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ForestGALES in Capsis: a new library in JAVA

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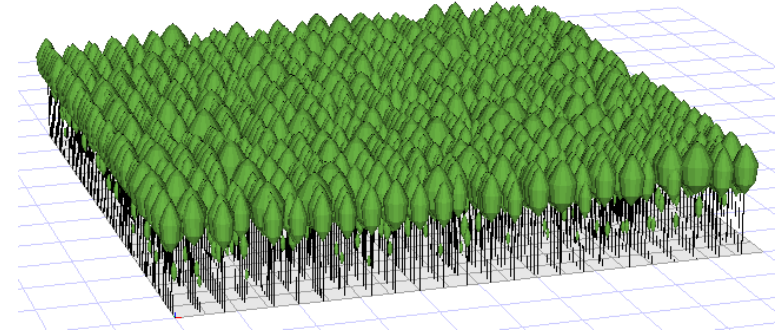
HAL Id: hal-01837376

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Submitted on 3 Jun 2020

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ForestGales in Capsis: a new library in JAVA



C. Meredieu

T. Labbé

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B. Gardiner

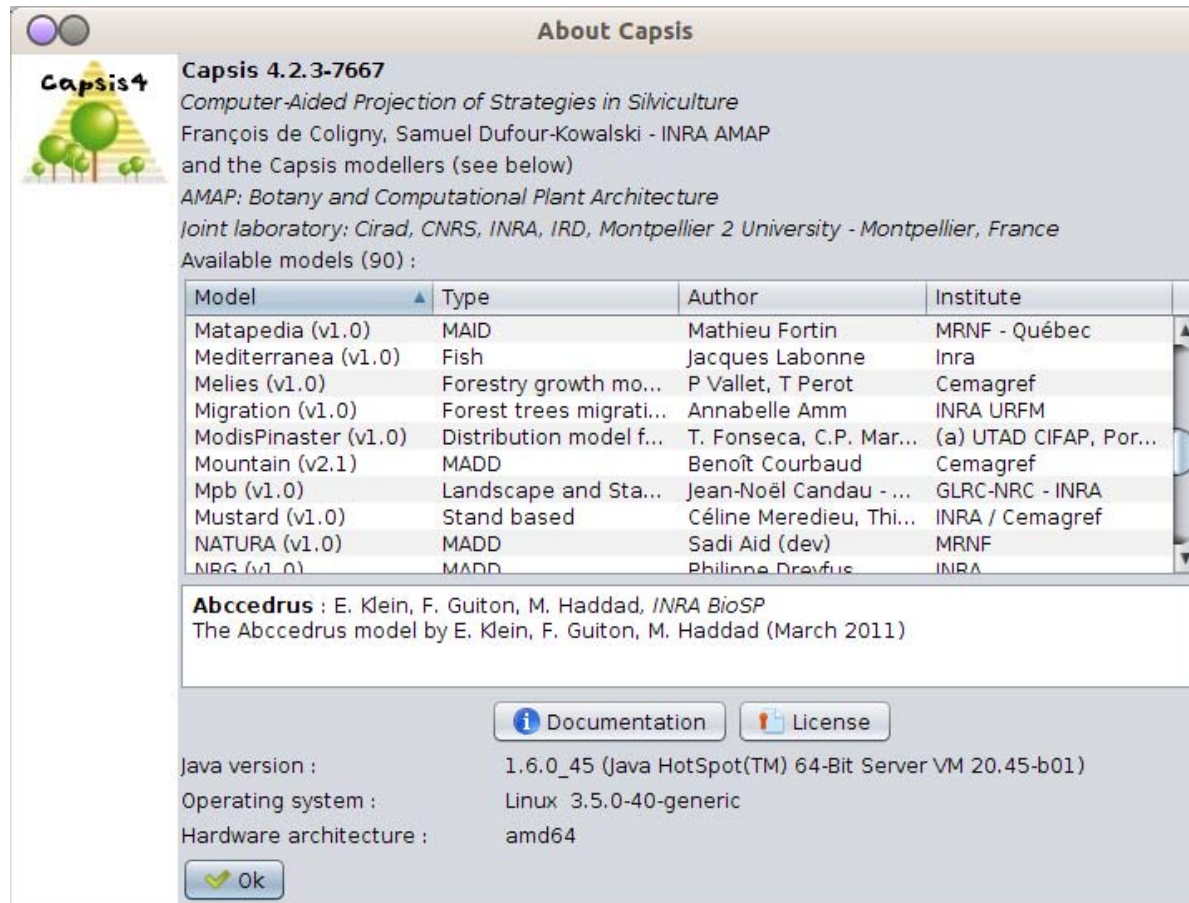
29/10/2015

WMMRWDF - Arcachon

Capsis: 1994-2014

A Generic Software Platform for forestry modelling

