Research Organization of Information and Systems
The Institute of Statistical Mathematics

Comparison of pruning regimes for Stone pine (Pinus pinea L.) using a Functional-Structural Plant Model

Peter Surovy

Presentation outline

- 3d measurement of plant architecture with topology (data)

- Forestry models and FSPM models : philosophy, advantages, disadvantages

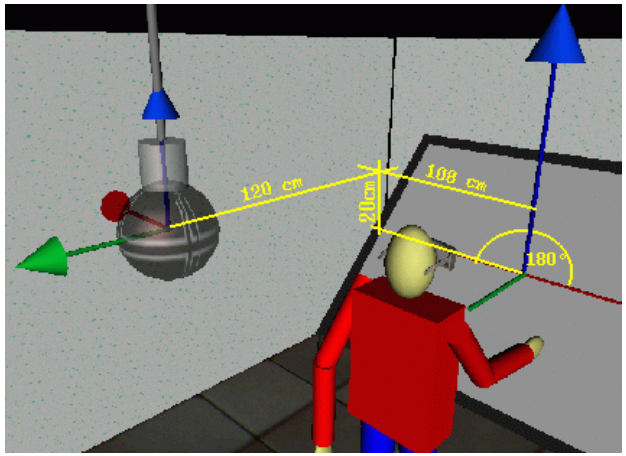
- Stone pine model – important modules and code parts (model)

- Optimization possibilities using 3d model

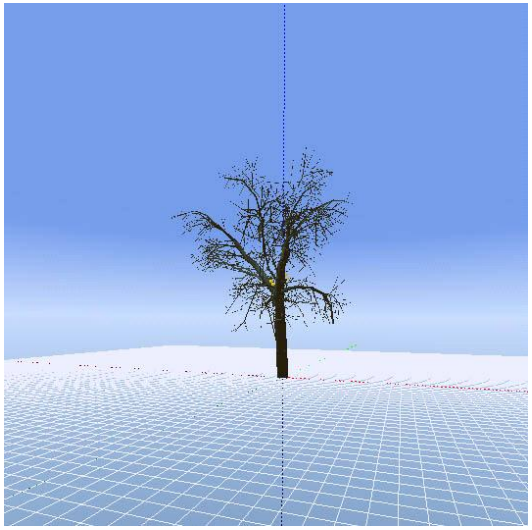
Magnetic motion tracker

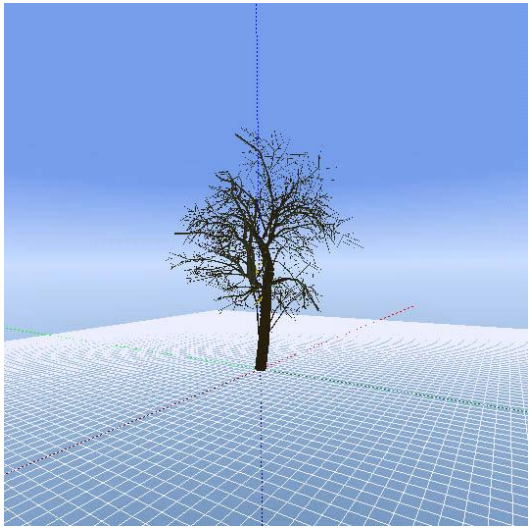
+ cheap (relatively)
+ offers directly relative coordinates
+ magnetic field passes “through” material

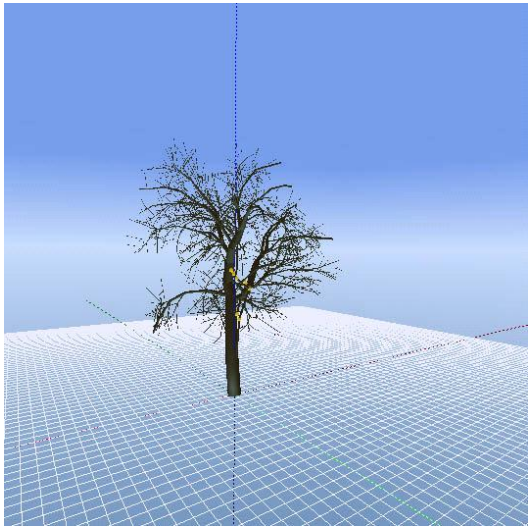
- no metalic object
- weather
- small amount of works (communication+math)

