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A new tool to accurately calculate root reinforcement: the Root Bundle Model software RBM++

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This contribution has two aims:

1. To present a new tool written in C++ and based on Root Bundle Model with Weibull survival function (RBMw, Schwarz et al 2013), called **RBM++**, easy to use that enables anyone to quantify the effect of roots on slope stability.

2. To show new parameters of root reinforcement effects of Robinia pseudoacacia (L.), species commonly used for the mitigation of rainfall-induced landslides at small scale.

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Scheme of the new tool

Two input files

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Scheme of the new tool

RBMw++

- Root distribution of diameters classes
- Tree file

Root_distribution.csv

```
Nr_albero,Stand,Age,DBH,Distance,Depth,1,2,3,4...d_max
1,Onani,22,"0,23,0.7,,136,114,52,39...0
1,Onani,22,"0,23",1.4,,66,61,45,35,20...0
1,Onani,22,"0,23",2.1,,8,15,16,11,13...0
1,Onani,22,"0,23",2.8,,0,2,1,2,0,0,2...0
```

Tree_file.csv

```
X,Y,DBH,Trench_dist,Force_max
538267.895,4480033.085,20
538279.205,4480030.54,19
538272.154,4480035.582,23,0.5,72281.66
538272.154,4480035.582,23,1.0,33214.74
538272.154,4480035.582,23,1.5,14202.65
538272.154,4480035.582,23,2.0,4750.14
538279.148,4480035.582,15
```

Scheme of the new tool

RBMw++

- Root distribution of diameters classes
- Tr[illegible]e

Two calculation modes

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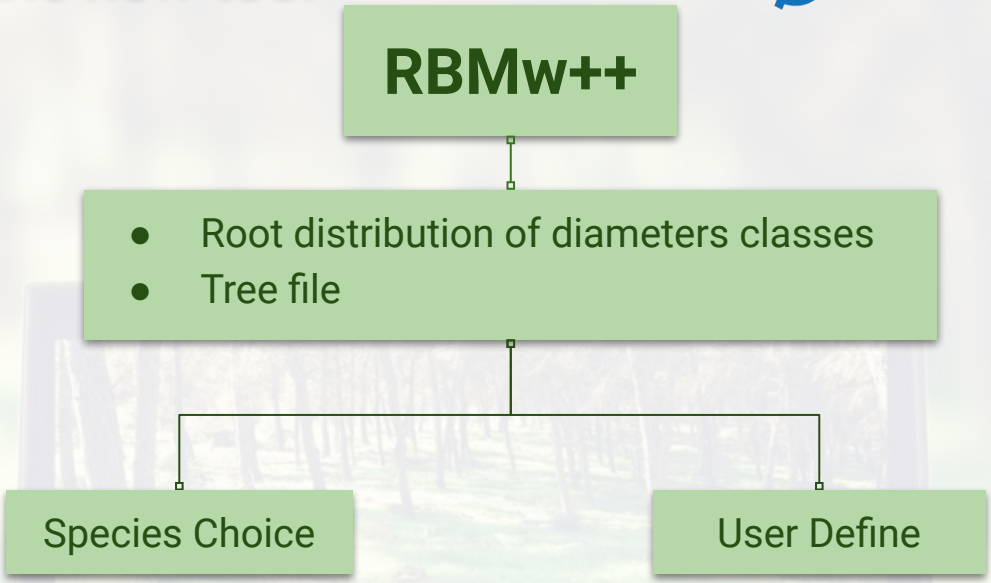
Scheme of the new tool



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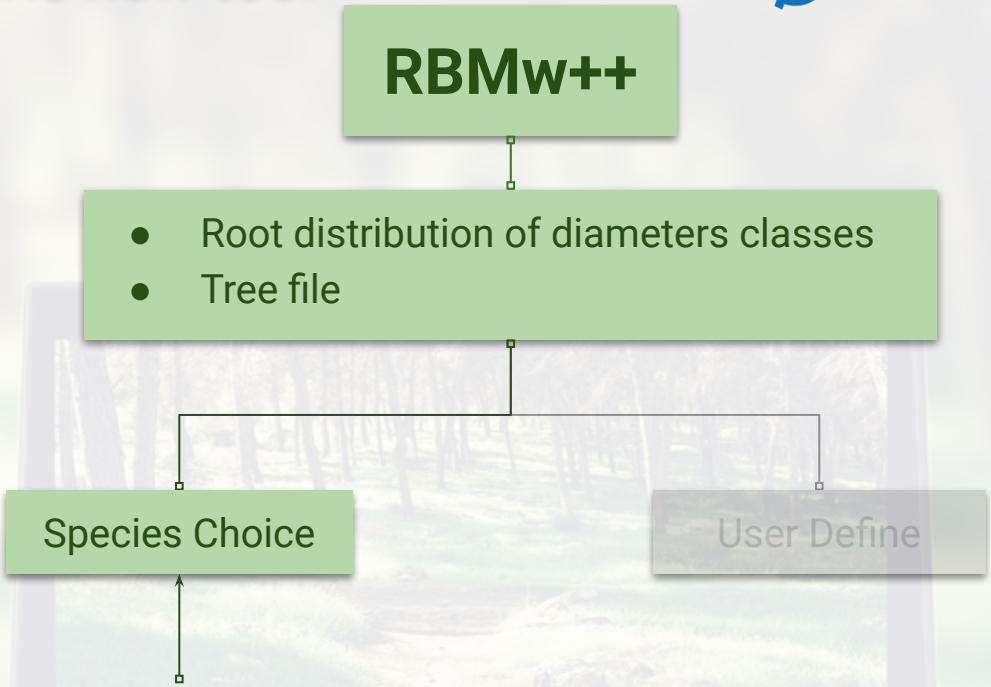
Scheme of the new tool



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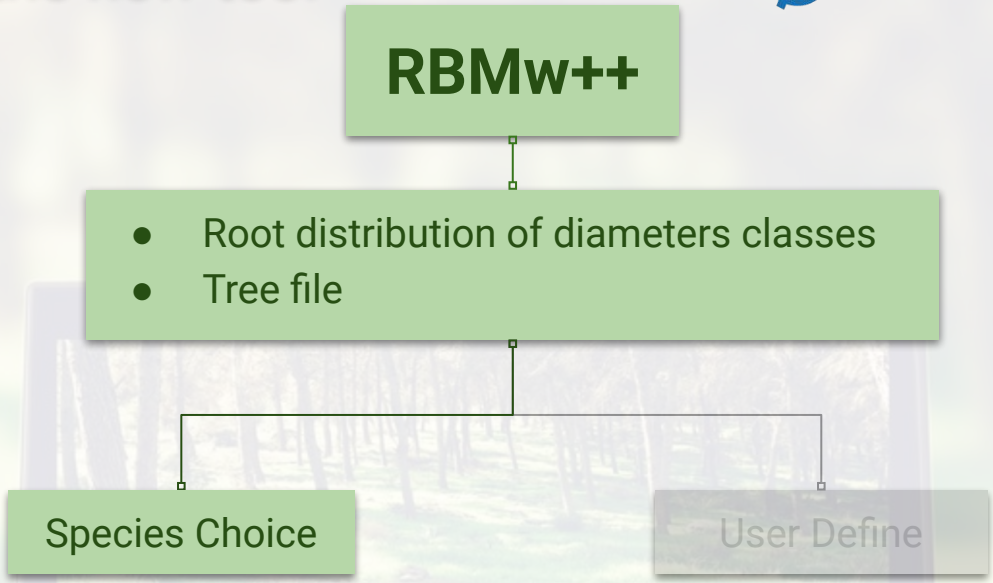
Scheme of the new tool



Species list

- *Ailanthus altissima* (Tree of heaven)
- *Betula pendula* (Birch)
- *Castanea sativa* (Chestnut)
- *Fagus sylvatica* (European beech)
- *Picea abies* (Spruce)
- *Pinus radiata* (Radiata pine)
- *Quercus pubescens* (Pubescent oak)
- *Robinia pseudoacacia* (Black locust)
- *Trachycarpus fortunei* (Chinese windmill palm)