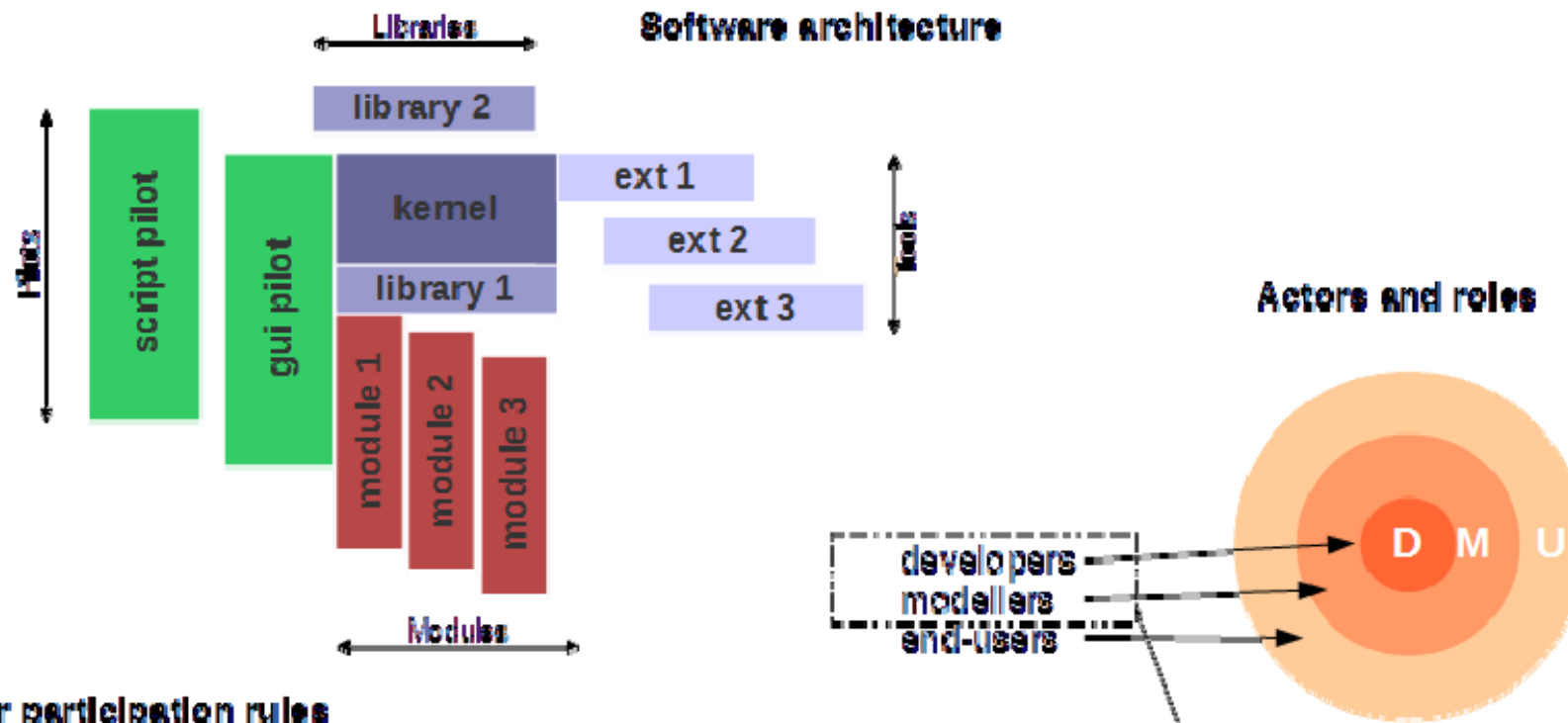
Objectives: Build a **software platform** to integrate **forest growth & yield / dynamics models** for **modellers, managers and teaching**



Started in 1994 by Philippe Dreyfus (INRA URFM, Avignon)



Capsis : main options



Clear participation rules

The common parts are free software (LGPL): everything except the **red parts** is reusable by anybody

The Capsis charter (extract):

- the modellers are in charge of the development of their models
- the growth models are not free: **red parts**
- all the source codes are freely accessible by all members in the Capsis community...

