ForeMa DSS User Manual

About

ForeMa DSS is a desktop based decision support tool aiming to assess forest management and climate change impacts on multiple Ecosystem Services at a stand level. It incorporates SORTIE-ND, a spatially explicit and sensitive to climate change tree-level simulator for projecting forest dynamics, and linking functions to evaluate Ecosystem Services and potential risks. Detailed information about the implementation of the software can be found in Forests Cristal et al, 2018, “A Decision Support Tool for Assessing the Impact of Climate Change on Multiple Ecosystem Services”.

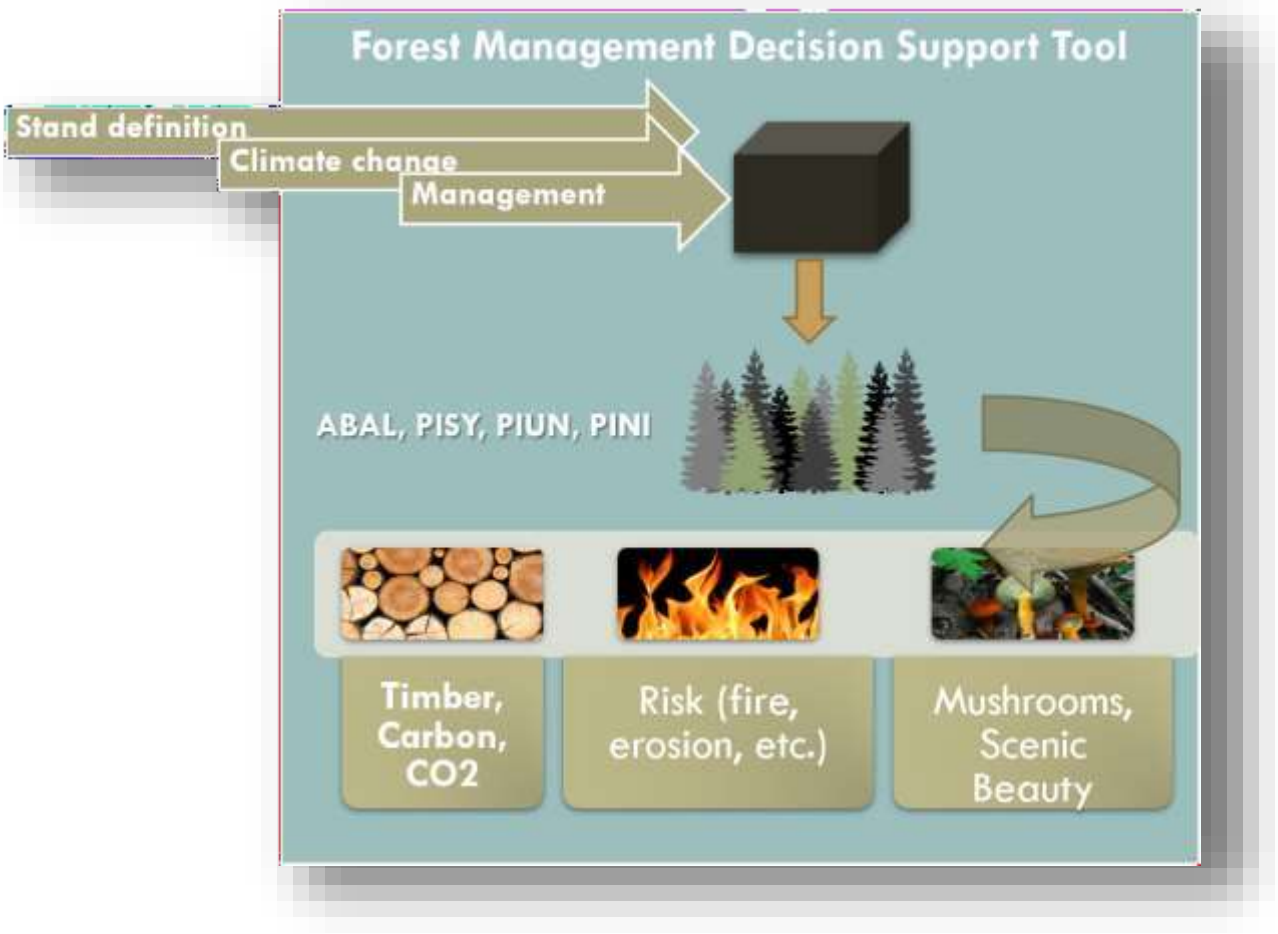

Figure 1. ForeMa DSS Conceptualization

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Basic concepts

Simulation horizon

Simulation horizon is the number of years to be simulated from the current year, year zero.

Stand description

ForeMa DSS operates at a stand level, where each stand is fixed at a size of 1ha. The attributes describing the stand, such as climate, geographic location, topography etc., should be given as input data for the simulation. To take advantage of the full functionality of the software, each stand should be described by the following attributes: forest id, stand id, latitude in degrees, total annual precipitation in mm and average annual temperature in degrees Celsius for the starting year, slope in degrees, elevation in meters, distance from road in meters, and aspect in grad.

The data can be either loaded in a tab delimited file, or inserted manually.

Trees distribution

The trees describe the current state of the stand. Trees are defined by their species and their Diameter at Breast Height (DBH) class distribution. Size classes are user defined and will be used to display the results a well. Trees data can be either loaded in a tab delimited format, or inserted manually in the corresponding interface.

Climate data

Climate data used in the system are temperature and precipitation. Annual mean temperature and annual precipitation are required to run the simulation.

To assess the climate change impact on the stand development, the simulation operates in two ways: either by using an exponential precipitation and temperature trend for the simulation horizon, or by importing future projections of monthly climate data directly.

For calculating the temperature and precipitation trend, the simulator uses the following formulas:

For the Temperature: $T = T1 + Bt^c$

where:

T is the annual temperature, in degrees C, at time t

T1 is the mean annual temperature value, as assigned in the initial parameters

B is the Temperature Change - B values of the Annual Precipitation parameter

C is the Temperature Change - C parameter

t is the time elapsed, in years, since the start of the run

Precipitation trend: $P = P1 + Bt^c$

where:

P is the annual precipitation, in mm, at time t

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P1 is the annual precipitation value at the start of the run, as assigned in the Plot parameters

B is the Annual Precipitation Change - B parameter

C is and the Mean Annual Precipitation Change - C parameter

t is the time elapsed, in years, since the start of the run

Parameters B and c are defined by the user. In the cases where climate should be considered constant, these parameters can be set to zero.

