



Help getting started manual



Manual Version of May 8, 2019

Introduction

Dear forest modeler,

Welcome to the *FORMIND - Help getting started manual*. Think of this as a work flow, providing you everything you need to know in order to start simulating forest growth dynamics by using the FORMIND forest model. The best way to get familiar with a program is learning by doing! By the end of this manual you will be able to apply the FORMIND model for your own forest site.

This manual is going to provide you with a brief overview of the model's structure and main processes. It also explains how to run FORMIND and how to compile the source code of the main model processes. As part of the tutorial, we introduce you to some exemplary FORMIND projects for developing your own parameterization. You will be guided through executing your first FORMIND forest simulation and viewing simulation results for an Amazonian tropical forest. Once this is running on your computer, our tutorial will then guide you through how to parameterize FORMIND for your own project. At the end, we will give you a brief overview of the currently downloadable source code files.

If at any point you get stuck or are confused while executing the tutorial, please let us know by sending an email to info@formind.org. Please also send us any suggestions. We are grateful for ideas! Additionally, if you are interested in further information about the FORMIND forest model itself, or any of the forest sites where FORMIND has been applied so far, please visit our website: www.formind.org

With best regards,

The FORMIND-developers

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1. Overview of the forest model FORMIND

In this chapter, we will give a short overview of the basic model structure as well as main processes. For a full model description, please read FISCHER ET AL. (2016)¹ or go to www.formind.org. The FORMIND-Handbook contains the entire range of different model versions, which can be currently applied (i.e. choices of different geometries of the vegetation, climatic zone, or various disturbance types). You find the FORMIND-Handbook and FISCHER ET AL. (2016) in the literature-folder.

FORMIND is an individual-based, forest gap model that is able to simulate the growth of species-rich forests (Fig. 1).



Fig. 1: Progressive succession of a forest gap.

Individual-based means that growth is calculated for each tree individually. Trees in highly diverse forests are aggregated into different plant functional types in order to facilitate the parameterization and to reduce computing time.

The simulation area (1ha to 50ha) is divided into 20m x 20m patches (Fig. 2). Patches are implemented in order to simulate forest structure and dynamics. Gaps can occur due to dying trees or external disturbances like fire or landslides. Once a gap has formed, pioneer species (light-demanding) can be established (Fig. 1).

For forests with high species richness, e.g. tropical rainforests, an aggregation of tree species into functional groups is useful. So called plant functional types (PFTs) are aggregated by light demands (e.g. light-demanding pioneer, shade-tolerant climax species, or intermediate) and maximum growth height.

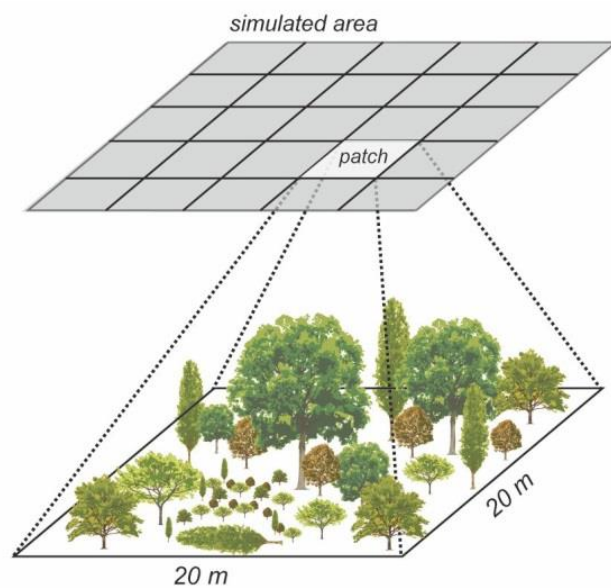


Fig. 2: FORMIND patch structure.

Within each simulated time step, the following main processes are calculated (Fig. 3.):

¹ Fischer, R., Bohn, F., Dantas de Paula; M., Dislich, C., Groeneveld, J., Gutiérrez, A.G., Kazmierczak, M., Knapp, N., Lehmann, S., Paulick, S., Pütz, S., Rödig, E., Taubert, F., Köhler, P., Huth, A. (2016): Lessons learned from applying a forest gap model to understand ecosystem and carbon dynamics of complex tropical forests. *Ecol. Modell.* 326, p. 124-133. doi:10.1016/j.ecolmodel.2015.11.018

- **Establishment:** Seeds are distributed over the forest area. If light conditions are suitable, a new individual can establish and competes for light and space in a forest patch.
- **Growth:** The growth of an individual is determined by its gross primary productivity (GPP), respiration and type-specific physiological parameters.
- **Mortality:** An individual can die due to a specific mortality rate. If one tree falls, neighboring trees of its patch can be damaged as well. Additional mortality can also be activated in relation to tree density or growth rate.
- **Competition for light:** The main driving factor of the model is light. Light decreases within the forest in order to include competition of light between individuals.
- **Environmental limitations (optional):** Depending on its latitude, forest dynamics can be influenced by additional climatic variables like precipitation and temperature.
- **Disturbances (optional):** FORMIND enables to include different disturbance types like fire events, landslides, logging and fragmentation.
- **Carbon Cycle:** The model calculates the gross primary production, respiration and net primary production for each tree individually. Based on this the carbon balance for a whole forest area can be calculated (including soil respiration and net ecosystem productivity NEP).