The Capsis community:
developers + modellers
co-develop together

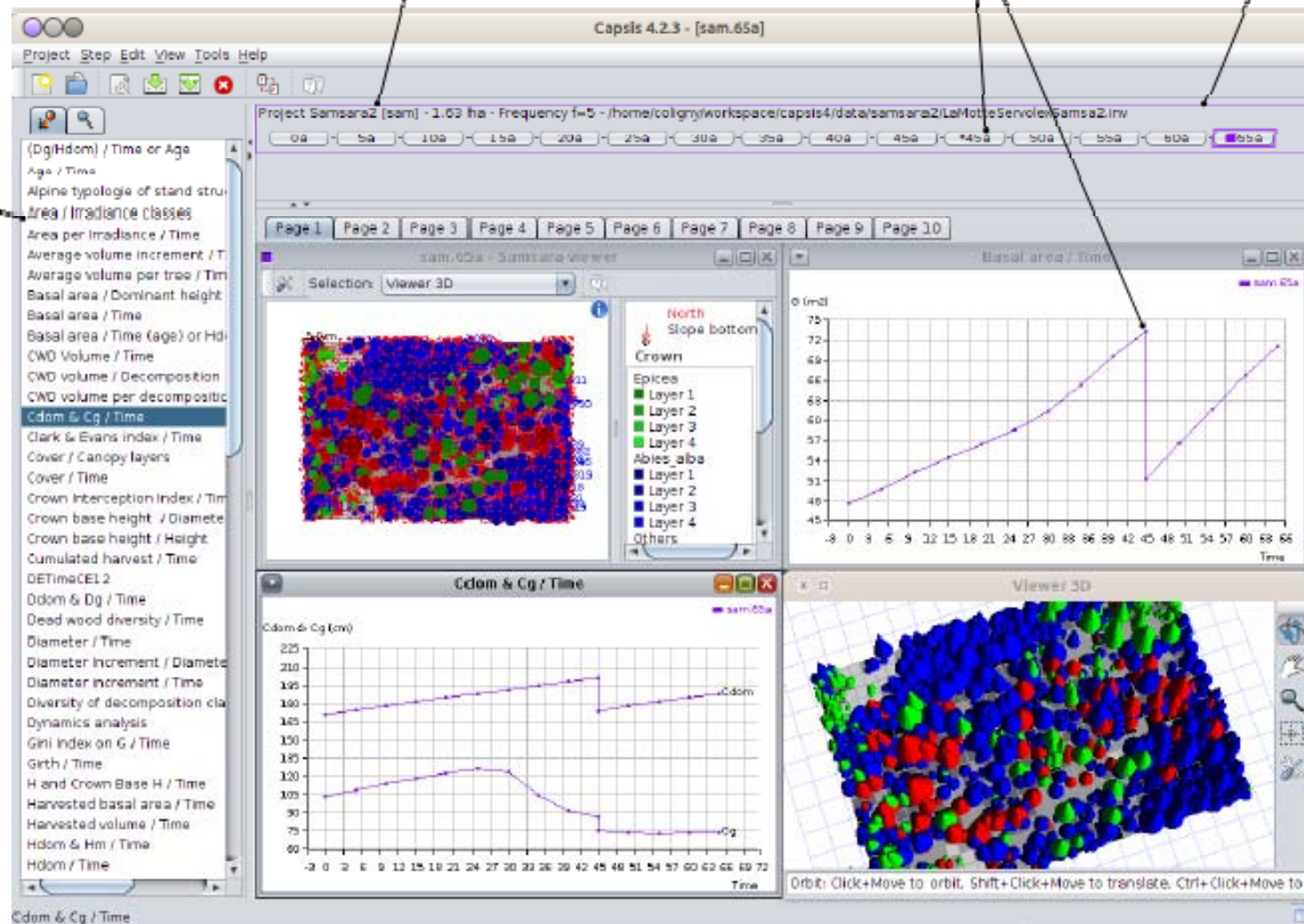
Capsis: how does it work ?

model : **Initialisation + time loop**

Intervention

project

Integrated viewers and charts

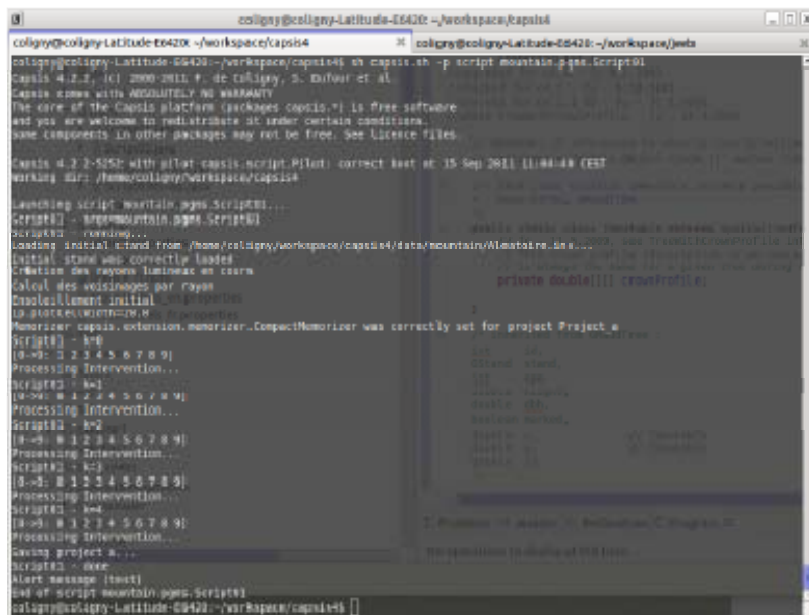
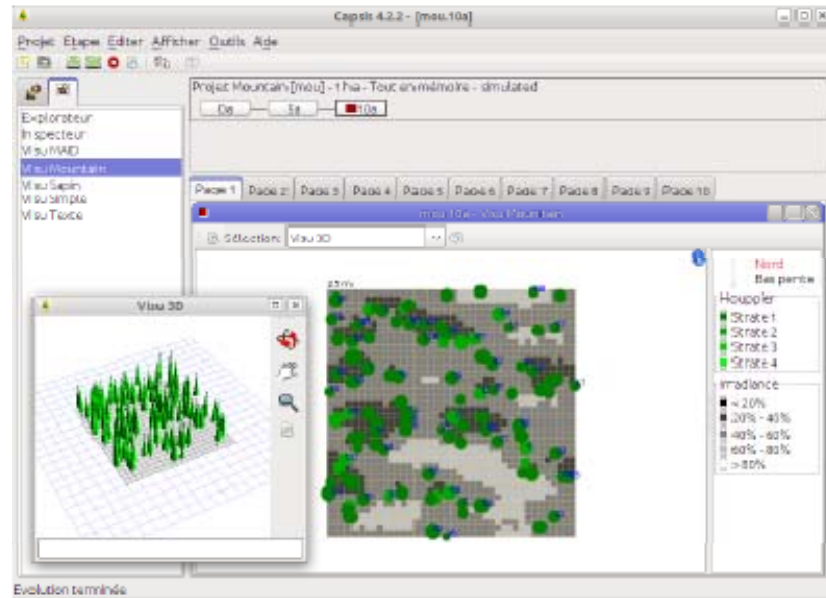


