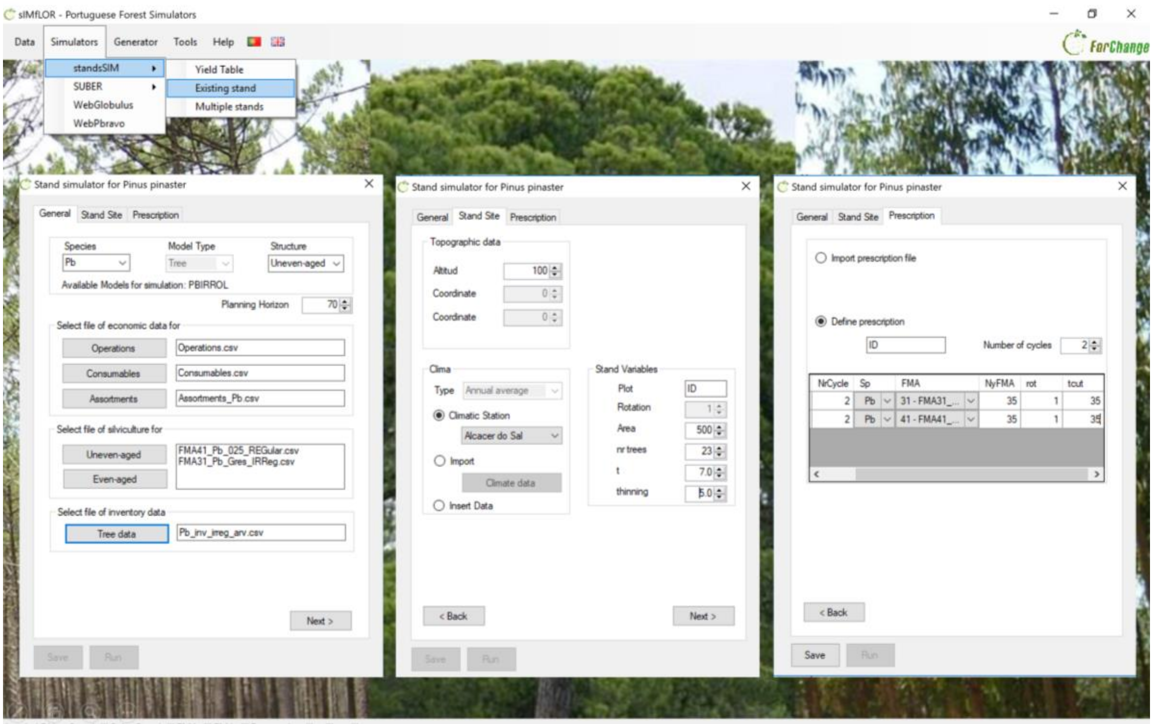
Stand structure: uneven-aged

Plot area: 500 m^2

Tree data file: *Pb_inv_irreg_arv.csv*

Number of trees in the plot: 23 trees

Number of years since the last thinning: 5



StandsSIM input files created:

C:\SIMFLOR_2017\STANDSSIM\ini_standsSIM.csv	C:\SIMFLOR_2017\STANDSSIM\PINASTER\input_stand.csv C:\SIMFLOR_2017\STANDSSIM\PINASTER\input_clima.csv	C:\SIMFLOR_2017\STANDSSIM\PINASTER\input_prescr.csv

Figure 26. Print-screen of the filled in forms for simulating a maritime pine existing stand.

After saving the information (generating the input files) you can run your simulation. When the simulation is terminated, you get the black window with a summary of the run (**Figure 27**).

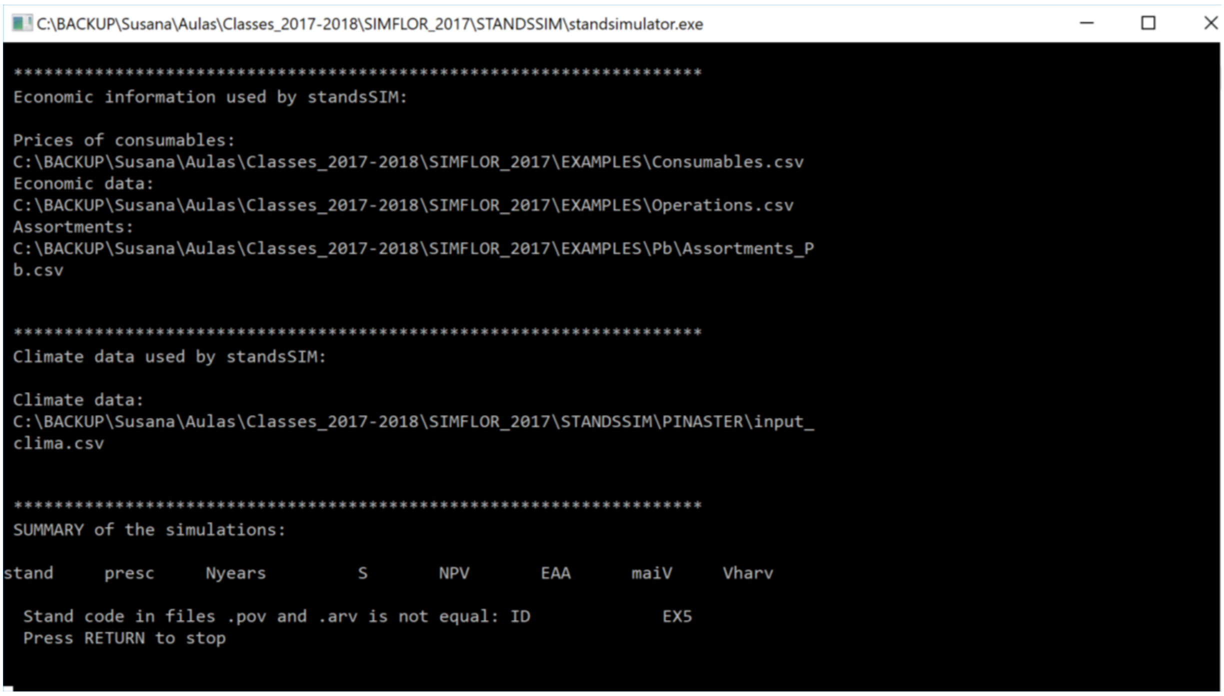


Figure 27. Print-screen of the black window showing a warning message for an inconsistency detected in the input files.