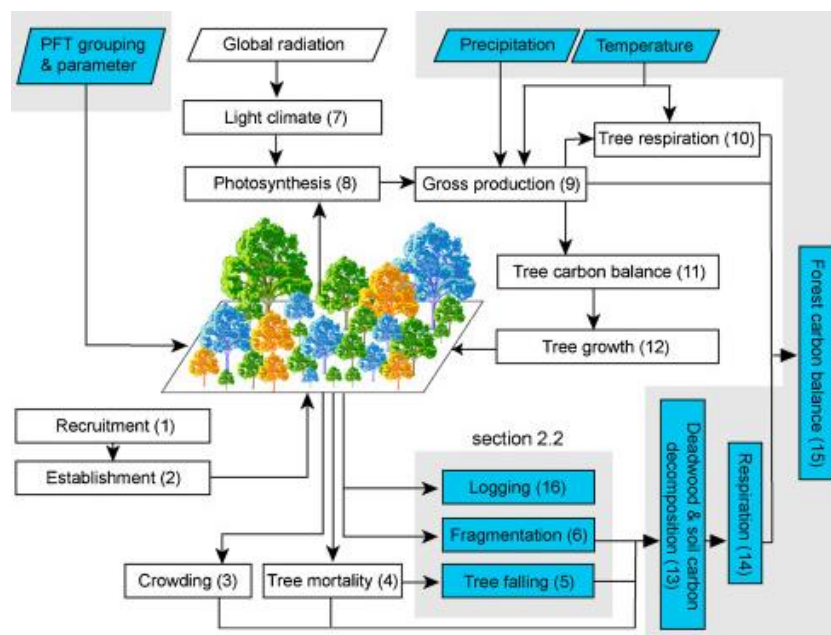


Fig. 3: The basic concept of FORMIND (white) and its extensions required for certain applications (blue). Boxes show physiological and demographic processes with numbers in brackets representing their scheduled flow. Parallelograms indicate important information (Fischer et al. 2016).

2. Before you start

FORMIND is available for Windows XP/7/8/10 and Linux GCC. You find the executable program in *Formind_Model\bin* and compilable source code files of basic FORMIND processes (Fig. 3 white boxes) in *Formind_Model\bin\src*.

What is required?

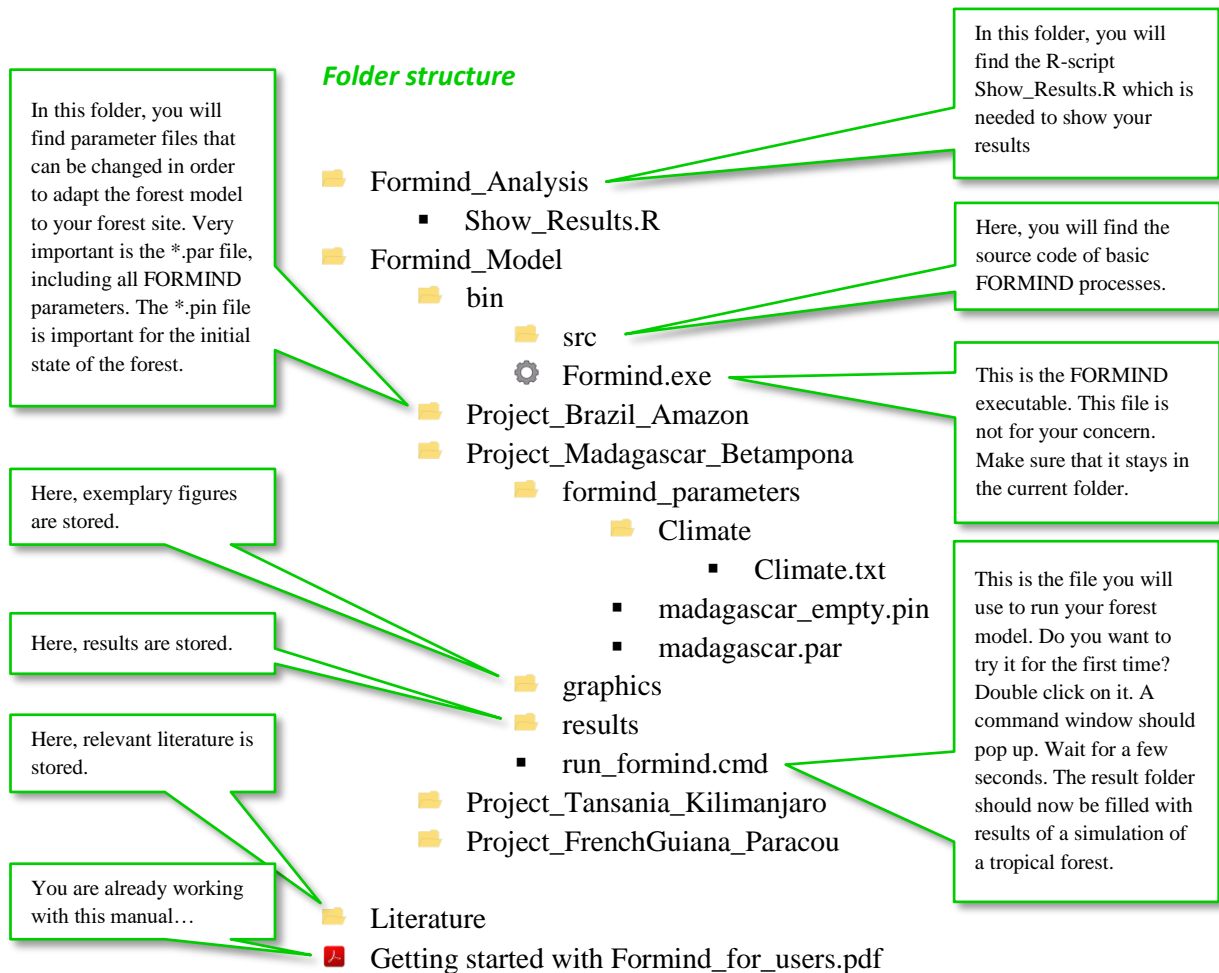
You will need a text editor such as the common windows Notepad, or the more advanced Notepad++ (<https://notepad-plus-plus.org/download/>) to edit parameter and result files. Make sure to install the current version of Notepad++. Notepad++ is a free editor.

