The ModisPinaster model: an overview (2009-2014)

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Meeting CAQSIS - 2015

7 - 9 April 2015, AgroParisTech, Nancy, France

COST is supported by the EU Framework Programme

Forest in Portugal

35 % of the area is forest area

31% softwood species

69% hardwood species

Major species

Eucalyptus (812 000 ha; 26%)

Cork oak (737 000 ha; 23%)

Maritime pine (714 000 ha; 23%).

ICNF, 2013. *IFN6 – Áreas dos usos do solo e das espécies florestais de Portugal continental. Resultados preliminares.* [pdf], 34 pp, Instituto da Conservação da Natureza e das Florestas. Lisboa.

Outline

(1) Silvicultural models for maritime pine in Portugal

(2) ModisPinaster (2000-2009)

(3) ModisPinaster (2009-2014)

Silvicultural models for the species

Typical silvicultural model

The thinning interval is short to medium (5-10 years), corresponding to a top height growth of 2 to 3 m.

t0

natural regeneration or plantation/seeding

1st thinning
15 < t < 20

2nd thinning
25 < t < 30

t harvest = 35 yrs (minimum)

top height : 8 – 10m

Silvicultural models for the species

Thinnings, for different stand ages and site indexes, are usually from below (and mixed) commonly computed using the **Wilson spacing factor**:

$$Fw = 100\ N^{-0.5}\ hd^{-1}$$

Options include setting up a **residual G or N** or the use of the **Stand density index**, by Reineke:

$$SDI = N(dg/25)^{b}$$

with b being 1.897 for maritime pine (Luis & Fonseca 2004)

Luis, J.S., T. Fonseca, 2004. The allometric model in the stand density management of *Pinus pinaster* Ait. in Portugal. Annals of Forest Science, 61 (8): 807-814.

N – trees.ha^{-1}
hd – dominant height (m)
dg – quadratic mean diameter (cm)
G – basal area (m^2.ha^{-1})

Growth models available for the species

Santos Hall (1931) →
Stand Tables for even-aged stands of MNL
…..

Hall & Martins (1986) →
Stand Tables for even-aged stands
…..

Páscoa (1987/88) →

PBRAVO
…..

More than 33 models or major model components (mainly regional)

The beginning of ModisPinaster (2000)

In 2000 it was formally stated*, **the need for a new model for maritime pine stands** in North Portugal to help for forest management of the species.

Tâmega's Valley
North Portugal

(the actual largest area of pine 173 500 ha)

37% Forest Area

2/3 Pinus pinaster(41 250 ha)

Distribution map of Maritime pine (*Pinus pinaster*)
EUFORGEN 2009, www.euforgen.org

"Baldios" (communales areas) owned by the local populations co-managed by the oficial forest services

***C.P. Marques, et al. 2000. Maritime pine stands management in the Tâmega Valley. Research and Developing Project PAMAF 4004 (1997-2000) Final Report, UTAD.**

Design

Main desirable features of the new model G&Y:

Easy of use for Inventory update & Thinning simulation

Flexible description of the diameter classes

Inclusion of a Mortality module

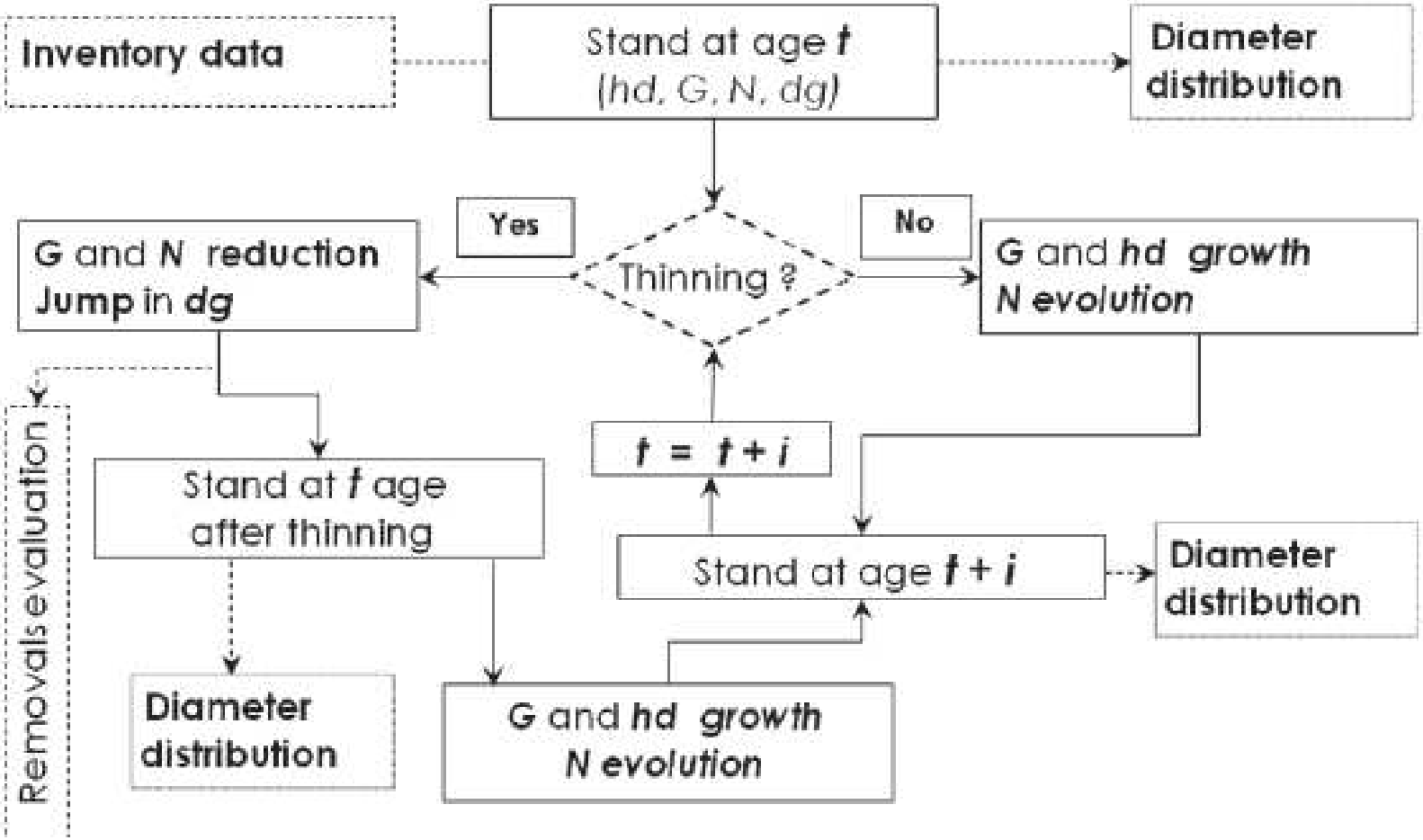
Available models:

Site Index and Dominant Height Growth Curves (Marques, 1991)

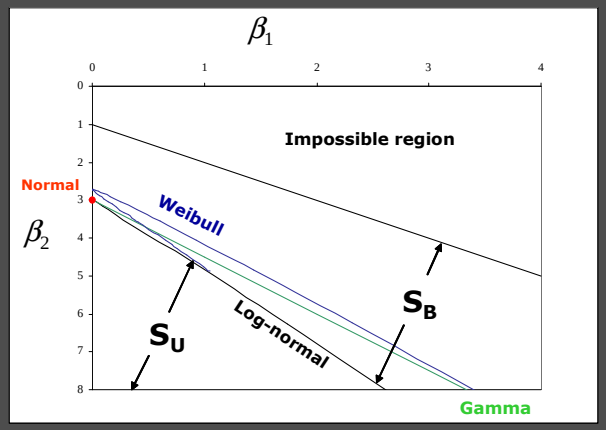
Marques, C.P. 1991. Evaluating site quality of even-aged maritime pine stands in northern Portugal using direct and indirect methods. For. Ecol. Manage. 41: 193-204.

