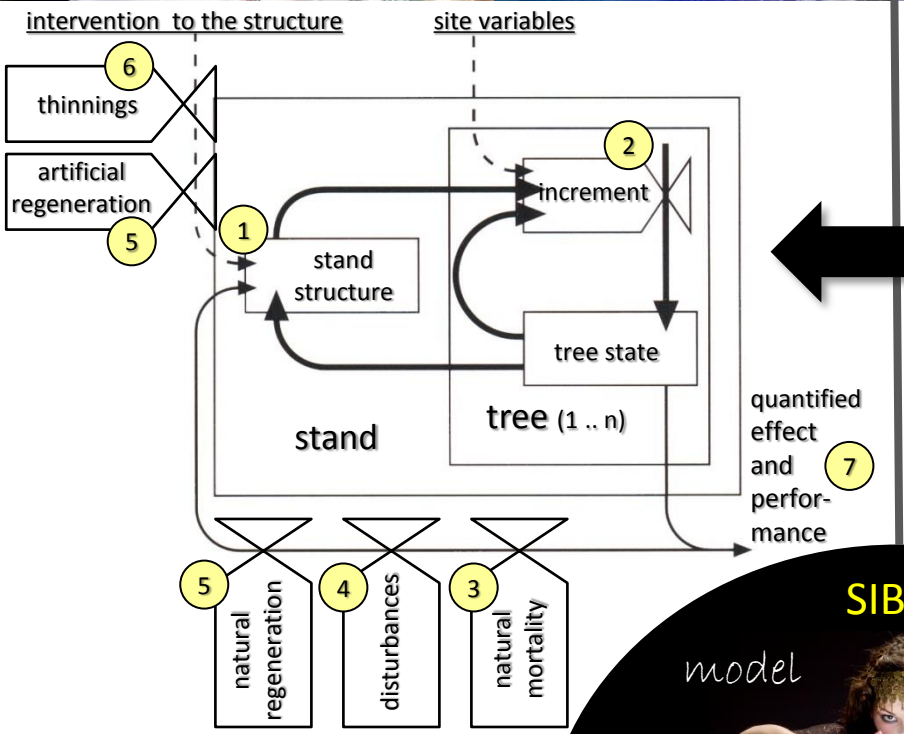
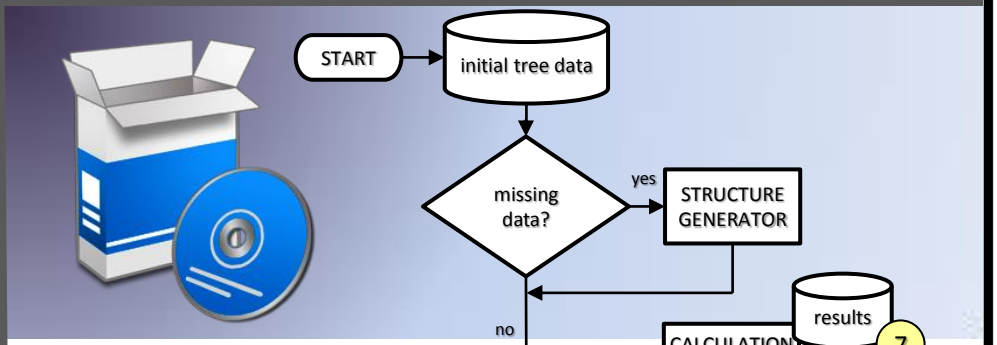

MAREK FABRIKA
and the
Secret of
SIBYLA modelling for DSS

System diagram of the model



Flow diagram of the software



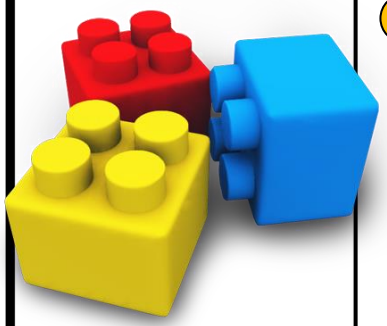
LECTURES BY MAREK FABRIKA

STRUCTURE GENERATOR

1th level: tourist	2nd level: scout	3rd level: adventurer	4th level: superman
			
Information adapting	Measuring	GIS Mapping	Laser scanning
 	  		 

LECTURES BY MAREK FABRIKA

3D STRUCTURE MODEL



Tree - VRML

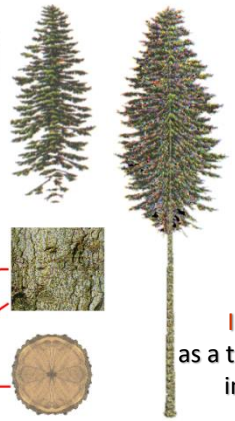
2

crown
(IndexedFaceSet)
rotated using
Transform

crown projection
(IndexedFaceSet)

stem
(Cone)