FORMIND gives out simulation results in *ASCII* files. We have prepared an R-script which will ingest the results files and give a quick overview of your results. Install R from <https://www.r-project.org> as well as RStudio from <https://www.rstudio.com/products/rstudio/download/>.

3. Running FORMIND for the first time

3.1. The folder structure of FORMIND

All of the files that you need to get FORMIND running on your Windows computer are located in the folders that you downloaded along with this tutorial. Listed here is the folder structure of the downloaded-folder:



... Don't worry, if you haven't completely understood, yet. We'll guide you to your own forest model step by step.

3.2. Starting your first simulation

Run the forest model for the first time by executing:

```
Formind_Model\Project_Brazil_Amazon\run_formind.cmd
```

A command window should pop up. “Simulation finished” indicates the end of simulation. Please push a button and the window will close automatically.

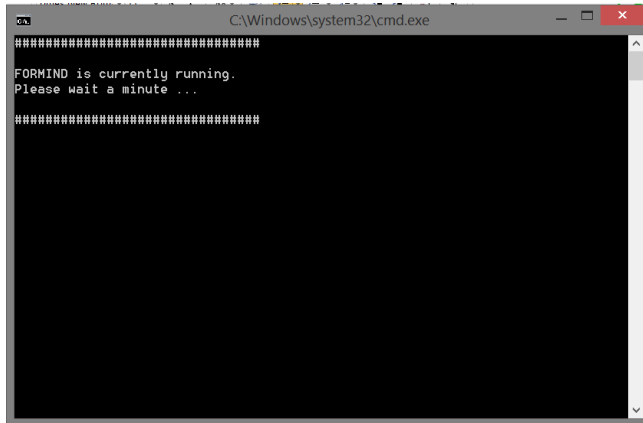


Fig. 4: Command window that pops up after executing `run_formind.cmd`

Some new files were created in the *Project_Brazil_Amazon* folder:

sterr.txt	Gives out errors and warnings
stout.txt	Documents the simulation run

Is `sterr.txt` empty?

The program ran successfully and you are ready to see some results.

Does `sterr.txt` give out warnings?

This is okay for the moment, but please let the FORMIND-developers know (info@formind.org).

Does `sterr.txt` give out errors?

The program has not run successfully. Please contact the FORMIND-developers for assistance (info@formind.org).

This was your first FORMIND simulation run. You will find all simulation result files in the folder *Project_Brazil_Amazon\results*.

3.3. Visualizing your simulation results

Now that the simulation was executed successfully, you can start visualizing the simulation results. The *results* folder should now contain some files, which can be opened using any ASCII compatible text editor.

For now, our main focus of interest will be the result file of the aboveground biomass, named *generalAmazonianForest_3pft.bt*. With this as an example, we will guide you either through (1.) Notepad++ or (2.) MS Excel, and (3) R-Studio in order to provide an overview of how to read and

produce graphs of the simulation results of FORMIND. We will then have a look into this result file to explain how to interpret its content.

Besides Notepad++ and MS Excel, please note that there are several more possibilities to work with the result files of FORMIND, such as Python, SPSS, etc. If you feel confident, feel free to use one of those programs on your own.

1. Using Notepad++ to open result files.

The steps are similar when using other simple text editors. To open the file *generalAmazonianForest_3pft.bt* with Notepad++, please click right on your mouse and choose Edit with Notepad++.