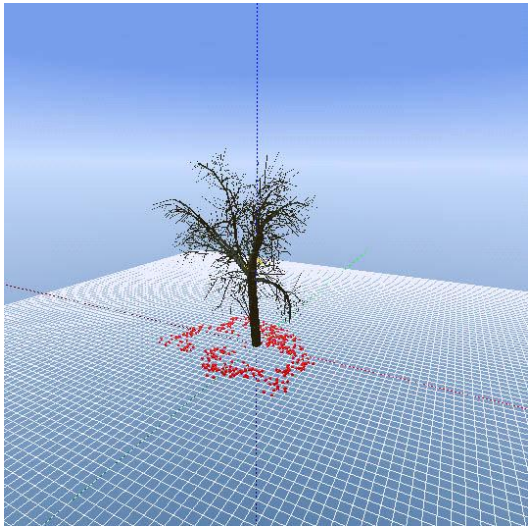


3d measurement of plant architecture with topology

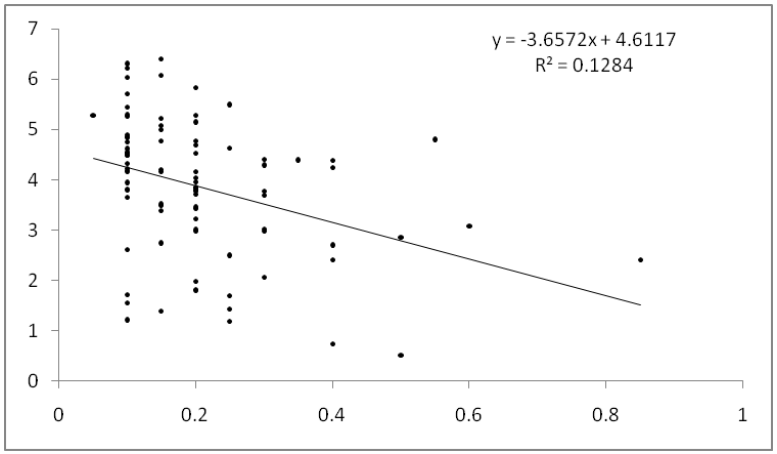


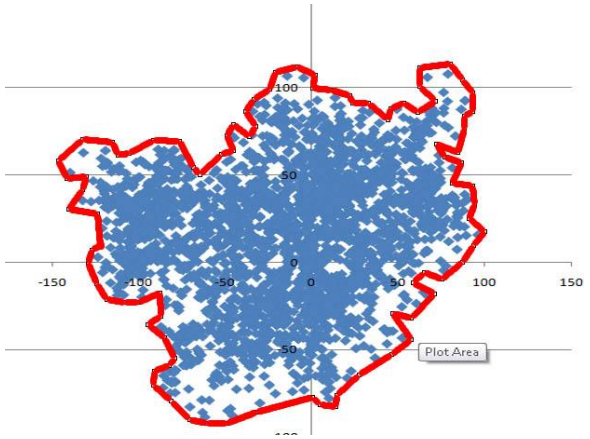






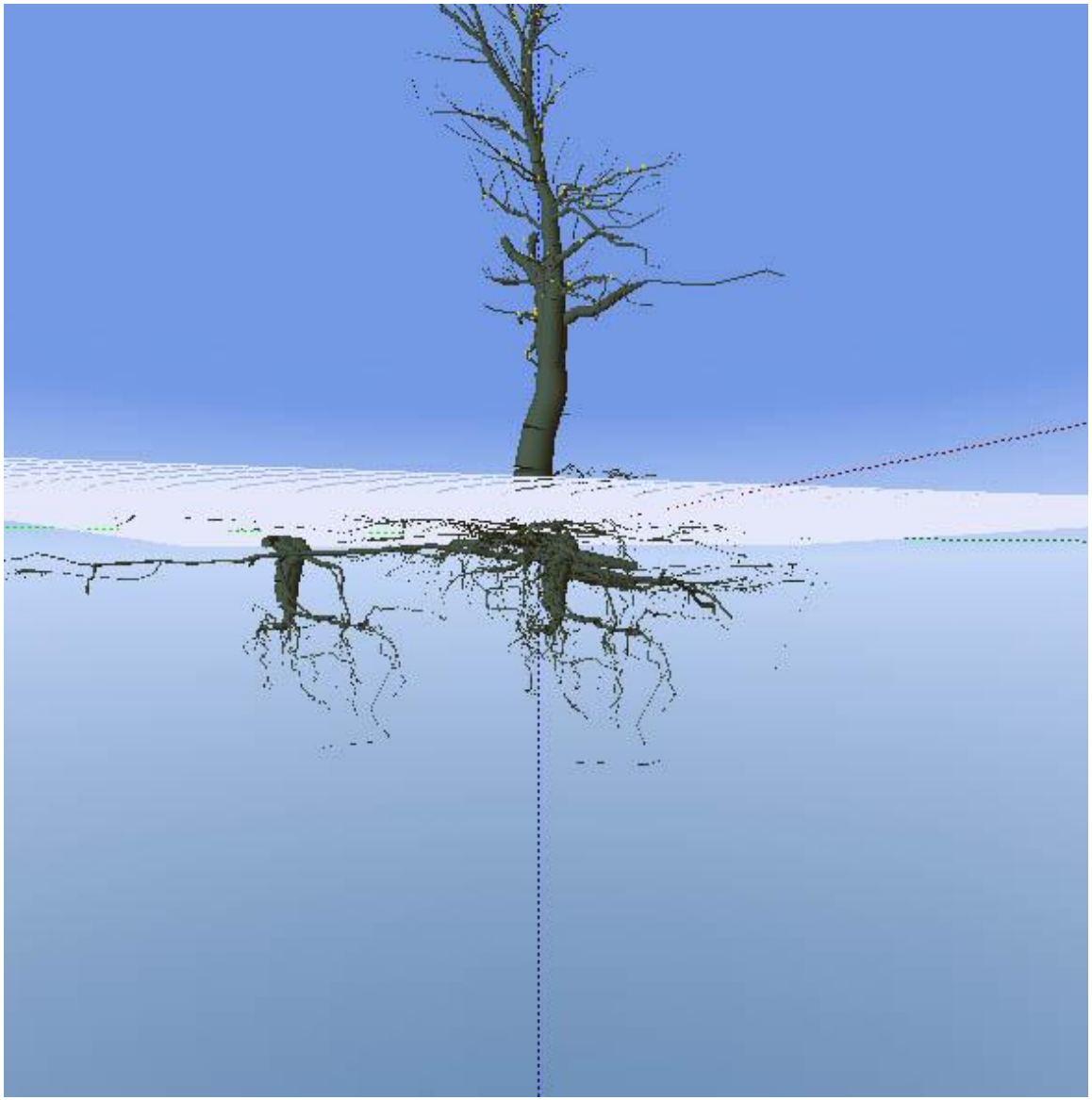
Not destructive measurements of Leaf Area Index



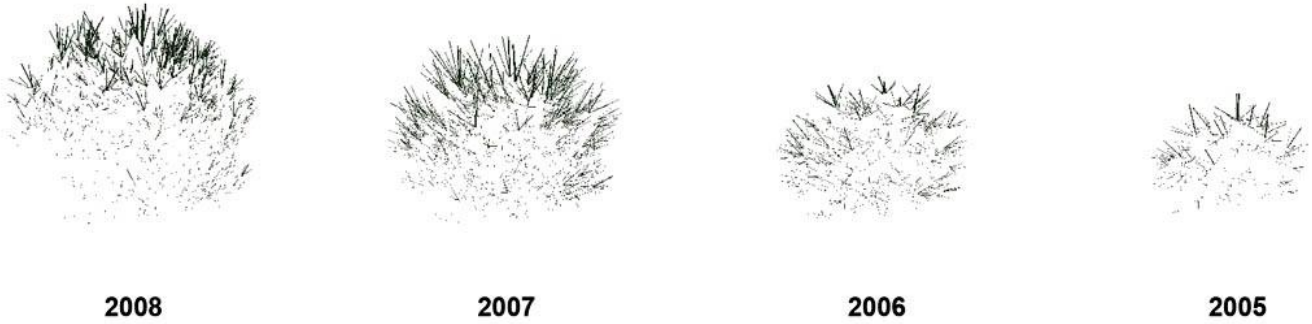


LAI = LA / CA = 2.33

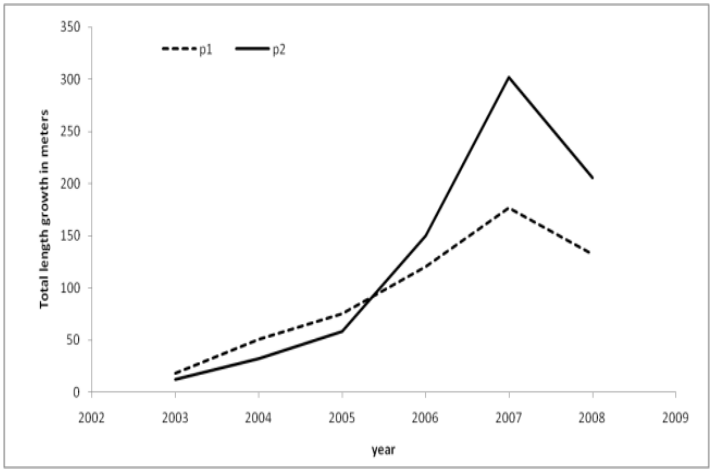
Measurement of
Above and bellow
Plant architecture