However, for more accurate calculations, monthly climatic data are required. Monthly average temperature and monthly total precipitation per each year of the simulation can be loaded directly in separate tab delimited files.

Management Alternatives

ForeMa DSS defines forest management alternatives in terms of number and intensity of thinnings. The basic attributes to be considered are: number of thinnings, thinning year (the year of simulation, not the age of the stand), amount to cut: number of trees, or percent of basal area to remove per each diameter class, type of thinning: from above or from below, and final cut for even-aged management.

Simulation

After defining the management alternatives, the system is ready to run the simulations. It can be done for one or multiple stands. The simulation interface allows to define which management alternatives to run, and the type of the outputs.

Outputs

The simulated data are stored in csv and xml files, and can be processed further independently, and also can be visualized in the ForeMa Intefrace. There are three output files organized as follows:

General simulation outputs: number of trees, average DBH, and average height per species and per each DBH class;

Harvest information: number of harvested trees, basal area, volume and price per species and dbh class;

Ecosystem Services outputs: biomass production, standing timber volume, carbon, CO2 emission, mushroom production, scenic beauty, potential fire damage etc. per each simulated year.

Within the system, the outputs can be visualized either in aggregated values per simulated years in form of graphs and tables, or in form of 2D stand interactive maps for each simulated year.

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Software Overview

Architecture

ForeMa basic components are the Input module, which at the moment is file based, SORTIE-ND– an external forests dynamics simulator, Ecosystem Services module, ForeMa UI and a browser-based 3D viewer (Figure 2).

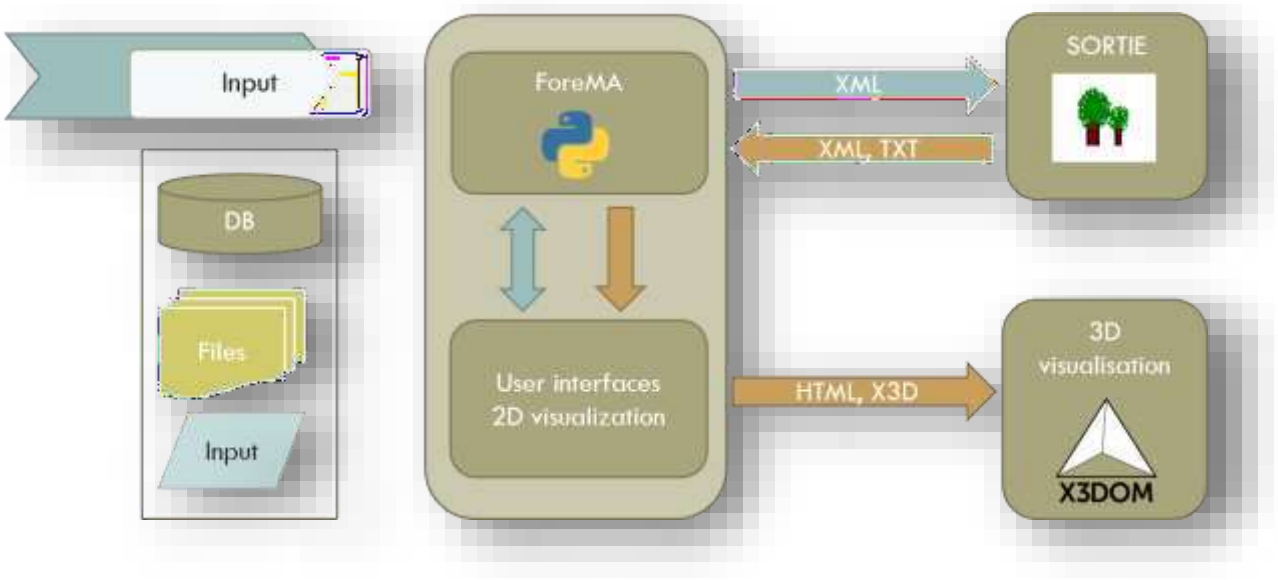

Figure 2. Software Architecture

User Interface

The user interface (UI) reflects the basic requirements of a modern software system according to ISO. The Menu bar contains file menu, Edit and Help. The toolbar contains shortcuts of most used functionalities. The UI body holds input data interfaces, simulation and visualization of the simulated outputs interfaces, which are arranged in UI tabs, as to facilitate the logical workflow. These are: Stand definition, Climate Scenario Definition, Alternative Generation, Simulation of the Alternatives (including ES simulation), and Visualization of the outputs. Finally, the status bar is located at the bottom of the UI

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Initial Stand UI

Stand description

The initial stand tab is used to input data referring to the initial state of the stand(s).

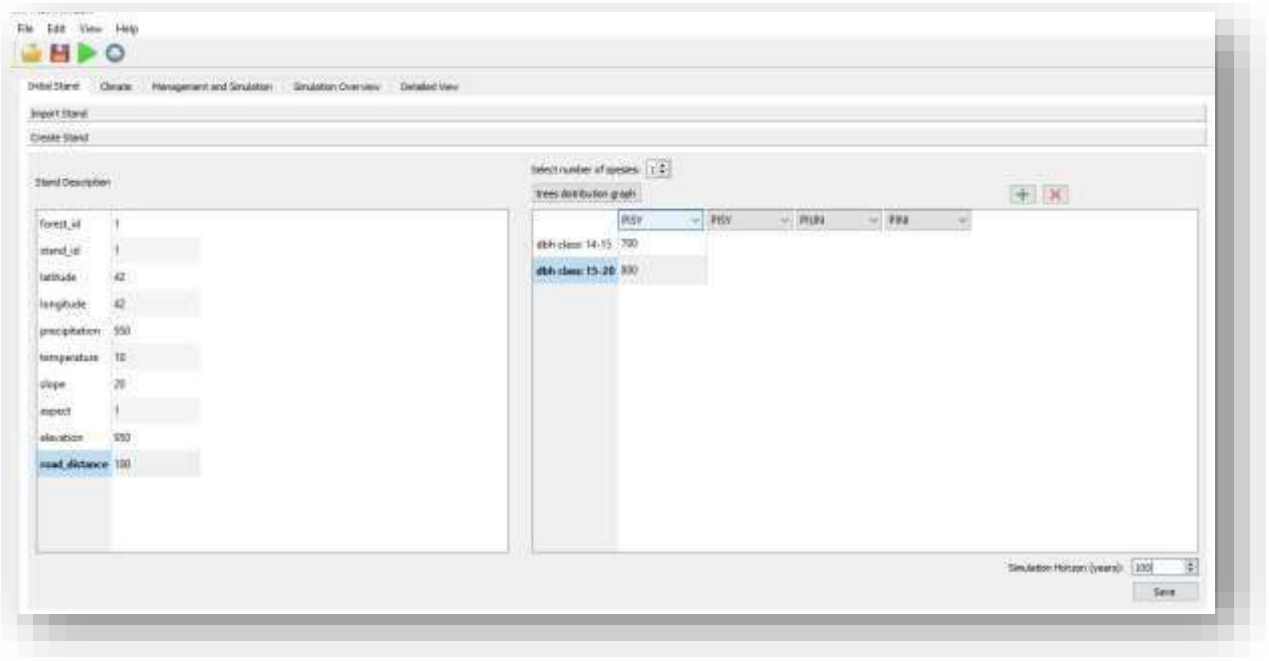

Figure 3 Stand UI

For the stand description, the required fields are:

- **Stand id**
- **Latitude in degrees**
- **Annual precipitation**
- **Average annual temperature**

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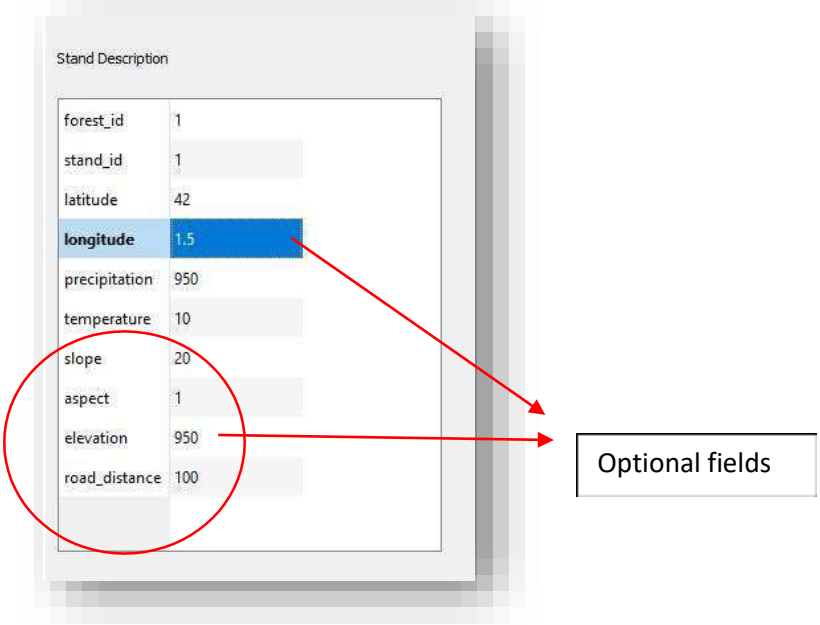
The optional fields include:

Slope (degrees), elevation (meters), distance from road (meters), aspect (grad).



The simulation can run without the optional fields, however, the results will be limited to the forest dynamics and the biomass production. The optional fields are used in the estimation of the ecosystem services and potential risks.

Trees description

The trees are described by their species and DBH, and are provided as number of trees per DBH class for each species.

It is possible to create stand data, or import them.

In the case of crating stand data, the first step would be to specify the number of species. In the trees distribution table, it is possible to select the desired species, change the dbh classes, add more rows/classes to the table, or delete rows, type the number of trees per dbh class per species, and finally, visualize the trees distribution graph (Figure 4).

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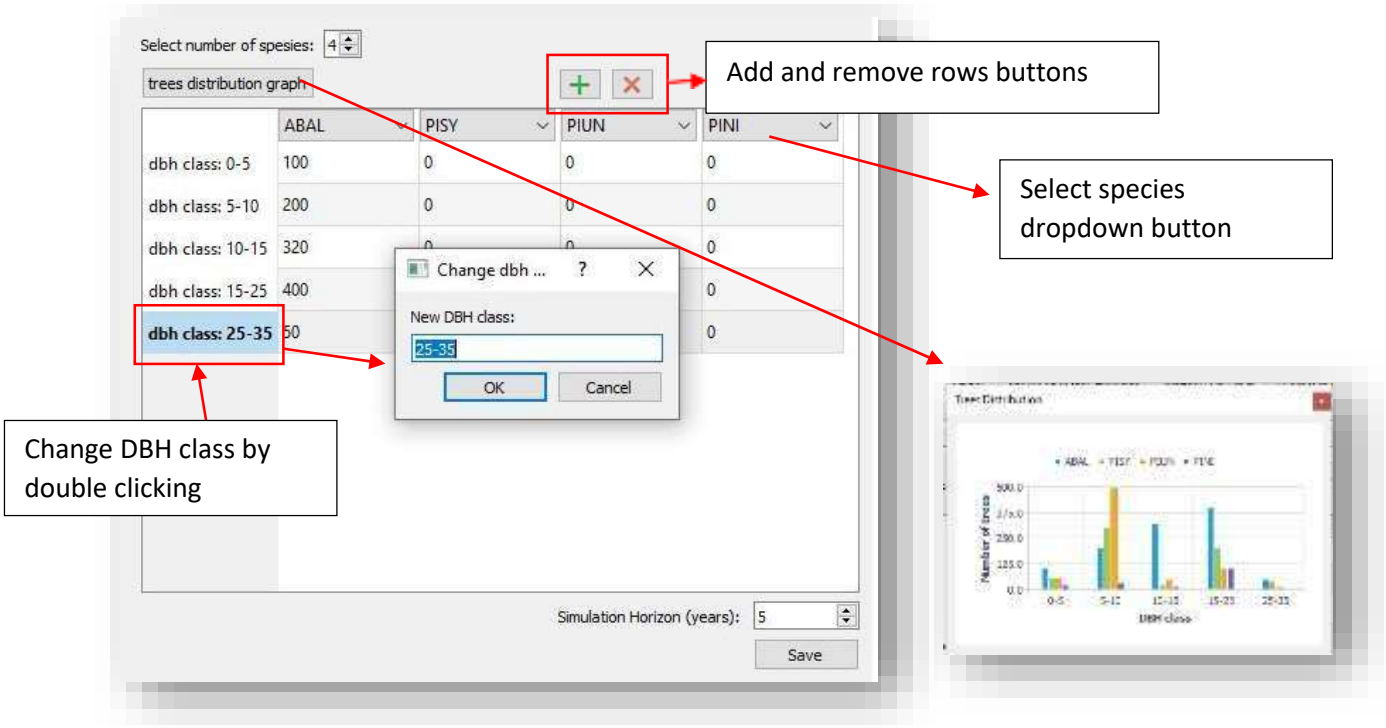

Figure 4. Create stand

Data import

Both stand description and trees description can be loaded to the system in a tab delimited file, or in an excel file. The structure should be as follows:

Table 1. Stand description file structure

Forest id	Stand id	Latitude (deg)	Total Annual Precipitation (mm)	Avg. annual temperature (^{0}C)	Slope (deg)	Elevation (m)	Dist. from road (m)	Aspect (grad)
1	1	46	800	8	30	900	500	200
1	2	47	600	10	20	500	1000	270

Table 2. Trees description file example

Forest id	Stand id	Species	DBH	Number of trees
1	12	PISY	15	750
1	12	PISY	20	800
1	23	PIUN	30	1100

The easiest way is to upload an excel file.