The name: Model with diameter distribution for Pinus pinaster

Design

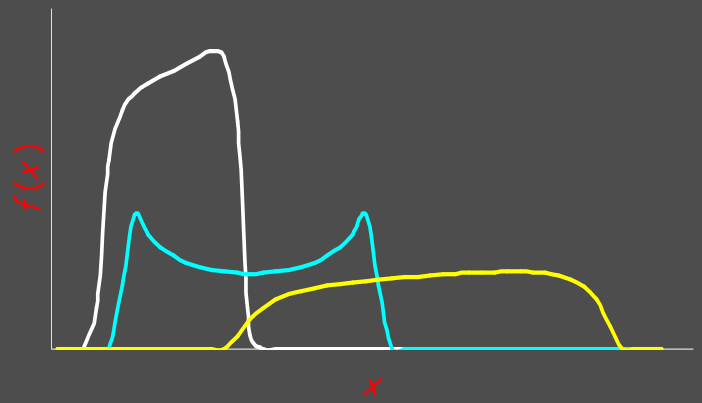

Inventory data
Stand at age t
(hd, G, N, dg)
Diameter distribution
Yes
No
Thinning ?
G and N reduction
Jump in dg
G and hd growth
N evolution
Removals evaluation
t = t + i
Stand at t age
after thinning
Stand at age t + i
Diameter distribution
Diameter distribution
G and hd growth
N evolution

Diameter distribution model – Johnson S_B distribution



System of distributions proposed by Johnson (1949):
S_U, S_L e S_B

"Bounded" $\xi < x < \xi + \lambda$



$$-\infty < \xi < \infty \qquad \lambda > 0 \qquad \delta > 0 \qquad -\infty < \gamma < \infty$$

$$x \sim S_B(\xi, \lambda, \delta, \gamma) \quad \Rightarrow \quad z = \gamma + \delta \ln\left(\frac{x - \xi}{\xi + \lambda - x}\right) \sim N(0,1)$$

Procedure to obtain the parameters of the S_B distribution

- Parameter recovery method
  - percentil-moment
  - recovers lambda, delta and gamma parameters

Parresol, B.R. 2003. Recovering parameters of Johnson's SB distribution. USDA For. Ser. Res. Pap. SRS-31.

ξ $d_{0.50}$ $\bar{d}$ G N

$0.8d_{min}$

Mortality – wind and competition related

Wind damages (estimated to occur in the region 6 years each decade)

- tree leaning
- uprooting
- stem breakage

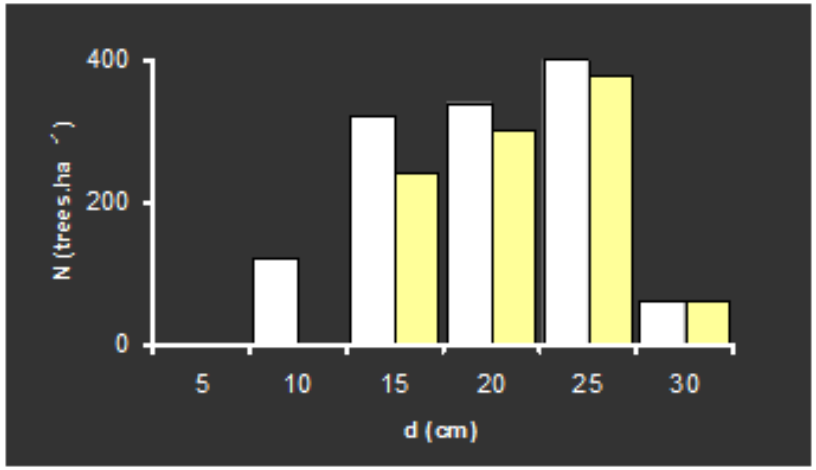
Mortality records (41cases in the 121 permanent plots monitorized)

Thinning

Trees to be removed from the diameter distribution were identified with a thinning algorithm (Alder, 1979).

The procedure assumes a probability of survival to cut proportional to a tree's size,

$$l(F) = Fc, \text{ with } c \text{ given by } N_t / N_a.$$



It depends on thinning weigth

$$N_{ja} = N_b L\left[F(d_j)^{1/L} - F(d_{j-1})^{1/L}\right]$$

N – trees.ha^{-1}
b – before (white bars), t – thinned
a – after thinning (yellow bars)

Alder, D. (1979). A Distance-independent Tree Model for Exotic Conifer Plantations in East Africa. For. Sci., 25:59-71.

ModisPinaster

Starting point (2000)

Design

Development (2000-2004)

Implementation
(June, 2009)

ModisPinaster

C.P. Marques
(Scientific and professional mentor & Leader of the funding Projects)

M. Tomé
(PhD supervisor)

C. Meredieu
(the Promoter of the implementation into the Capsis platform, INRA)

Starting point (2000)

Design

Development (2000-2004)

Implementation (June, 2009)

F. de Coligny
(the Developer responsible for achieving it, INRA, AMAP)

Barcelona COST Action FP0603 Meeting, 15-16 January 2009

Why Capsis 4?

Good reputation of the supporting institutions (e.g. INRA)

Secure platform (confidence on perennity)

Professional and **technical support by the Developers**

Easy to run in different operative systems (Windows, MacOSX, Linux)

Free software

+ all the properties of using Java language
(easier than others, free, easier for distribution, stable)