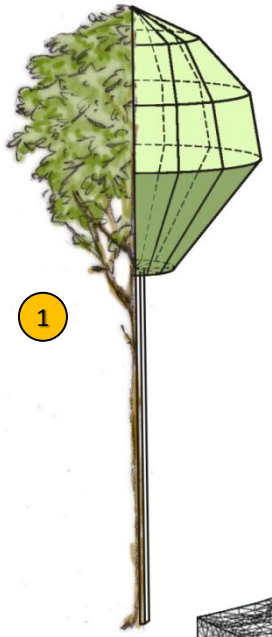
root stump
(Cone)



ImageTexture
as a texture parameter
in Appearance

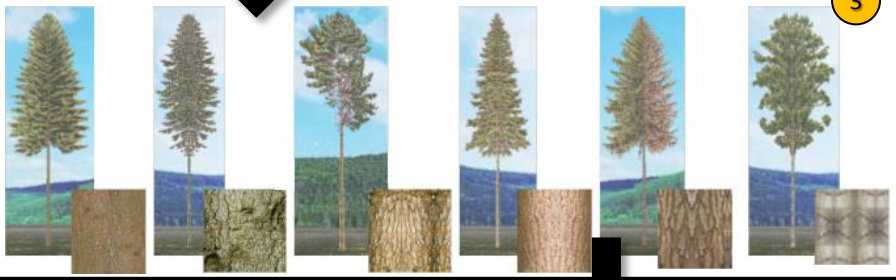
Tree - model

1



Species - VRML

3



Stand - VRML

4

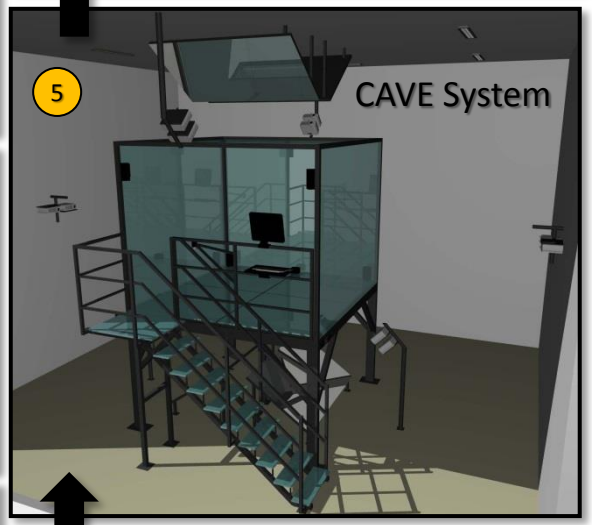
terrain
(TIN Surface)

Stand - VR

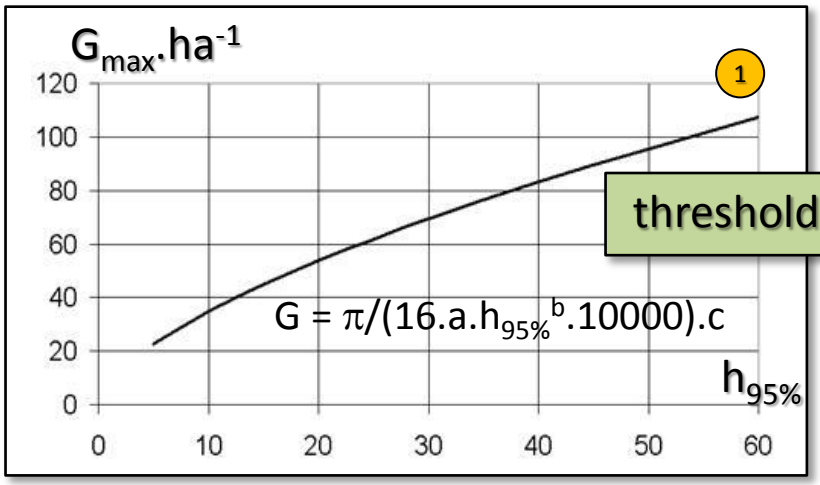
6

CAVE System

5



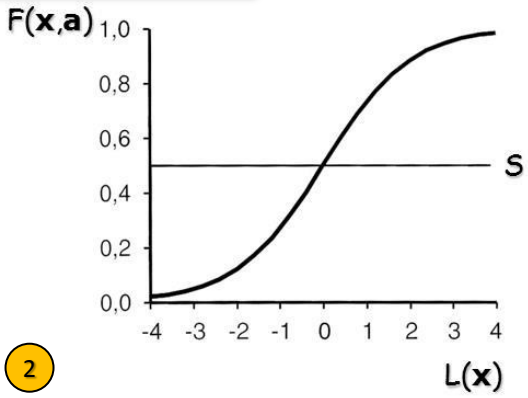
LECTURES BY MAREK FABRIKA



threshold density

Limits of production area
⇒ intrinsic mortality

logit function



$$F(\mathbf{x},\mathbf{a}) = \frac{1}{1+e^{-L(\mathbf{x})}}$$

$$L(\mathbf{x}) = a_0 + a_1.x_1 + \ldots + a_n.x_n$$

$$T = \begin{cases} \text{alive, if } F(\mathbf{x},\mathbf{a}) \geq S \\ \text{dead, if } F(\mathbf{x},\mathbf{a}) < S \end{cases}$$

Limits of site and competition
⇒ growth-dependent mortality

Influence of risk
⇒ exogenous mortality

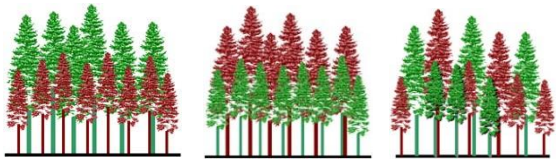
Hazard = P(What?)