The “open template” button, opens an excel file, which can be modified and saved as a separate file. It is loaded then pressing the browse button, and shown in the interface. At this point, editing is not allowed. All the changes are done in the excel file.

Same as with the create stand window, it is possible to visualize the trees distribution button above the table (Figure 5)

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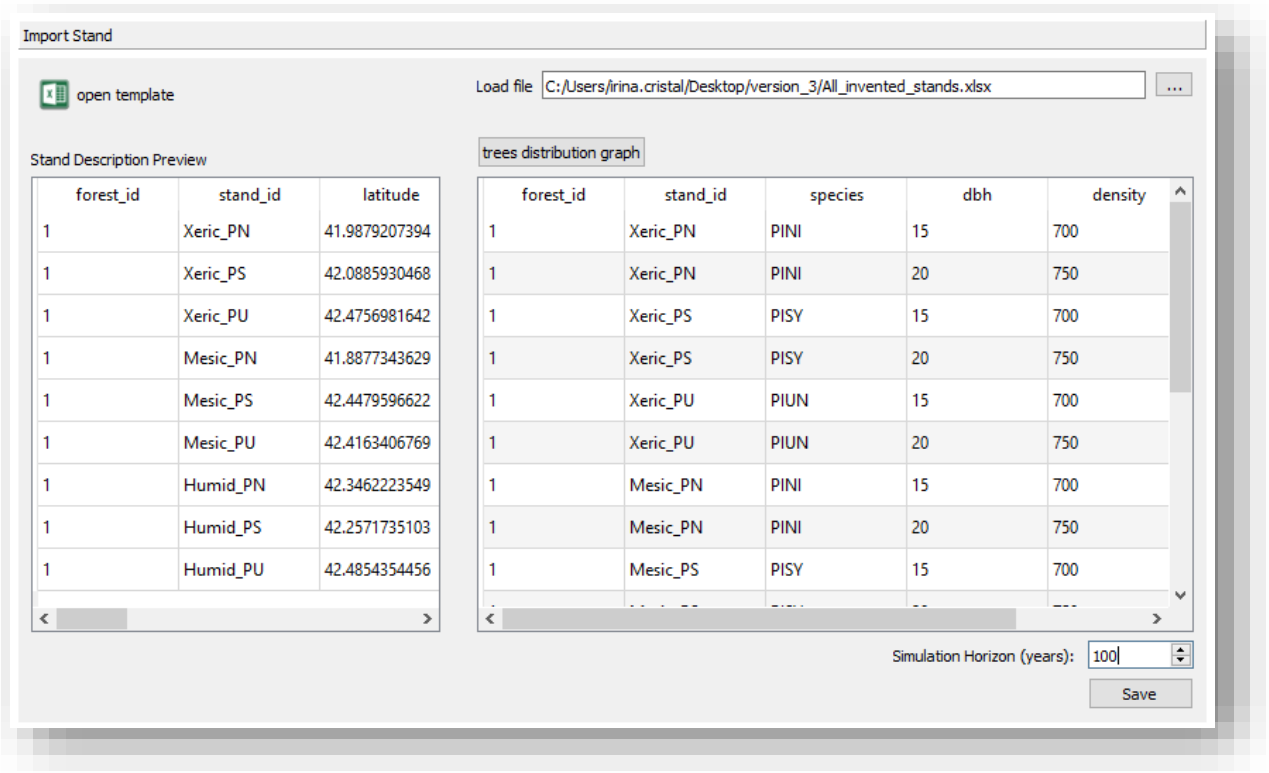

Figure 5. Upload stands UI

Climate Change UI

The climate change interface allows the user to define the future climatic scenarios for the simulation. Depending on the desired outputs, or availability of data, the system can offer a degree of flexibility.

No climate change

If the climatic data are unknown, or the climate change effect is not desired in the run, it can be specified in the interface.

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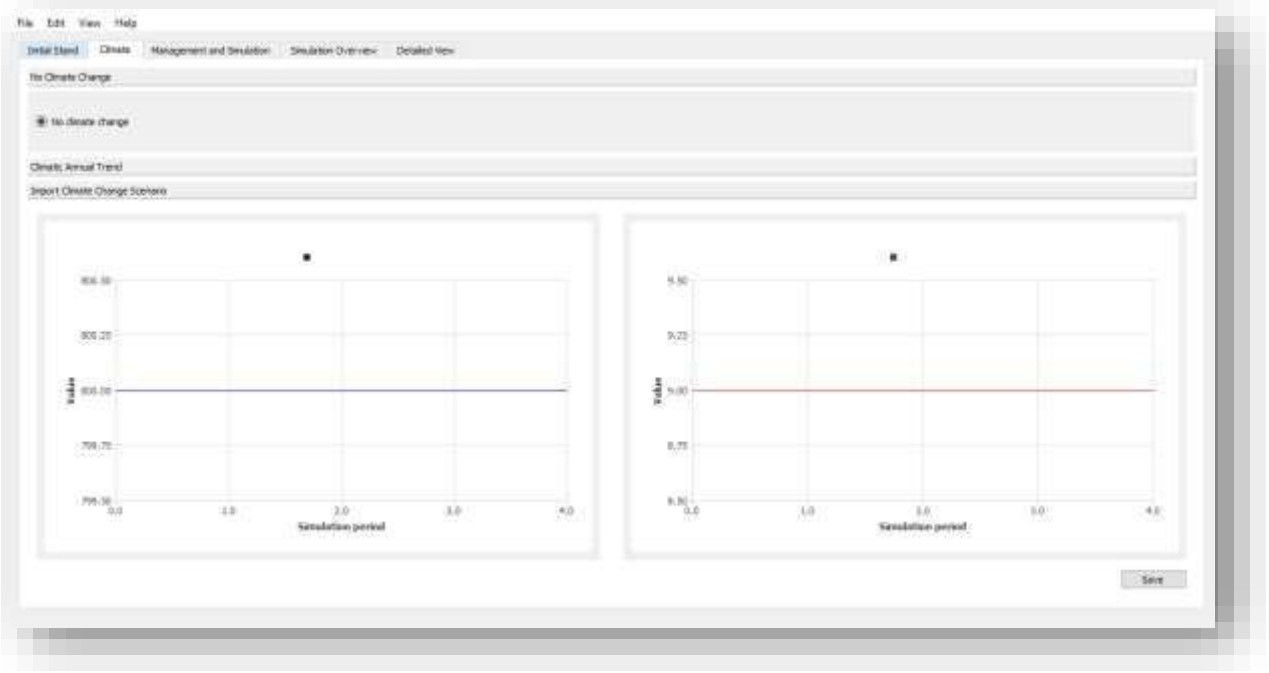