Capsis - Linux - Graphical user Interface - English

export

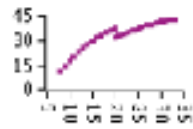
Capsis: several ways of use

Interactive (french / english)

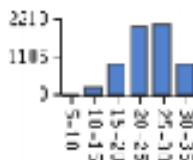


Not interactive: with scripts
- long simulations
- run on clusters
- sensitivity analyses...

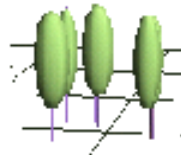
Models for maritime pine in the *Landes de Gascogne*



Lemolne model (stand level, plantation):
 - age, number of trees, girth (dominant, mean), basal area, height (dominant, mean), volume (mean)

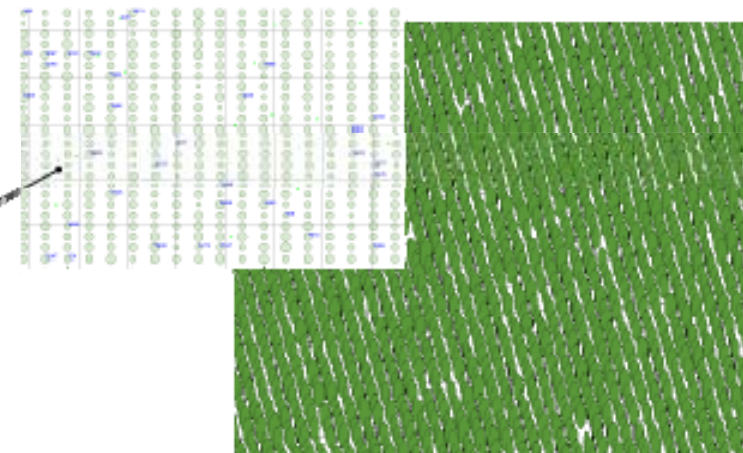


PP3 model (distribution model, plantation):
 a list of trees
 - age, diameter, height, volume of each tree, crown (height, diameter), other information (biomass, carbon, etc.) + number



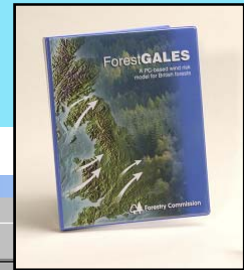
Pinus Pinaster (Individual-based, spatialized)
 a rewriting of PP3
 Integration of spatialized processes

stumps



- Applications, further works:**
- a permanent resource analysis system (with IFN - National Forest Inventory)
 - dead wood modelling and biodiversity
 - models transfer to the silviculture prescribers

Software ForestGALES 2 in 2004



ForestGALES batch mode - GALES1

Batch mode input file

Drainage	Top Height(m)	DBH(m)	Spacing(m)	Upwind_G	DAMS
1	12	0.12	1.7	0	15
1	13.1	0.126	1.7	9	15
1	15	0.134	2.3	0	15
1	16	0.142	2.6	0	15
8	14.9	0.139	3	1	15
8	15.7	0.145	3	5	15
8	16.9	0.153	3	5	15
8	17.8	0.162	3	0	15
8	19.3	0.171	3	0	15
8	21.4	0.177	3	0	15
		0.105	3	0	19
		0.11	3	0	19
	14.8	0.115	3	0	19
	17.2	0.13	3	0	19
2	19.1	0.139	3	0	19