Exposure = P(How often?)

Vulnerability = P(How much?)

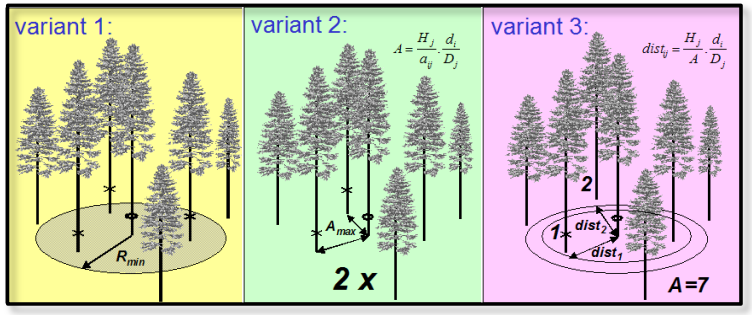
Risk = Hazard . Exposure . Vulnerability
Loss = Population . Risk
MONTE CARLO METHOD

1

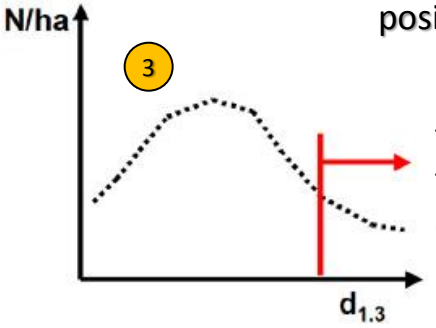


thinning based on the sociobiology position of a tree

2

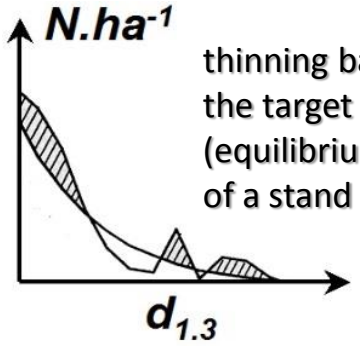


thinning aimed at supporting future crop trees



3

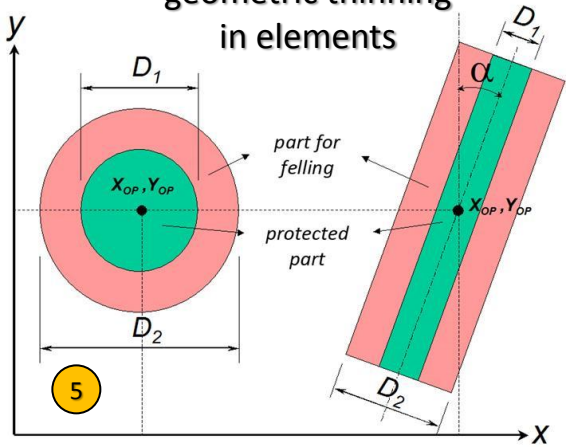
thinning based on the target dimensions of trees