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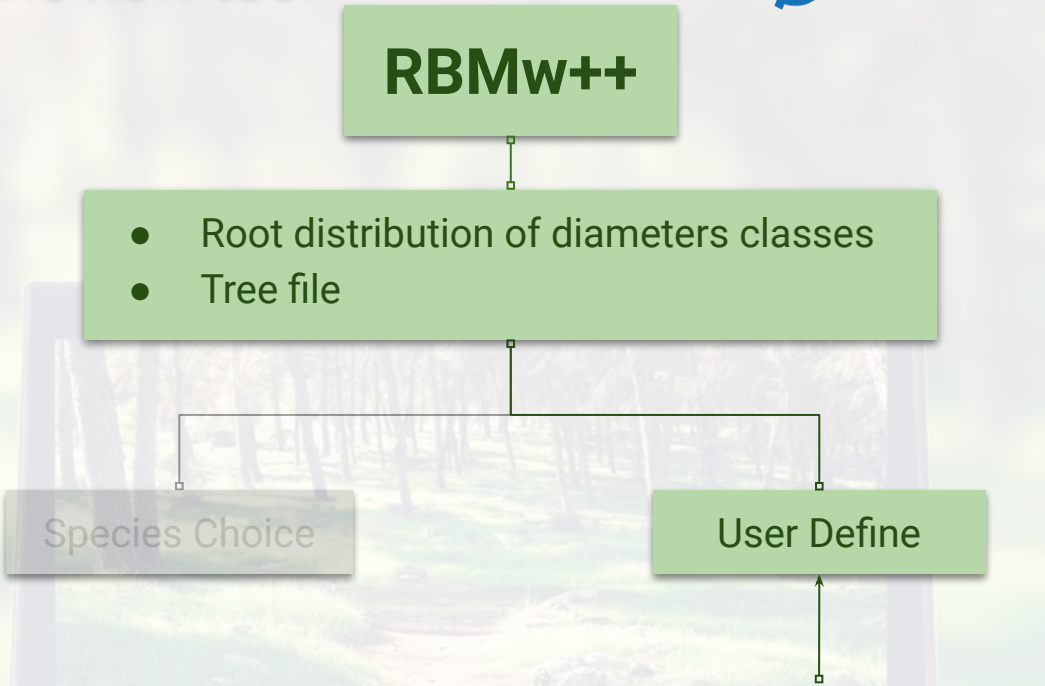
Scheme of the new tool



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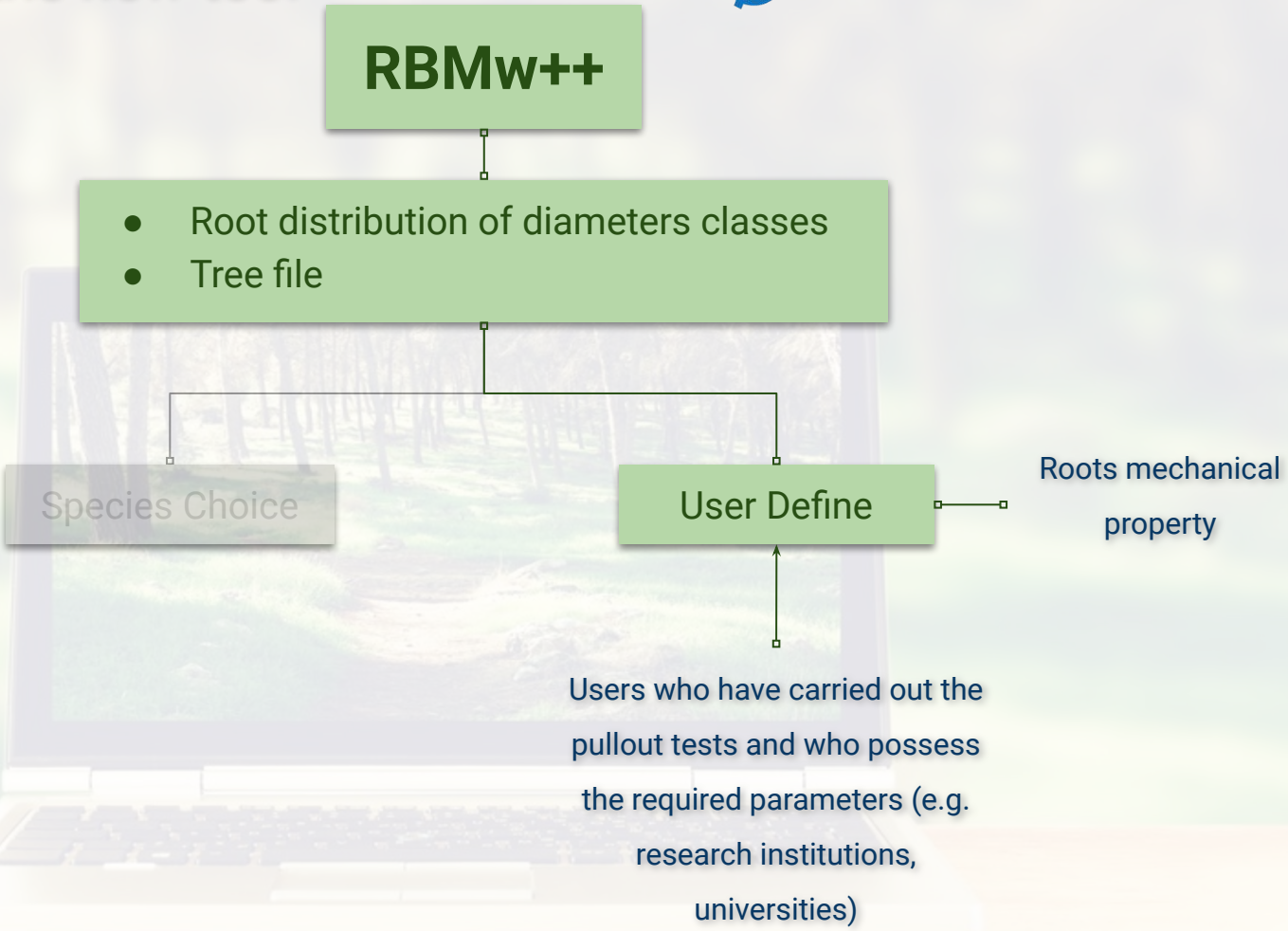
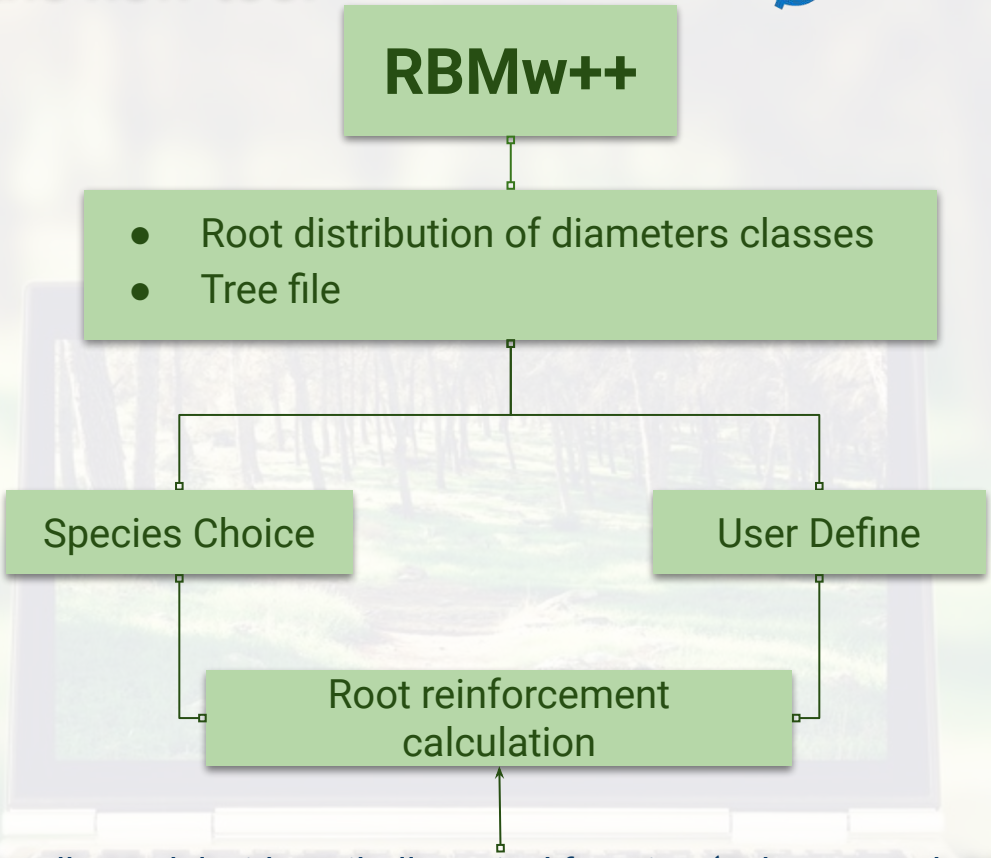
Scheme of the new tool