You must always read the information provided in this window. In **Figure 27** there is a warning informing you of an inconsistency detected between the stand ID in the stand and tree files. At this point, if you press “Run”, the summary of outputs will not be made available when pressing on “Table”. To solve the problem click “Back” until you reach the “Stand Site” tab (clicking directly on this tab will not allow editions); then, under the section “Stand variables” change the stand ID to “EX5” (the stand ID in the tree input file), save the change and run the simulation. If for any reason you are not allowed to make this correction, repeat the process making sure you have the same stand ID is used in both files, either by changing it in one or the other. After this second run, you will get the message indicating a successful run: “`Press enter to finish`” and the summary of the evolution of the most important stand variables will be displayed by clicking on “Table”. After the summary is displayed, the Graphs functionality becomes available.

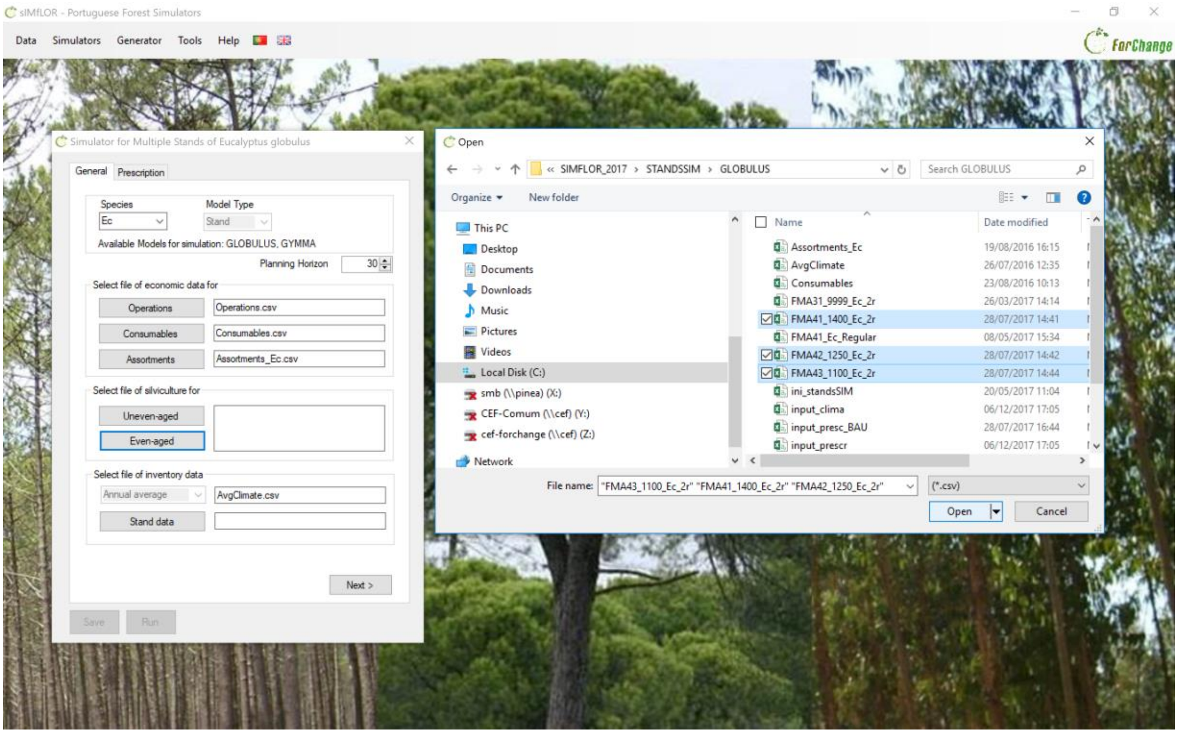
To run your simulations smoothly for an existing stand <u>you have to make sure that</u>:

1) the same requirements listed for the yield table simulation run are both met

2) no inconsistencies between the stand and tree input files exist, in terms of Stand ID or number of trees in the plot.

5.3 Simulating Multiple stands

sIMfLOR was not conceived for generating the input files for more than one stand, thus if you want to simulate several stands, you will have to prepare most of the inputs outside the interface. In fact, the interface will only be used to create the *ini_standsSIM.csv* file. When you simulate several stands it is likely that you will need to use more than one FMA. The FMAs for even- and uneven-aged stand structures have to be imported separately, but all FMA of the same type MUST BE imported in a single step. Suppose you want to simulate 330 eucalypt even- and uneven-aged stands to which you want to assign 1 uneven-aged FMA and 3 even-aged FMAs. **Figure 28** illustrates a situation for which the user desires to import 3 FMAs for even-aged management and one for uneven-aged management**.** By clicking on "Even-aged" you are given the possibility to select the 3 files at the same time. After these appear in the FMA box, you can then select the uneven-aged FMA.