4

thinning based on the target frequency (equilibrium) curve of a stand

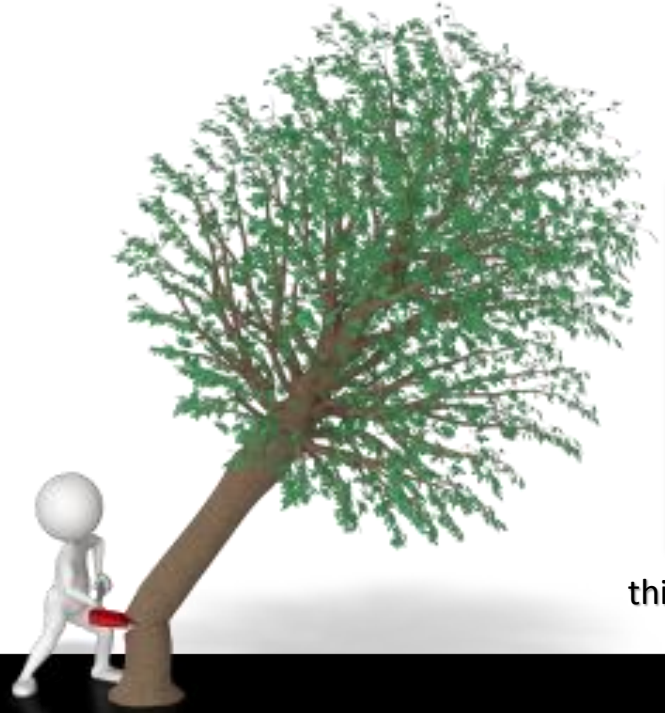
geometric thinning in elements

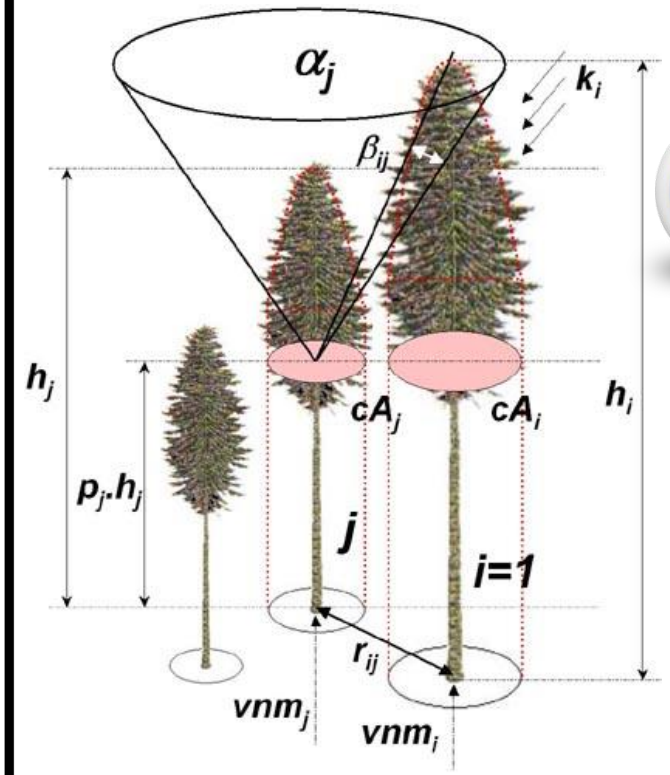


5

6

thinning using the interactive method



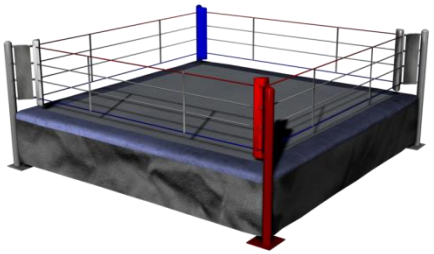


$$\beta_{ij} = \frac{\pi}{180} \cdot \left(\frac{\alpha_j}{2} - arctg \frac{r_{ij}}{(vnm_i + h_i) - (vnm_j + p_j h_j)} \right)$$

$$CCL_j = \sum_{\substack{i=1 \\ i \neq j}}^{n} \beta_{ij} \cdot \frac{cA_i}{cA_j} \cdot k_i$$

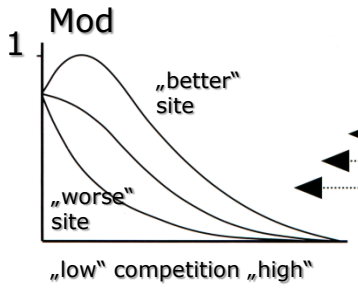
competition asymmetry

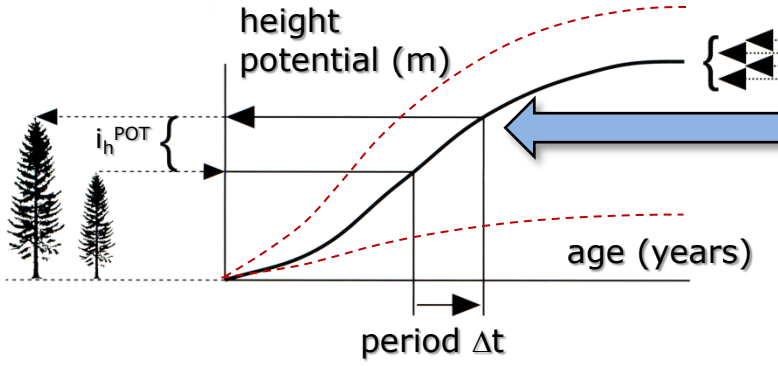
edge effect correction

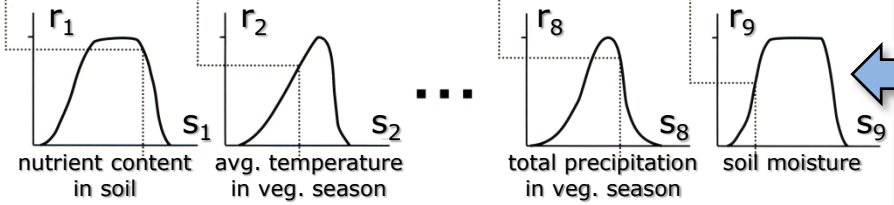


competition mixture

$i_h = i_h^{POT} . Mod$
$i_h^{POT} = f(site)$
$Mod = f(competition, vitality, site)$