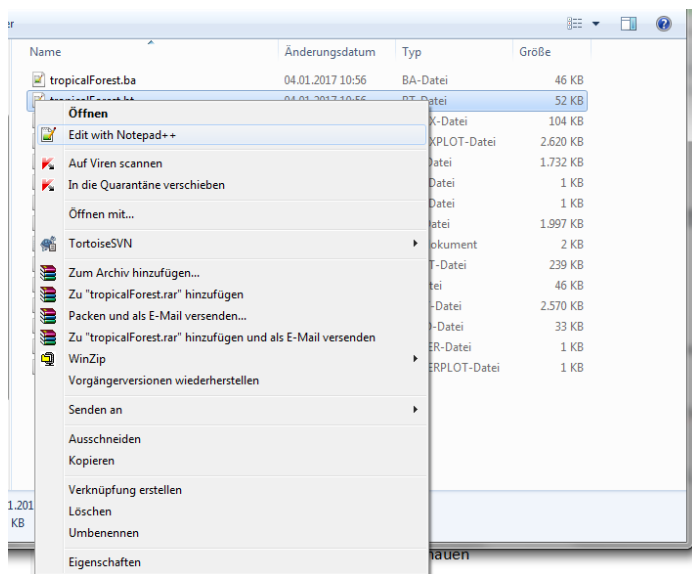


Fig. 5: Please choose “Edit with Notepad++”.

Notepad++ opens and shows the content of the *generalAmazonianForest_3pft.bt* file. The first three lines of text show the description of each variable, and the values are produced in the scientific notation (power of 10). The first column is indicating the simulation time and the following ones are total values and in sequence for each plant functional type individually. Values are always shown as an average per hectare. The file structure is similar for all result files.

In this example, we have the result file of the aboveground biomass, named *generalAmazonianForest_3pft.bt*. The first three rows characterize its content with line 1 giving a general description and rows 2 and 3 describing the columns' headers (either with long descriptions including units (line 2) or with short descriptions (line 3). Starting from row 4 downwards, the simulation results of the aboveground biomass are listed, with each row representing one time step. The columns contain the following in read direction: simulation time (1), total aboveground biomass of the simulated forest stand (2), aboveground biomass of each PFT (here, three plant functional types, see chap. 1), data about commercial use can be ignored for now (6-7), and mean wood density (8; averaged over aboveground biomass). When scrolling down to time step 300 (last row), you will find biomass values for the old growth forest stand. In our example this is about 258 t/ha.

Time [a]	Total biomass [t_ODM1 ha-1]	Total biomass per PFT 1 [t_ODM1 ha-1]	Total biomass per PFT 2 [t_ODM1 ha-1]	Total biomass per PFT 3 [t_ODM1 ha-1]	Total biomass per NonCommercial [t_ODM1 ha-1]	Total biomass per Commercial [t_ODM1 ha-1]
0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
1.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00	0.000000e+00
2.000000e+00	6.548121e-01	2.707502e-01	2.318732e-01	1.521887e-01	6.548121e-01	0.000000e+00
3.000000e+00	1.798952e+00	7.923040e-01	6.394711e-01	3.671773e-01	1.798952e+00	0.000000e+00
4.000000e+00	3.808156e+00	1.836946e+00	1.332582e+00	6.386282e-01	3.808156e+00	0.000000e+00
5.000000e+00	6.762774e+00	3.541427e+00	2.233413e+00	9.879340e-01	6.762774e+00	0.000000e+00
6.000000e+00	1.115030e+01	6.155544e+00	3.569700e+00	1.425055e+00	1.115030e+01	0.000000e+00
7.000000e+00	1.705017e+01	9.807501e+00	5.223782e+00	2.018883e+00	1.705017e+01	0.000000e+00
8.000000e+00	2.446159e+01	1.438396e+01	7.377223e+00	2.700399e+00	2.446159e+01	0.000000e+00
9.000000e+00	3.425289e+01	2.060454e+01	1.008591e+01	3.562447e+00	3.425289e+01	0.000000e+00
10.000000e+00	4.389244e+01	2.712582e+01	1.231457e+01	4.452050e+00	4.389244e+01	0.000000e+00
11.000000e+00	5.391015e+01	3.328913e+01	1.532568e+01	5.295341e+00	5.391015e+01	0.000000e+00
12.000000e+00	6.415019e+01	3.973703e+01	1.813653e+01	6.276631e+00	6.415019e+01	0.000000e+00
13.000000e+00	7.477088e+01	4.726602e+01	2.052525e+01	7.227451e+00	7.477088e+01	0.000000e+00

Fig. 6: FORMIND output (simulated biomass) in Notepad++.

2. Using MS Excel to open result files.

Alternatively, the result file *generalAmazonianForest_3pft.bt* can be opened with MS Excel.

Before you import the simulation results into MS Excel, it is necessary to set the decimal separator in the Excel-options to “.” (Watch out in a non-English operating system!). Then, load the result file *generalAmazonianForest_3pft.bt* into MS Excel per drag and drop.

As the results file’s columns are separated with tabulators, each column and row will be arranged automatically (see figure below). The content of the result file is the same as explained in the Notepad++ section.