Figure 6. No Climate Change Option

Climatic exponential trend

Users can define the parameters B and C (see Climatic Data in Basic Concepts) for projecting precipitation and temperature trends in the run.

Press the “Apply” button to see the graphs, and “Save” to save the changes.

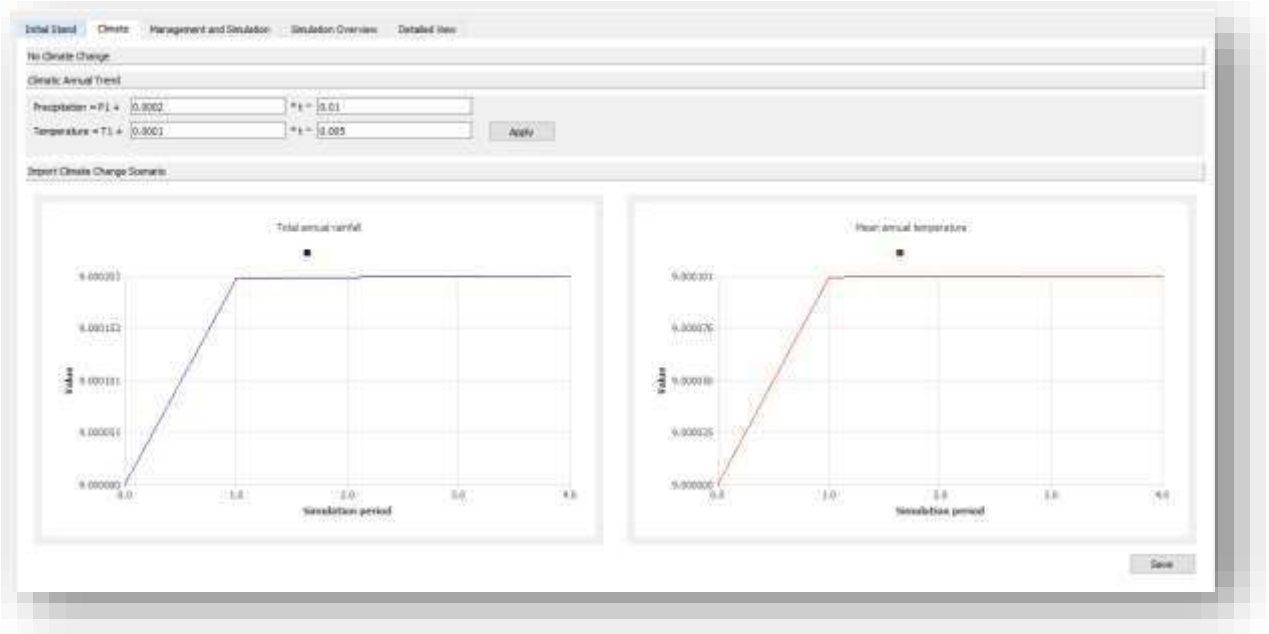

Figure 7. Climatic Trend Option

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Monthly climate change data

For more accurate simulations, projections of monthly precipitation and temperature are required. The structure of the files is shown in Table 3, where each row corresponds to each year of the simulation, and each column to each month of the year. The cells are the values either of monthly average temperature in degrees Celsius, or the total monthly precipitation in mm.

Table 3. Climatic data file structure

Year	01	02	03	04	05	06	07	08	09	10	11	12
2006	54.56	30.5	38.4	151.1	33.3	12.7	37.6	0.0	53.4	115.1	102.6	78.
2007	48.1	12.8	4.6	100	58.4	160.2	6.4	70.6	158.4	71.7	39	66
2008	57.9	10.6	23.2	84.1	94.3	86.0	35.4	10.9	26.8	120	59.2	41

Figure 8. Load External Climate Change files

Management UI

The management can be created either by manually specifying the management options in the interface (Figure 9), or by uploading an excel file containing multiple management alternatives.

For creating the management alternative, first step would be to select the number of thinnings. The years of thinning should be introduced in the corresponding fields. ***The years correspond to the years of the simulation, not the age of the sand.***

Other options are, “Apply to species”, where the user can specify the species for which the thinning will be applied. The default option in “All”. The “Thinning type” gives two options: percent of basal area, or percent of density to be cut. “Tallest first” refer to from above or from bellow thinning.

In the next table, the thinning amount is specified for each thinning year. The amount is categorized

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per four DBH classes, where each class can be modified by double clicking on it.

Finally, there are dissemination and final cutting options, where the year and amount to cut has to be introduced.

If the simulation is to be done without management, the user should tick the “No Management” box.

The “Save as” button will save the management alternative for the number of stands created in the previous session. The dialog will ask for the path to save the alternative. Good practice is to create a new folder in the “data/sortie_input” directory.