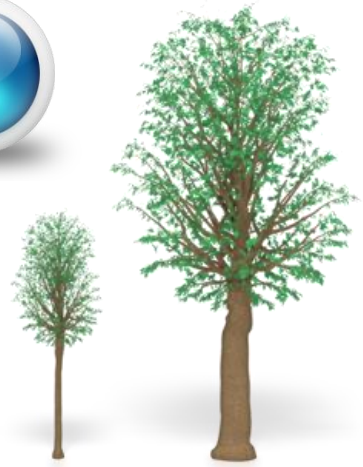




Function by Korf

$$y = a.e^{-bt^{-c}}$$

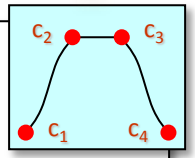
polymorphic interpolation



Function by Kahn

transformation (fuzzy) function

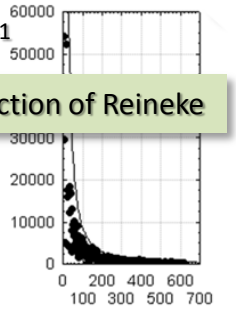
$$w = \begin{cases} (s \ge c_1) \wedge \left(s < c_1 + \frac{c_2 - c_1}{2}\right) \Rightarrow 2.\left(\frac{s - c_1}{c_2 - c_1}\right)^2 \\ \left(s \ge c_1 + \frac{c_2 - c_1}{2}\right) \wedge (s < c_2) \Rightarrow 1 - 2.\left(\frac{s - c_2}{c_2 - c_1}\right)^2 \\ (s \ge c_2) \wedge (s < c_3) \Rightarrow 1 \\ (s \ge c_3) \wedge \left(s < c_3 + \frac{c_4 - c_3}{2}\right) \Rightarrow 1 - 2.\left(\frac{s - c_3}{c_4 - c_3}\right)^2 \\ \left(s \ge c_3 + \frac{c_4 - c_3}{2}\right) \wedge (s < c_4) \Rightarrow 2.\left(\frac{s - c_4}{c_4 - c_3}\right)^2 \\ (s < c_1) \vee (s \ge c_4) \Rightarrow 0 \end{cases}$$



c_1 , ... , c_4 breakpoints where
$c_1 = s_{min}$
$c_4 = s_{max}$

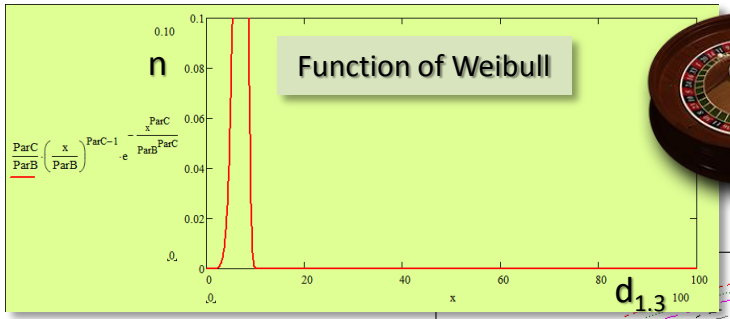
REDUCTION OF GROWTH POTENTIAL

Regeneration density



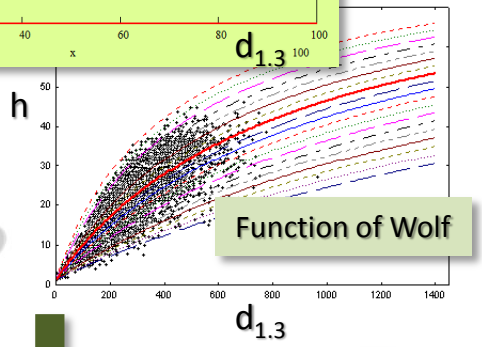
Function of Reineke

⇒ influence of climate
⇒ influence of mature density



Function of Weibull

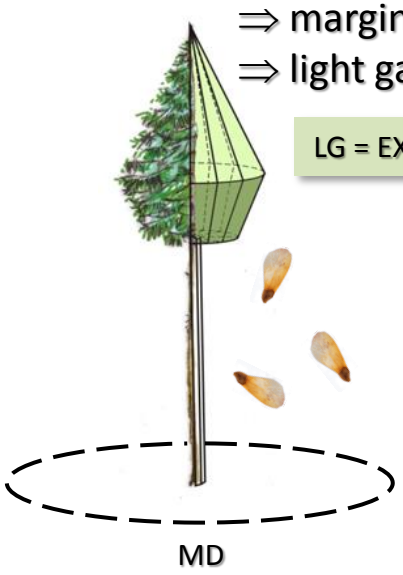
Regeneration dimensions

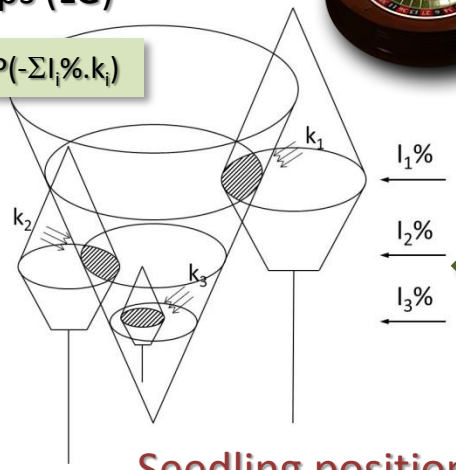


Function of Wolf

⇒ marginal distance (MD)
⇒ light gaps (LG)