Time [a]	Total biomass [t_ODM1 ha-1]	Total biomass per PFT 1 [t_ODM1 ha-1]	Total biomass per PFT 2 [t_ODM1 ha-1]	Total biomass per PFT 3 [t_ODM1 ha-1]	Total biomass per NonCommercial [t_ODM1 ha-1]	Total biomass per Commercial [t_ODM1 ha-1]
0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
1.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2.00E+00	6.55E-01	2.71E-01	2.32E-01	1.52E-01	6.55E-01	0.00E+00
3.00E+00	1.80E+00	7.92E-01	6.39E-01	3.67E-01	1.80E+00	0.00E+00
4.00E+00	3.81E+00	1.84E+00	1.33E+00	6.39E-01	3.81E+00	0.00E+00
5.00E+00	6.77E+00	3.54E+00	2.23E+00	9.88E-01	6.77E+00	0.00E+00
6.00E+00	1.12E+01	6.16E+00	3.57E+00	1.43E+00	1.12E+01	0.00E+00
7.00E+00	1.71E+01	9.81E+00	5.22E+00	2.02E+00	1.71E+01	0.00E+00
8.00E+00	2.45E+01	1.44E+01	7.38E+00	2.70E+00	2.45E+01	0.00E+00
9.00E+00	3.43E+01	2.06E+01	1.01E+01	3.56E+00	3.43E+01	0.00E+00
10.00E+00	4.39E+01	2.71E+01	1.23E+01	4.45E+00	4.39E+01	0.00E+00
11.00E+00	5.39E+01	3.33E+01	1.53E+01	5.30E+00	5.39E+01	0.00E+00
12.00E+00	6.42E+01	3.97E+01	1.81E+01	6.28E+00	6.42E+01	0.00E+00
13.00E+00	7.31E+01	4.53E+01	2.05E+01	7.23E+00	7.31E+01	0.00E+00
14.00E+00	8.23E+01	5.16E+01	2.25E+01	8.19E+00	8.23E+01	0.00E+00
15.00E+00	8.89E+01	5.61E+01	2.36E+01	9.17E+00	8.89E+01	0.00E+00
16.00E+00	9.42E+01	5.88E+01	2.52E+01	1.02E+01	9.42E+01	0.00E+00
17.00E+00	9.80E+01	6.01E+01	2.66E+01	1.13E+01	9.80E+01	0.00E+00
18.00E+00	1.02E+02	6.14E+01	2.87E+01	1.21E+01	1.02E+02	0.00E+00
19.00E+00	1.04E+02	6.17E+01	2.94E+01	1.30E+01	1.04E+02	0.00E+00
20.00E+00	1.04E+02	5.99E+01	3.03E+01	1.37E+01	1.04E+02	0.00E+00
21.00E+00	1.07E+02	6.08E+01	3.18E+01	1.46E+01	1.07E+02	0.00E+00
22.00E+00	1.09E+02	6.12E+01	3.21E+01	1.53E+01	1.09E+02	0.00E+00
23.00E+00	1.12E+02	6.13E+01	3.24E+01	1.63E+01	1.12E+02	0.00E+00
24.00E+00	1.10E+02	5.84E+01	3.38E+01	1.75E+01	1.10E+02	0.00E+00
25.00E+00	1.14E+02	5.90E+01	3.64E+01	1.88E+01	1.14E+02	0.00E+00
26.00E+00	1.16E+02	5.82E+01	3.75E+01	2.04E+01	1.16E+02	0.00E+00
27.00E+00	1.12E+02	5.46E+01	3.69E+01	2.09E+01	1.12E+02	0.00E+00
28.00E+00	1.12E+02	5.13E+01	3.80E+01	2.23E+01	1.12E+02	0.00E+00
29.00E+00	1.10E+02	4.69E+01	3.98E+01	2.37E+01	1.10E+02	0.00E+00
30.00E+00	1.12E+02	4.62E+01	4.05E+01	2.52E+01	1.12E+02	0.00E+00
31.00E+00	1.13E+02	4.33E+01	4.21E+01	2.74E+01	1.13E+02	0.00E+00
32.00E+00	1.15E+02	4.30E+01	4.21E+01	3.00E+01	1.15E+02	0.00E+00
33.00E+00	1.09E+02	3.61E+01	4.28E+01	2.99E+01	1.09E+02	0.00E+00
34.00E+00	1.12E+02	3.44E+01	4.62E+01	3.12E+01	1.12E+02	0.00E+00
35.00E+00	1.17E+02	3.45E+01	4.93E+01	3.34E+01	1.17E+02	0.00E+00
36.00E+00	1.17E+02	3.45E+01	4.93E+01	3.34E+01	1.17E+02	0.00E+00

Fig. 7: FORMIND output (simulated biomass) in Excel.

3. Using R-Studio to visualize result files.

The smartest way to produce the graphs for your simulation results is using R and RStudio. We prepared Show_Results.R that works with all R versions of version 3.2.2 or higher. You will find Show_Results.R in the folder *Formind_Analysis*.

1. Open the R-script Show_Results.R. Before it is possible to execute this script with RStudio, you need to prepare the script setting the folder variable in the General options section (path to your result folder, Figure 8). Don't forget that the path should end with a "/". Please check if the simulation files are located in the result folder. Please also check the project name (project = name of your project/result files), the area of simulation (N_ha, 1 is the default) and the number of PFTs (N_pft, 3 is the default). If you later have your own project you have to adapt "project", "N_ha" and "N_pft".
2. Next, execute the script using the *source* button in order to generate the output graphics.