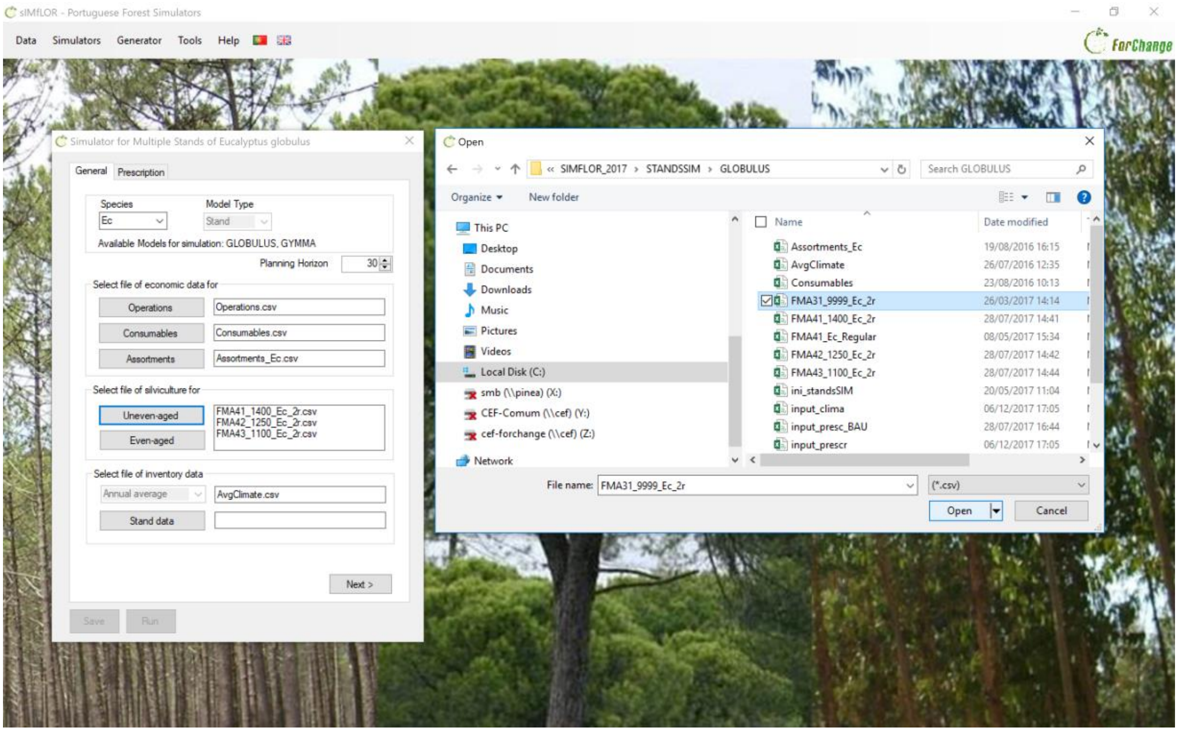


Figure 28. Print-screen illustrating the process of importing several FMAs.

After importing the FMA files, you have to import the stand inventory file. The last step will be importing the prescription file (**Figure 29**).

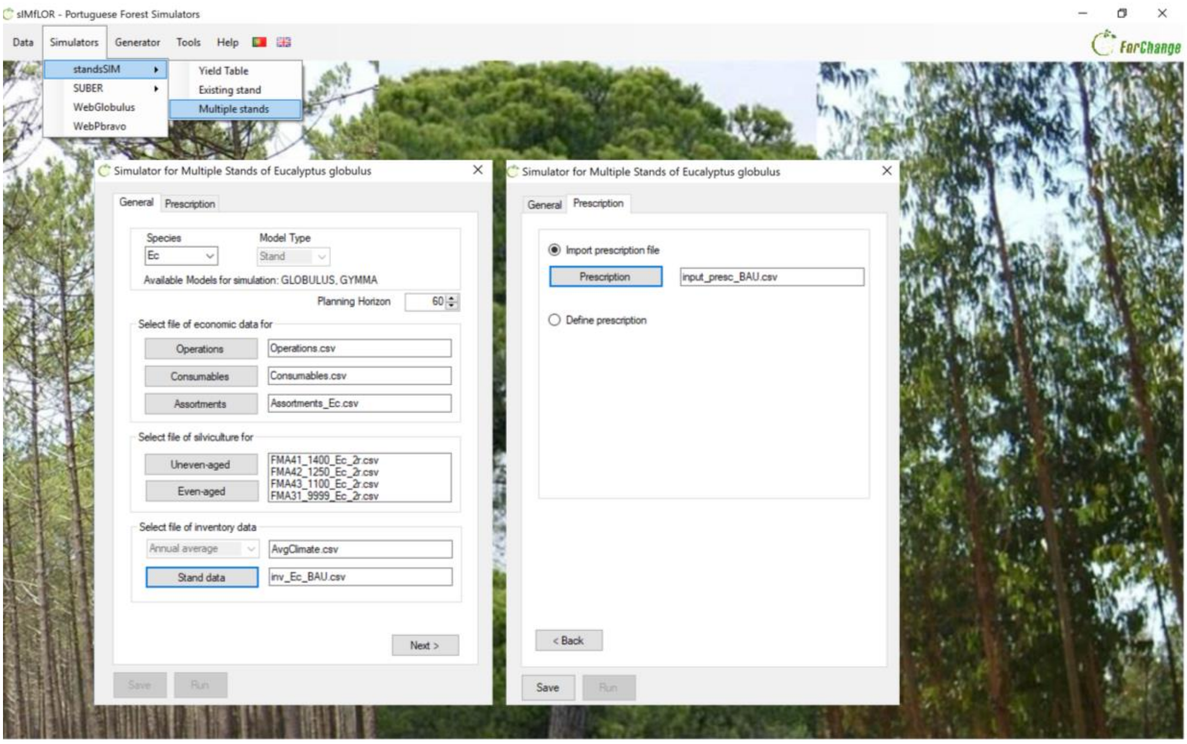


Figure 29. Print-screen illustrating the filled in forms for a simulation run for Multiple Stands.

Please note, if you import the FMAs for even-aged management individually (several steps), they will all show in the in the box, HOWEVER only the first one will be truly imported (to which the code 4,1 is assigned) and will be written in the *ini_standsSIM.csv* (**Figure 30)**.

