Strategy

The main idea of the research in predicting the "size" distribution of the trees in the forest is to come up with a mathematical model, which could actually consider the importance of competition between the trees.

Our approach is based on creating a computer simulation of dynamics in forest, finding the relative parameters, which affect the tree growth and death and defining the laws guiding all the relative processes.

Currently, the process is mainly based on reading the available literature and writing a code, which will allow the simulations with the appropriate parameters.

Parameters, which we are focused on in the beginning as a simple model:

$R - resources\ other\ than\ light(soil, weather, etc.)$
$L - light\ available\ for\ a\ tree$
$C - competition\ parameter\ which\ will\ depend\ on\ the\ sizes\ of\ neighbouring\ trees\ and\ the\ tree\ itself$

Functions, which will be presented in the model:

$S(t,c,g) - size\ of\ the\ tree,\ which\ will\ depend\ on\ time,$
$vector\ of\ predefined\ parameters\ and\ a\ competition\ parameter$
$and\ a\ growth\ rate$
$L(S) - survival\ function\ of\ a\ tree,\ which\ will\ depend$
$on\ the\ tree\ size$

Furthermore we will consider the feedback from the tree to the nature. Basically, by feeding on soil, the tree changes the quality of soil:

$D(S) - loss\ of\ soil\ quality,\ which\ will\ depend\ on\ the\ tree\ size,\ feeding\ on\ that\ soil$
$A(t,g) - aging\ function,\ which\ will\ represent\ how\ the\ tree\ age\ affects\ the\ growth\ function\ g$

Some explicit examples of our functions:

In order to have more meaningful results, the parameters have been normalized:

$$S_{i,j,t_n} = (1 + \frac{R+L}{A_{i,j,_{n-1}}} + C(S_{i+1}, S_{i-1}))S_{i,j,t_{n-1}}$$

So the motivation for this choice of the function is the following:

1) whenever the Age of a tree is small (say in the interval (0,1)) the parameter "A" helps the tree to grow , so the tree grows faster and after certain time the age of a tree becomes bigger, which is not good for the future growth.

2) Function "C" will depend on the sizes of the neighboring trees and as a result will be a competition factor which will somehow affect the growth of the tree.
3) Resources are giving positive effect for the tree growth.
4) Our tree cannot grow down, but will have a death function and this function will be presented later

$$D_{i,j,t_n}(S_{i,j,t_{n-1}}) = (1 - dS_{i,j,t_{n-1}}) + N_{t_{n-1}}$$

The function "D" will represent the dynamics of soil for a tree, using that part of the soil. Soil is considered a decreasing function of a tree size, since the bigger is the tree, the more soil quality it uses and the positive factor N is number of the trees died in that place which will add additional soil quality.

This is not yet the final model of our team, but only the first approach towards modeling the competitive forest dynamics.

Further models will be chosen to fit the reality and consider all the most important details.

Revised Literature:

1) Lauri Mehtatalo, Modeling the Size of Forest Trees, Using Statistical Distributions. University of Helsinki, 2009. (http://cs.uef.fi/~lamehtat/documents/Presentation.pdf)
2) Pierre Magal and Zhengyang Zhang, Univ. Bordeaux, IMB, UMR 5251, F-33400 Talence, France. (https://www.math.u-bordeaux.fr/~pmagal100p/papers/MZ-JTB17.pdf)
3) Thomas P. Adams, Drew W. Purves† and Stephen W. Pacala. Understanding height-structured competition in forests: is there an *R*_ for light? Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544, USA
4) Pierre Magal, Zhengyang Zhang. Competition for light in forest population dynamics: From computer simulator to mathematical model. Univ. Bordeaux, IMB, UMR 5251, F-33400 Talence, France.
5) Aarssen, L. W. & Keogh, T. 2002 Conundrums of competitive ability in plants: what to measure? Oikos 96, 531–542. (doi:10.1034/j.1600-0706.2002.960314.x)
6) Coates, K. D., Canham, C. D., Beaudet, M., Sachs, D. L. & Messier, C. 2003 Use of a spatially explicit individual-tree model (SORTIE/BC) to explore the implications of patchiness in structurally complex forests. Forest Ecol. Manage. 186, 297–310. (doi:10.1016/S0378-1127(03)00301-3)