Scheme of the new tool



By using the Root Bundle Model with Weibull survival function (Schwarz et al, 2013). Recent studies have shown how the RBMw is a very efficient model by considering the heterogeneity of both root mechanical characteristics and their distribution in the soil.

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Scheme of the new tool

Two type of output file

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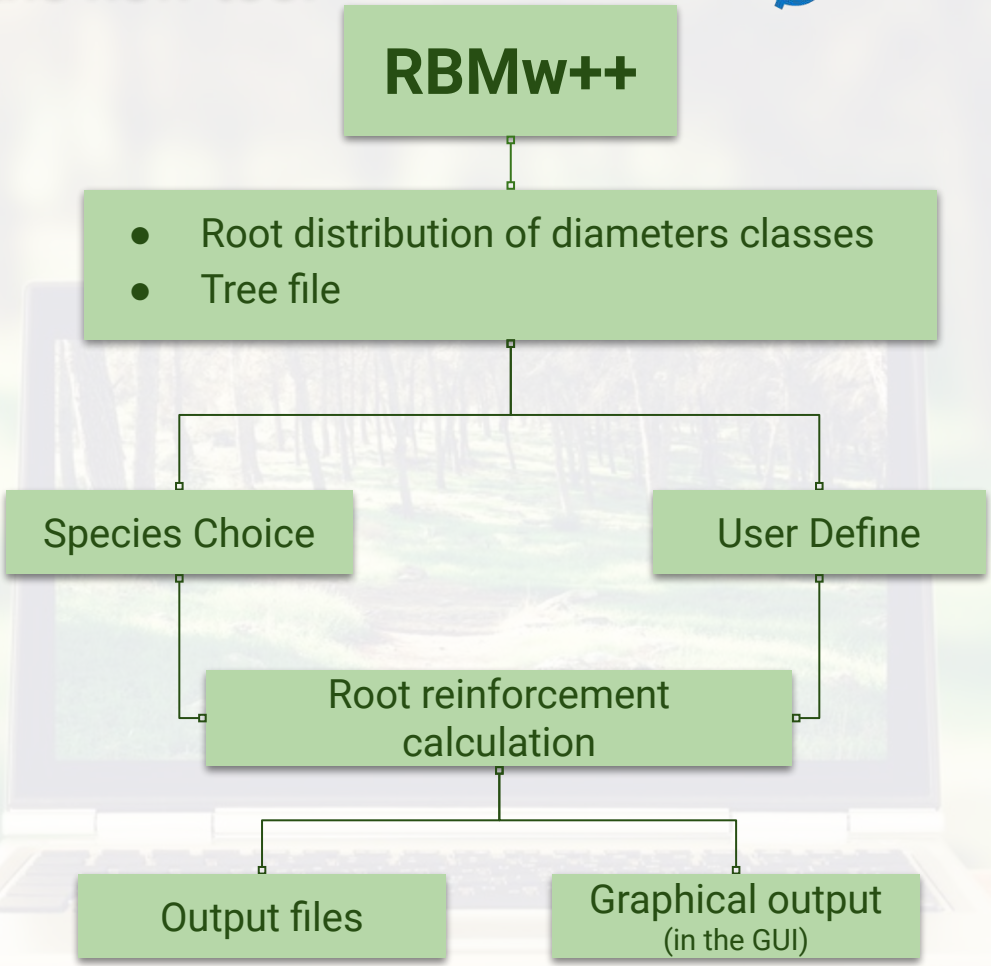
Scheme of the new tool



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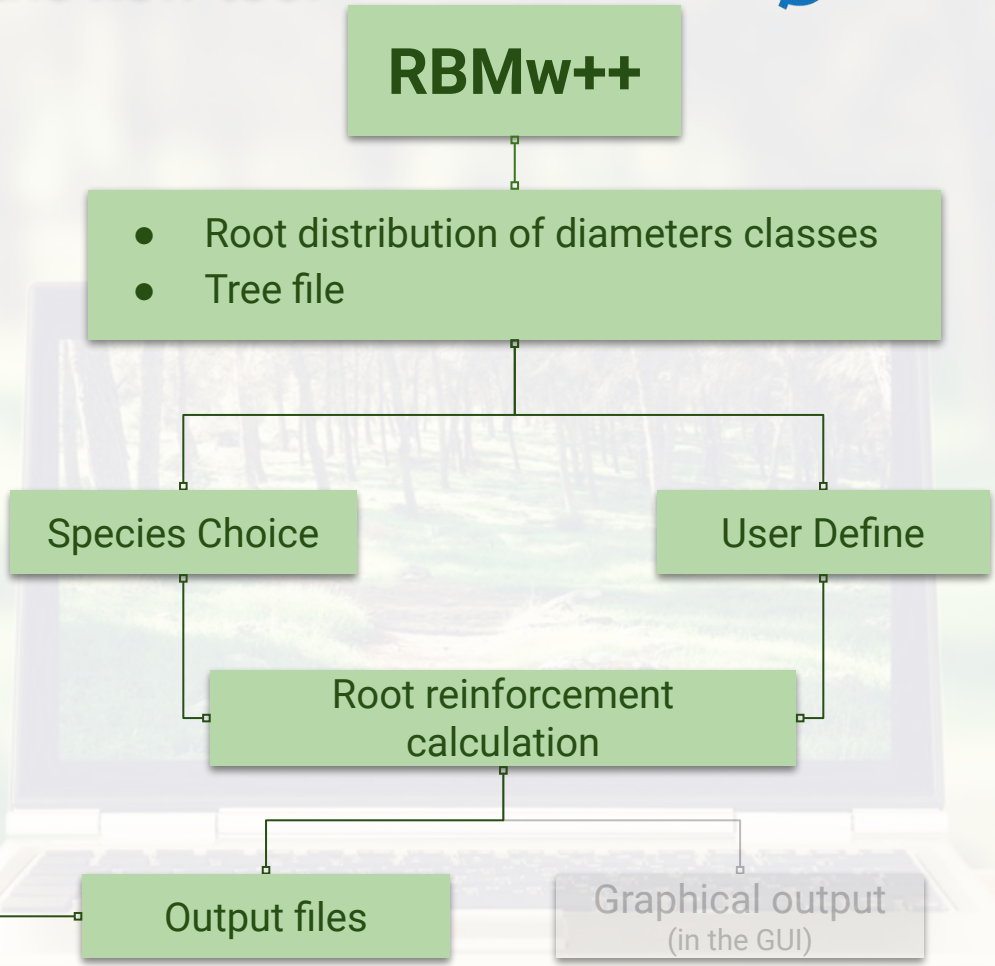
Scheme of the new tool