Use of existing extensions ➔ model improvement

Easy to share the model with the forest managers

Easy to do simulations within the Capsis platform

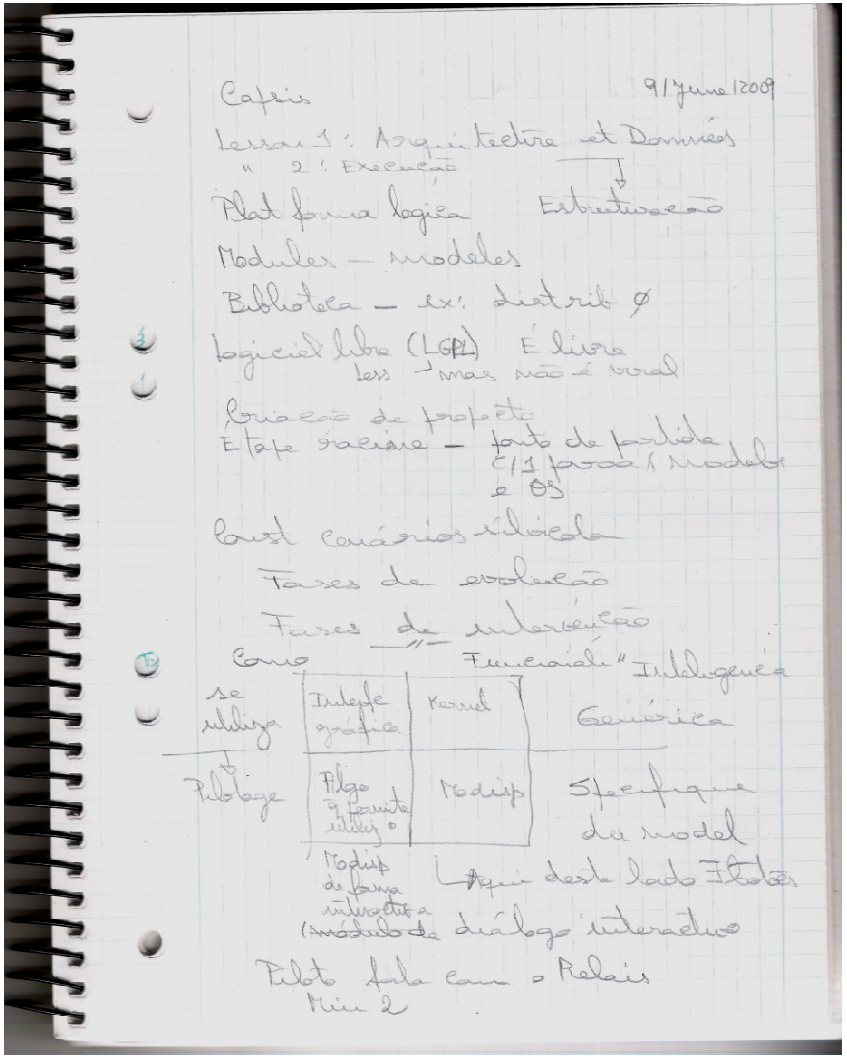
Implementation

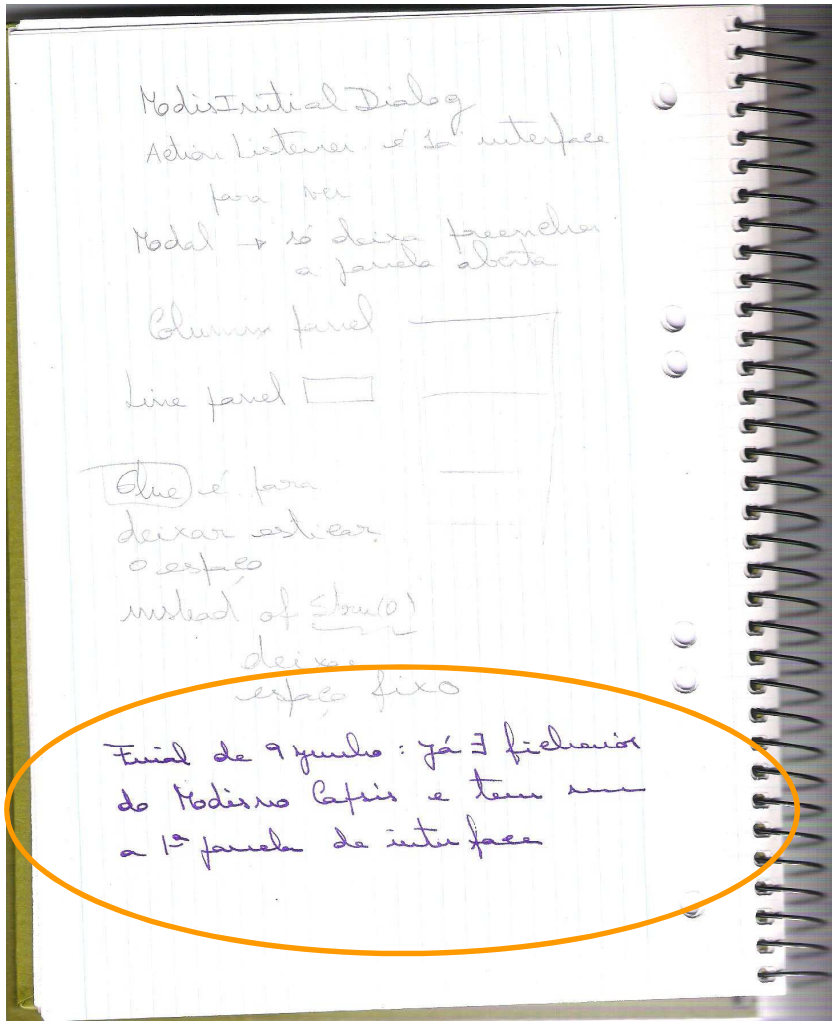
Integration of ModisPinaster in Capsis platform

Capsis
Computer-aided projection of strategies in silviculture

François de Coligny
(Capsis Developer)

- Training / Discussions (fc, cm)
- Integration of the stand level modules
- Integration of the distribution part
- Submodels revision





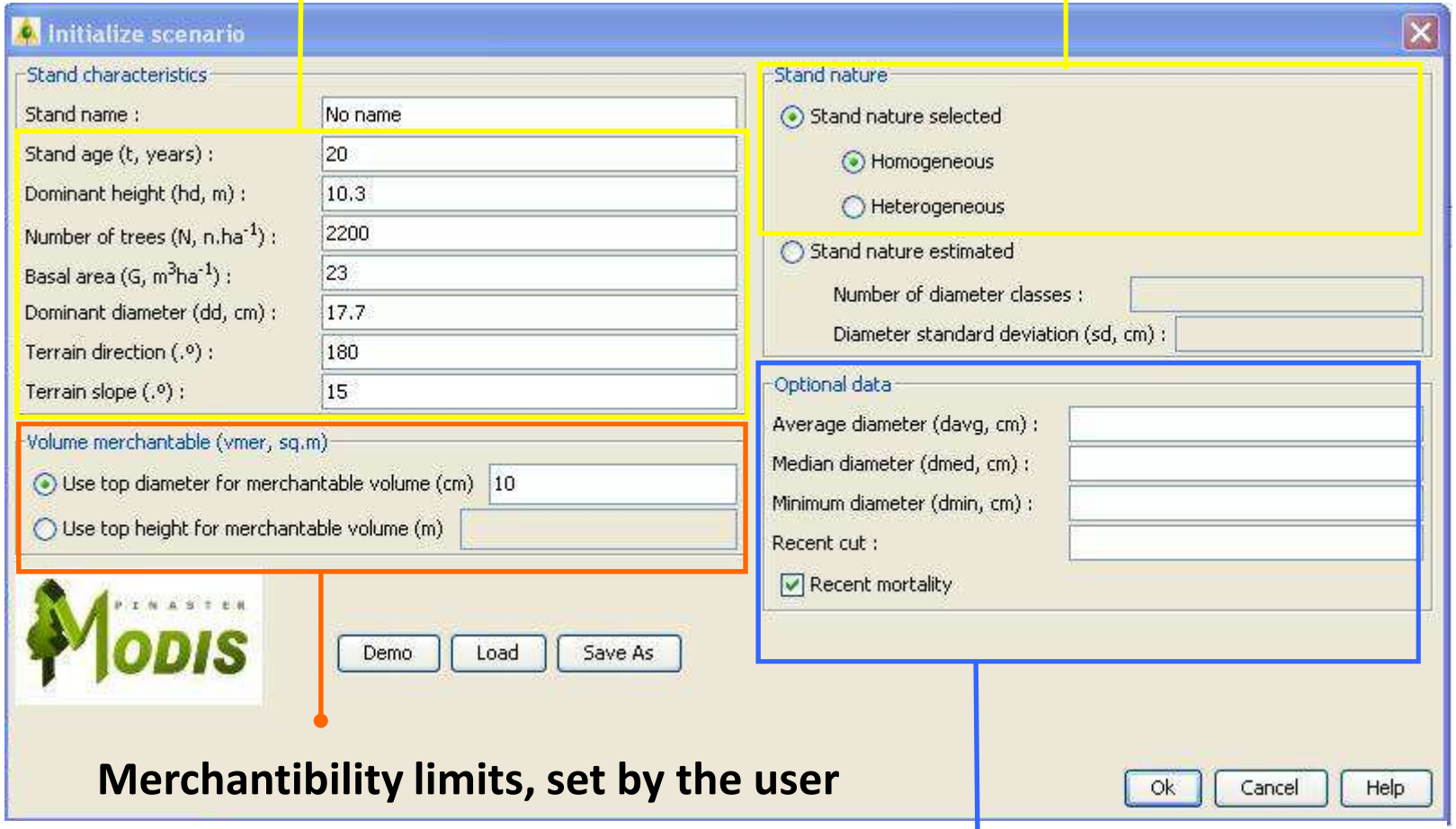
Formation: CAPSIS trainning

7-9 June 2009 ⟶ **9 of June: the 1st interface was built!**

Results (first version – June 2009)