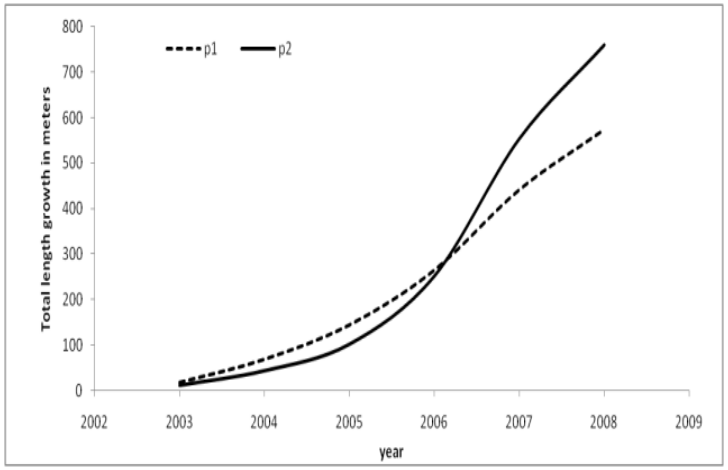


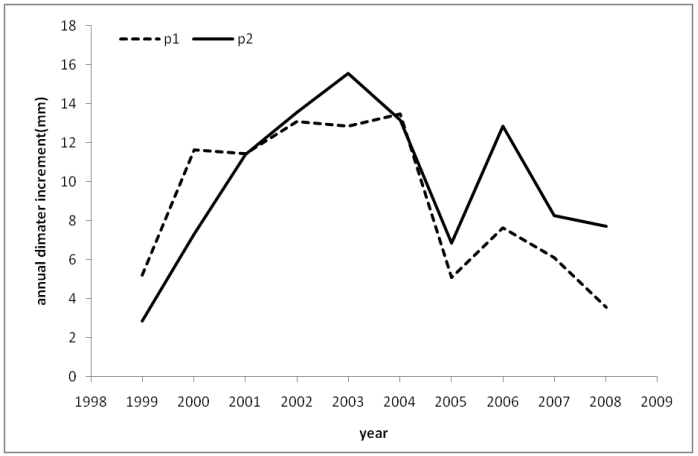
Data dynamics

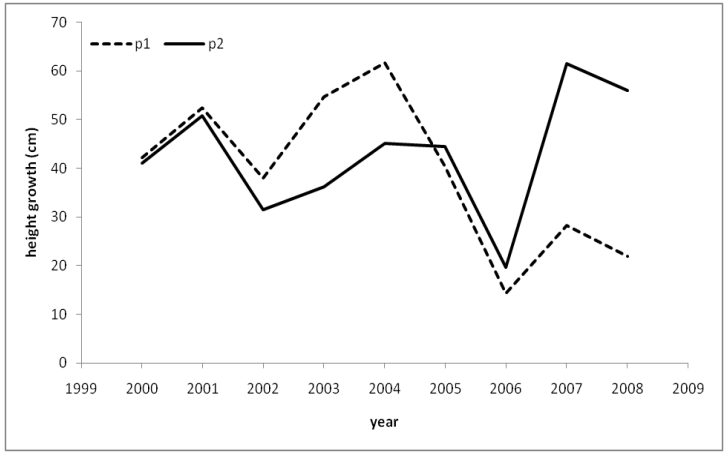


Results from measurements





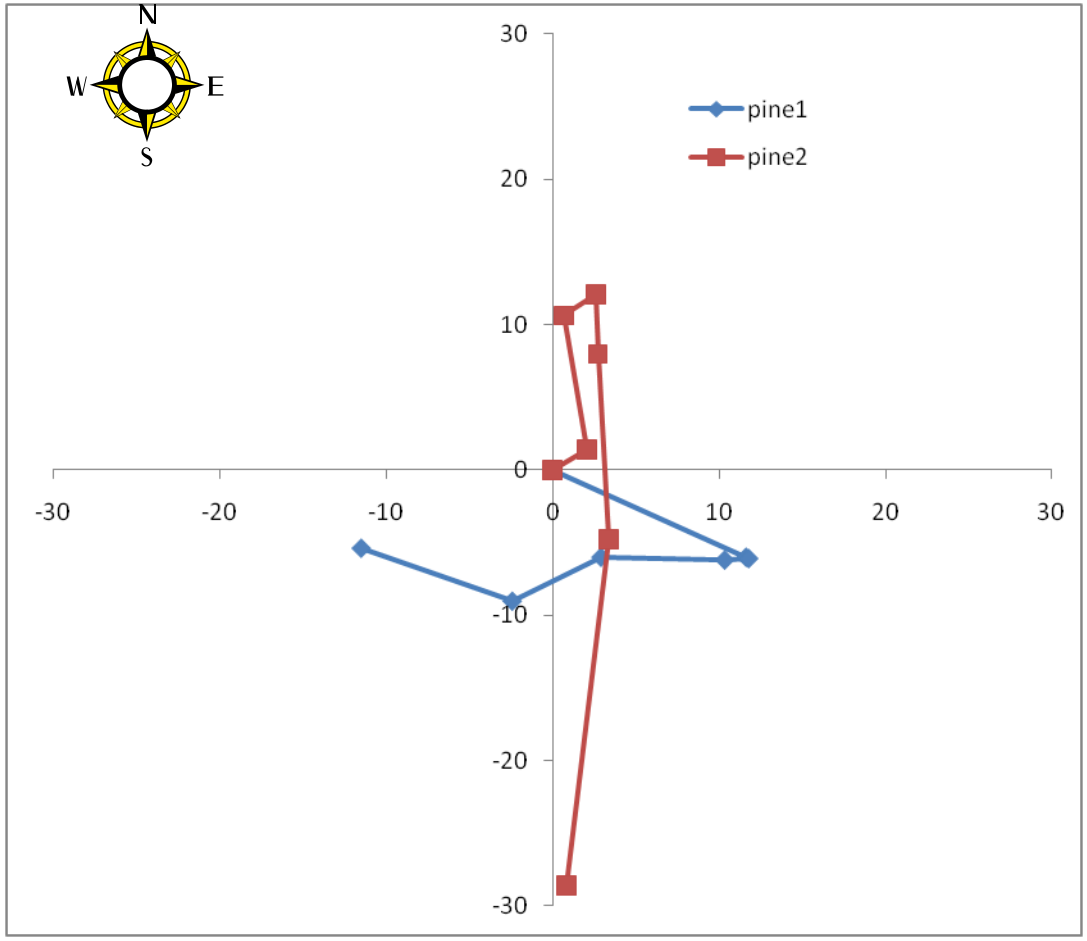


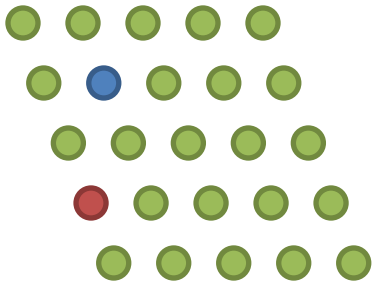


	Number of shoots	Total shoots length (m)	Height (m)	$d_{1.3}$ (cm)	Number of competitors
Tree 1	4377	574.96	3.81	16.0 (16.3)	8
Tree 2	4363	759.68	4.16	15.6 (16.0)	5