- Results_Fmax.csv
- Results_Displ.csv

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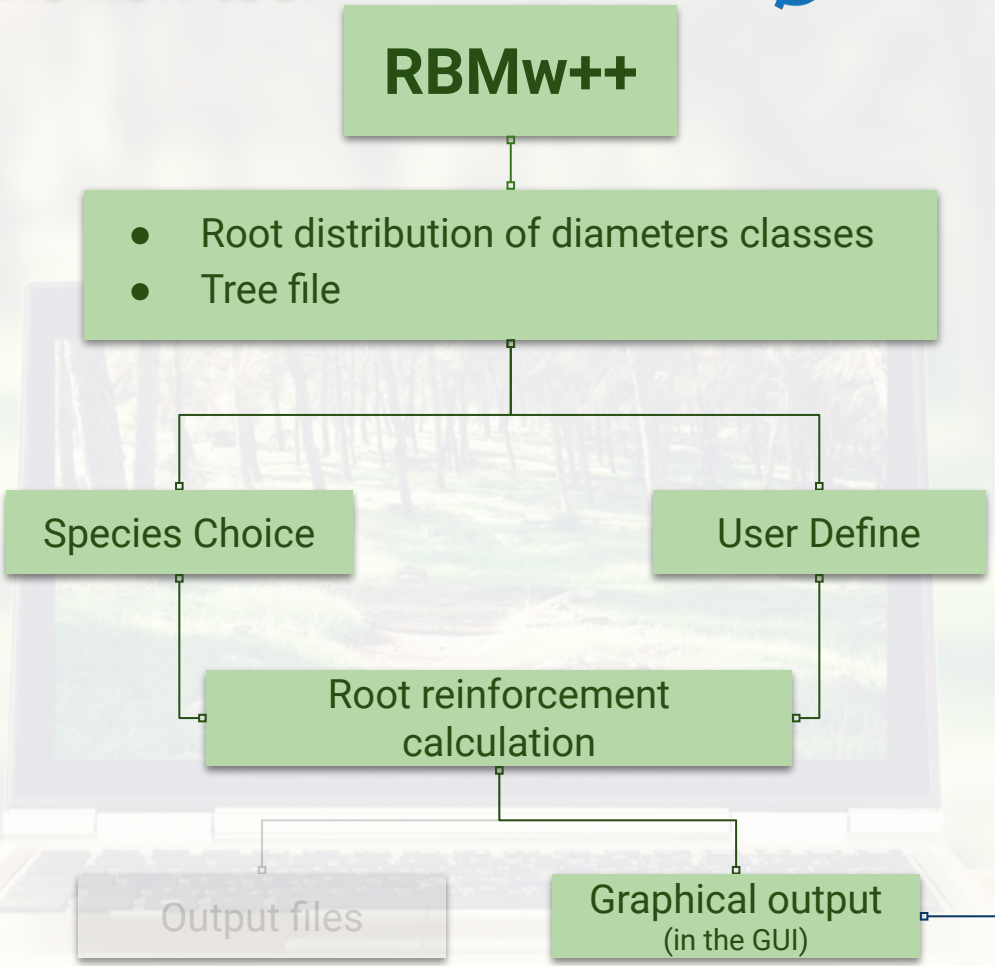
Scheme of the new tool



- Maps root reinforcement space distribution
- Displacement-Force curves

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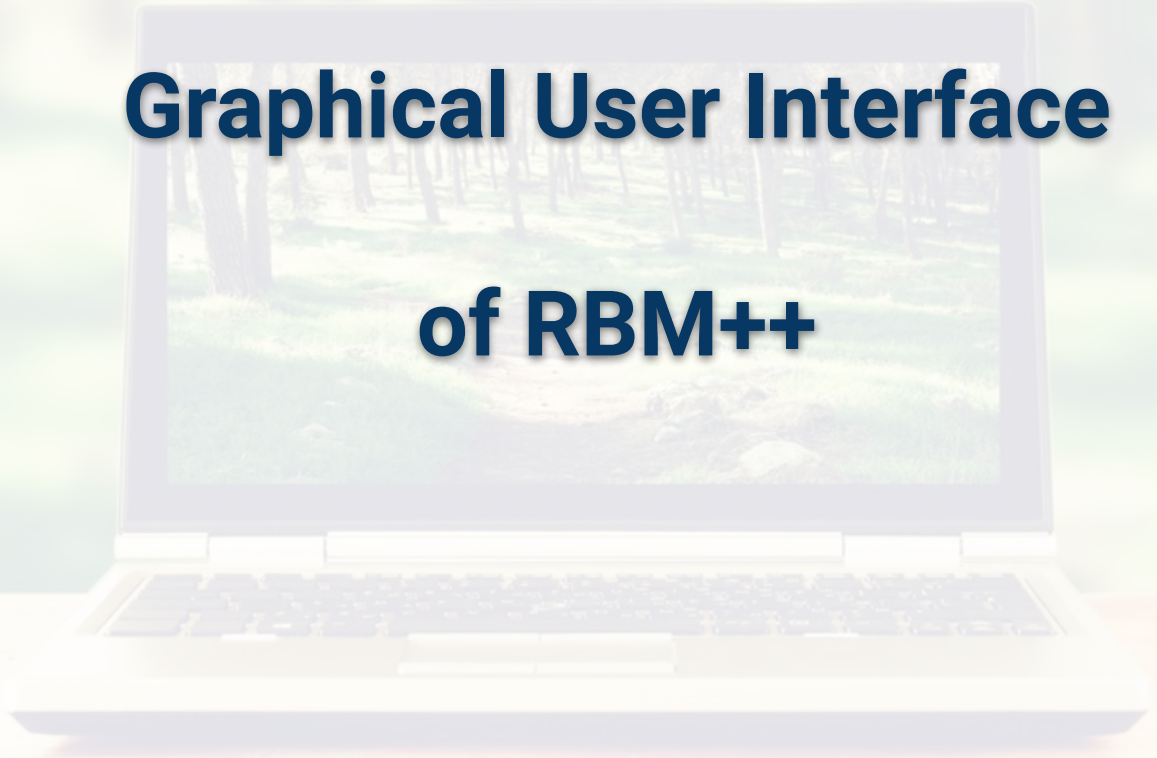
Graphical User Interface of RBM++



A new tool to accurately calculate root reinforcement: the Root Bundle Model software RBM++

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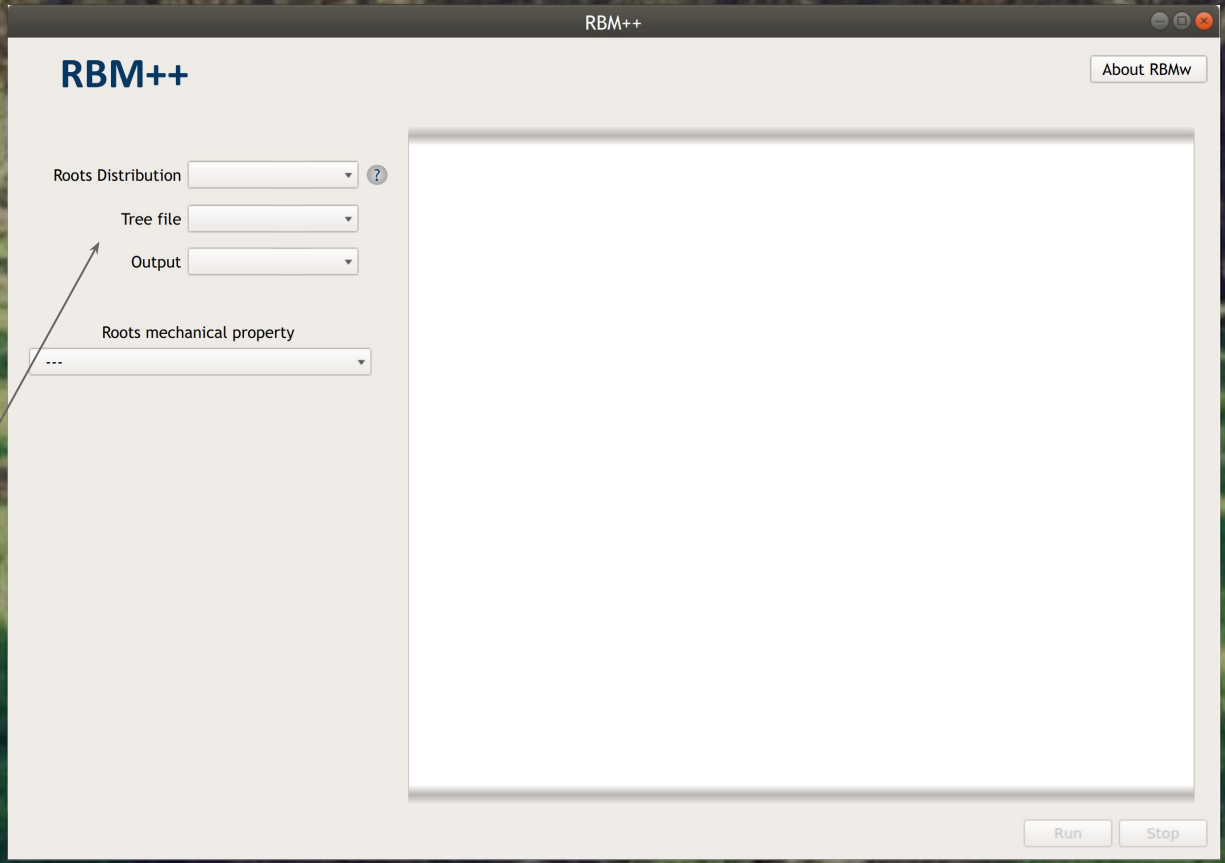
1. Insert the two input files and choose the folder in which to insert the output files.