Batch mode helper

Stand ID: SC003 SITE: 2

DESCRIPTION: Corsican Pine VALUE: 2

Soil type: Littoral Soil VALUE: 15

Cultivation: Shallow Ploughing < 45cm VALUE: 3

Drainage: Good drainage VALUE: 3

Top Height (m): 28 DBH (cm): 21.4

Spacing (m): 6.7 Up Wind Gap (m): 0

DAMS: 24

Number Points: 19

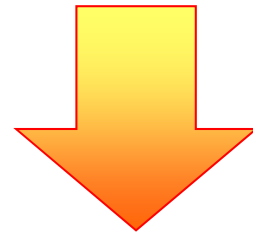
OUTPUT	Stand ID	Overturn Retn	Breakage Retn	Crit_Wind	Species	Soil	Cultivation	Drainage	Top Height(m)	DBH(m)	Spacing(m)	DAMS	Gap Size
1	SC001	200	200	29.58	10	7	4	1	12	0.12	1.7	15	0
2	SC001	11	31	23.15	10	7	4	1	13.1	0.13	1.7	15	9
3	SC001	2	2	19	10	7	4	1	15	0.13	1.7	15	9
4	SC001	1	1	17.02	10	7	4	1	16	0.14	1.7	15	9
5	SC002	2	1	18.67	8	6	1	3	16.9	0.153	3	15	5
6	SC002	1	1	16.1	8	6	1	3	15.7	0.145	3	15	5
7	SC002	1	1	15.75	8	6	1	3	14.9	0.139	3	15	1
8	SC002	3	2	19.2	8	6	1	3	17.8	0.162	3	15	0
9	SC002	3	1	18.51	8	6	1	3	19.3	0.171	3	15	0
10	SC002	2	1	16.79	8	6	1	3	21.4	0.177	3	15	0
11	SC002	1	1	14.4	8	6	1	1	22.6	0.18	3	15	0
12	SC003	39	200	31.18	1	4	3	2	10	0.1	1.7	15	0
13	SC003	1	3	22.61	1	4	3	2	11	0.1	1.7	15	0
14	SC003	1	1	15.08	1	4	3	2	13.2	0.11	1.7	15	0
15	SC003	1	1	13.27	1	4	3	2	14.8	0.12	1.7	15	0
16	SC003	1	1	11.48	1	4	3	2	17.2	0.13	1.7	15	0
17	SC003	1	1	10.75	1	4	3	2	19.1	0.14	3	19	0

Input :
 Classical yield table,
 mean and dominant
 stand values; each
 line corresponds to a
 stand at a given age

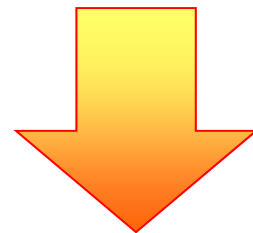
Outputs :
 Critical wind speed and its return
 period for breakage and overturning
 for each stand description of the
 input table

ForestGALES 2.3

Predicts the critical wind speeds

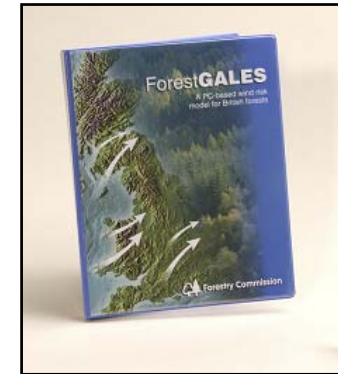


For monospecific and even-aged stands
Implemented in a specific software Forest Gales