+3d growth

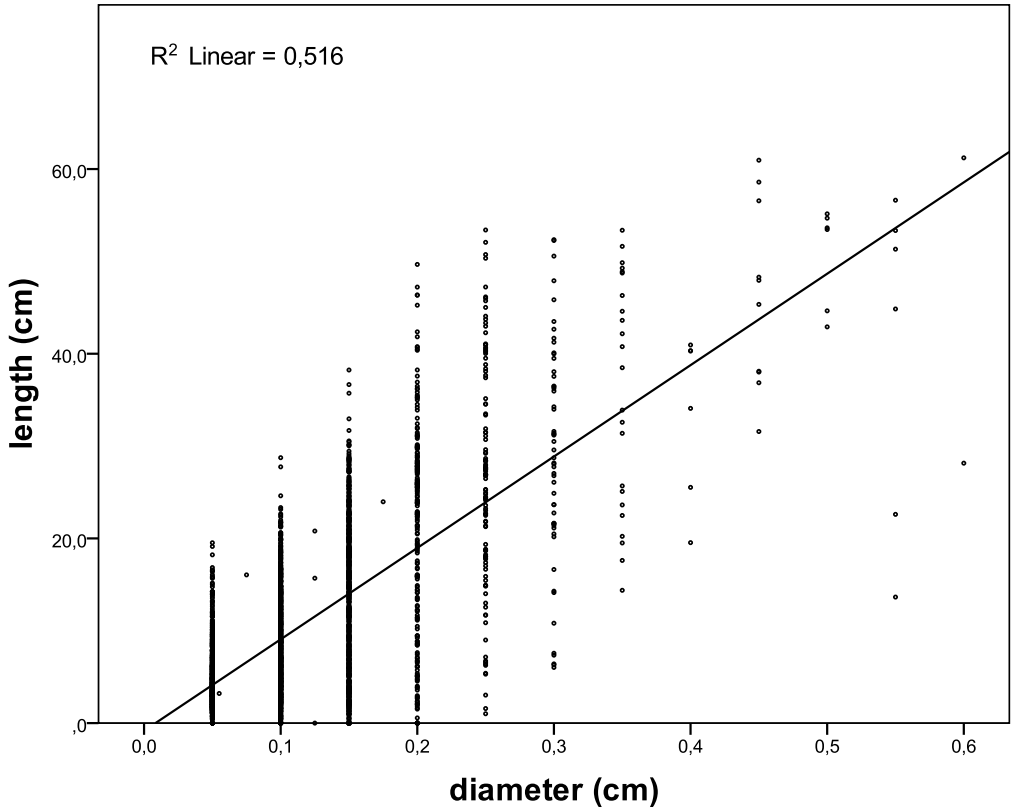
Orientation towards north





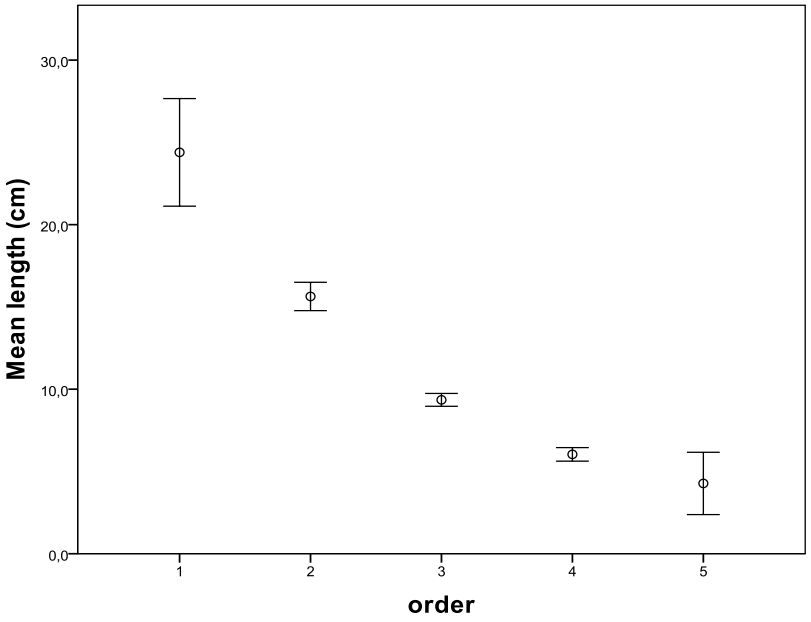
Plot +-

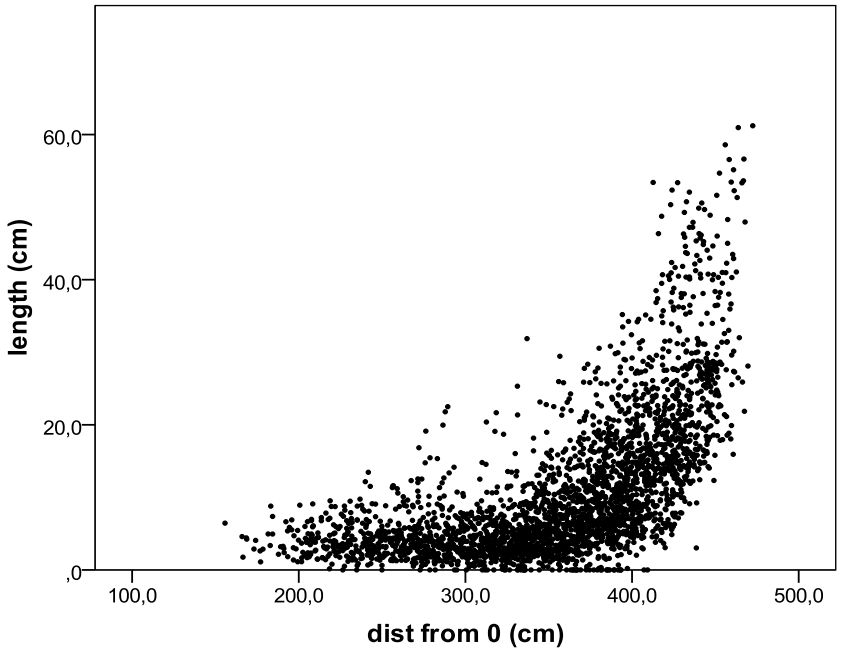
Data for individual tree increment



Correlation between diameter and length of shoots

Data for individual tree increment





The dependence between branch order and length (left), and between branch distance from 0,0 point and length (right)

- **There are data from 3d space**

(possibility to study, important is to understand the source of the data, as it can be also a source of variability)

- **This data may be interpreted as continuous or discrete**

(continuous increment of size, discrete steps in structure change)

- **We can model!!!**

But how??