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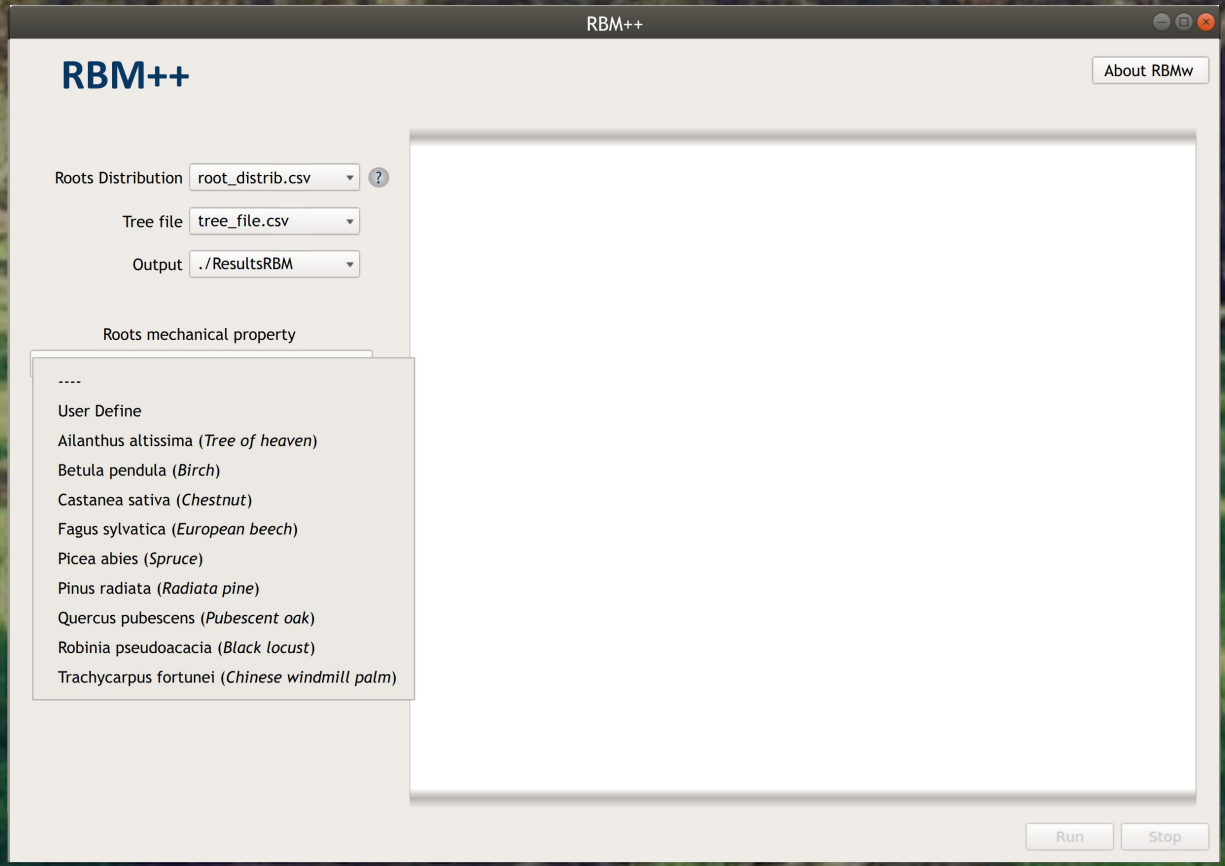
2. Choose the calculation mode you prefer:
   - User Define if you have the mechanical parameters of the roots;
   - or choose the species from the list.



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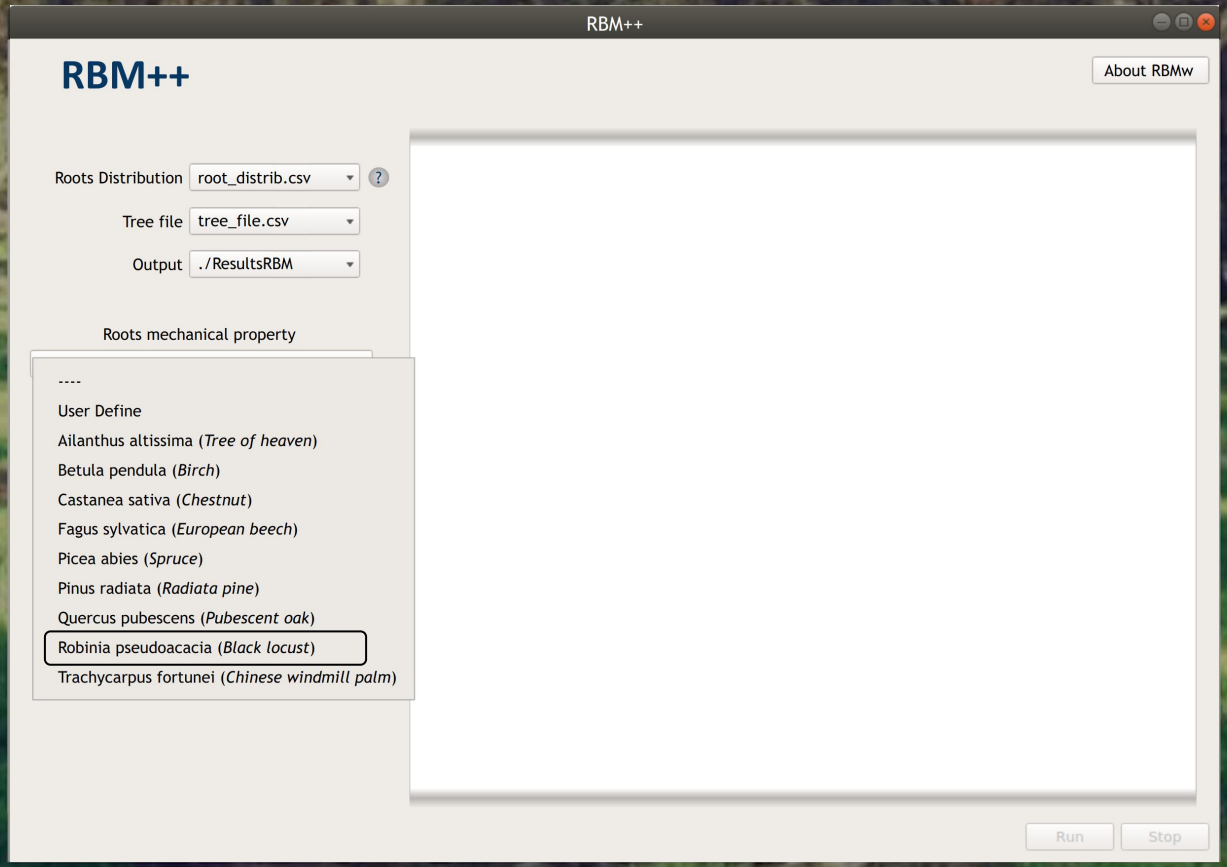
3.A Species Choice: Data analysis choosing Black Locust species. This tool will also contain values on the mechanical properties of the roots of this species, obtained from recent studies.