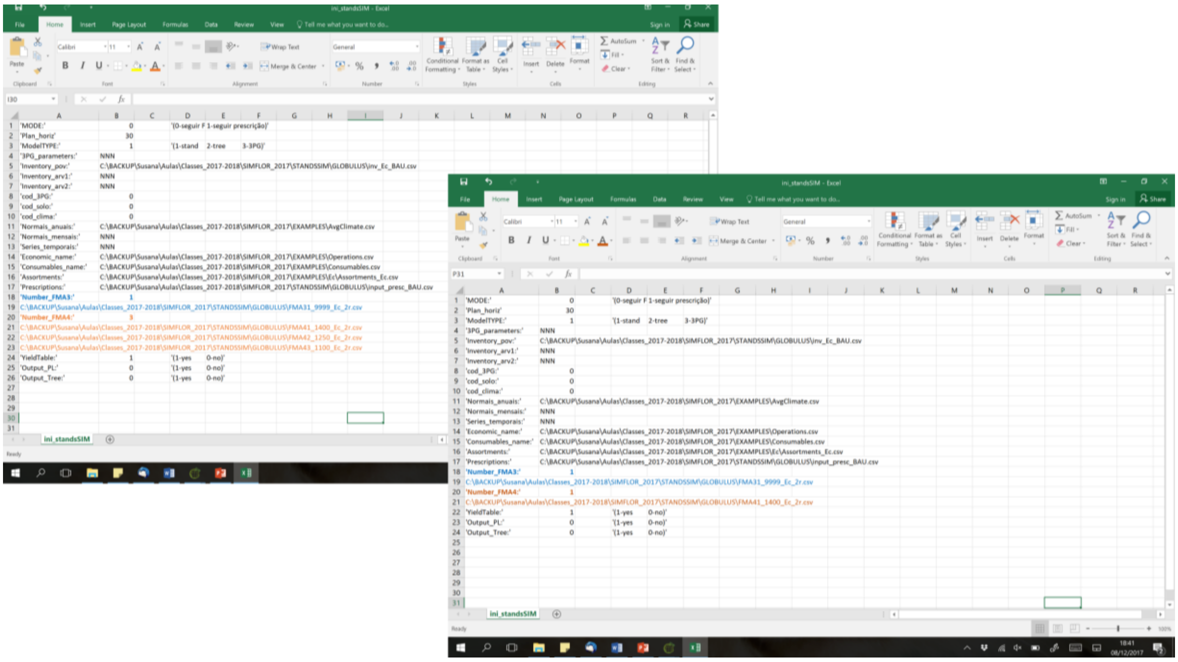


Figure 30. Illusration of the *ini_standsSIM.csv* file with the 3 FMAs imported in a single step (leff handside) and with the 3 FMAs imported in three steps (right handside).

In case you import the even-aged FMAs individually, you will not get any error message or warning. The simulator will run, but the black window will show some NAN and/or infinity values for the stands that had an FMA of 4,2 or 4,3 assigned in the stand input file that could not be found in the *ini_standsSIM.csv* file (**Figure 31**).

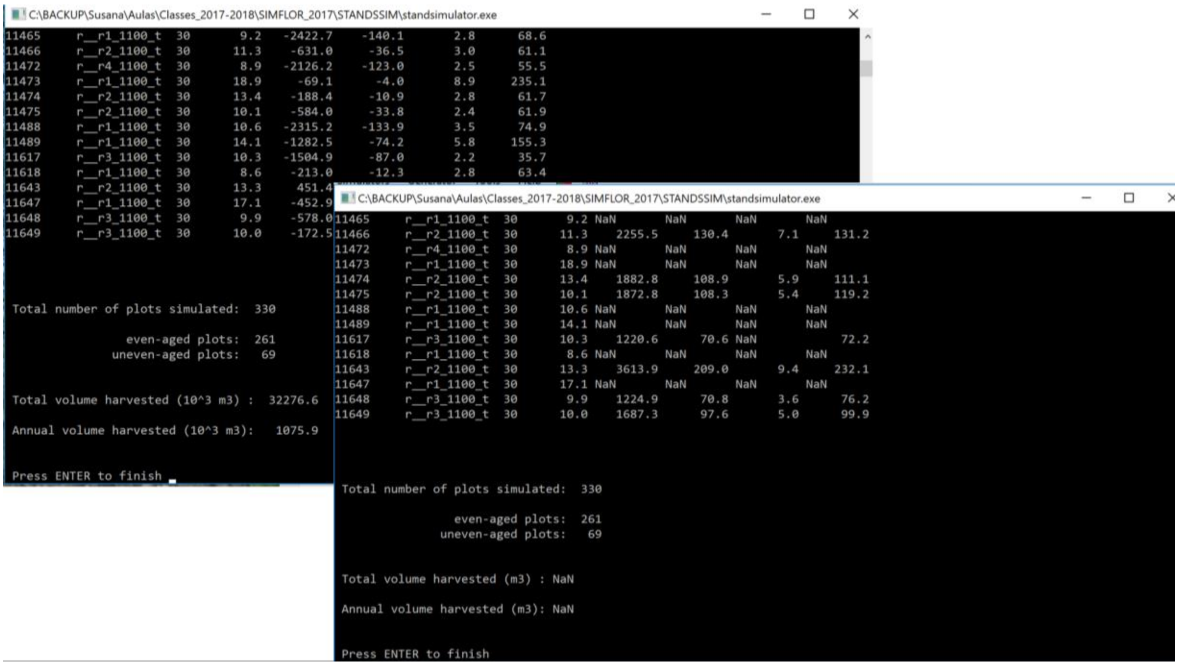


Figure 31. Print-screen of the black window showing the summary of the simulation details for a situation for which the 3 FMAs were imported in a single step (left) and in three steps (right).

5.3.1 Consistency between input files

The consistency between the information provided in the different input files must be considered when running the tool under the Multiple Stands mode. The consistency between the variables in the different files will be explained using "*file name*"."*variable name*", follow the files and variables in **Figure 32**. The core of all inputs are the files describing the stand and trees, in the case of individual tree level models. In this case, the first consistency that needs to be ensured is between these 2 files where:

- input_stand.id_stand = input_tree.id_plot
- input_stand.narvp = count(input_tree.id_arv)
- input_stand.Sp1 = input_stand.Sp2 = input_tree.specie

The next consistency is between the stand file and the prescription file, where:

- input_stand.id_presc = input_prescr.idPresc
- Only for the 1st prescription cycle (NrCiclos=1):
    - input_stand.Sp1 = input_stand.Sp2 = input_prescr.sp1 = input_prescr.sp1
    - input_stand.rotation = input_prescr.rot
    - input_stand.structure = input_prescr.FMA (with Structure=R -> FMA=4; Structure=J -> FMA=3)

The following consistency relates to the weather and is between the stand file and the clima file, where:

- input_stand.id_meteo=input_clima.id_met

Finally, the last consistency is between the prescription and the FMA files, where:

- Input_FMA."A1 cell in the file"=input_prescr.FMA
- When different FMAs of the same type are imported they are assigned a number of order that represents an option for a given type of management. The set of numbers of order available will identify which FMA to apply in each cycle through the input_prescr.opt.