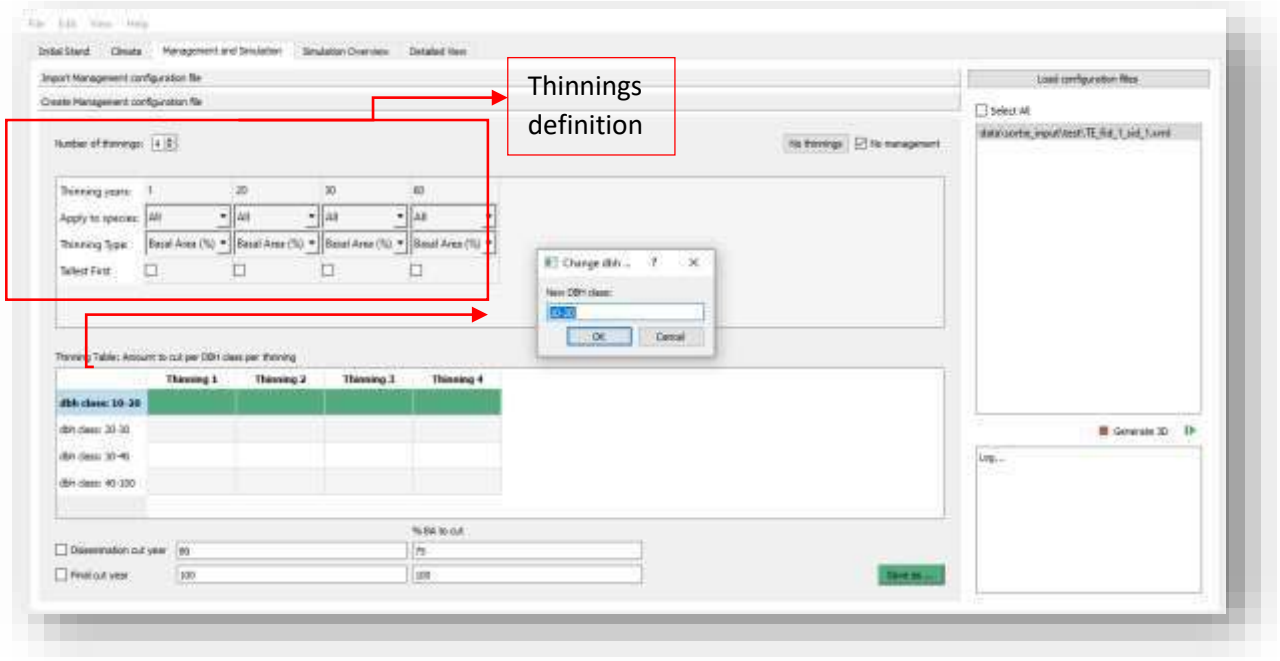

Figure 9. Create Management alternative

The management interface allows importing excel files. The excel template can be open and modified accordingly, then loaded to the interface. The figures below show the structure of the file: the sheet “Management” contains all the managements differentiated by their id value and the thinning options per each thinning year (Figure 10).

The “Link” sheet, specifies to which stands the managements should be applied (Figure 11).

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	A	B	C	D	E	F	G	H	I
1						Amount to cut per DBH class			
2	management_	thinning_year	thinning_type	apply_to_species	tallest_first	15-25	25-35	35-45	45-100
3	1	10	percent of basal area	All	yes	25	25	25	25
4	1	20	percent of basal area	All	no	20	20	20	20
5	2	20	percent of basal area	All	yes	10	10	10	10
6	2	50	percent of basal area	All	yes	35	35	35	35
7	2	75	percent of basal area	All	yes	65	65	65	65
8	2	100	percent of basal area	All	yes	100	100	100	100
9	3	50	percent of density	All	no	30	30	30	30
10									
11									
12									

Figure 10. Upload Management file: Management Sheet

	A	B	C
1	management_id	stand_id	forest_id
2	1	All	1
3	2	All	1
4	3	All	1
5	4	All	1
6			
7			
8			

Figure 11. Upload Management file: Link Sheet

The management file has to be loaded to the Forema interface, Management and Simulation tab, *"Management configuration file"* option (Figure 12)

When pressing the Save as button, good practice is to save the alternatives in a separate file inside the "data/sortie_input" directory.

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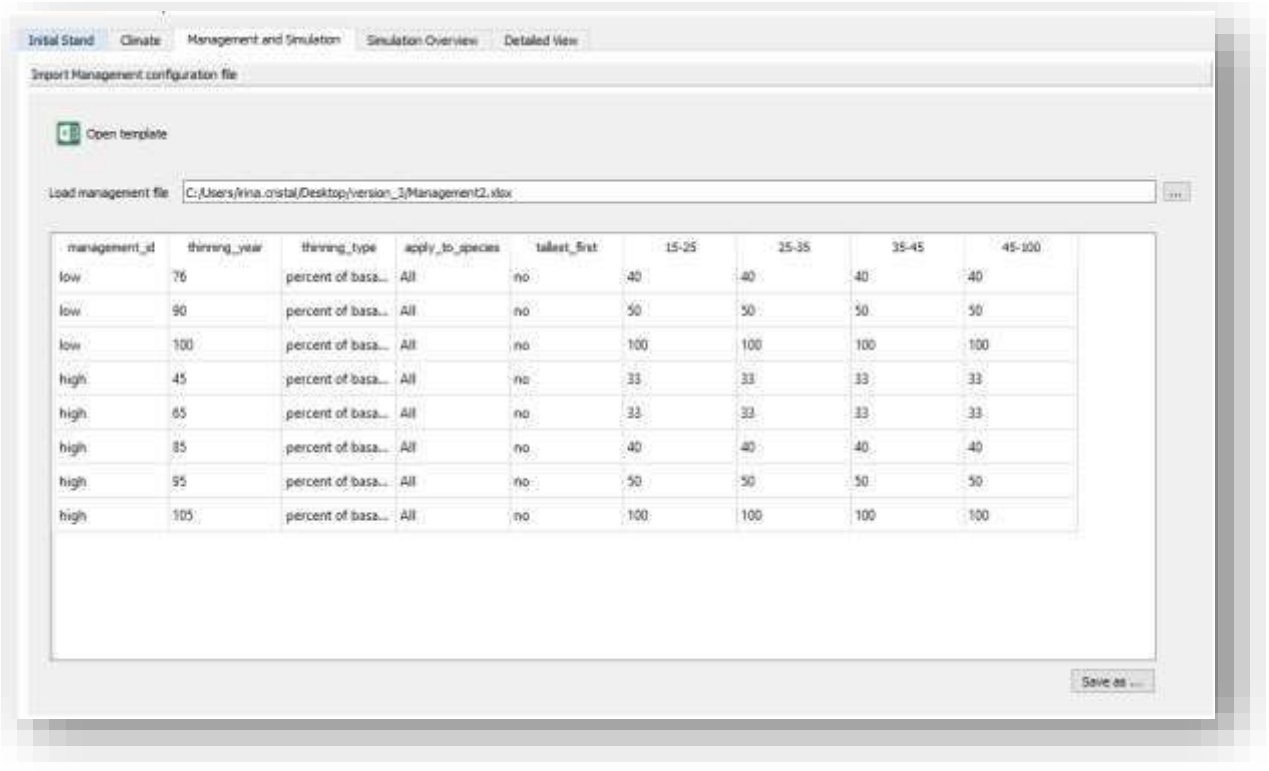

management_id	thinning_year	thinning_type	apply_to_species	tallest_first	15-25	25-35	35-45	45-100
low	76	percent of basa...	All	no	40	40	40	40
low	90	percent of basa...	All	no	50	50	50	50
low	100	percent of basa...	All	no	100	100	100	100
high	45	percent of basa...	All	no	33	33	33	33
high	65	percent of basa...	All	no	33	33	33	33
high	85	percent of basa...	All	no	40	40	40	40
high	95	percent of basa...	All	no	50	50	50	50
high	105	percent of basa...	All	no	100	100	100	100

Figure 12. Import Management configuration file.