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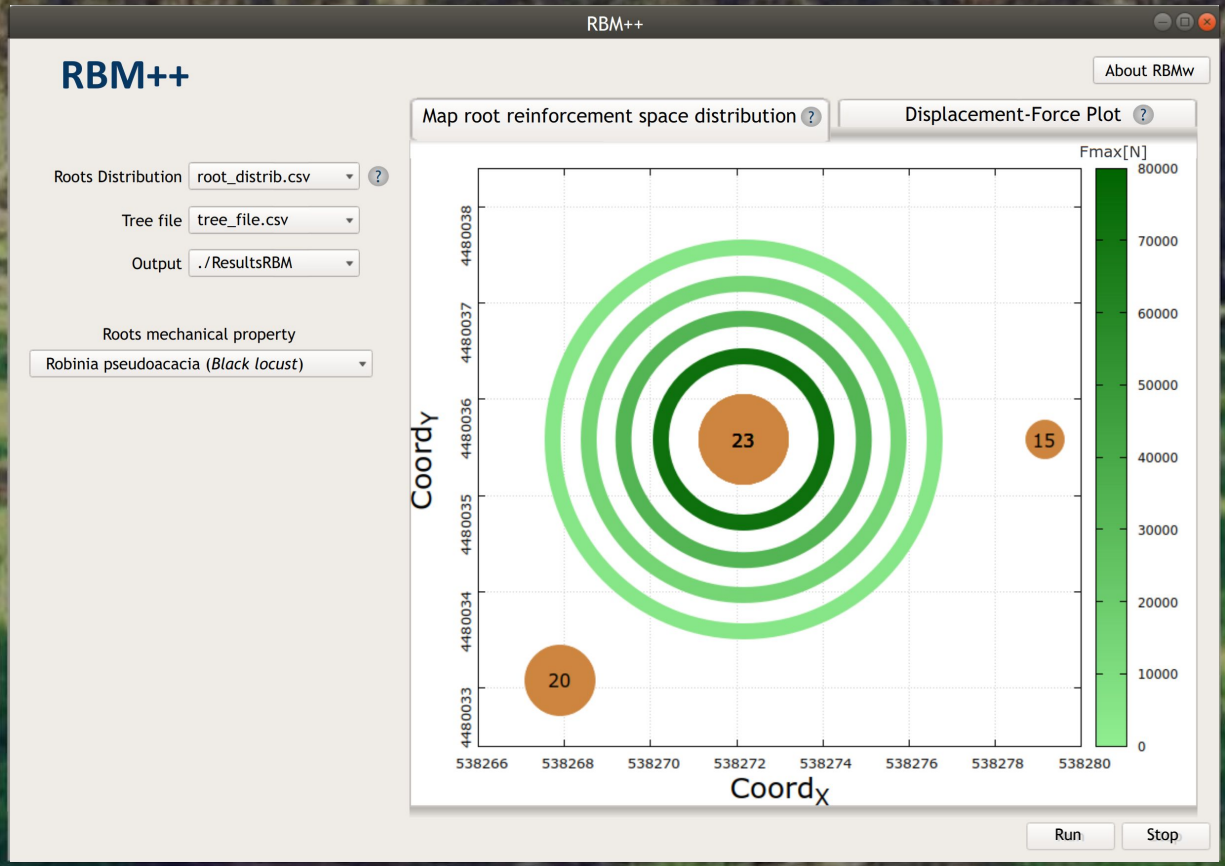
4.A Map root reinforcement space distribution:

The spatial distribution of the trees and their diameters at 1.3 m (DBH) can be displayed. For trees where the root distribution has been analyzed, it is possible to visualize the trenches and display the maximum estimated force based on the intensity of the color.



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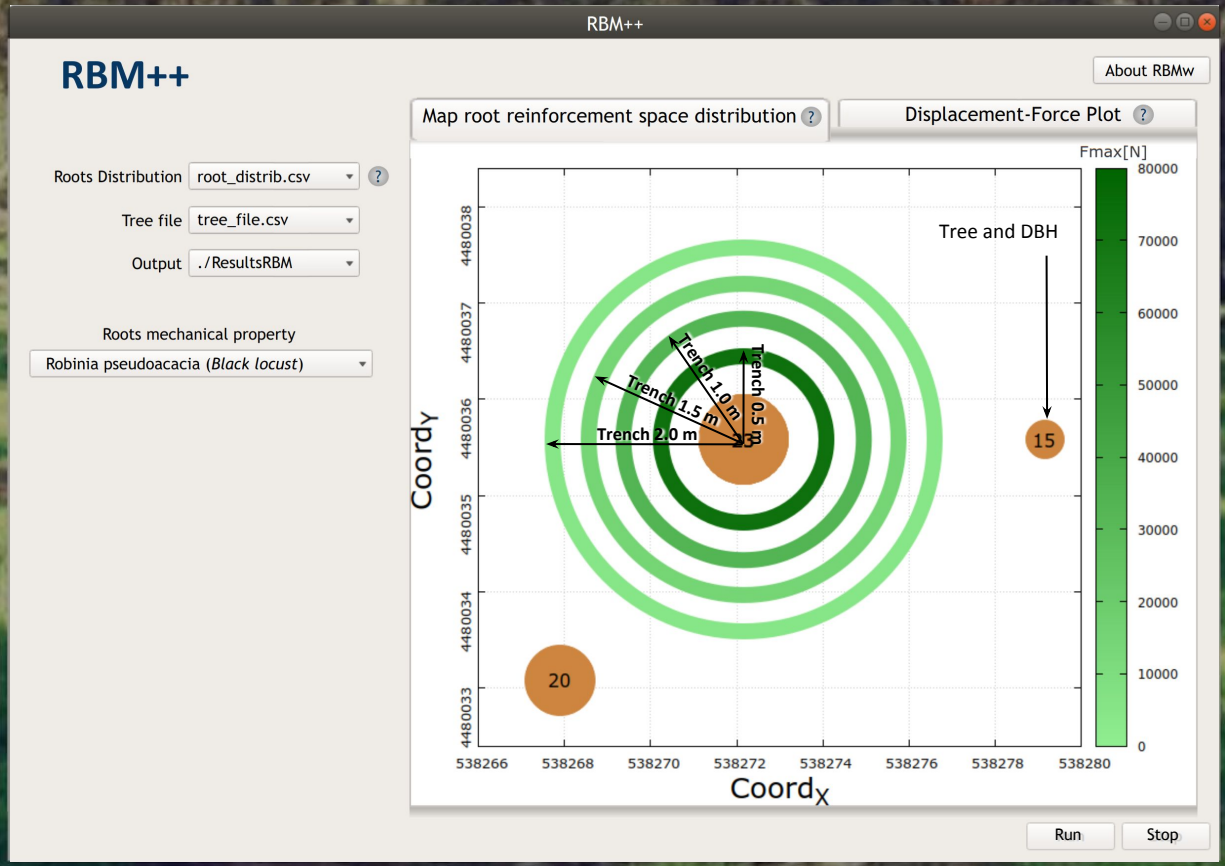
In this example the density of the root diameter classes was analyzed on 4 trenches 0.5m apart.