Minimal Input

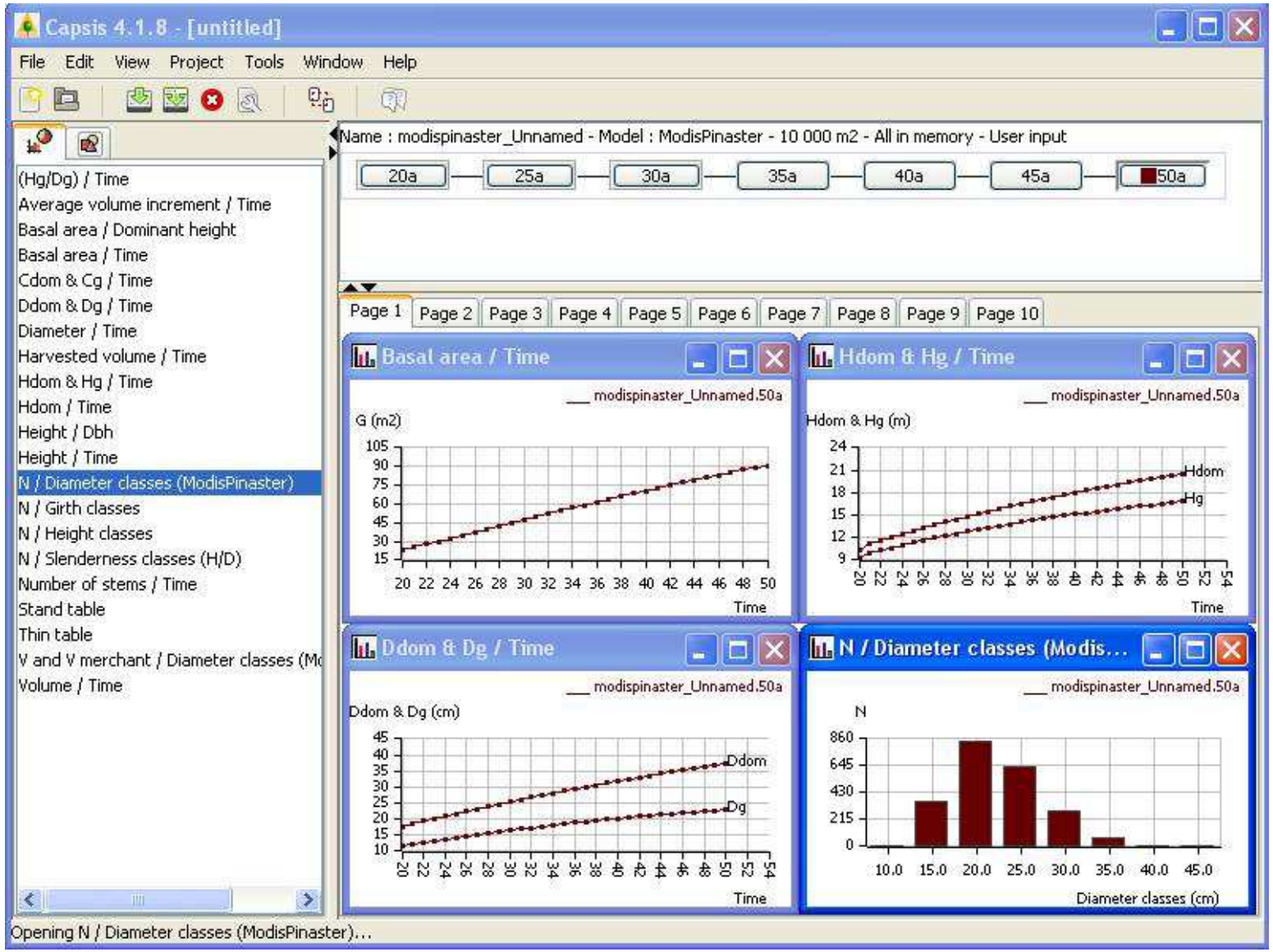
Homogeneous stands, by default



Merchantibility limits, set by the user

To improve the initialization of stand variables

Evolution


Capsis 4.1.8 - [untitled]
File Edit View Project Tools Window Help
Name : modispinaster_Unnamed - Model : ModisPinaster - 10 000 m2 - All in memory - User input
20a 25a 30a 35a 40a 45a 50a
(Hg/Dg) / Time
Average volume increment / Time
Basal area / Dominant height
Basal area / Time
Cdom & Cg / Time
Ddom & Dg / Time
Diameter / Time
Harvested volume / Time
Hdom & Hg / Time
Hdom / Time
Height / Dbh
Height / Time
N / Diameter classes (ModisPinaster)
N / Girth classes
N / Height classes
N / Slenderness classes (H/D)
Number of stems / Time
Stand table
Thin table
V and V merchant / Diameter classes (Mo
Volume / Time
Page 1 Page 2 Page 3 Page 4 Page 5 Page 6 Page 7 Page 8 Page 9 Page 10
Basal area / Time
modispinaster_Unnamed.50a
G (m2)
Time
Hdom & Hg / Time
modispinaster_Unnamed.50a
Hdom & Hg (m)
Hdom
Hg
Time
Ddom & Dg / Time
modispinaster_Unnamed.50a
Ddom & Dg (cm)
Ddom
Dg
Time
N / Diameter classes (Modis...
modispinaster_Unnamed.50a
N
Diameter classes (cm)
Opening N / Diameter classes (ModisPinaster)...

Project ModisPinaster [mod] - 1 ha - All in memory - User input

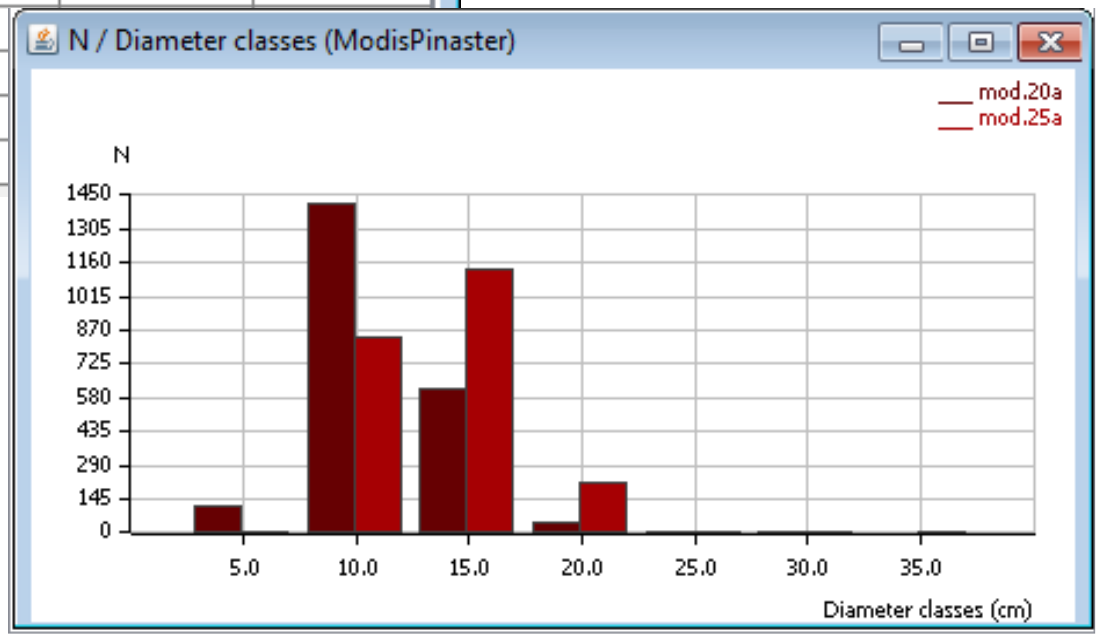
20a - 25a

Page 1 | Page 2 | Page 3 | Page 4 | Page 5 | Page 6 | Page 7 | Page 8 | Page 9 | Page 10

Stand table

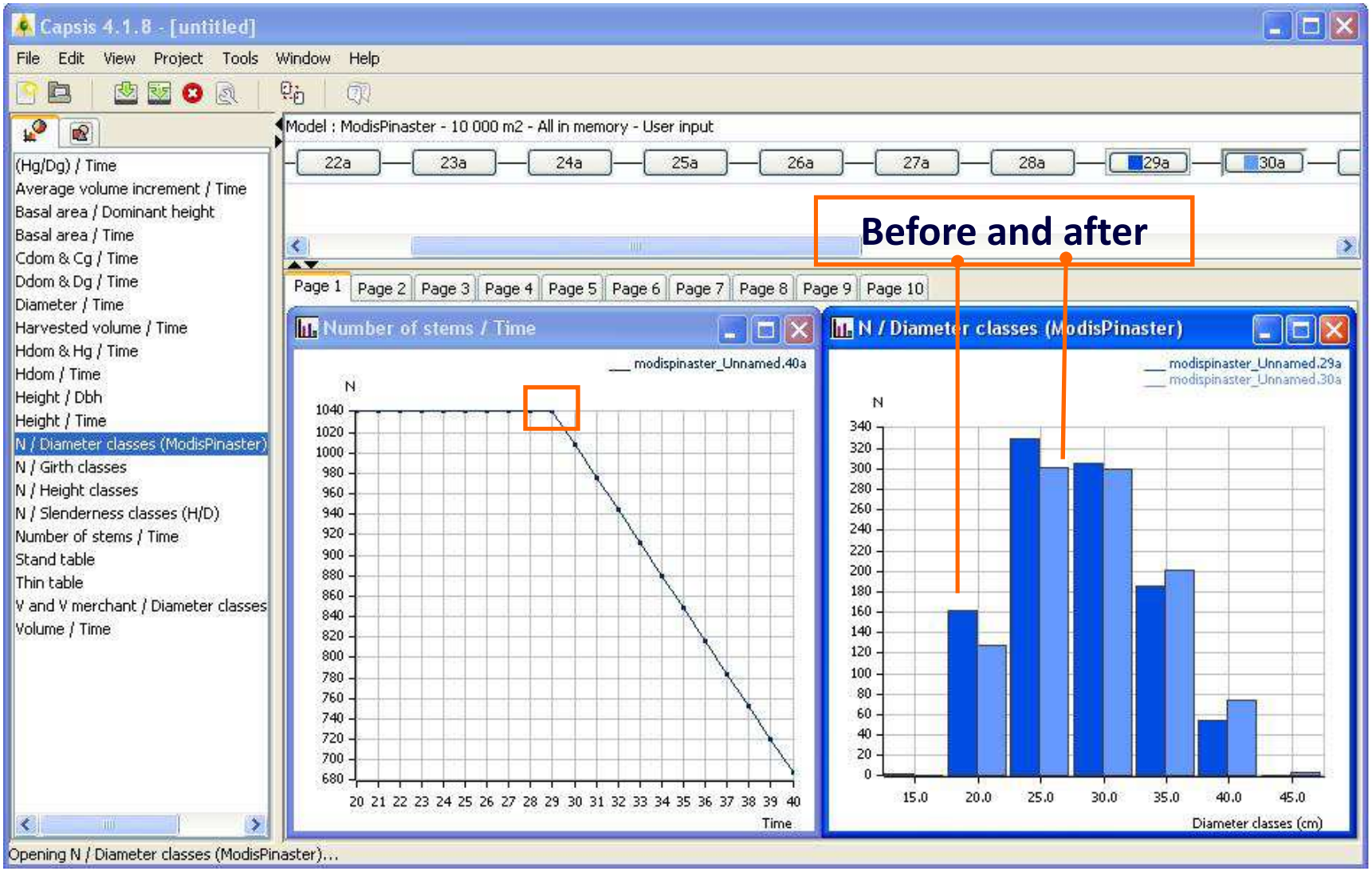
mod.25a

A	B	C	D	E	H
Stand	Stand	Stand	Stand	Stand	Production
Date	N	G	Hg	Dg	V prod
20	2200.0	23.00	9.31	11.54	115.18
21	2200.0	25.02	9.95	12.03	132.08
22	2200.0	27.06	10.31		
23	2200.0	29.14	10.66		
24	2200.0	31.22	10.99		
25	2200.0	33.33	11.31		