	Stand level models	Individual tree level models				
StandsSIM input files:	input_stand	input_stand	input_tree	input_FMA	input_presc	input_clima
Variables in the files:	idstand	id_stand	id_plot	A1 cell in the file	IdPrescr	id_met
	Area_ug	Area_ug	id_arv		NrCiclos	daysRain
	id_presc	id_presc	specie		sp1	rain
	tlag	tlag	d		sp2	Temp
	CoordX	CoordX	h		sp3	daysFrost
	CoordY	CoordY	cod_dom		FMA	Prec3
	id_meteo	id_meteo	cod_estado	Must match the number of order by which the different FMAs of the same type are selected	Opt	Prec4
	Altitude	Altitude			NyFMA	X
	year	year	nr of trees in each plot		tlag	Y
	month	month			Npl	
	Composition	Composition			rot	
	plot_Type	Plot_Type			tcut	
	Sp1	Sp1			nsprouts	
	Sp2	Sp2			t_nsprouts	
	structure	Structure			thin_type	
	S	S			thin_crit	
	rot	Rotation			thin_weight	
	t	t			t_1st_thin	
	tst	tst			thin_gap	
	tsd	tsd			t_last_thin	
	hdom	Aplot				
	…	narvp				

Figure 32. List of input files and their variables with the common variables marked with the same colours.

6 References

Comissão de Acompanhamento das Operações Florestais (CAOF), 2012. Matriz de Referência com Custos Minimos e Maximos para as Principais Operações (Re)Arborização e Execução de Infraestruturas para 2010. ANEFA. [online] URL: http://www.anefa.pt/servicos/representatividade.html

APPENDIX 1 – INPUT VARIABLES DESCRIPTION

List of variables in the different input files and variables description

inicia_standsSIM.csv

'MODE:'	Simulation mode, indicates whether to follow the instructions in the FMA file (0) or in the prescription file (1)
'Plan_horiz'	Number of years for which you want to run the simulation
'ModelTYPE:'	Model type: empirial stand level model (1), empirical individual tree level model (2), process-based stand level model (3)
'3PG_parameters:'	only filled in if ModelType=3 (path to the trees species parameters file of the 3PG)
'Inventory_pov:'	only filled in if ModelType=2 (path to the stand inventory file)
'Inventory_arv1:'	only filled in if ModelType=1 (path to the stand inventory file)
'Inventory_arv2:'	only filled in if ModelType=1 (path to the tree inventory file)
'cod_3PG:'	only filled in if ModelType=3 ()
'cod_solo:'	only filled in if ModelType=3 ()
'cod_clima:'	only filled in if ModelType=3 ()
'Normais_anuais:'	only filled in if ModelType<>3 (path to the climate file)
'Normais_mensais:'	only filled in if ModelType=3 (path to the climate file with monthly averages per month)
'Series_temporais:'	only filled in if ModelType<>3 (path to the climate file with monthly values for a series of years)
'Economic_name:'	path to the cost of operations file
'Consumables_name:'	path to the cost of consumables file
'Assortments:'	path to the asortments and wood prices file
'Prescriptions:'	path to the prescriptions file
'Number_FMA3:'	number of uneven-aged FMA files to be used in the simulation
IF Number_FMA3 >0 THEN path to the FMA files (one per each row) ELSE line deleted	
'Number_FMA4:'	number of even-aged FMA files to be used in the simulation
IF Number_FMA4 >0 THEN path to the FMA files (one per each row) ELSE line deleted	
'YieldTable:'	Whether you wish the output_yieldtable.csv file (keeps track of the evolution of all stand variables) to be written: yes (1), no (0)
'Output_PL:'	Whether you wish the output_PL.csv file (input for the Linear Programming) to be written: yes (1), no (0)
'Output_Tree:'	Whether you wish the output_tree.csv file (keeps track of the growth of each tree) to be written: yes (1), no (0)

input_stand.csv (ModelTYPE=1)

idstand	identifier of the stand
Area_ug	area of the management unit characterized by the stand
id_presc	identifier of the prescription

tlag	number of years to wait before the prescription will start being implemented
CoordX	xx rectangular coordinate of the stand centroid
CoordY	yy rectangular coordinate of the stand centroid
id_meteo	identifier of the meteorological station
Altitude	altitude of the stand (m)
year	year of measurement
month	month of measurement
Composition	stand composition: pure or mixed
plot_Type	Type of plot: Stand, gap, clump, burnt, harvested
Sp1	dominant tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
Sp2	dominated tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
structure	stand structure: J=uneven-aged; R=even-aged
S	site index (m)
rot	rotation: 1=planted; 2= 1st coppice; 3=2nd coppice, …
t	stand age (years)
tst	number of years since the last thinning (only for Pm and Pb)
tsd	number of years since the last debarking (only for Sb)
hdom	stand dominant height (m)
Nst	Number of trees (ha-1), of stools for eucalyptus
N	Number of trees (ha-1), of sprouts for eucalyptus
G	Stand basal area (G2 ha-1)
Vu	Volume with stump under bark (m3 ha-1)
Vb	Volume of bark (m3 ha-1)
Vs	Volume of stump (m2 ha-1)
Wr	Root stand biomass (Mg ha-1)
Ww	Wood stand biomass (Mg ha-1)
Wb	Bark stand biomass (Mg ha-1)
Wbr	Branches stand biomass (Mg ha-1)
Wl	Leaves stand biomass (Mg ha-1)

input_stand.csv (ModelTYPE=2)

id_stand	identifier of the stand
Area_ug	area of the management unit characterized by the stand
id_presc	identifier of the prescription
tlag	number of years to wait before the prescription will start being implemented
CoordX	xx rectangular coordinate of the stand centroid
CoordY	yy rectangular coordinate of the stand centroid
id_meteo	identifier of the meteorological station
Altitude	altitude of the stand (m)
year	year of measurement
month	month of measurement
Composition	stand composition: pure or mixed
Plot_Type	Type of plot: Stand, gap, clump, burnt, harvested