Simulation

The simulation interface in integrated into the Management and Simulation tab (Figure 13).

After saving the management alternatives, the alternatives path will appear in the text box on the right side of the screen. By selecting the path and pressing the run button on the bottom of the textbox, the simulator will be activated. Simulations will be performed for both stand dynamics and Ecosystem Services in one run. If desired, 3D models of the stand can be created after the simulation, by selecting the alternative and pressing the “Generate 3D” button.

The text box on the right bottom will show the information of the simulated alternatives or the errors, if something went wrong.

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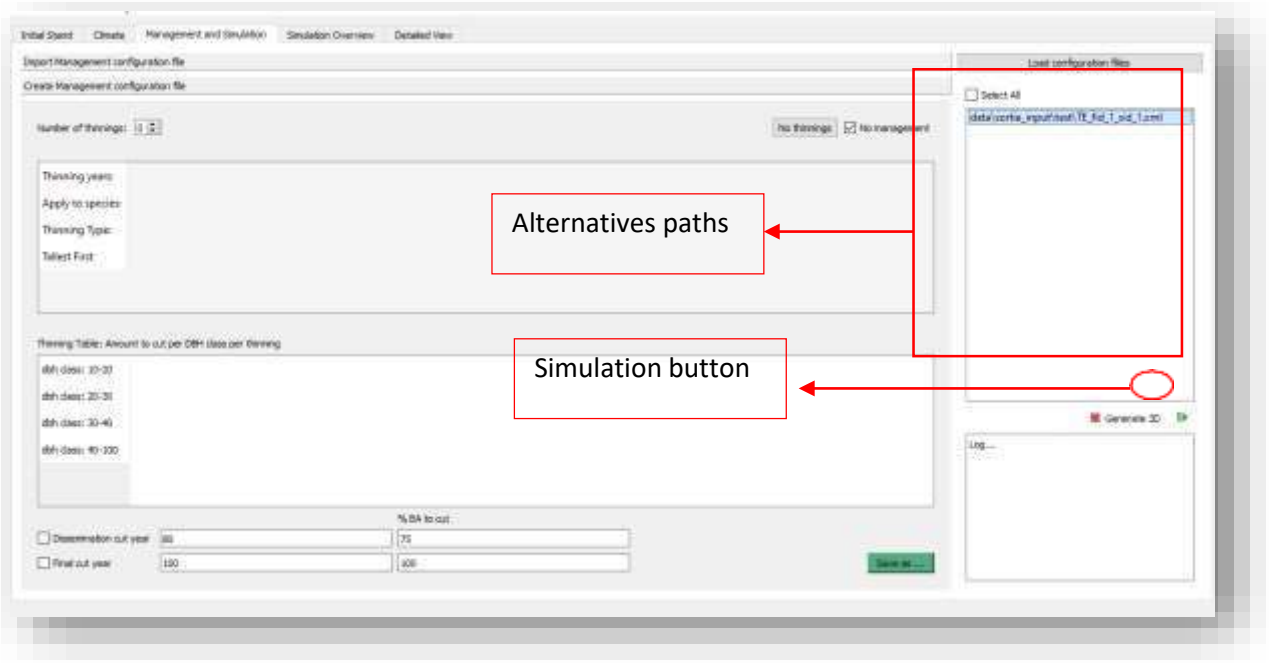

Figure 13. Simulation

Visualization of the outputs

The outputs

The results of the simulation are organized in different formats. The general tree is the following:

├──data folder (contains the input and the output folders)

| ├──output folder (contains all the simulation outputs)

| | ├──Alternatives folder (contains all the alternatives created in one session)

| | ├──Alternative folder (stand id)

| | | ├──xml folder (same name as the upper level folder; contains xml files)

| | | └──XY folder (csv or txt files, used for the 3D simulation)

| | | └──ES.csv (csv file contains ecosystem services values per simulation year)

| | | └──General.csv (csv file contains general simulation info organized per dbh class)

| | | └──Harvest.csv (csv file contains harvest info organized per dbh class)

| | | └──Sum_xxx.out (tab delimited file contains info aggregated per simulation year)

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The simulation overview tab (Figure 14) reads the information from the ES.csv file and generates graphs of the variables, such as number of trees, Basal Area, Biomass and other Ecosystem Services, per simulation year. If management was applied, then Harvest table will be populated with Timber Volume and Roadside price per thinning year. This info is extracted from Harvest.csv.

The alternatives can be compared in pairs, by loading two alternatives (ES.csv files) in the corresponding fields.