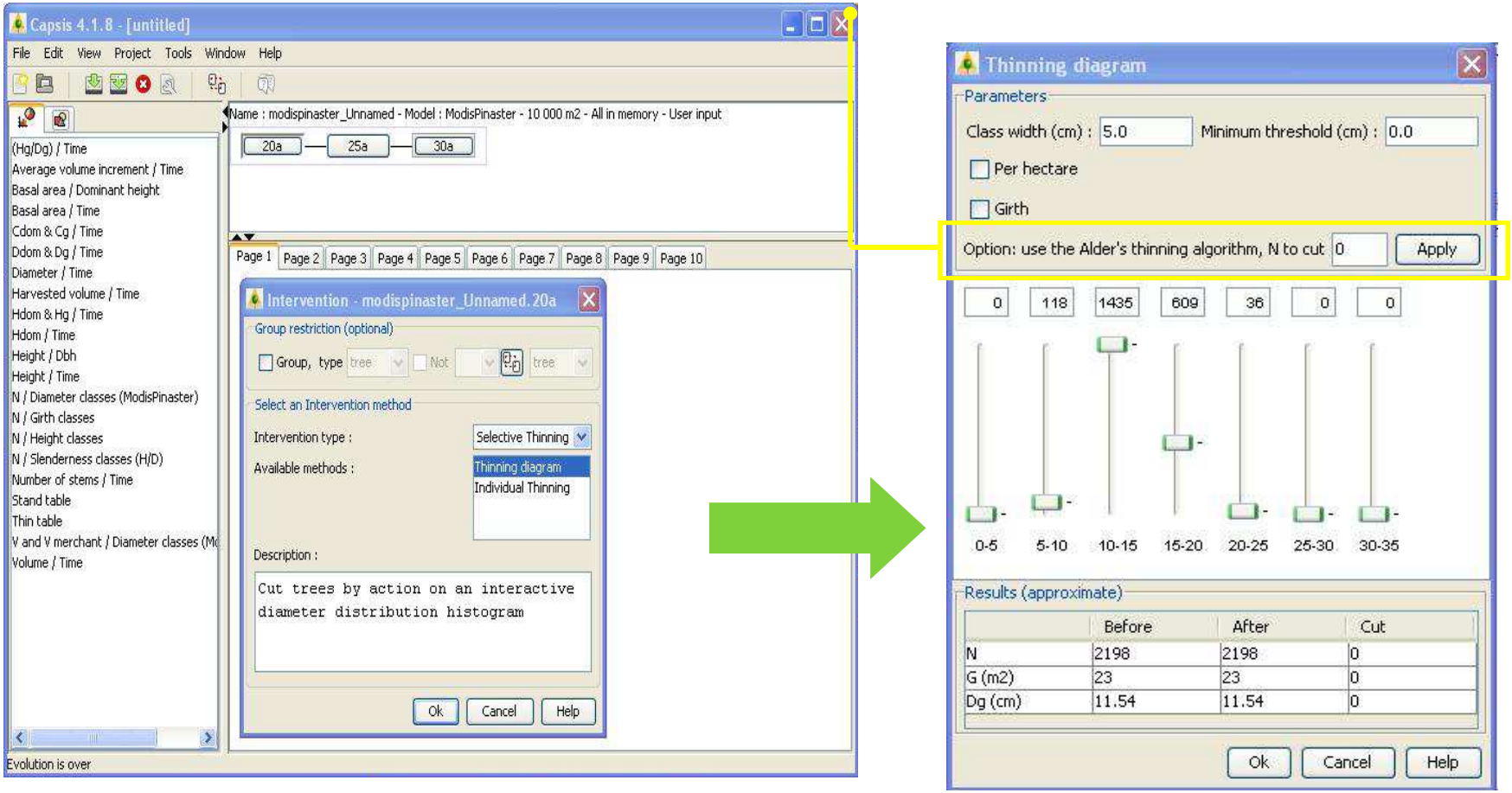
5 years projection
Stand table and Diameter Distribution

Mortality


Capsis 4.1.8 - [untitled]
File Edit View Project Tools Window Help
Model : ModisPinaster - 10 000 m2 - All in memory - User input
22a 23a 24a 25a 26a 27a 28a 29a 30a
Before and after
Page 1 Page 2 Page 3 Page 4 Page 5 Page 6 Page 7 Page 8 Page 9 Page 10
(Hg/Dg) / Time
Average volume increment / Time
Basal area / Dominant height
Basal area / Time
Cdom & Cg / Time
Ddom & Dg / Time
Diameter / Time
Harvested volume / Time
Hdom & Hg / Time
Hdom / Time
Height / Dbh
Height / Time
N / Diameter classes (ModisPinaster)
N / Girth classes
N / Height classes
N / Slenderness classes (H/D)
Number of stems / Time
Stand table
Thin table
V and V merchant / Diameter classes
Volume / Time
Number of stems / Time
modispinaster_Unnamed.40a
N
Time
N / Diameter classes (ModisPinaster)
modispinaster_Unnamed.29a
modispinaster_Unnamed.30a
N
Diameter classes (cm)
Opening N / Diameter classes (ModisPinaster)...

Thinning

Interactive procedure (low, high, mixed) by F. de Coligny or automatic procedure (Alder's thinning algorithm), or both



Next steps

What was considered necessary to do in a short term?

Standardization of variables symbols (and definitions)
(compatible with programming languages)

dd
Ddom
d_{dom}
d0

Use of the model to find out for deficiencies (if any)
Divulgation
Feedback from the users

Presentation to the potential users

Amendments/modifications to improve ModisPinaster

Use of the model and improvements

COST

STSM FP0603 090511-007846 (9-19 May 2011 , at AMAP, Montpellier)