LG = EXP(-ΣI_i%.k_i)





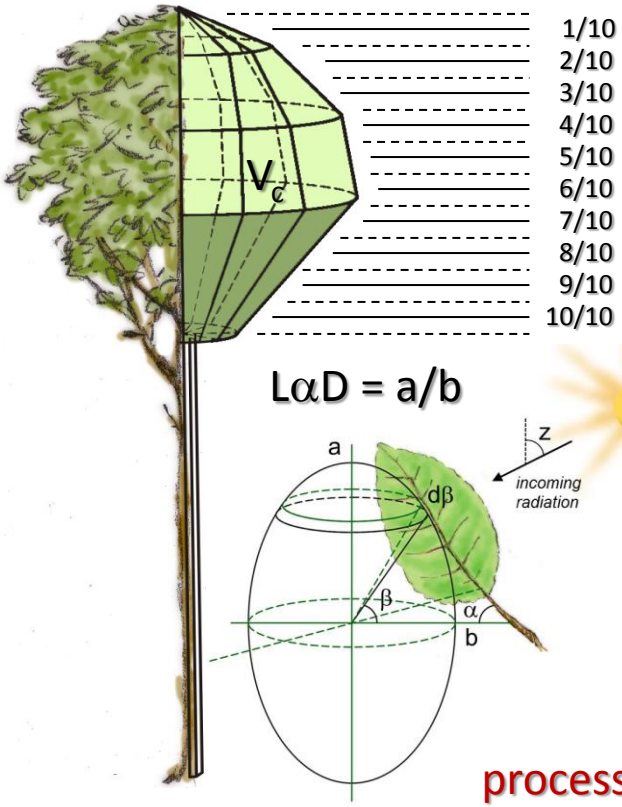
Seedling position

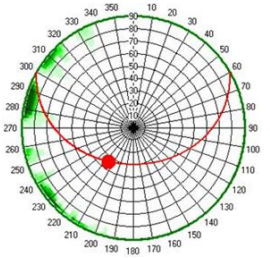
Mature tree selection

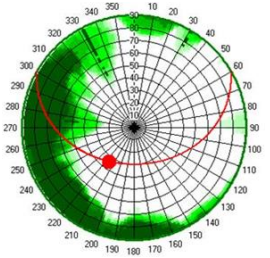
+ possible seed crop
– possible seed loss

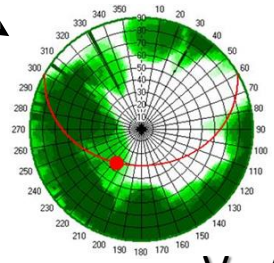
probability proportional to rest seed crop

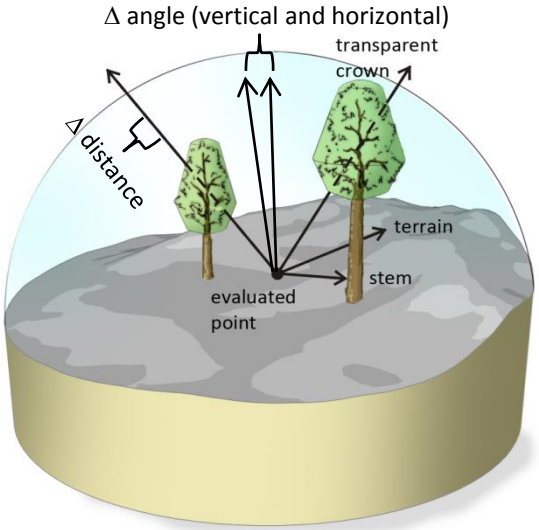
„ray tracing“ method
+ Lambert-Beer law
+ Campbell ellipsoid











$L\alpha D = a/b$

process-based downscale

$$\varphi = \varphi_0 . e^{-k_z . LAI_z}$$

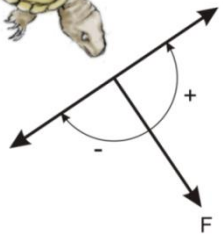
$$k_z = \frac{\sqrt{L\alpha D^2 + tg^2(z)}}{L\alpha D + 1.744.(L\alpha D + 1182)^{-0.733}}$$

$$LAI_z = SLA.LBD.r_z = SLA.\frac{B_l}{V_c}.r_z$$

Processes: pedotransfer functions, hydrological balance, stomata activity, leaf energy balance, transpiration, photosynthesis, respiration, leaf phenology, carbon production