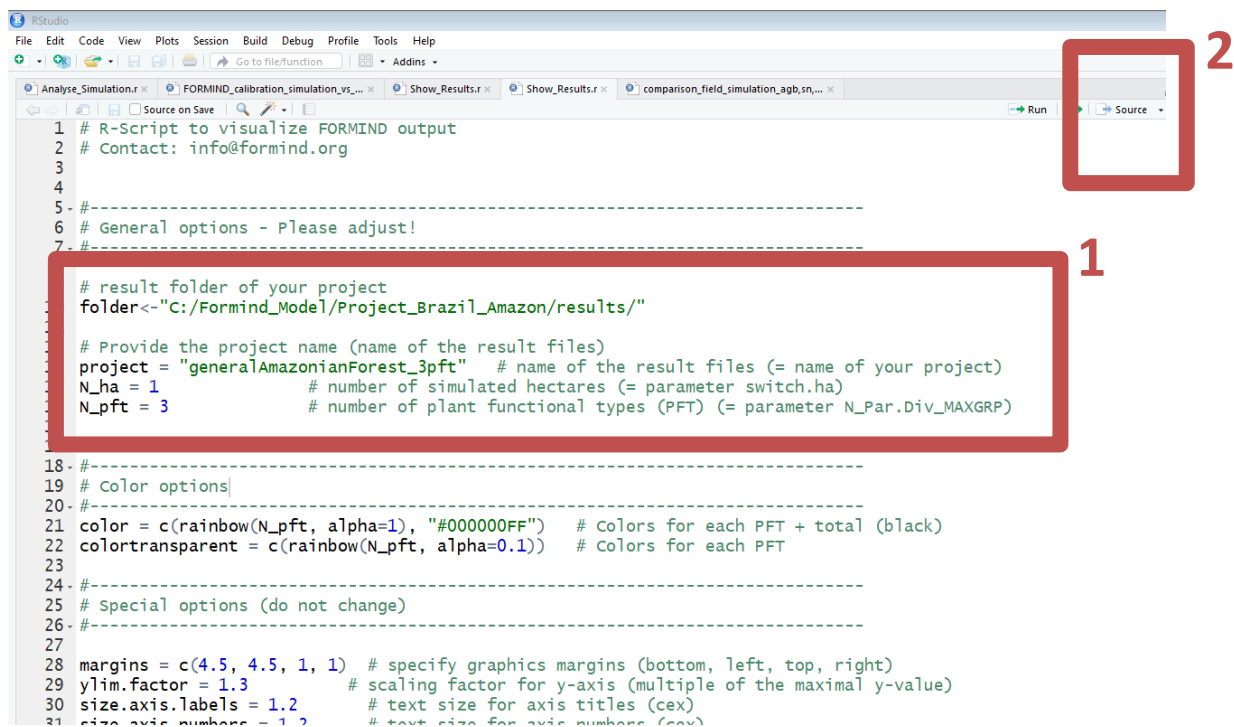


Fig. 8: Setting the correct file path to your result folder and running the R-script with Source (red circles).

If the analysis (read result files) was successful, the graphical output appears on the right bottom in RStudio (Figure 9).

... Congratulations! You've just created your first graphical output of a tropical forest with 3PFTs by simulating with FORMIND.

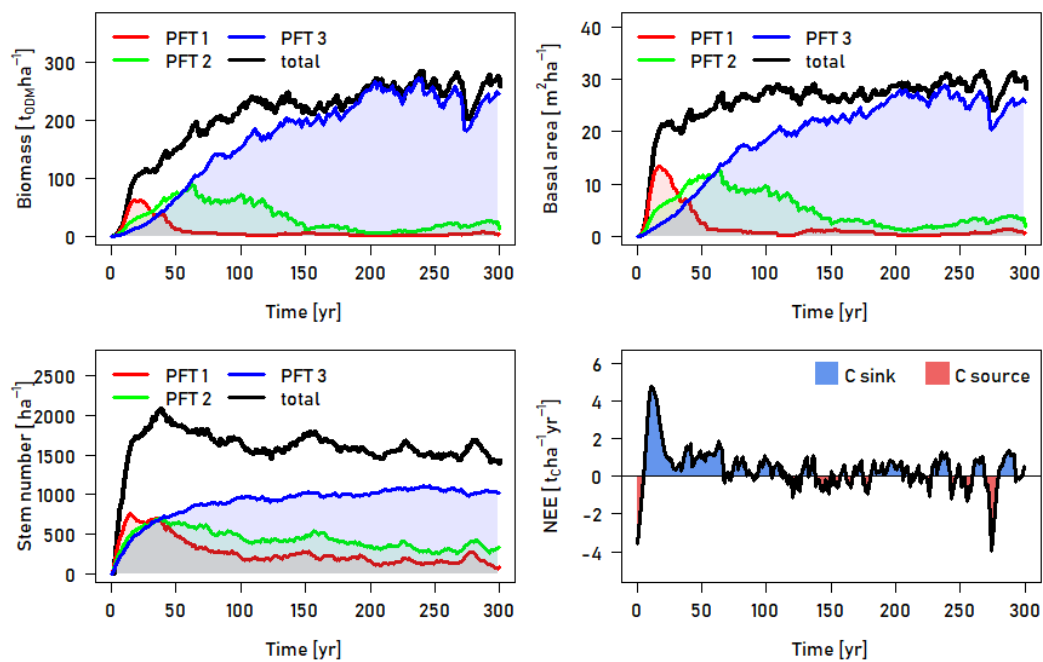


Fig. 9: Visualization of the current FORMIND run. You can see the aboveground biomass, basal area, stem count and net ecosystem exchange over time. The colors represent different plant functional types. Black line represents the total value.