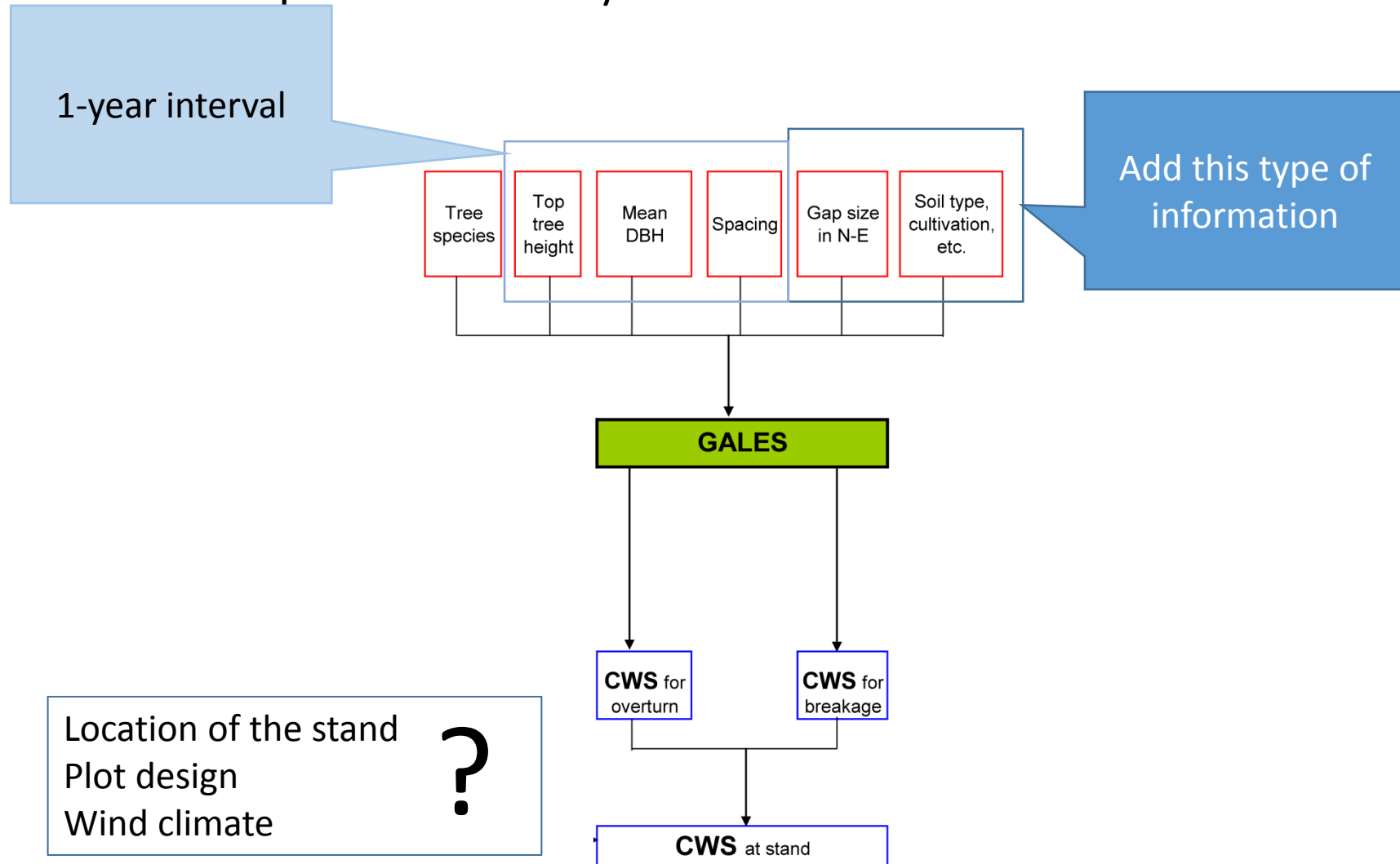


Aim in 2004 : **Adapt this model to Maritime Pine
cultivated in Les Landes de Gascogne**

Determine the species' mechanical behaviour
depending on local silviculture conditions



The outputs of PP3/Lemoine for GALES



How to adapt GALES to Maritime pine?

- Requirements
 - Crown width equation
 - Crown depth equation
 - Stem taper equation (for calculating stem weight)
 - Wood Modulus of Rupture (MOR)
 - Wood Modulus of Elasticity (MOE)
 - Wood density (for calculating stem weight)
 - Rooting resistance (function of tree size, rooting depth and soil type)
 - Inputs
 - Species
 - Height
 - Diameter (1.3 m)
 - Spacing (*for Roughness Method*)
 - Soil type
 - Rooting Depth
- Tree-pulling measurements

Trees (2004) 18: 460–466
DOI 10.1007/s00468-004-0330-2

ORIGINAL ARTICLE

Véronique Cucchi · Céline Meredieu · Alexia Stokes ·
Stéphane Berthier · Didier Bert · Mohamed Najjar ·
Alain Denis · Roland Lastennet

Root anchorage of inner and edge trees in stands of Maritime pine (*Pinus pinaster*Ait.) growing in different podzolic soil conditions

Simulations at stand scale



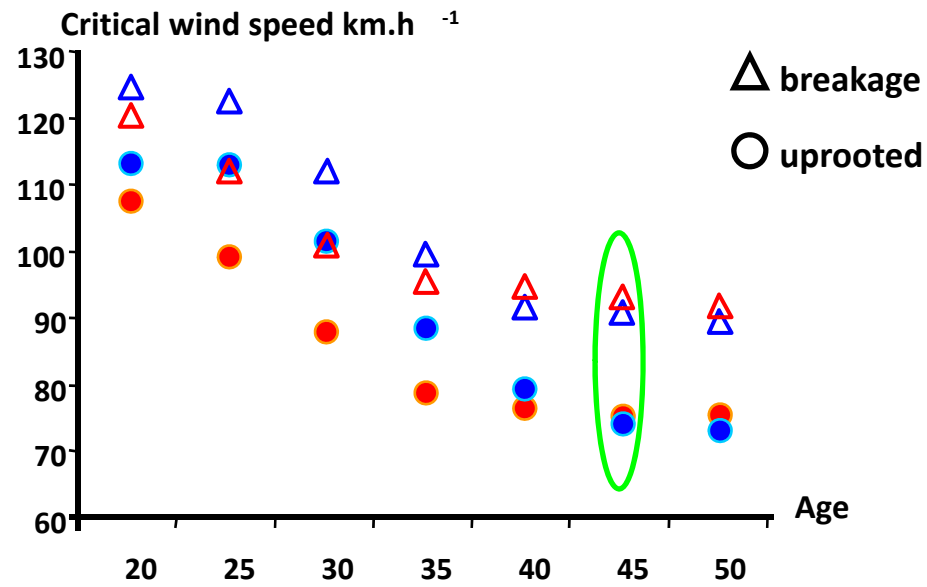
Available online at www.sciencedirect.com
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 Forest Ecology and Management 213 (2005) 184–196

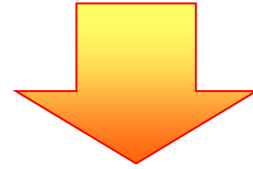
Forest Ecology
and
Management
www.elsevier.com/locate/foreco

Modelling the windthrow risk for simulated forest stands
of Maritime pine (*Pinus pinaster* Ait.)