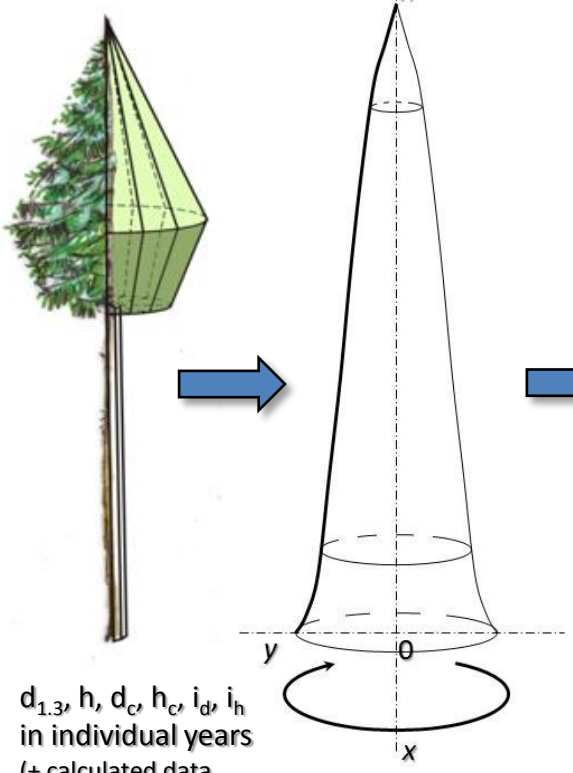
growth grammars

database interface:
growth grammars ⇔ SIBYLA simulations

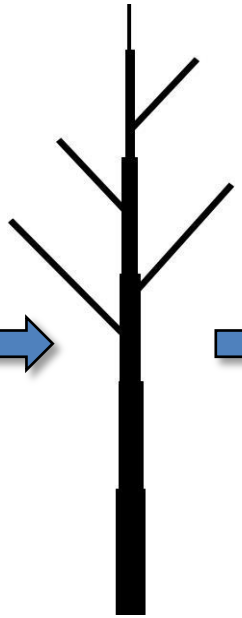


turtle graphics

stem taper curve
based on $d_{1.3}$ and h

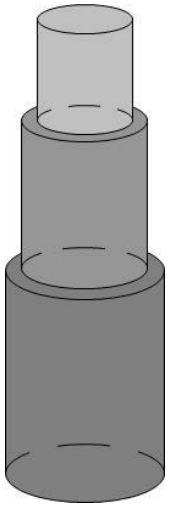


$d_{1.3}$, h, d_c, h_c, i_d, i_h
in individual years
(+ calculated data
before beginning
of simulation)