Sp1	dominant tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
Sp2	dominated tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
Structure	stand structure: J=uneven-aged; R=even-aged
S	site index (m)
Rotation	rotation: 1=planted; 2= 1st coppice; 3=2nd coppice, …
t	stand age (years)
tst	number of years since the last thinning (only for Pm and Pb)
tsd	number of years since the last debarking (only for Sb)
Aplot	area of the plot measured in the field (m2)
narvp	number of trees in the plot

input_tree.csv (ModelType=2)

id_plot	identifier of the stand
id_arv	identifier of the tree
specie	tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
d	tree diameter at 1.30m height (cm)
h	tree height (m)
cod_dom	dominant tree code (dominant=1, not dominant=0)
cod_estado	status tree code (living=0, dead=4)

input_prescr.csv

IdPrescr	identifier of the prescription
NrCiclos	identifier of the cycle within the presciption (from 1 up to the number of cycles need to cover the planning horizon)
sp1	dominant tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
sp2	dominated tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
sp3	terciary tree species: Ec= eucalyptus; Pb= maritime pine; Pm= sone pine; Sb= cork oak
FMA	identifier of the FMA (4= even-aged; 3 uneven-aged)
Opt	identifier of the FMA option (from 1 up to the number of FMAs of the FMA type imported)
NyFMA	number of years during which you want to manage according to the combination of (FMA,opt) defined for the current cycle
tlag	number of years to wait before the prescription/FMA,opt for the first cycle will start being implemented (not active at the moment)
Npl	number of trees at planting (ha-1) (only active under MODE=1)
rot	rotation: 1=planted; 2= 1st coppice; 3=2nd coppice, …
tcut	harvest age
nsprouts	number of sprouts left per stool (only active under MODE=1)
t_nsprouts	stand age at which the sprouts selection is carrid out in the field (only active under MODE=1)

thin_type Thinning type (1=FW; 2= residual basal area) (only active under MODE=1)
thin_crit Thinning criteria (1=from below; 2= from above) (only active under MODE=1)
thin_weight Thinning weight (1=from below; 2= from above) (only active under MODE=1)
t_1st_thin Age of the first thinning (only active under MODE=1)
thin_gap Thinning periodicity (only active under MODE=1)
t_last_thin Age of the last thinning (only active under MODE=1)

input_clima.csv

id_met identifier of the meteorological station
daysRain Number of days with rain
rain Precipitation >0.1 (mm)
Temp Average temperature (ºC)
daysFrost Number of days with frost
Prec3 Precipitaion >0.1 (mm)
Prec4 Precpitation >1 (mm)
X xx rectangular coordinates of the meteorological station
Y yy rectangular coordinates of the meteorological station

Assortments.csv

'Nr_Assortments:' indicates the number of assortments to be considered
label name given to each assortment and for each assortment the following information needs to be provided (*by column*):

diameter - diameter of the log (cm),

length – length of the log(m),

bark – whether bark is considered in the assortment (1 if bark is included, 0 if excluded),

value – price of the assortment (€ /m3)

as many rows with the label name as the number of assortments defined above

'Bark:' Havest residues - bark removal indicator (1 if removed from the stand, 0 if left on the site)
'Branches:' Havest residues - branches removal indicator (1 if removed from the stand, 0 if left on the site)
'Top:' Havest residues - top removal indicator (1 if removed from the stand, 0 if left on the site)
'Topbranches:' Havest residues - top + branches removal indicator (1 if removed from the stand, 0 if left on the site)
Pinha_kg Stone pine cone price (€/Kg)

Consumables.csv

Ncons: number of consumables
'Description' Prices of the different consumables distributed by unit type (by column):

Price of 'Atlantic pine Seedlings' ('eur_tree')

Price of 'Eucalypt Seedlings' ('eur_tree')

Price of 'Cork oak Seedlings' ('eur_tree')

Price of 'Atlantic pine Seeds' ('eur_kg')

	Price of 'Cork oak Seeds' ('eur_kg')
	Price of 'Fertilizer for manual application (slow release)' ('eur_kg')
	Price of 'Fertilizer for mechanical application' ('eur_kg')
	Price of 'Fertilizer for mechanical application (subsoil)' ('eur_kg')
	Price of 'Plant Protectors' ('eur_tree')
	Price of 'Pesticides' ('eur_tree')
	Price of 'Diesel' ('eur_l')
	Price of 'Petrol' ('eur_l')
	Price of 'Maintenace annual costs' ('eur_year')
	Price of 'Fencing' ('eur_km')
	Price of 'Game additional costs (licences)' ('eur_year')
	Price of 'Game guard' ('eur_year')
	Price of 'Cost of red deer male' ('eur_animal')
	Price of 'Cost of red deer female' ('eur_animal')
	Price of 'Game trophy' ('eur_animal')
	Price of 'Game meat' ('eur_kg')
	Price of 'Specialized male labour cost' ('eur_h')
	Price of 'Non-specialized male labour cost' ('eur_h')
	Price of 'Specialized female labour cost' ('eur_h')
	Price of 'Non-specialized female labour cost' ('eur_h')