4. Parameterizing Your Own Model

In the previous example, FORMIND was simulated using data from a tropical forest in the Amazon. In this tutorial you will learn to prepare FORMIND to simulate forests from any region, by including local information on species traits and site properties. In order to produce a specific simulation, this information must be included in the *parameter file* (.par).

Make sure that you copy the original folder, which is *Project_Brazil_Amazon* (see folder *Formind_Model*), before you start making any changes towards your own parameterization. Copy this folder in the *Formind_Model* folder. Rename this new folder to the name of your site (e.g. *MyForest*). In the folder *formind_parameters*, you find all files that can be edited to adapt the FORMIND model to your own forest site.

4.1. The Parameter (.par) file

The parameter file *.par contains all of the key parameters that are driving the FORMIND model. This means that it includes all values, which FORMIND uses for functions, routines and algorithms.

In the following, we show exemplarily the structure of *.par-file:

```
comment =====
comment ----- Section name -----
comment =====
```

LOOK OUT for “\ld”!

Here, you will find useful hints to explore FORMIND.

```
float parameter-name value
  \u unit
  \r parameter range
  \d short description of parameter
  \ld detailed description of parameter and hints
  \i additional description (unused)
```

Array

In this parameter type each species or PFT receives a value according to their traits. N is the total number of species/PFTs. Each column represents the parameters of one PFT.

```
array array-name
  \u unit
  \r parameter range
  \d short description of parameter
  \ld detailed description of parameter and hints

typeOfArray array type
dimension   N 2
data
  value 1    value 2 ... value N
  value 1    value 2 ... value N

end
```

As explained in the introduction, FORMIND uses the plant functional type concept. Although information on individual species can be added, grouping them in categories facilitates the parameterization process due to availability of information. For tropical forests, the most common grouping concepts are growth response in relation to light availability, and maximum height, although many more grouping strategies can be used such as response to water availability, or seed size and dispersal.

Change the name of the .par file in the copied *formind_parameters* folder to your forest site name (MyForest.par). Open the cmd-file (in folder *MyForest*) with a text editor and rename the parameter file as shown in the following command:

```
Formind.exe %olddir%\formind_parameters\MyForest.par 1> stout.txt 2> sterr.txt
```

All result files will have now the defined site name. Please define the number of species or plant functional types (PFT) which should be simulated, and collect the most field or literature information for the forest site as possible, according to the parameter file (Please note: if you change the number of PFTs, you have to adopt the dimensions of all parameters in the par-file). If you do not understand the function of a particular parameter, please check the FORMIND Handbook (folder Literature\FORMIND_Handbook; or download from <http://formind.org>), or contact the FORMIND-developers for assistance (info@formind.org).

In addition, the parameter file contains variables regarding the result files that can be written by the simulation. FORMIND can generate different result files, containing different aspects of the simulated forest. FORMIND save the different results in separated text files with different file extensions in the result folder. The file extensions indicate the type of the output (e.g., ba stands for basal area). The most important output files are listed below:

Defines which result files will be generated in the output folder.
 "1" activates a result file,
 "0" deactivates it.
 The most important are described below.

comment =====

List of output files

int	myResultFileSwitch.ba	1	Basal Area
int	myResultFileSwitch.bt	1	Biomass
int	myResultFileSwitch.cflux	1	Total Carbon Flux
int	myResultFileSwitch.dia	1	Diameter Class Distribution
int	myResultFileSwitch.mort	1	Tree Mortality
int	myResultFileSwitch.n	1	Stem Number

Each line stands for an output file. '1' indicates the corresponding result file will be written, '0' no writing of this result. The more result files you want FORMIND to save, the longer the runtime will be.

The format of all result files is the same as explained for the biomass file in Tutorial 1. One exception is the myResultFileSwitch.res result file, because it contains the full information of the simulation. This file contains detailed information for each tree in each time step. Switching on this result file increases runtime considerably.

4.2. The Pin (.pin) file

The other essential file which must be defined is the PIN file, which defines the initial forest state.

Rename the PIN file in the copied *formind_parameters* folder *empty_1ha_3pft.pin* to *empty_Myforest.pin* and edit the text accordingly:

In the following you will find the description of the *.pin-file. In the pin-file the forest stand structure is described:

Line	Value	Description
1	file pinfile	Keep that as it is. Here we tell Formind that it is actually using a pin file.
2	regionheader = "tropical forest (1ha), 9 plant functional types"	Geographical description of your project location. You may change what is written within the hyphens.
3	dclass=	DO NOT CHANGE! Just announcing that in the next line we will find the borders for our diameter classes
4	0.001 0.035 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95 1 1.05 1.1 1.15 1.2 1.25 1.3 1.35 1.4 1.45 1.5 1.55 1.6 1.65 1.7 1.75 1.8 1.85 1.9 1.95 2 2.05 2.1 2.15 2.2 2.25 2.3 2.35 2.4 2.45 2.5	Each value describes the right class boarder for the diameter at breast height (dbh) in meter. By setting this values, it is possible to define dbh classes for your measured data.
-----	-----	-----
	END OF GENERAL PART START OF THE REPEATING PLOT DESCRIPTION PART.	(25 REPETITIONS IN TOTAL FOR 1ha)
-----	-----	-----
5	block plot	Just a marker, that we start a new 20mx20m plot data point, DO NOT CHANGE!
6	name = "plot 1"	Here you can give every plot a distinct name, e.g. plot n, where n is the plot number 1-25.
7	position = 0 0 20 20	Describes the position of the lower left (0 0) and upper right (20 20) corner of the plot. First value is x and second value is y. The last plot is (80 80 100 100) for reference. Please adapt for larger inventories.
8	code = 1	DO NOT CHANGE! Technical parameter!!!
9	mel = 0	DO NOT CHANGE! Technical parameter!!!
10	n0 =	DO NOT CHANGE! Technical parameter!!!
11-13	0 ,	Every number represents the amount of trees within the corresponding diameter class. Every repeating line corresponds to a plant functional type (PFT), beginning with PFT1 and ending with PFT3.
14	seeds = 0 0 0	Every number represents the amount of seeds within a PFT on the corresponding plot. So this parametrisation starts with 0 seeds in every PFT.
-----	-----	-----
	END OF REPEATING PART	
-----	-----	-----

Return to the parameter file and include the name of the PIN file you edited as the input FORMIND should use to simulate the forest:

```
string PinFileNameX "empty_MyForest.pin"
```

Run now FORMIND again (*FOLDER\...\run_formind.cmd*, see Chp. 3) and check for errors in *sterr.txt*. If none, go the result folder *MyForest\results*.

These files can be opened using a common text editor, or analysed with the same R script used (*Show_Results.R*). Don't forget to set the appropriate folder and project (e.g. *MyForest*) names in the R script.

5. Source code of FORMIND

The FORMIND model family contains a wide range of model versions, which can be applied (i.e. choices of different geometries of the vegetation, climatic zone, or various disturbance types). You find all information on model versions in the FORMIND-Handbook and FISCHER ET AL. (2016) in the literature-folder. Here, the provided source code only covers the main processes of the forest model and so far, does not include any extensions (e.g., fire or logging).

You can find compilable source code files in *Formind_Model\bin\src*. The main processes of FORMIND (see Fig. 3 white boxes) are captured in the following source files (.cpp/.h):

- **for_seed**: dispersal and establishment of seeds
- **for_grow**: growth of individual trees
- **for_dead**: mortality of trees including gap building by large falling trees
- **for_comp**: calculation of the light climate in a forest stand and competition for light between trees
- **for_carbon**: decomposition of litterfall in soil and the net ecosystem exchange (NEE) of the forest ecosystem

You find additional files in the source folder which capture more general and technical issues:

- **for_iommparset and MMParSet-folder**: parser for reading-in parameter files (e.g., for parameter files provided in the folder “Project_Tropical_Forest”).
- **main.cpp**: main function starting the console application
- **formind**: initialization and step functions of FORMIND
- **for_var**: constructor of hectare, plot and tree classes
- **for_res**: calculation and aggregation of results
- **for_io**: writing results to text-files
- **for_misc**: miscellaneous technical functions
- **for_const.h**: definition of global constants, macros and result-file extensions
- **random**: random number generators

So far, we do not provide source code files of sub-models describing climatic impacts on tree growth, disturbances like fire or landslide, or logging routines. Regularly, we will inform you in our newsletter on new releases of the source code extended by sub-models.

5.1. Compiling the source code

FORMIND is written in C++ and can be compiled under Windows and Linux, for example by using the GNU compiler (<https://gcc.gnu.org/install/index.html>) or Embarcadero RAD Studio.

After compiling the source code, an executable of FORMIND is created. Please make sure that you give it a different name than “Formind-full.exe” to avoid conflicts with the precompiled executable (which we provided already in the downloaded folder).

You can run your own compiled executable with the same parameter files provided in each projects’ folder. For this, copy and paste your own executable to the folder “*Formind_Model\bin*”. In a last step you just have to modify the file “*run_formind.cmd*” in the respective projects folder, so that

your own compiled executable (with your own chosen name) is used instead of the precompiled “Formind-full.exe”.

```
1 @echo off
2 set var1=FORMIND is currently running
3 set var2=Please wait a minute ..
4 set var3=Simulation finished.
5 echo #####
6 echo.
7 echo %var1%.
8 echo %var2%.
9 echo.
10 echo #####
11
12 set olddir=%CD%
13
14 cd ..\bin
15
16 Formind-full.exe %olddir%\formind_parameters\general\AmazonianForest_3pft.par 1> %olddir%\stout.txt 2> %olddir%\sterr.txt
17
18 echo.
19 echo %3%.
20 echo.
21 echo #####
22
```

Modify the name of the FORMIND executable, here. Use the name of your own compiled executable.

Please note that if you run with your own compiled executable a specific project, in which sub-modules are activated in the parameter file (*.par), then these sub-modules won't be simulated and thus, don't have an effect on your simulation results. In order to include simulation of sub-modules, please use the precompiled executable “Formind-full.exe”.

In case you have any problems with compiling or running FORMIND, please do not hesitate to contact us under <mailto:info@formind.org>.