New available data and new ideas and suggestions

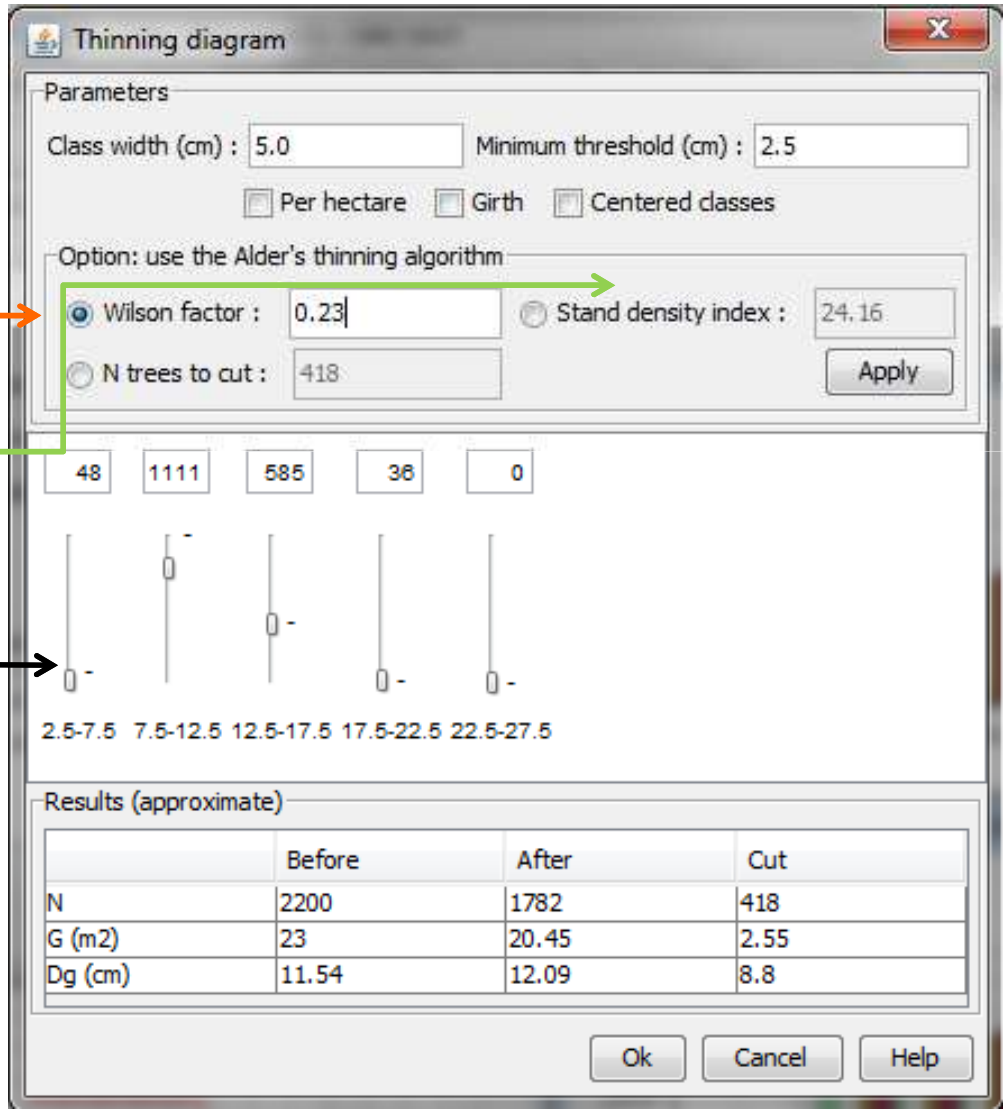
↓

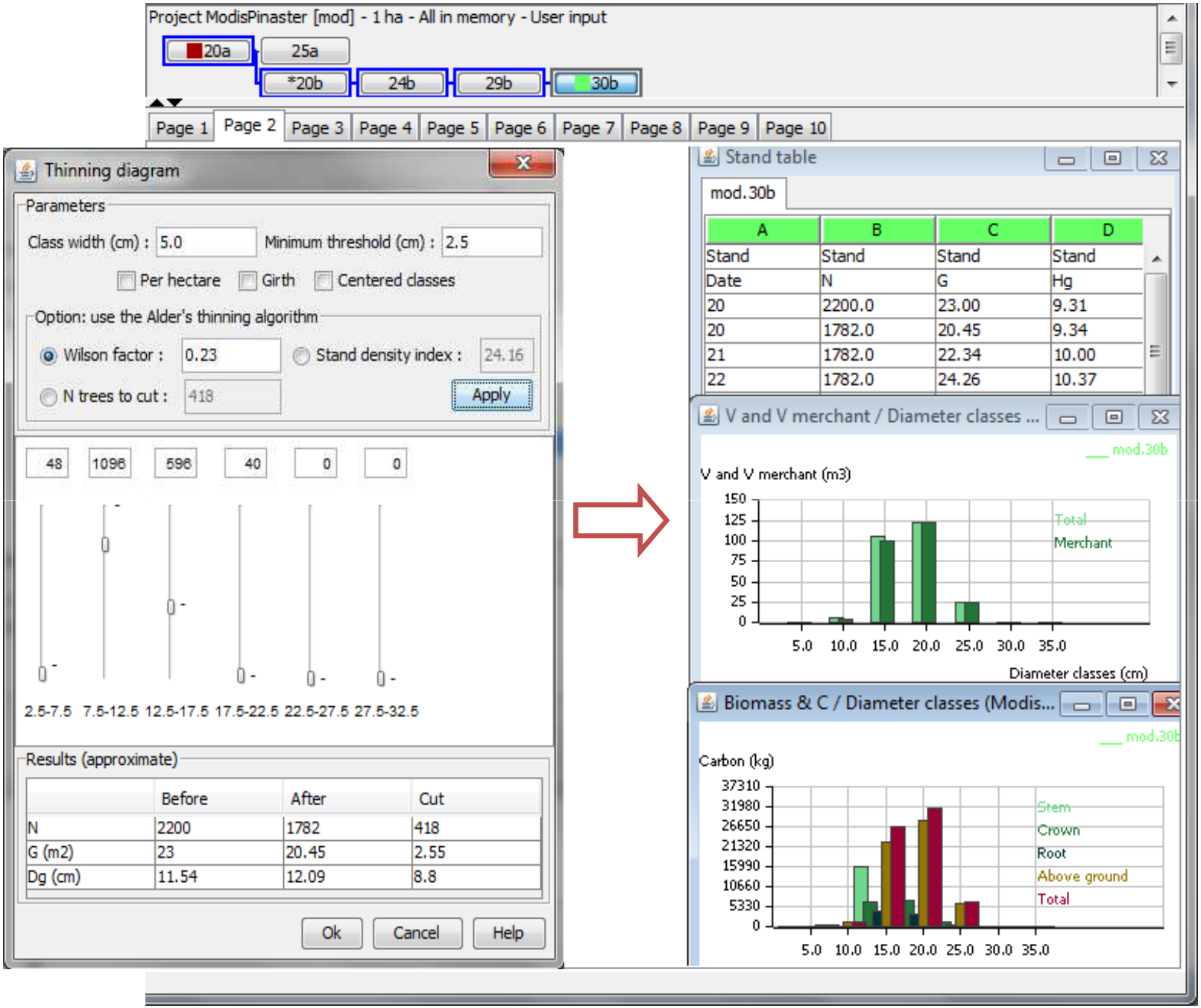
more accurate equations calculated from new field data, thinning with the Wilson factor or the Stand density index, better mortality assessment.

Thinning options

1. Wilson Spacing Factor
2. Number of trees
3. SDI %
4. Thinning diagram

(By F. de Coligny)
Cut trees by action on an interactive diameter distribution histogram




Project ModisPinaster [mod] - 1 ha - All in memory - User input
20a
25a
*20b
24b
29b
30b
Page 1
Page 2
Page 3
Page 4
Page 5
Page 6
Page 7
Page 8
Page 9
Page 10
Thinning diagram
Parameters
Class width (cm) : 5.0
Minimum threshold (cm) : 2.5
Per hectare
Girth
Centered classes
Option: use the Alder's thinning algorithm
Wilson factor : 0.23
Stand density index : 24.16
N trees to cut : 418
Apply
48
1096
596
40
0
0
2.5-7.5
7.5-12.5
12.5-17.5
17.5-22.5
22.5-27.5
27.5-32.5
Results (approximate)
Before
After
Cut
N 2200 1782 418
G (m2) 23 20.45 2.55
Dg (cm) 11.54 12.09 8.8
Ok
Cancel
Help
Stand table
mod.30b
A B C D
Stand Stand Stand Stand
Date N G Hg
20 2200.0 23.00 9.31
20 1782.0 20.45 9.34
21 1782.0 22.34 10.00
22 1782.0 24.26 10.37
V and V merchant / Diameter classes ...
mod.30b
V and V merchant (m3)
150
125
100
75
50
25
0
Total
Merchant
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Diameter classes (cm)
Biomass & C / Diameter classes (Modis...
mod.30b
Carbon (kg)
37310
31980
26650
21320
15990
10660
5330
0
Stem
Crown
Root
Above ground
Total
5.0
10.0
15.0
20.0
25.0
30.0
35.0

Divulgation

Technical Meeting and Training session

Management of maritime pine: use of the ModisPinaster simulation model

by Teresa Fidalgo Fonseca and François de Coligny

Projeto INEF-PINUS: Informação Estratégica para a Fileira do Pinho.

INEF-PINUS

19 - 21 October 2011, Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal

Universidade de Trás-os-Montes e Alto Douro, Vila Real, 19/10/2011, 14h30m, F2.18 (25 participants)

Divulgation

Presentation of the model
Selection of “case studies” for simulation purposes

Feedback from the users

1

Experimentação e Questões

Dados de entrada “Demo”

Obter o gráfico da distribuição de N por classe de d aos 20 anos.

Cenário 1

- Evolução até aos 45 anos.
- Gestão automática com SDI% entre 25 e 35%

Obter gráficos de evolução das variáveis N e dg em função do tempo.

Obter dados de N e de volume ao longo do tempo, sob a forma gráfico e como tabela.

Description of the model in:

Fonseca, T.F., B. Parresol, C. Marques, F. de Coligny, 2012. Models to Implement a Sustainable Forest Management – an Overview of the ModisPinaster Model. In: Sustainable Forest Management / Book 1", InTech - Open Access Publisher. ISBN 979-953-307-136-6.