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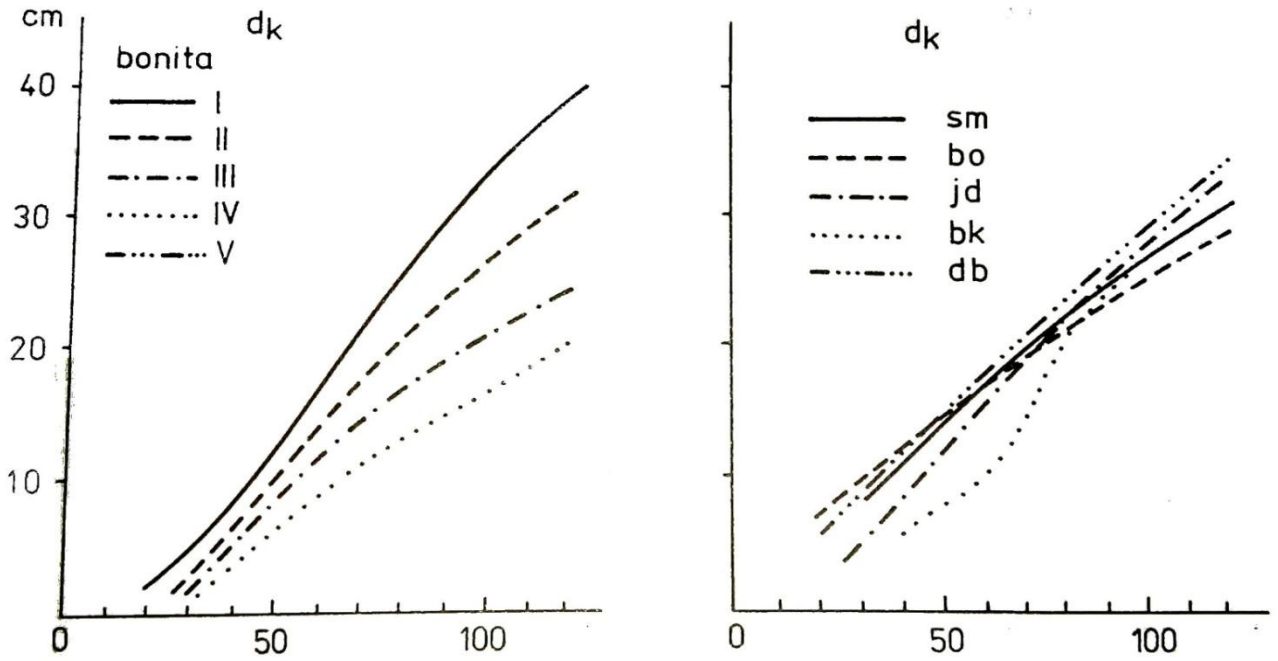
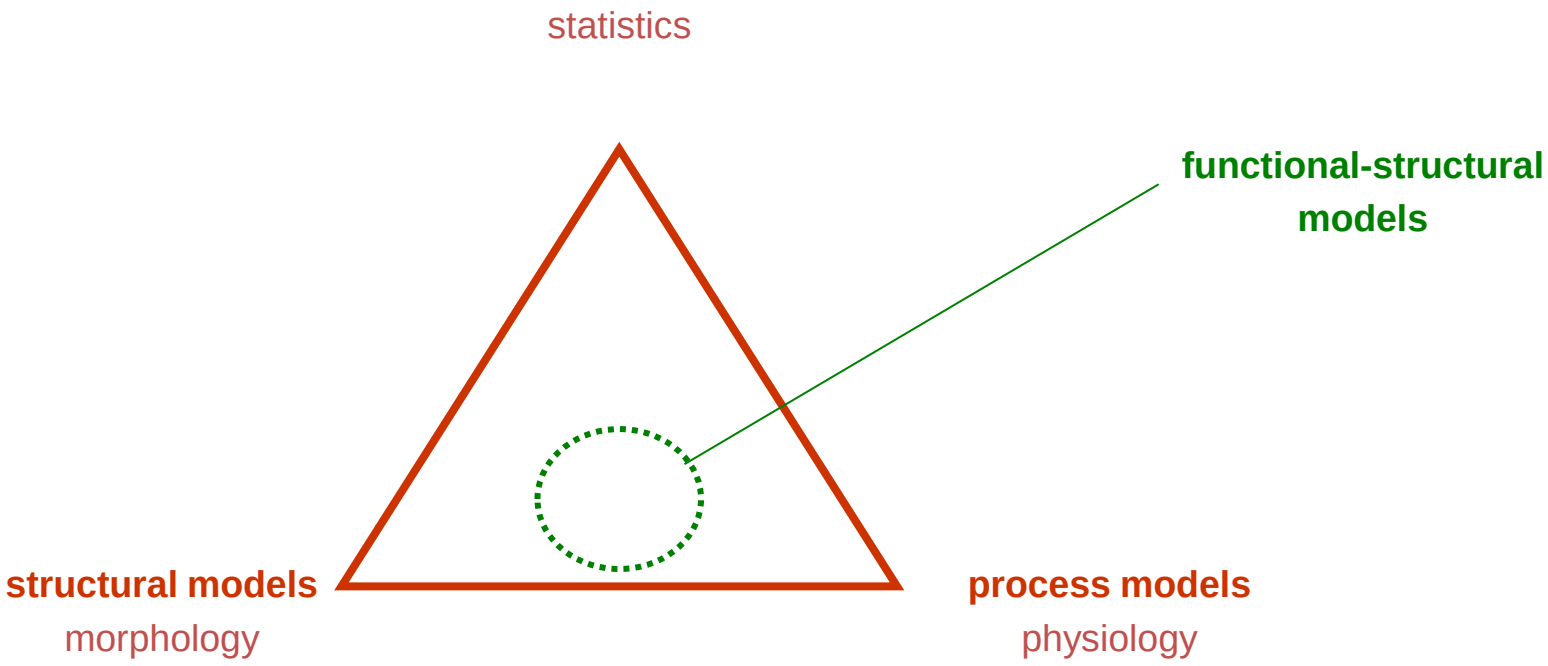
What is a model??

An abstract model (or conceptual model) is a theoretical construct that represents something, with a set of variables and a set of logical and quantitative relationships between them.

Forestry models??



Dynamics (causality problem)