Véronique Cucchi^{a,b,1}, Céline Meredieu^{a,*}, Alexia Stokes^b,
François de Coligny^c, Juan Suarez^d, Barry A. Gardiner^d

	S1	S2
Initial density t/ha	1250	1500
Final density t/ha	300	300
Number of thinning	4	5





- **Wind-firmness** of stand **decreases with stand age**
- Dominant type of damage = **uprooting**
- Space between trees : impact on **wind penetration**



Consistent with observations made on real damages

BUT ForestGALES is thought to be too pessimistic
BUT ForestGALES do not integrate thinning impacts

- **Strong influence** of the **slope** of the regression on predictions
- **Weak influence** of **crown size** in high stand density

Forest Gales/Capsis+PP3 in 2004 : two softwares which exchange data; ouputs in Capsis

Windows to lauch
ForestGales

Table of forest parameters (FG_1_290304.50a):

Date	N/ha	G/ha	V/ha	Hg	Dg	Vg	N/ha	G/ha	V/ha	Vm	Eclaircie
12	752	16,99	59,22	7,81	11,11	0,033					
13	752	20,72	84,03	8,90	12,27	0,047					
14	1752	24,49	108,24	9,61	13,34	0,061					
15	1752	28,29	134,48	10,26	14,34	0,076					
16	1250	23,36	114,10	10,54	15,43	0,091	502	4,93	20,38	0,041	
17	1250	26,82	138,92	11,23	16,53	0,111					
18	1250	30,28	158,07	11,85	17,56	0,133					
19	1250	33,74	177,78	12,47	18,54	0,156					
20	1250	37,18	195,76	13,07	19,46	0,180					
21	850	40,58	215,68	13,65	20,33	0,133	400	9,88	59,36	0,148	
22	850	30,70	156,32	13,92	21,44	0,166					
23	850	33,55	174,19	14,50	22,42	0,201					
24	850	36,39	199,91	15,05	23,35	0,236					
25	850	39,21	230,09	15,59	24,23	0,271					
26	850	42,00	260,67	16,11	25,08	0,307					
27	850	44,77	291,39	16,61	25,90	0,343					
28	560	32,41	219,27	16,84	27,14	0,392	290	12,36	72,11	0,249	

Graph in
Capsis to
visualize
results



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Forest Ecology
and
Management
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Modelling the windthrow risk for simulated forest stands
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In 2005, wind risk is a forgotten subject for INRA....

- But Klaus in 2009 !



- And Barry Gardiner came to Bordeaux in 2011... Be careful Wind Risk, a new team is ready !

Accueil > Europe et international > Accueil et formation > Packages scientifiques/Attractivité de l'Inra

Barry Gardiner, scientifique écossais reconnu internationalement, modélise les risques liés au vent dans les forêts



© Inra

L'accueil de scientifiques internationaux est une des priorités de l'Inra. Parmi les dispositifs en place, les packages scientifiques offrent des moyens significatifs en termes de rémunération et d'environnement scientifique. Barry Gardiner fait partie des deux chercheurs recrutés pour l'année 2011. Il a intégré pour quatre ans l'unité Ecologie fonctionnelle et physique de l'environnement (Ephyse) aux côtés d'Yves Brunet.

Why implement ForestGales in Capsis ?

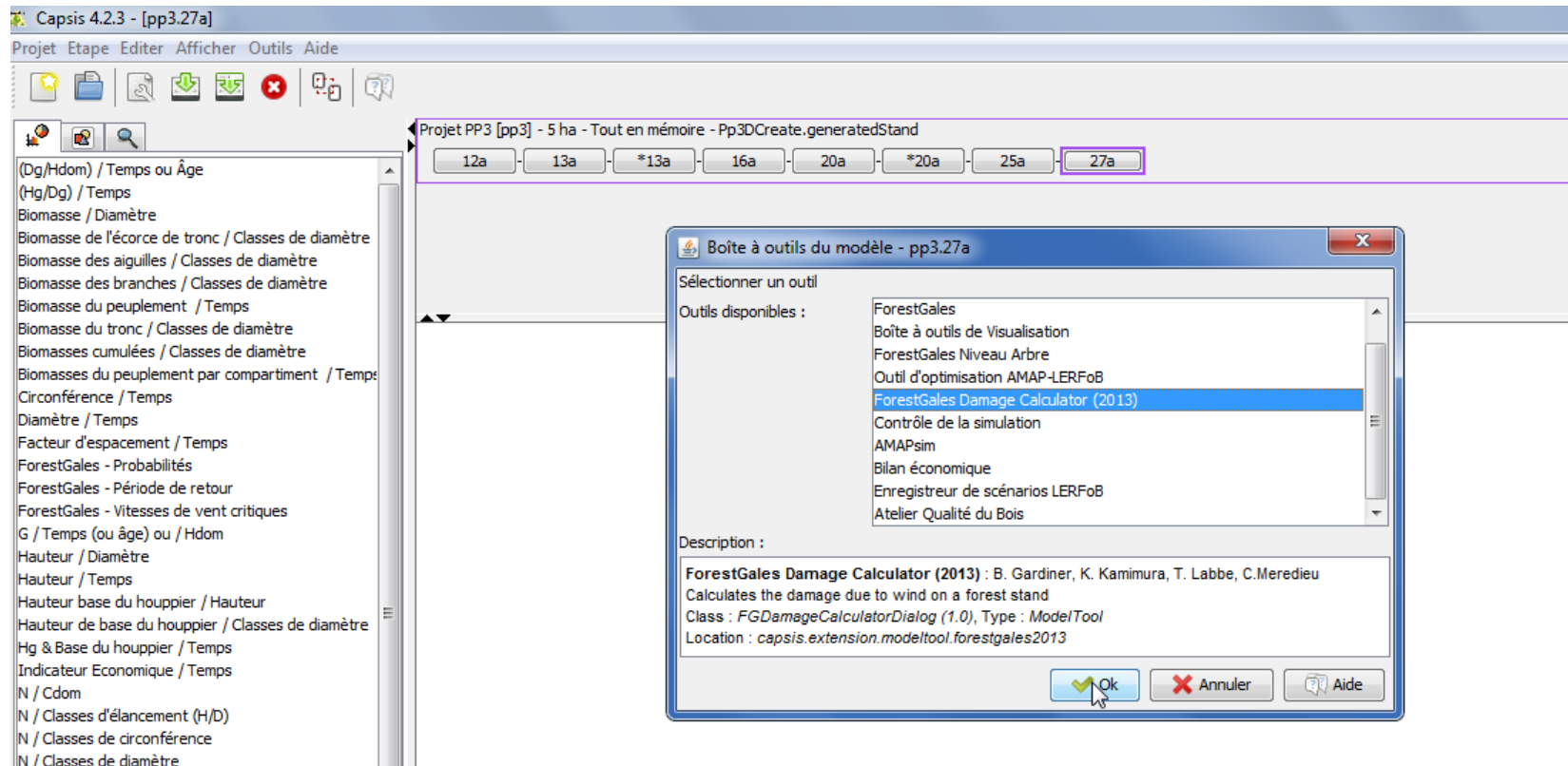
Barry's answer:...