Use of the model and improvements

COST | **STSM FP0902 151012-023494 (15-23 October 2012, at AMAP, Montpellier)**

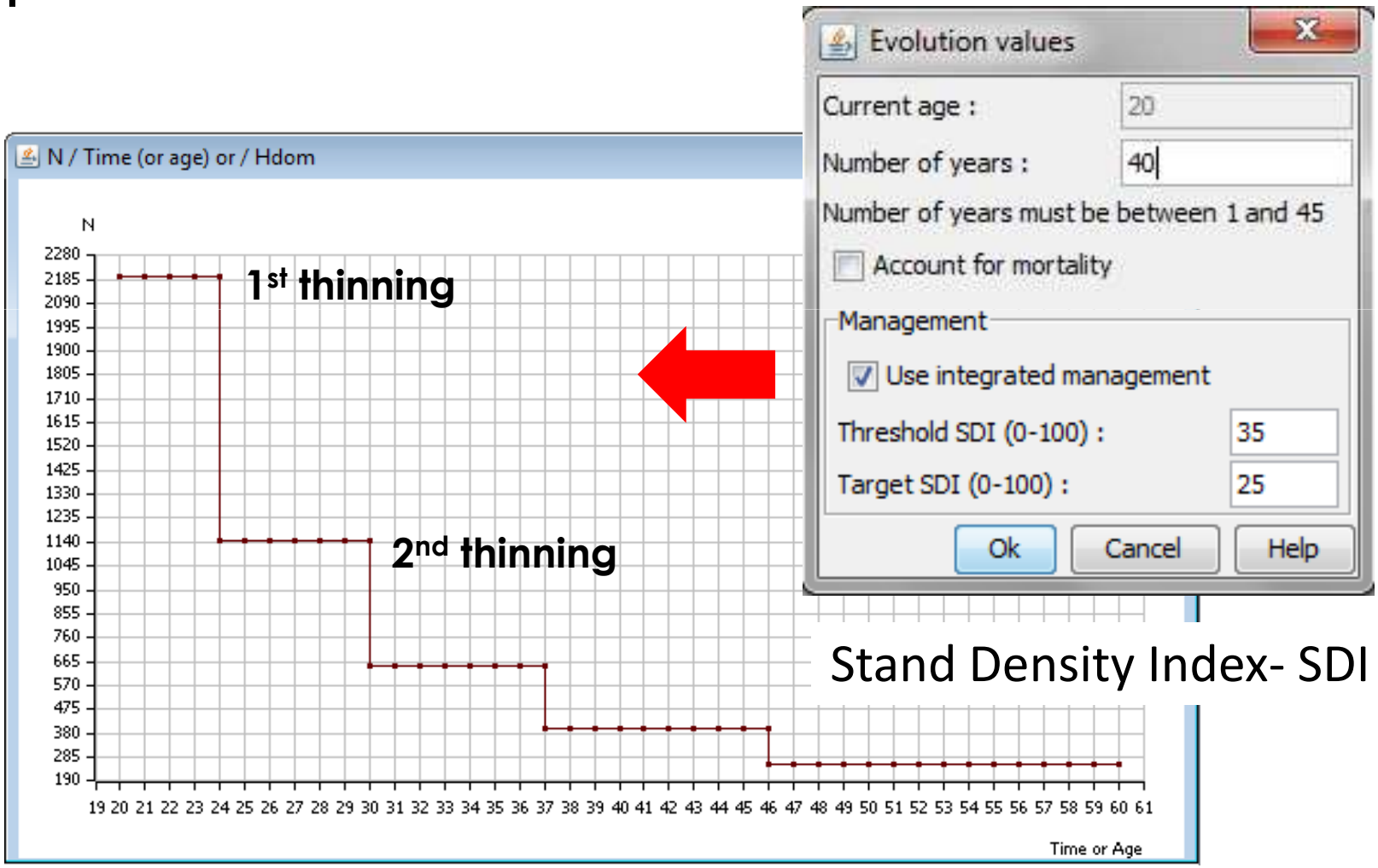
Adaptation of ModisPinaster model within Capsis to provide estimates of wood energy. Several sub-models were adapted and new outputs about biomass, fuel and energy were added.

Erasmus | **Program for formation (21-28 May 2014, at AMAP, Montpellier)**

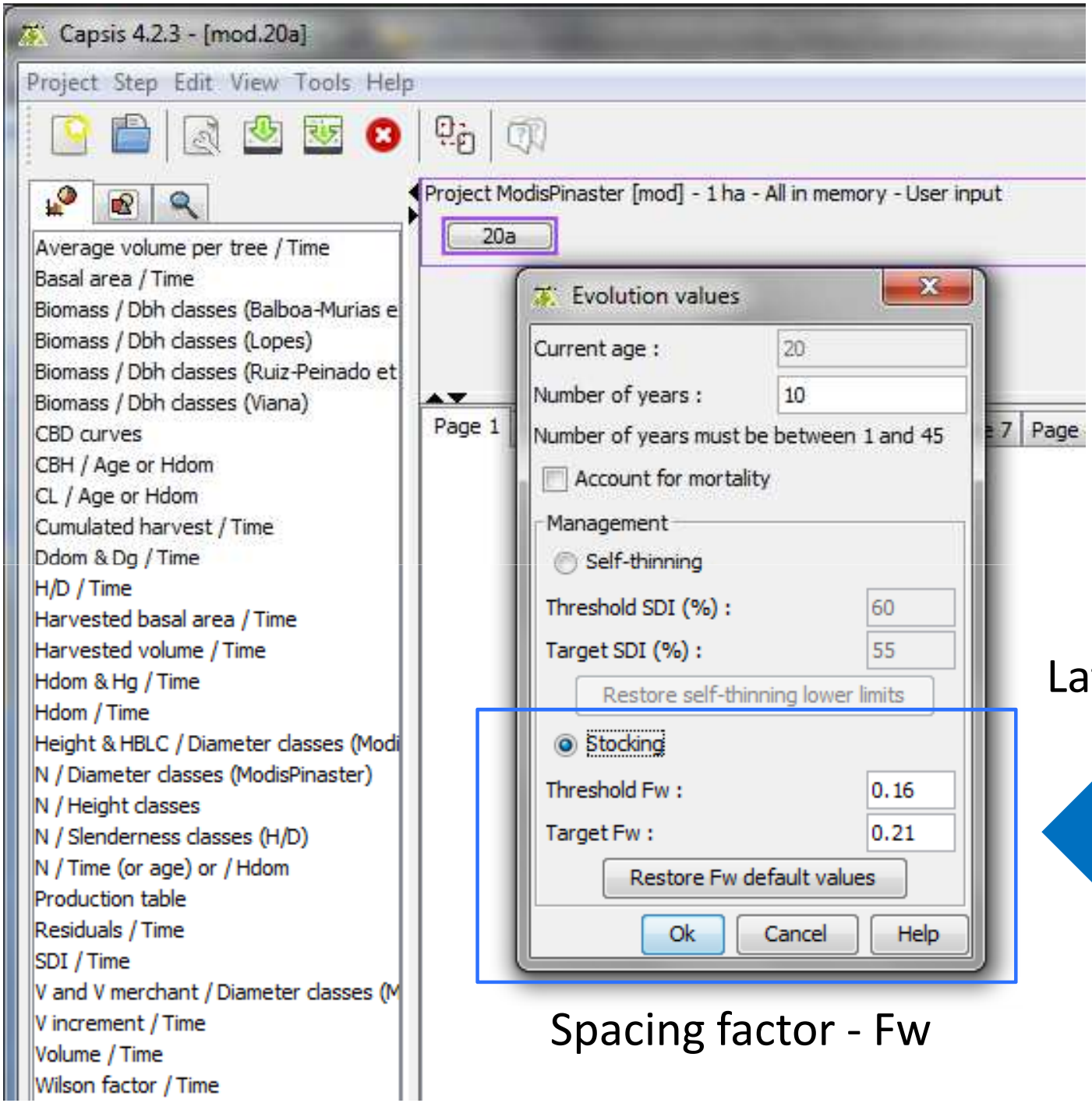
Stocking management and several new outputs concerning crown height and crown bulk density were added.