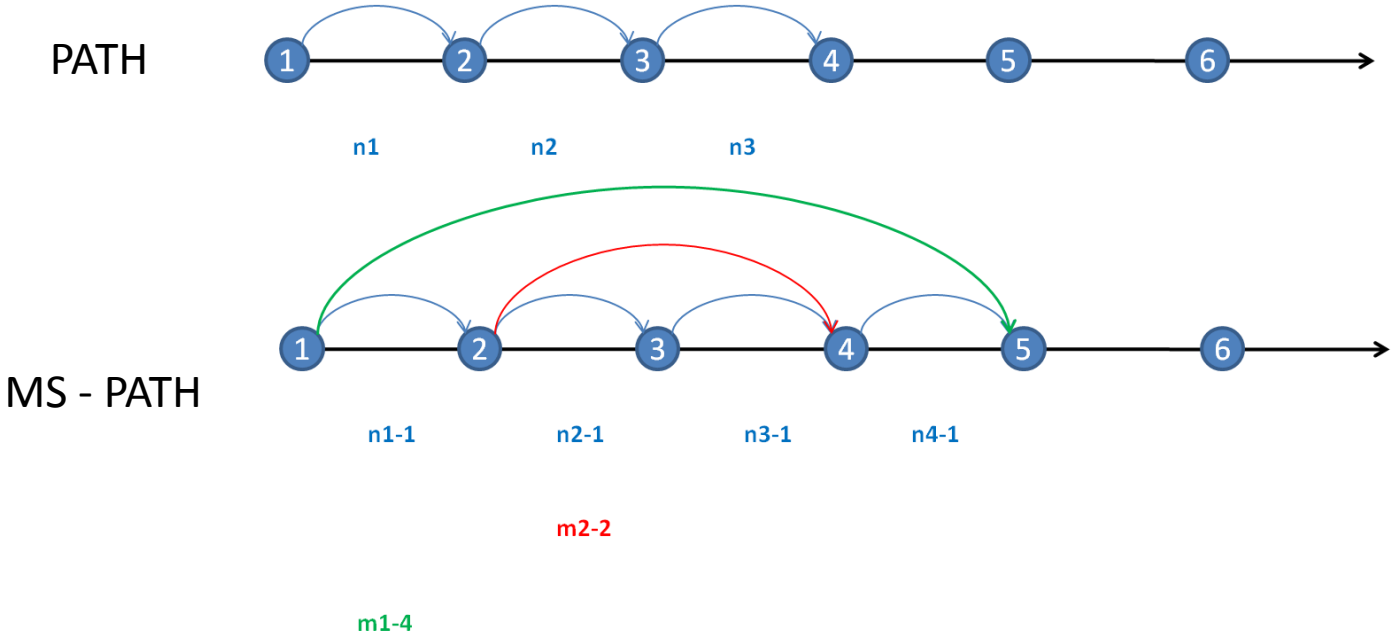


Causality (scaling problem)

- Modeling leads to decision support (impact of decision)

- The ultimate decision support is: to find the best solution (using model)

very good to test model feasibility
stochasticity and randomness are not acceptible
extreme cases may become optimal solutions (incorrectly)



Objective – maximize cork production, keep crown cover limits (what should I do?)

Case Study 1 (101)	No constraint	Constraint 70%	*Constraint 50%*
Year		tree ha^{-1}(kg ha^{-1})	
10	0 (1000.47)	0 (1000.47)	0 (1000.47)
20	320 (1550.42)	320 (1550.45)	200 (1548.415)
30	320 (1449.51)	320 (1449.58)	180 (1447.55)
40	320 (8421.99)	320 (8421.99)	**140 (4722.22)**
Case Study 2 (317)	**No constraint**	**Constraint 70%**	***Constraint 50%***
10	0 (1958.348)	0 (1958.348)	0 (1958.348)
20	320 (2764.25)	160 (2758.88)	0 (2757.85)
30	320 (3167.17)	100 (3161.62)	0 (3161.43)
40	320 (9959.97)	**60 (4611.55)**	0 (3379.54)

Ribeiro, NA, Surovy, P, Yoshimoto, A (2012) Optimal regeneration regime under continuous crown cover requirements in cork oak woodlands, FORMATH 2011

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Stone pine model – important modules

First version of pine model:

Structure:

stem cylinder : dynamic in time

branch cylinder : time + order + dist

leaves (after 1 year change to bud)

bud

Functions:

Bud mortality

Second version of pine model:

Structure:

Branch cylinder (order)

leaves (light measure needed)

Bud

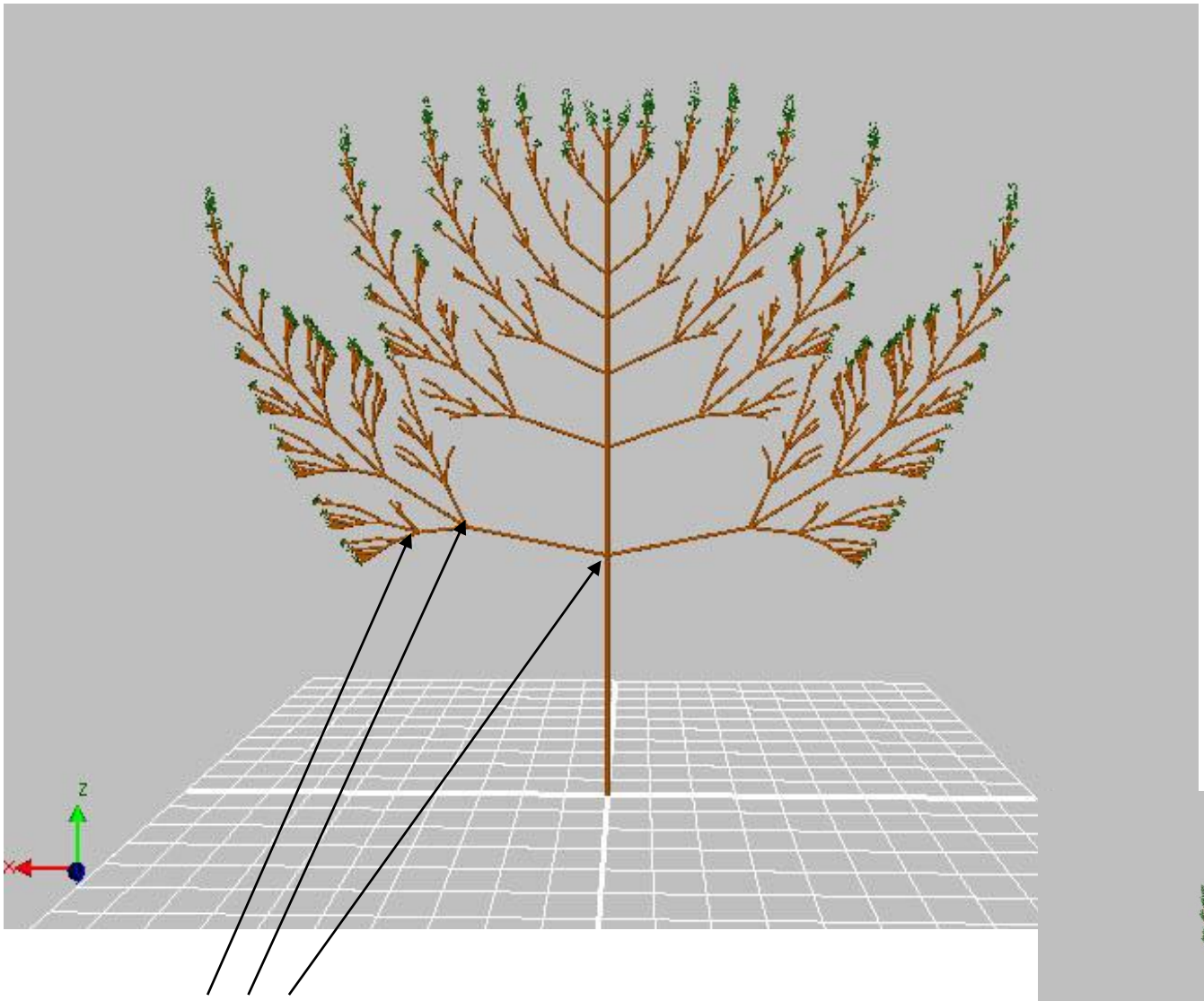
Bending (rotation)

Functions:

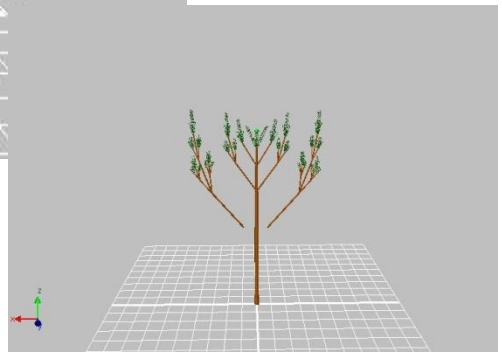
Bud mortality

Bending

Stone pine model – important modules and code parts



Branch rotation (order, distance)



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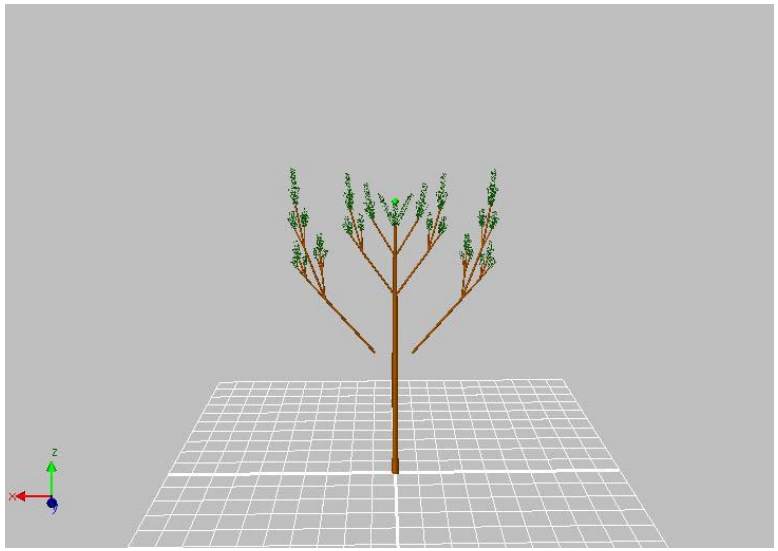
Optimalization possibilities



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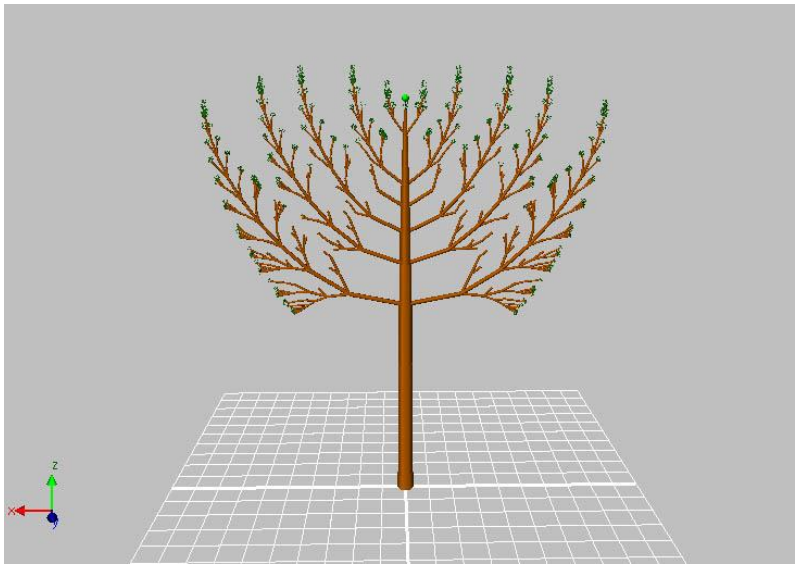
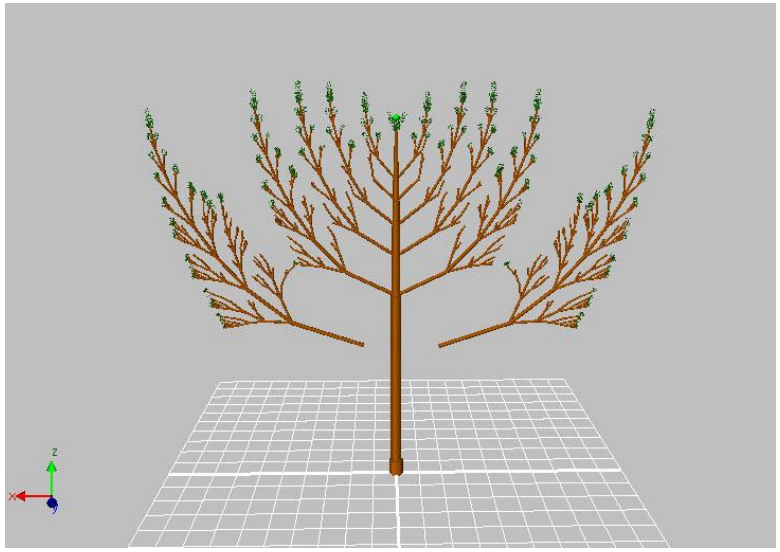
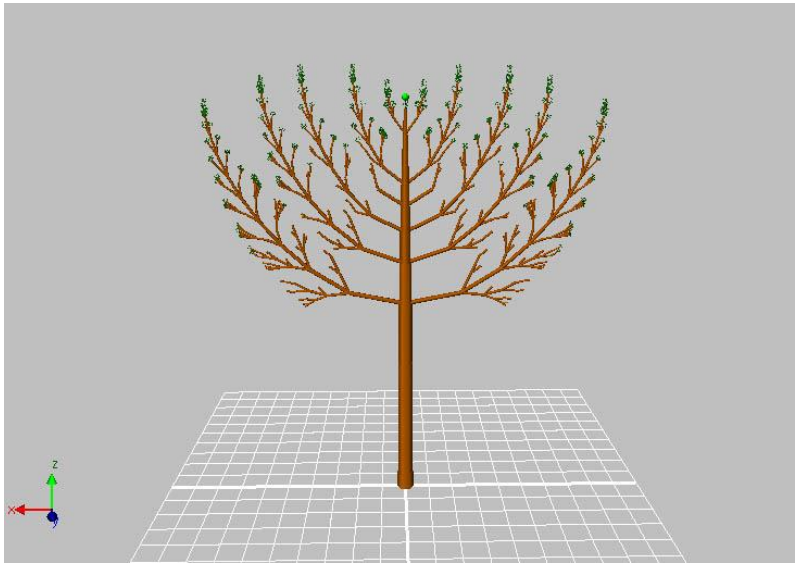
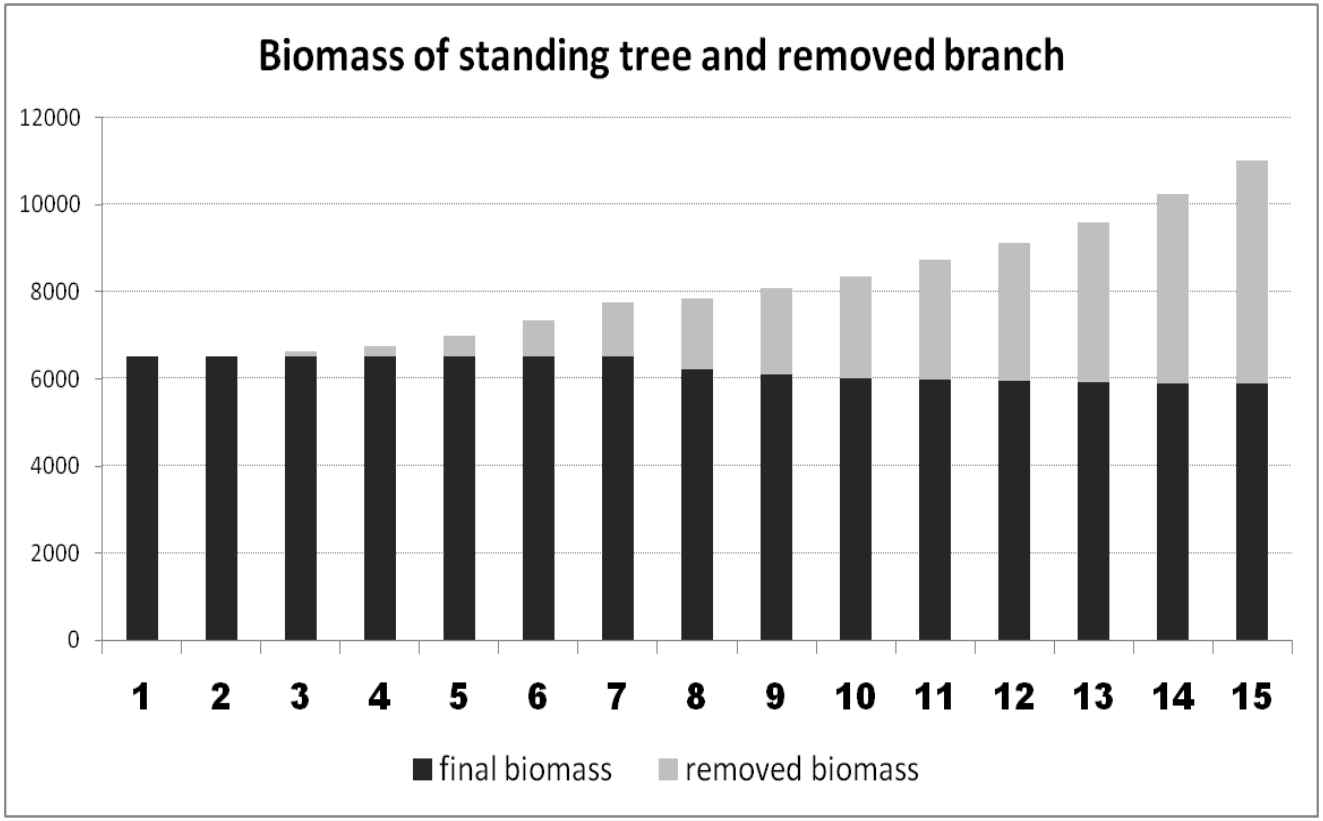