Economics.csv

'ActualRate'	First column: Interest rate (integer value, e.g. 3, 4, 5) Second column: Number of additional interest rates Following columns: Additional Interest rates (integer value, e.g. 3, 4, 5)
CostsMaint	Maintenance costs (€/year)
Noperations	Number of operations
By column:	*For each of the 68 silvicultural operations in each row*
Type	Silvicultural operation identifier
'OPERATIONS'	Name of the silvicultural operation
'unit_jorna'	Number of working hours
'OP_eur_tree'	Price of the operation (€/tree)
'OP_eur_km'	Price of the operation (€/km)
'OP_eur_m3'	Price of the operation (€/m^3)
'OP_eur_ha'	Price of the operation (€/ha)
'MA_labour_h_km'	Labour Machinery work (h/km)
'MA_labour_h_ha'	Labour Machinery work (h/ha)
'MA_energy_l_h'	Labour Machinery work (l/h)
'WAGExp_M'	Indicator for the male expert labour (1 if yes, 0 if no)
'WAGExp_F'	Indicator for the female expert labour (1 if yes, 0 if no)
'WAGNExp_M'	Indicator for the male non-expert labour (1 if yes, 0 if no)
'WAGNExp_F'	Indicator for the female non-expert labour (1 if yes, 0 if no)
Other costs	Other costs (€)

Input_FMA.csv

First row:	Forest Management Approach ID (4 for even-aged stands; 3 for uneven-aged stands)
Second row:	Indicator of management (1 represents plantation management, 2 represents plantation followed by coppice management after the first harvest)
Following row:	Maximum number of years for which the management operations will be defined (when the indicator of management is set to 2, the number of years defined will be applied both to the plantation and the coppice)
By column:	*For each stand age and rotation in each row*
T	Stand age (years)
Npl	Number of trees at planting (ha^{-1})
Mortality	Percentage of trees that die (%)
BeatUp	Percentage of trees that died and will be replaced by new ones (0-100)
ShootSel	Average number of sprouts left per stool after the shoots selection
DensIncr	Stand density increase (trees ha^{-1})
StripIncr	Debarking height increase (m)
Prunn	Percentage of trees to be pruned
Th_type	Thinning type (1 if Wilson Factor, 2 if Residual Basal Area)
ThGres	Residual basal area value (m^2 ha^{-1})
ThGrem	Removed basal area value (m^2 ha^{-1}) *(not implemented in this version)*
ThFw	Wilson factor value (varies from 0.1 up to 4)
ThCrCv%	Crown cover percentage left after thinning *(not implemented in this version)*
Operations $_{68}$	Identifier of occurrence of the silvicultural operation (for each of the 68 operations; 0 if is not carried out, 1 if it is carried out)

Silvicultural operation ID	Description of the silvicultural operation (costs unit)
1	'Protection tree tube' ('OP_eur_tree')
2	'Formation prunning in young trees' ('OP_eur_tree')
3	'Prunning young trees' ('OP_eur_tree')
4	'Getting the earth close to the roots;' ('OP_eur_tree')
5	'Burning formation prunning residuals' ('OP_eur_tree')
6	'Plantation - evergreen or deciduous trees in containers' ('OP_eur_tree')
7	'Plantation - deciduous trees with bare-root' ('OP_eur_tree')
8	'Beating up - evergreen or deciduous trees in containers' ('OP_eur_tree')
9	'Beating up - deciduous trees with bare-root' ('OP_eur_tree')
10	OPMan_AdensaRdFdCont ('OP_eur_tree')
11	OPMan_ADensaFdRaiz ('OP_eur_tree')
12	'Fertilization' ('OP_eur_tree')
13	'Placing plants protectors' ('OP_eur_tree')
14	'Seedling - a covacho' ('OP_eur_tree')
15	'Seedling - a lanço' ('OP_eur_ha')
16	'Open plants holes (30 x 30 x 30 cm)' ('OP_eur_tree')
17	'Open plants holes (40 x 40 x 40 cm)' ('OP_eur_tree')
18	'Selection of future trees' ('OP_eur_ha')
19	'Marking natural regeneration' ('OP_eur_ha')
20	'Control invasive plants' ('OP_eur_ha')

21 'Fire control in forestland' ('OP_eur_ha')
22 'Fire control in shrubland' ('OP_eur_ha')
23 'Marking out with stakes' ('OP_eur_ha')
24 'Cork stripping - virgin' ()
25 'Cork stripping' ()
26 'Sanitary prunning' ('OP_eur_tree')
27 'Prunning adult trees' ('OP_eur_tree')
28 'Formation prunning' ('OP_eur_tree')
29 'Shoot selection' ('OP_eur_tree')
30 'Reducing density in deciduous stands (> 8 years)' ('OP_eur_tree')
31 'Reducing density in umbrella pine stands (> 8 years)' ('OP_eur_tree')
32 'Reducing density in others conifers stands (< 8 years)' ('OP_eur_tree')
33 'Reducing density in others conifers stands (> 8 years)' ('OP_eur_tree')
34 'Harvesting shrubland for forestation - motorroçadora' ('OP_eur_ha')
35 'Control spontaneous plants in line' ('OP_eur_ha')
36 'Control total spontaneous plants' ('OP_eur_ha')
37 'Control total invasors plants' ('OP_eur_ha')
38 'Control high density' ('OP_eur_ha')
39 'Harvesting shrubland for forestation - corta matos de facas ou correntes ' ('OP_eur_ha')
40 'Harvesting shrubland for forestation - corta matos de martelos' ('OP_eur_ha')
41 'Harvesting shrubland for forestation - grade de discos' ('OP_eur_ha')
42 'Harrowing low cover of spontaneous vegetation' ('OP_eur_ha')
43 'Harrowing - breaking of clods' ('OP_eur_ha')
44 'Ripping - depth 3 m - 1 dente >= 60cm (*)' ('OP_eur_ha')
45 'Ripping - depth 3 m - 2 dentes >= 60 cm (*)' ('OP_eur_ha')
46 'Ripping - depth 3 m - 3 dentes >=60 cm (*)' ('OP_eur_ha')
47 'subsoiling - depth 3 m - 1 dente - tractor with moldboard' ('OP_eur_ha')
48 'subsoiling - depth 3 m - 3 dentes - tractor with moldboard' ('OP_eur_ha')
49 'Ditch and bund 3m with 30cm depth' ('OP_eur_ha')
50 'Ditch and bund 3m with 40cm depth' ('OP_eur_ha')
51 'Ditch and bund 3m with 50cm depth' ('OP_eur_ha')
52 'Ploughing' ('OP_eur_ha')
53 'Open channels for seedling' ('OP_eur_ha')
54 'Open holes for seedling' ('OP_eur_ha')
55 'Eucalyptus stump destruction' ('OP_eur_ha')
56 'Fertilization in line - wheels tractor' ('OP_eur_ha')
57 'Fertilization in line - caterpillar tractor' ('OP_eur_ha')
58 'Fertilization total - wheels tractor' ('OP_eur_ha')
59 'Fertilization total - caterpillar tractor' ('OP_eur_ha')
60 'Drip irrigation' ('OP_eur_ha')
61 'Control spontaneous plants' ('OP_eur_ha')
62 'Phytosanitary treatments' ('OP_eur_ha')
63 'Open forest roads' ('OP_eur_km')
64 'Improvement of forest roads' ('OP_eur_km')
65 'Open fire breaks' ('OP_eur_km')
66 'Improvement of fire breaks' ('OP_eur_km')
67 'Open water point' ('OP_eur_m3')
68 'Dam construction' ('OP_eur_m3')