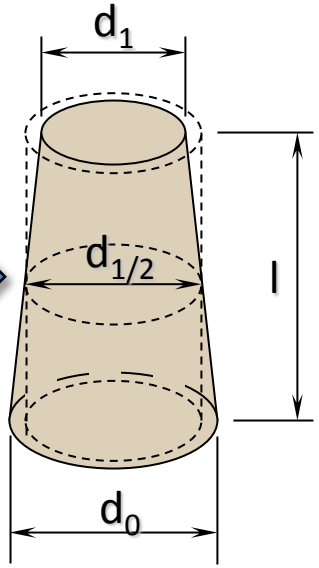


annual internodes
according i_h

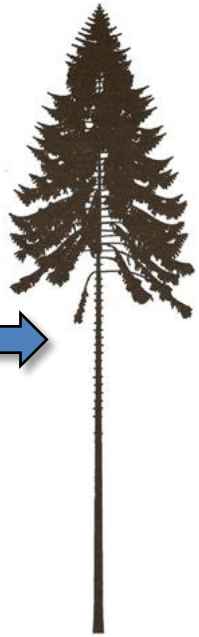
internodes diameters
from taper curve



new solids
for internodes



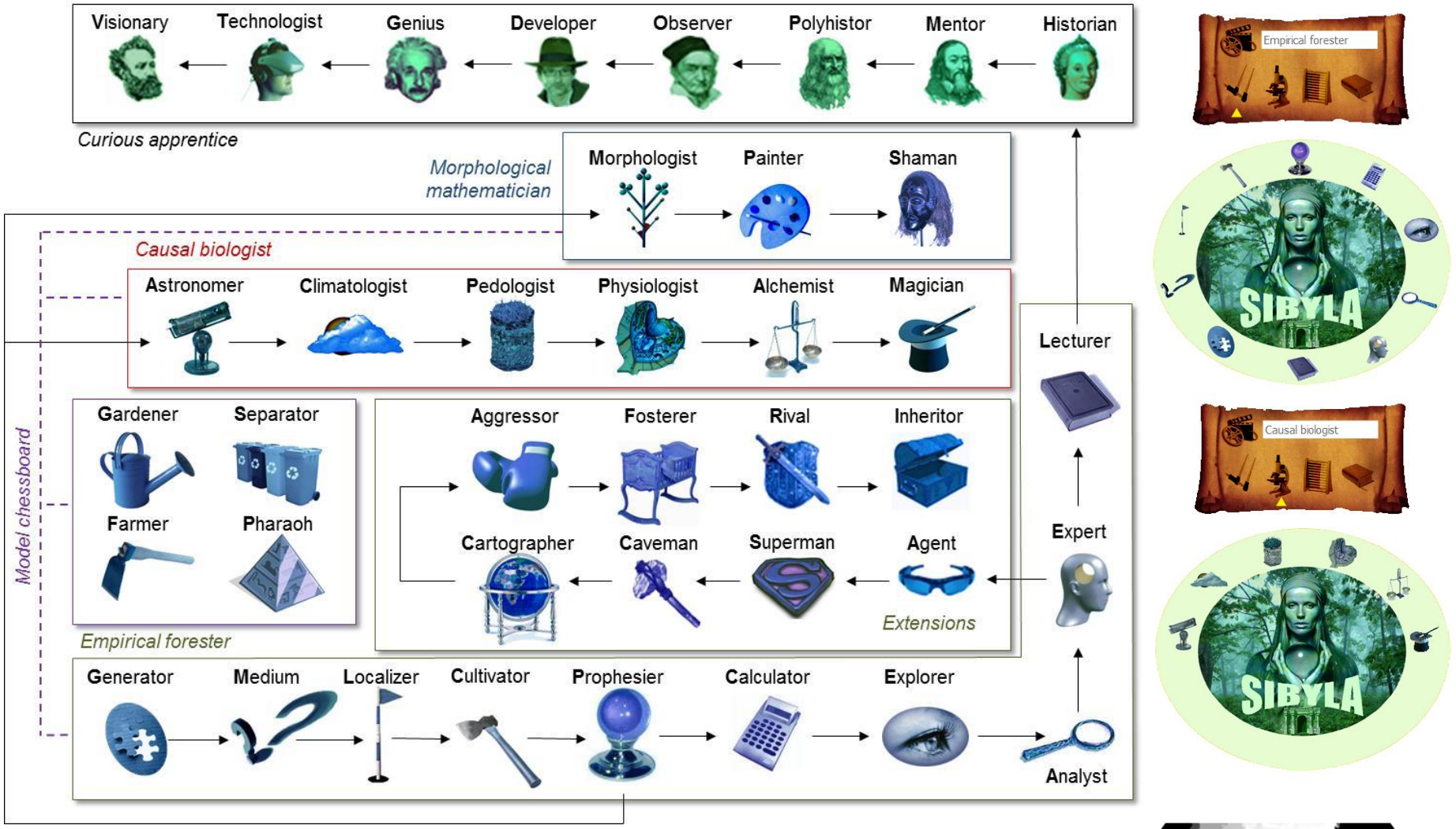
branch development
regulated by d_c and h_c
with mortality processes



structural downscale

EXTRAORDINARY PRODUCT FOR DECISION SUPPORT SYSTEMS

- modular architecture
- multi-concept approach
- multi-scale properties
- relational database
- batch and parallel processing
- flexible stand types and structures
- flexible forest management
- complex disturbance model
- regeneration model
- climate sensitivity
- user friendly
- opened for user calibration
- support of virtual reality
- educational support



SOFTWARE STRUCTURE

branch type	branch	module	description of the module
executive	empirical forester	Generator	generating of forest structure
		Medium	card file of simulation plots
		Localizer	specifying and generating of site
		Cultivator	specifying of management treatments
		Prophesier	simulation of forest development
		Calculator	calculation of outputs
		Explorer	exploring of outputs
		Analyst	analysing of outputs
		Expert	tree diagnostic card, calibration of empirical model, interface for extensions and for model chessboard
		Lecturer	handbook of the model and of the software
	causal biologist	Astronomer	generator of solar radiation
		Climatologist	weather generator
		Pedologist	generator of soil properties
		Physiologist	modelling of eco-physiological processes
		Alchemist	setting of process model parameters
		Magician	process-based downscale of empirical simulations
	morphological mathematician	Morphologist	description of tree growth grammar
		Painter	definition of visual properties of tree
		Shaman	structural downscale of empirical simulations
	extensions	Agent	data import
		Superman	interface for data from terrestrial laser scanner
		Caveman	interface to CAVE equipment
		Cartographer	management of simulation plots by GIS interface
		Aggressor	risk analysis of disturbances
		Fosterer	analysis of natural regeneration
		Rival	analysis of competition pressure
		Inheritor	genealogy of tree generations
	model chessboard	Gardener	big leaf model
		Separator	frequency stand model
		Farmer	population stand model (yield tables)
		Pharaoh	biome model
educational	curious apprentice	Historian	history of forest modelling
		Mentor	ecosystem, eco-physiological and forestry background of forest modelling
		Polyhistor	system and cybernetics background of forest modelling
		Observer	biometrical background of forest modelling
		Developer	classification of forest models
		Genius	functioning of empirical, process-based and structural forest models
		Technologist	application of technologies in forest modelling
		Visionary	visions of forest modelling to the future