Find the best year to remove the most bottom branch

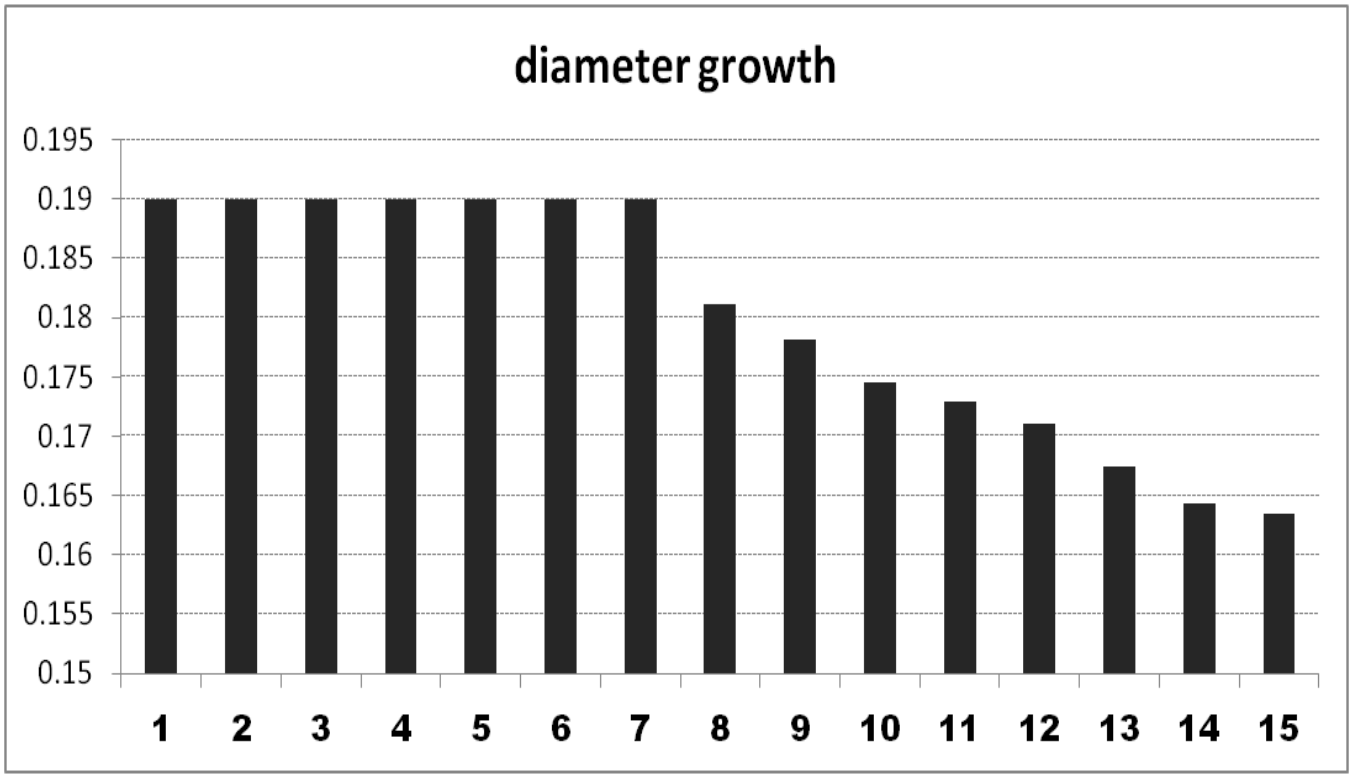


10





X axis shows the year of removal of branch (Y shows the total biomass)



Only green to brown branches ratio

Message :

At this stage the most important is to continue the model development with simultaneous testing of it in optimization processes (Let there be light…)

In this work optimization is focused on the branching – pruning planning

The same model however can be used for initial stand density optimization as well as for thinning optimization (parallel optimization testing is important)

Sensitivity analysis: *(what to measure, where to focus)*

-The branch elongation makes important difference

The total biomass of crown and the bottom branch is different

-The mortality based on Cone's angle makes important difference

Again the total biomass is influenced and also the look

-Though: the BranchRotation is the most decisive element

Smaller change in branch bending makes the survival rates of buds far different

Conclusions :

- 3d measurement and modeling may bring some new insight into our knowledge on tree growth and structure development .

- The functional structural plant models (computer research) allows combination of various necessary components (rules, mathematical functions, external environment simulation)

- It is possible with correct model construction the use these models also in optimization work.

Thank you for your attention…