APPENDIX 2 – OUTPUT VARIABLES DESCRIPTION

List of variables in the most important output files and the variables description.

<u>**output_yieldtable.csv**</u>

Ndead	Number of dead trees per hectare (ha^{-1})
N_ing	Number of ingrowth trees per hectare (ha^{-1})
Fw	Wilson factor – relative stand density measure (varies from 0.2 up to 0.4)
G	Stand basal area (m^2 ha^{-1})
dg	Quadratic mean diameter at breast height – corresponds to the dimeter of the average tree in the stand(cm)
Vu	Standing volume under-bark including stump (m^3 ha^{-1})
Vb	Volume of the bark including stump (m^3 ha^{-1})
Vst	Volume of the stump (m^3 ha^{-1})
V	Standing volume over-bark including stump (m^3 ha^{-1})
V_as1	Harvested volume of assortment 1 (m^3 ha^{-1})
V_as2	Harvested volume of assortment 2 (m^3 ha^{-1})
V_as3	Harvested volume of assortment 3 (m^3 ha^{-1})
V_as4	Harvested volume of assortment 4 (m^3 ha^{-1})
V_as5	Harvested volume of assortment 5 (m^3 ha^{-1})
Vharv	Total harvested volume sum of all assortments (thinning + final harvest)
Vtot	?
maiV	volume mean annual increment (m^3 ha^{-1})
iV	volume current annual increment (m^3 ha^{-1})
Ww	Stand wood biomass (Mg ha^{-1})
Wl	Stand leaves biomass (Mg ha^{-1})
Wb	Stand bark biomass (Mg ha^{-1})
Wbr	Stand branches biomass (Mg ha^{-1})
Wa	Stand aboveground biomass (Mg ha^{-1})
Wr	Stand root biomass (Mg ha^{-1})
WPmnuts	Stand pine-nuts biomass - stone pine (Mg ha^{-1})
Wtop	Stand residues biomass - top biomass (Mg ha^{-1})
Wtopbr	Stand residues biomass - top and branches biomass (Mg ha^{-1})
Wb_bic	Stand residues biomass - bark (Mg ha^{-1})
Wbrl	Stand residues biomass - leaves and branches (Mg ha^{-1})
C_seq_prod	Carbon sequestered in the products (Mg ha^{-1})
PC_tot	Total production costs from inside and outside the forestry wood chain and labour costs (seedling, seeds) (€)
PC_in	Production costs from inside the forestry wood chain (seedling, seeds) (€)
PC_out	Production costs from outside the forestry wood chain (fertilizers, fences,...) (€)
PC_lab	Production costs labour (€)

R_wood	Wood revenues (€)
R_biom	Biomass revenues (€)
R_Pmnuts	Pinenuts revenues (€)
NPV	Net present value (€)
NPVsum	Sum of the net present value (€)
EEA	? (€)

output_dd.csv

id_stand	Stand residues biomass - top and branches biomass (Mg ha^{-1})
id_presc	Carbon sequestered in the products (Mg ha^{-1})
year	Production costs from outside the forestry wood chain (fertilizers, fences,...) (€)
Thinning	Net present value (€)
Debark	Sum of the net present value (€)
0	Number of trees in the diameter class [0 - 2.5[(cm)
5	Number of trees in the diameter class [2.5 - 7.5[(cm)
10	Number of trees in the diameter class [7.5 - 12.5[(cm)
15	Number of trees in the diameter class [12.5 - 17.5[(cm)
20	Number of trees in the diameter class [17.5 - 22.5[(cm)
25	Number of trees in the diameter class [22.5 - 27.5[(cm)
30	Number of trees in the diameter class [27.5 - 32.5[(cm)
35	Number of trees in the diameter class [32.5 - 37.5[(cm)
40	Number of trees in the diameter class [37.5 - 42.5[(cm)
45	Number of trees in the diameter class [42.5 - 47.5[(cm)
50	Number of trees in the diameter class [47.5 - 52.5[(cm)
55	Number of trees in the diameter class [52.5 - 57.5[(cm)
60	Number of trees in the diameter class [57.5 - 62.5[(cm)
65	Number of trees in the diameter class [62.5 - 67.5[(cm)
70	Number of trees in the diameter class [67.5 - 72.5[(cm)
75	Number of trees in the diameter class [72.5 - 77.5[(cm)
80	Number of trees in the diameter class [77.5 - 82.5[(cm)
85	Number of trees in the diameter class [82.5 - 87.5[(cm)
90	Number of trees in the diameter class [87.5 - 92.5[(cm)
95	Number of trees in the diameter class [92.5 - 97.5[(cm)
100	Number of trees in the diameter class [97.5 - 102.5[(cm)
>102.5	Number of trees in the diameter class greater than 102.5 (cm)

output_annual.csv

year	year
V_Thin	Sum of thinned volume in all stands (m^3 ha^{-1})
V_harv	Sum of harvested volume in all stands (m^3 ha^{-1})