Evolution

"Automatic" integrated management procedures were incorporated



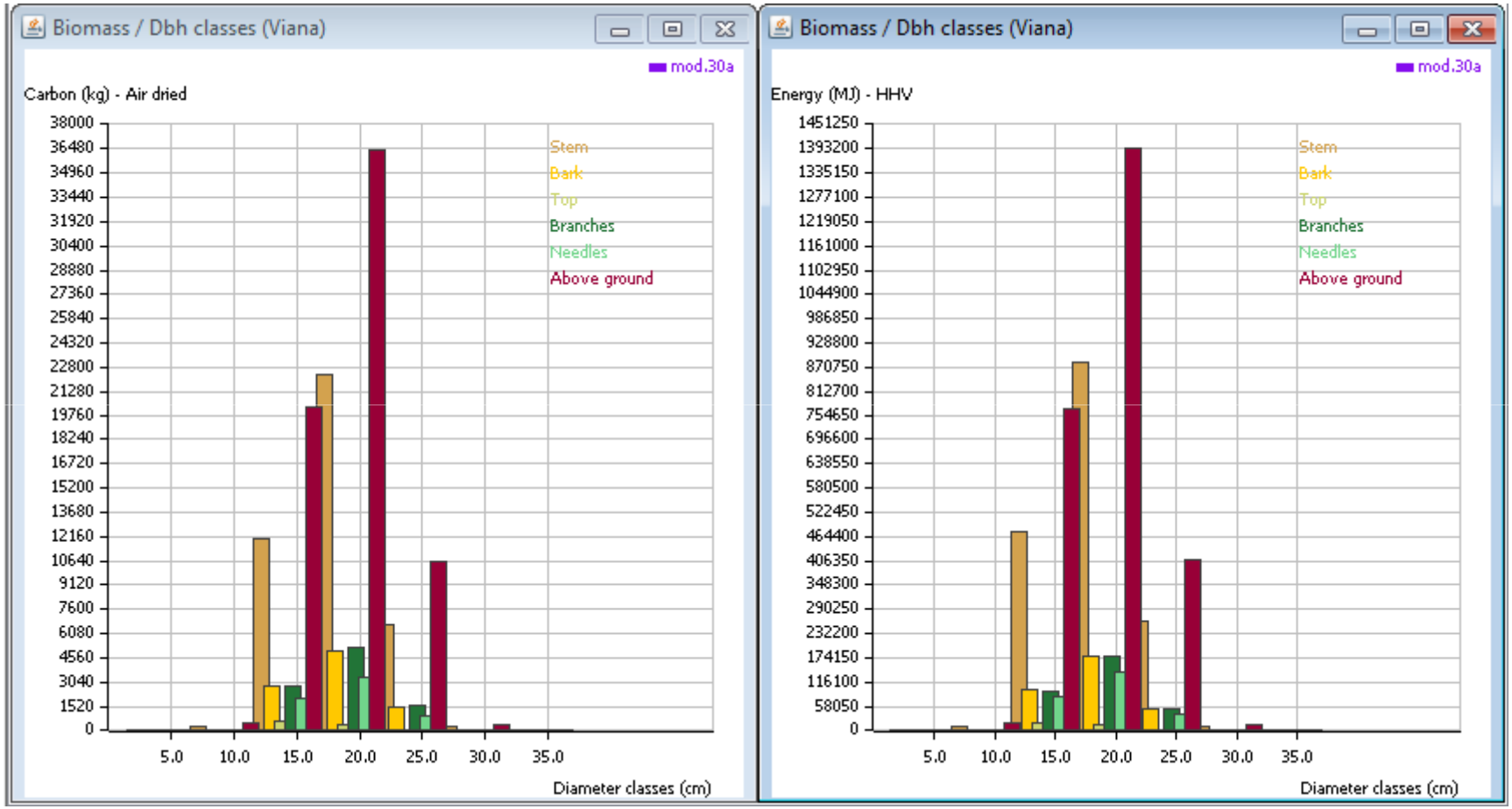
Stand Density Index- SDI



Later on:

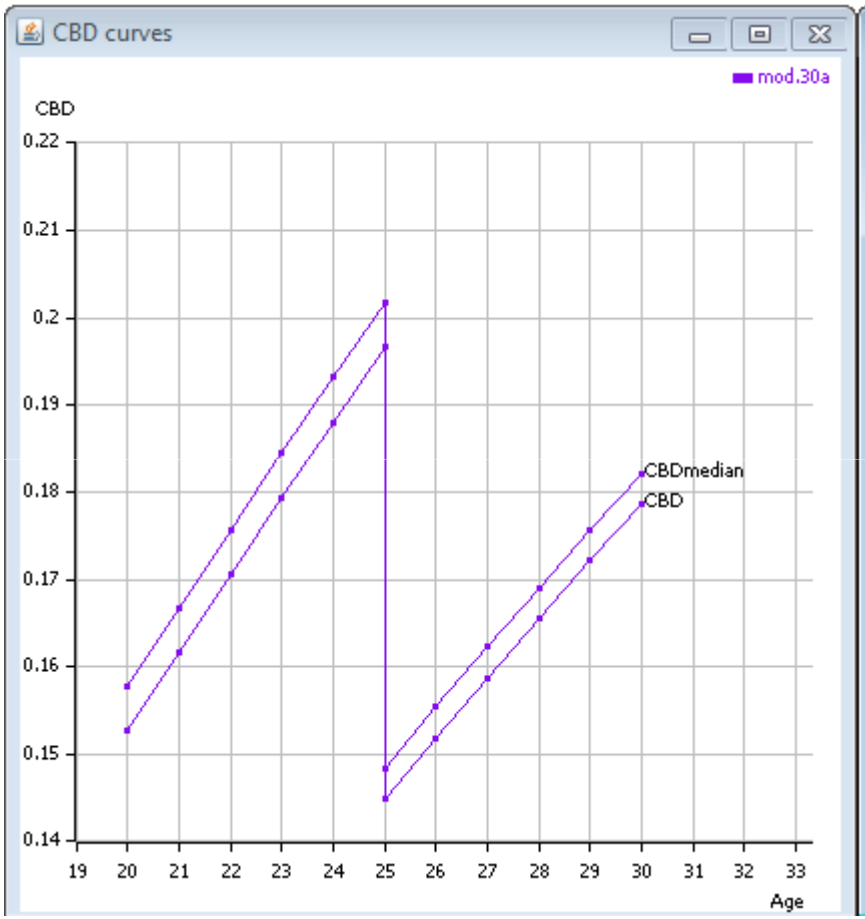
Spacing factor - Fw

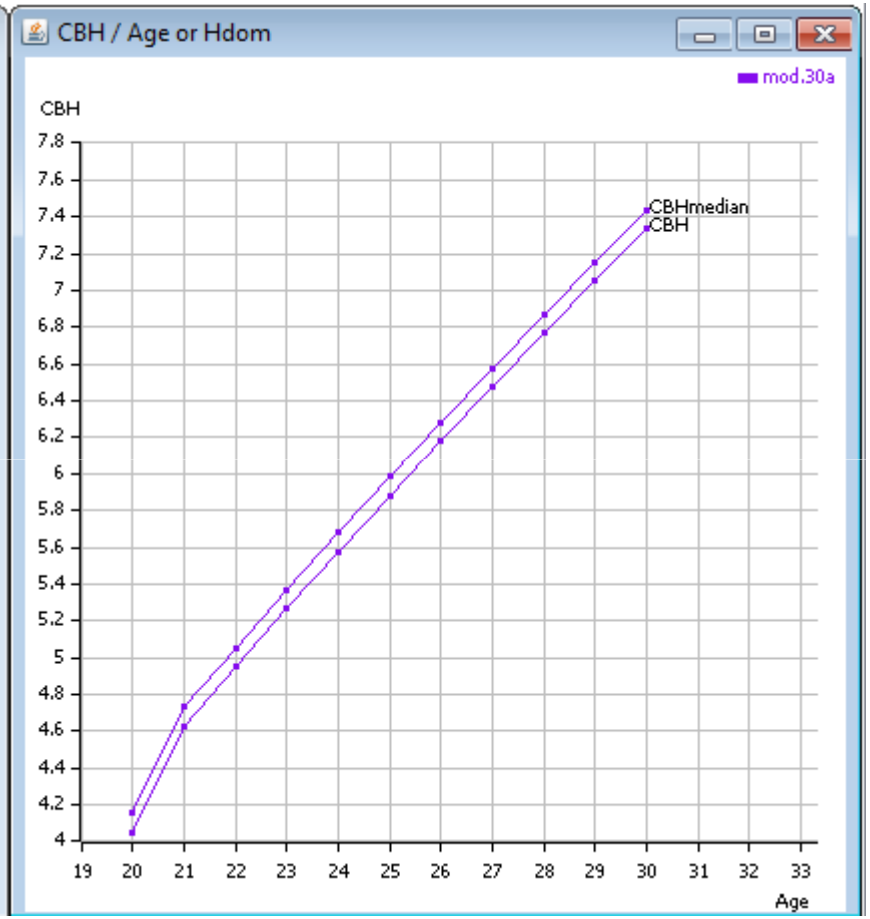
Biomass, carbon and energy by diameter class and by tree component



Viana, H., 2012. Modelling and mapping aboveground biomass for energy usage and carbon storage assessment in mediterranean ecosystems. PhD Thesis. University of Trás-os-Montes e Alto Douro, Portugal.

Crown and canopy descriptors





What was the contribution of Capsis to ModisPinaster?

Model improvement (use of already available features and extensions)

E.g. friendly interface

table and graphical extended outputs (biomass, energy, canopy variables,…)

new thinning algorithm options

…

Easy to do simulations within the Capsis platform

Easy to share the model with the forest managers

No cost for the users

What was the contribution of ModisPinaster to Capsis?

Jonhson S_B distribution model

LM code now available in a Capsis library

New thinning algorithm options

trees cut according to trees size and to thinning weight

Automatic management options (Wilson Factor /SDI values)

Mortality module

mortality related to wind

mortality related to density

ModisPinaster

2000
2004

....
2009
2014

A never ending story?

What's next?

- Coordinate the simulation outputs with optimization routines in order to compare results of management options subject to restrictions, for a set of stands.

- Incorporate models to allow the inicialization of state variables (e.g. stand basal area) from number of trees and stand age.

- Test the use of the model for short term rotation (…data collection needed, new models required…)

Thank you for your attention

T.Fonseca wish to express her acknowledgement to the institutions and programs that supported the project (namely to INRA, COST Actions FP0603 and FP0902 and the Erasmus Program).

Acknowledgments are extended to the network managers of CAQSIS 2015,

Céline Meredieu, Mathieu Fortin and François de Coligny

In memoriam to the co-author of the model, Bernard Parresol (dec. 29/09/2013), a great friend.