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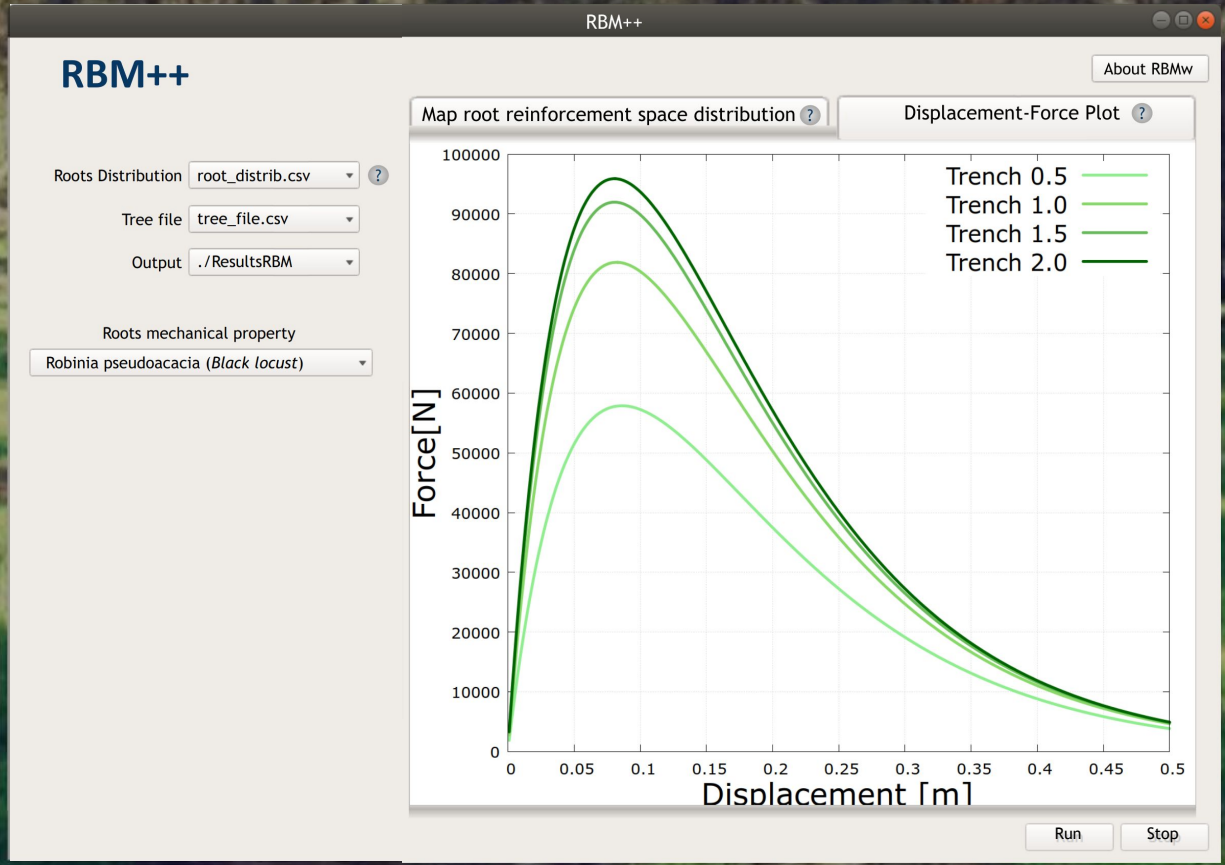
4.B Displacement-Force Plot:

you can view the change in force as a function of the displacement in detail for each trench.



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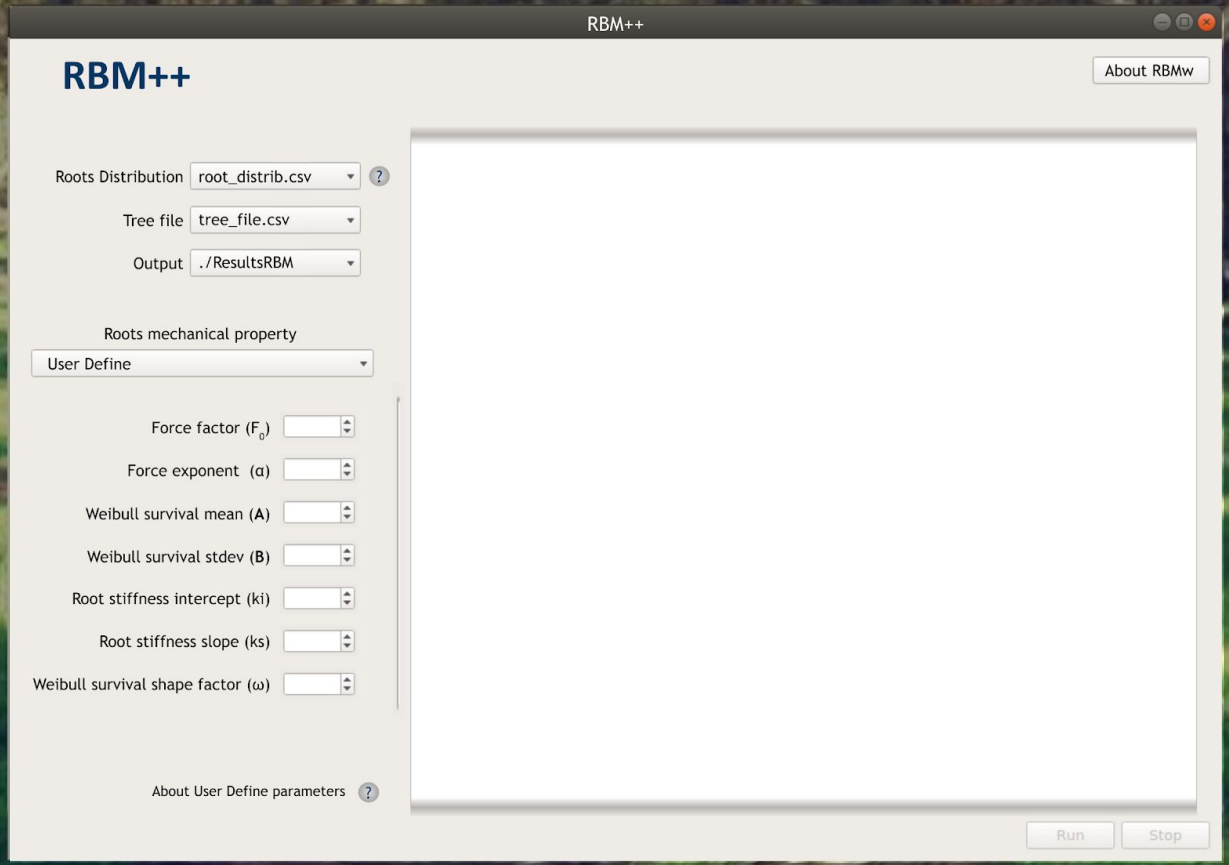
3.B User Define:

Using the RBMw equations in the literature (*Schwarz 2013, Dazio 2018*), estimate the required parameters from the data collected in the field and enter them in the appropriate box.