All the output files (except xml files) can be visualized in Excel

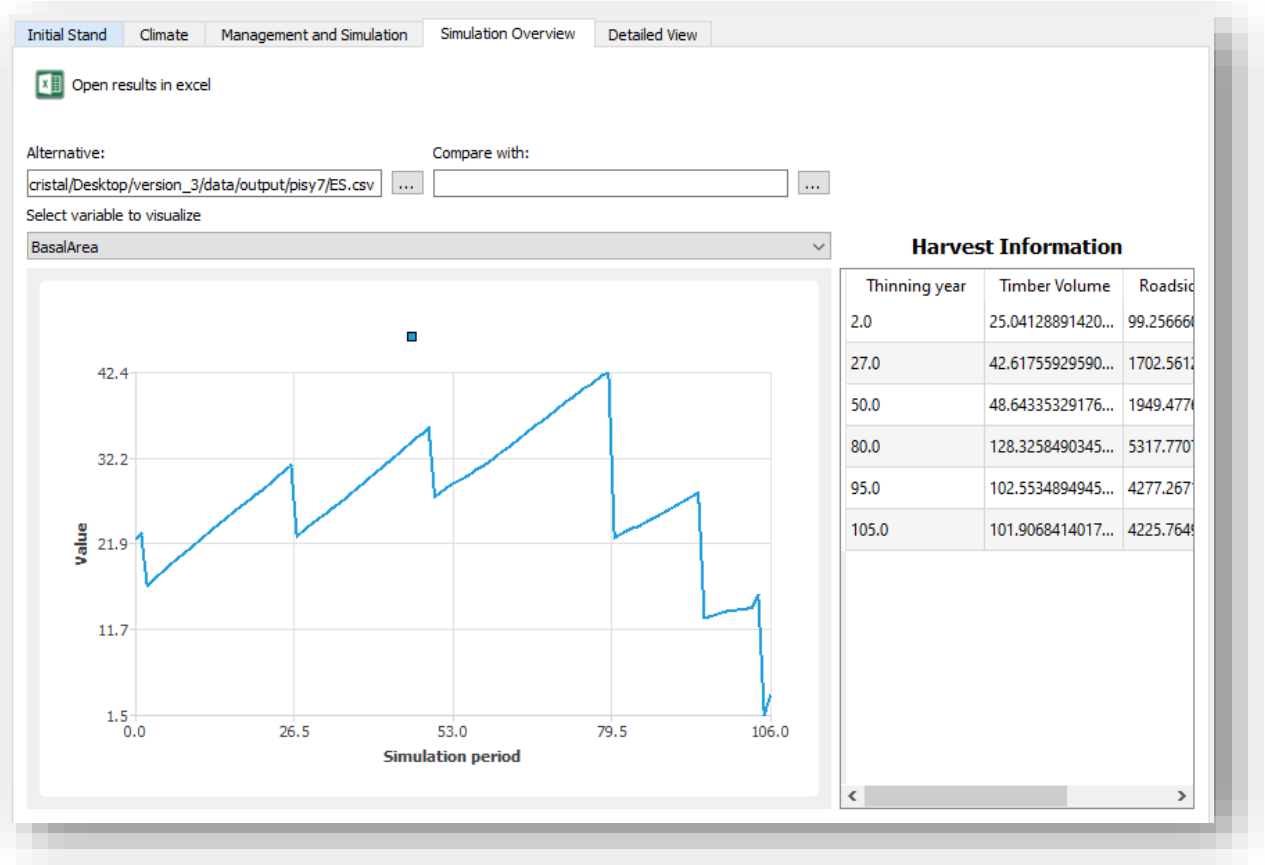

Figure 14. Simulation Overview tab

Simulation detailed view

The detailed view draws the trees in a 2D arbitrary coordinate system. Additionally, trees distribution graph and Ecosystem Services values are provided per each simulated year as shown in Figure 15.

The folder that should be loaded in order to visualize the map is the one containing the xml files.

In addition to the 2D representation, it is possible to generate 3D scenes of the stand (Figure 16).

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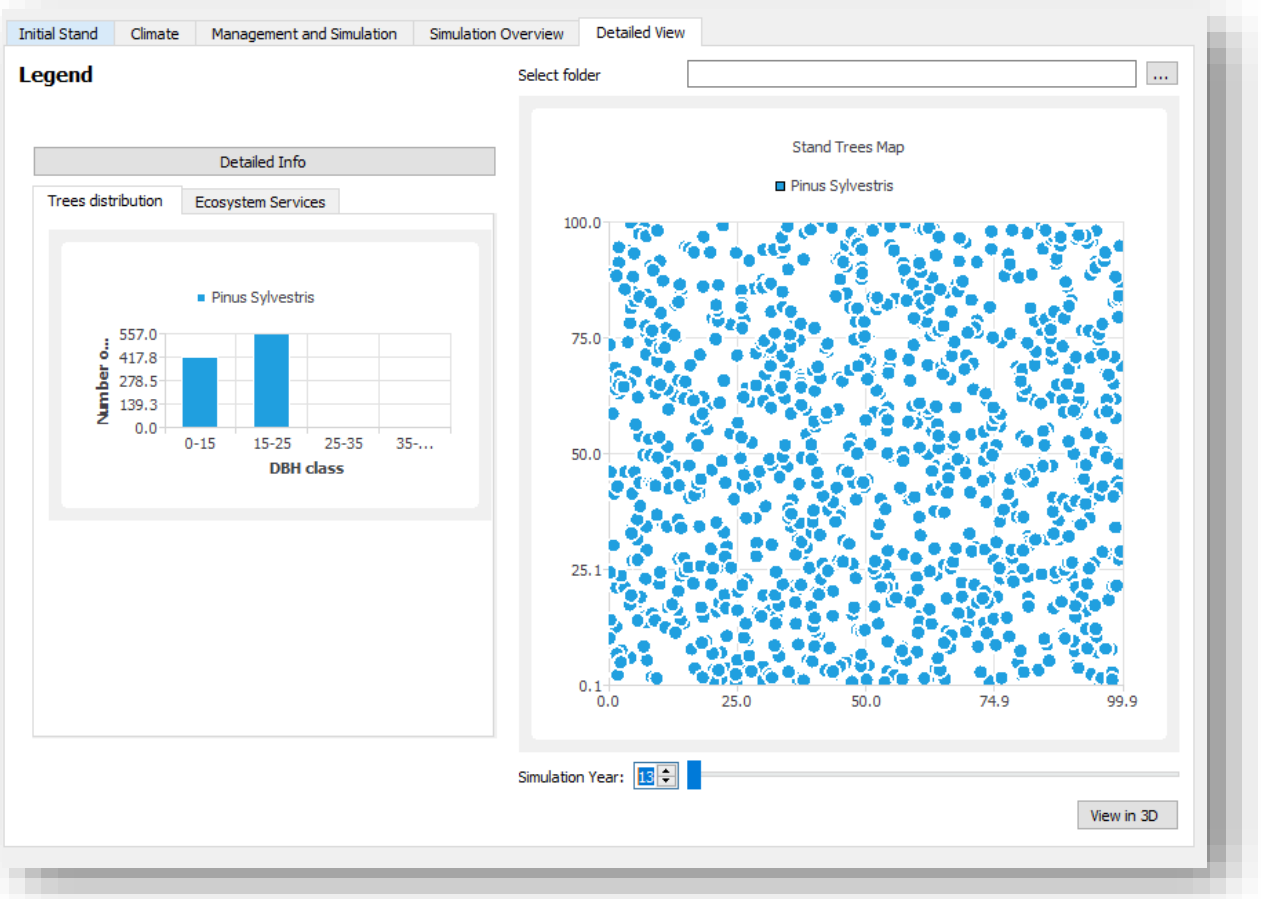

Figure 15. Detailed View Interface

Figure 16. 3D Simulation of the stand

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