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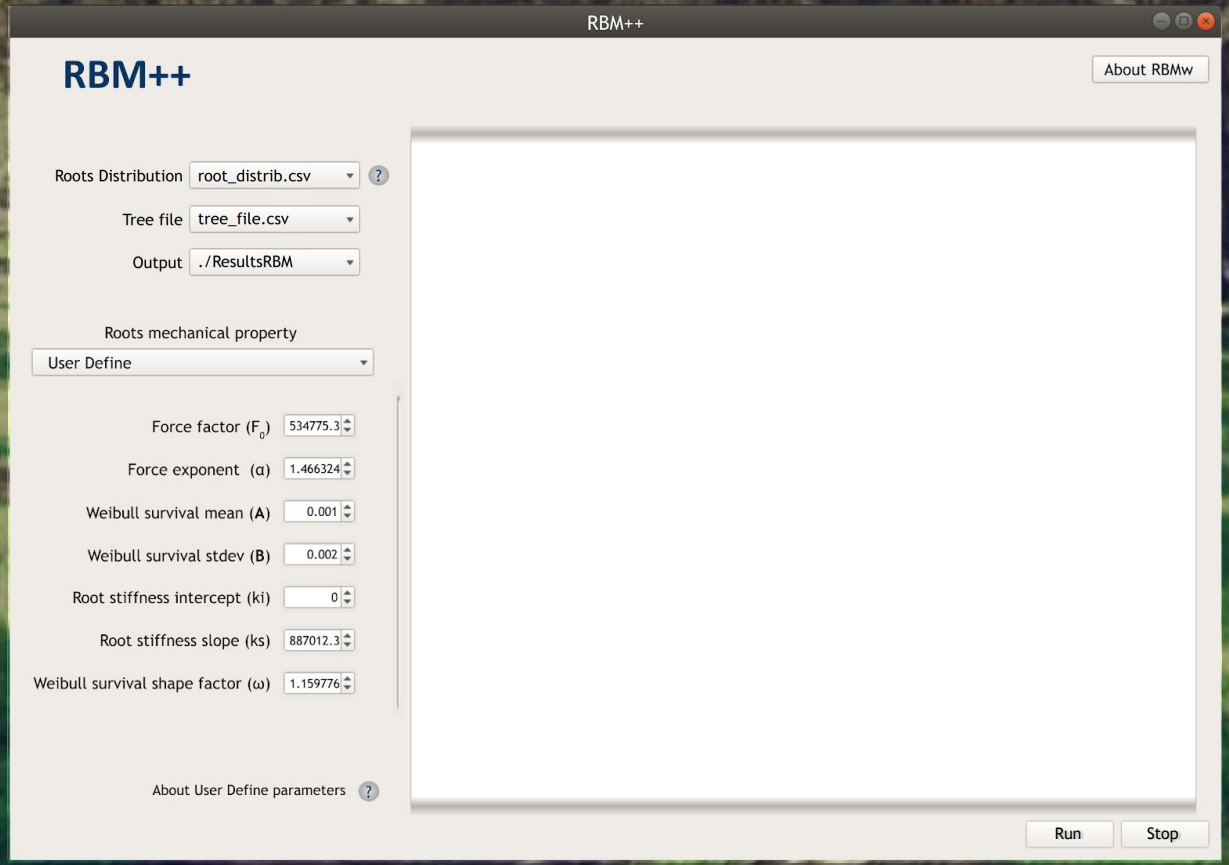
The values of the parameters inserted derive from recent analyses carried out on the radical reinforcement of the Black locust species in Sardinia.



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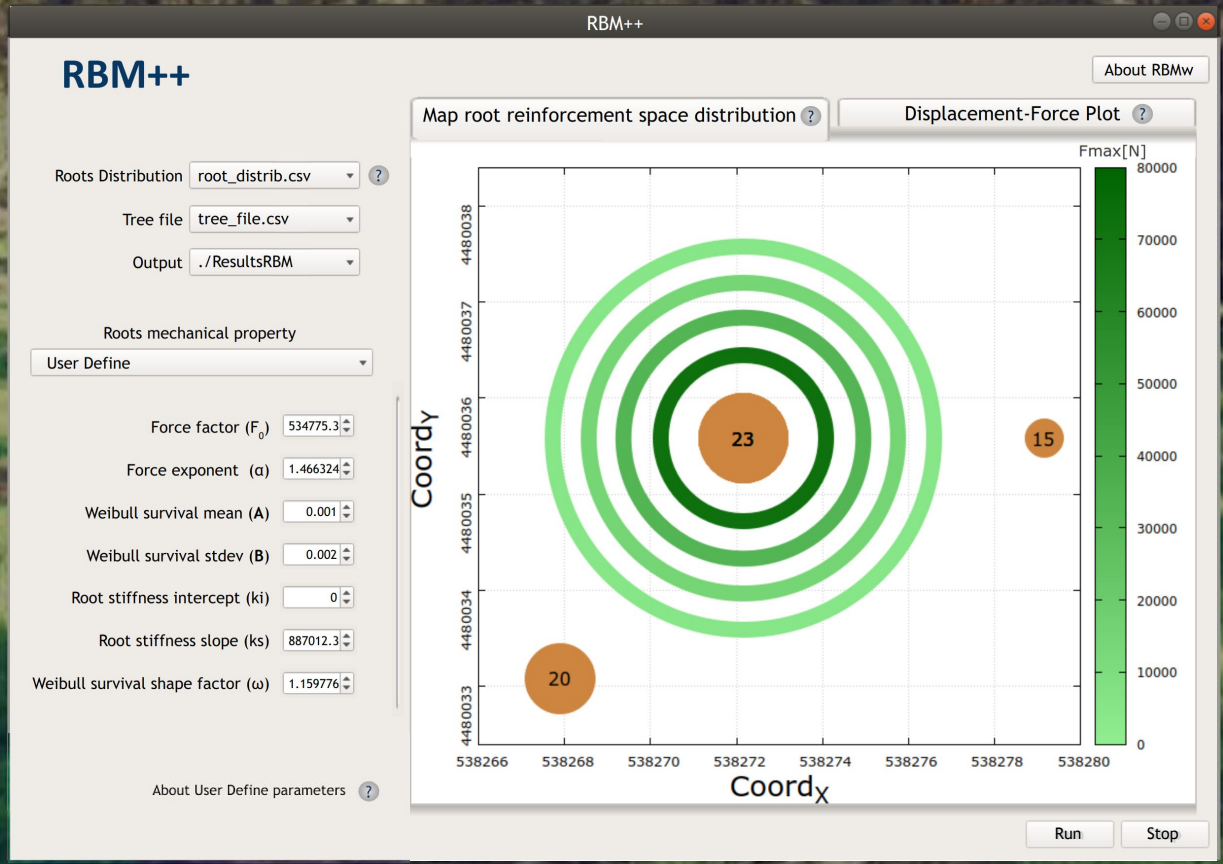
Even with this mode they get the same graphic outputs.
The map is identical to the previous case 4.A.



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Displacement-Force Plot is identical to the previous case 4.B.

RBM++

RBM++

About RBMw

Map root reinforcement space distribution | Displacement-Force Plot

Roots Distribution: root_distrib.csv

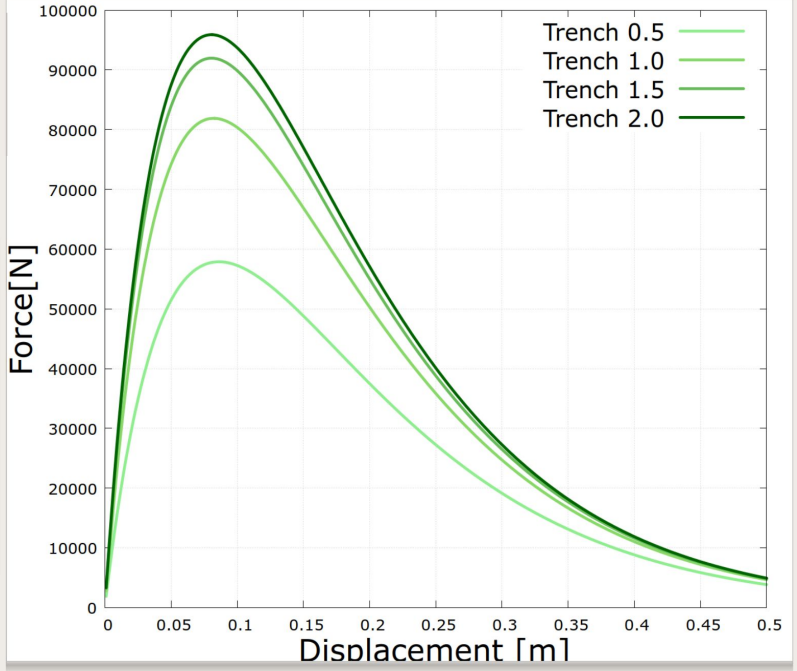
Tree file: tree_file.csv

Output: ./ResultsRBM

Roots mechanical property: User Define

Force factor (F_0)	534775.3
Force exponent (α)	1.466324
Weibull survival mean (**A**)	0.001
Weibull survival stdev (**B**)	0.002
Root stiffness intercept (ki)	0
Root stiffness slope (ks)	887012.3
Weibull survival shape factor (ω)	1.159776

About User Define parameters



Run Stop

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RBM++ makes it easier to share and exchange knowledge related to **root reinforcement**. Therefore, it will allow the realization of a database containing standard data on root mechanical behavior of tree species commonly used for **shallow landslide mitigation**.

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Thanks for your attention

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