- Need standard version that can be accessed from multiple software languages and packages (e.g. ARCGIS, CAPSIS, Web-based applications, etc.).
- Need to make model structure flexible enough to allow different types of application (research, operational, planning, etc.)
- Allows control of changes and upgrades so that we don't end up with multiple versions all round the world

A new Library Forest Gales in Capsis in 2014

- Forest Gales, a new library Capsis
 - In order to improve the connection with growth models
 - JAVA and LPGL licence
 - One tool which can be share by modelers and users easily: only one repository in the world
 - With or without Capsis
- First uses during a project: [ANR Forwind \(M. Fournier, UMR Lerfob\)](#)
 - For what? connection with different growth models and operational uses
 - **with PP3**, maritime pine growth model for Landes de Gascogne
 - **With Fagacees (oak and beech growth models)**

Capsis and ForestGales library in 2014 : connection with PP3



Capsis and ForestGales library in 2014

ForestGales Damage Calculator (2013)

Configuration

Snow density (kg/m3) : 150.0
 Von Karman constant : 0.4
 Air density (kg/m3) : 1.2226
 Gravity acceleration (m/s2) : 9.81
 Resolution of calculation (m/s) : 0.01
 Element drag coefficient (CR) : 0.3
 Surface drag coefficient (CS) : 0.0030
 Roughness constant (CW) : 2.0
 Height of calculation (m) : 10.0
 Surrounding land roughness (m) : 0.06
 Ua : 5.0
 U_C1 : -0.5903
 U_C2 : 4.4345
 U_C3 : -11.8633
 U_C4 : 13.569
 DAMS to Weibull A1 : -0.9626
 DAMS to Weibull A2 : 0.4279
 Intervention occurred in the 5 past years (for TMC)
 How many years in the past : 0
 Mean dbh before intervention (cm) : 0.0
 Mean height before intervention (m) : 0.0
 N/ha before intervention : 0.0

Placette

Type de sol : A - Free-draining mineral soils
 Profondeur d'enracinement : Shallow < 40cm
 Largeur de la trouée (m) : 0.0
 Hauteur de la trouée (m) : 0.0
 Nombre de hauteurs d'arbre depuis la bordure (nombre) : 9.0
 Taille de la trouée au vent (nombre de hauteurs d'arbre) : 10.0
 Wind climate available
 Weibull A (m/s) : 6.0
 Weibull K : 1.9

Species

Switch Maritime pine to Maritime pine
 Paramètres de l'espèce choisie

Specific settings

Apply the chosen method to every step in the scenario

Simple Stand level Roughness Method Stand level Roughness

Paramètres de l'espèce choisie

Nom de l'espèce : Maritime pine
 topHeightMultiplier : 1.0
 topHeightIntercept : 0.0
 Equation de la largeur du houppier : linear2p(0.15674;0.0)
 Equation de la hauteur du houppier : linear2p(0.3156;1.3424)
 Densité de bois vert : 903.4
 Densité du houppier : 2.73
 Module de rupture (10^7) : 3.6
 Facteur de nodosité : 0.85
 Facteur de houppier : 1.0
 Module d'élasticité (10^9) : 6.6
 canopyStreamliningC : 3.07
 canopyStreamliningN : 0.75
 rootBendingK : 0.0

	Shallow < 40cm	Medium 40-80cm	Deep > 80cm
Soil Type A :	125.8	144.5	168.8
Soil Type B :	123.8	126.7	144.4
Soil Type C :	135.1	138.3	157.7
Soil Type D :	153.7	157.3	179.4

Poids de tige maximum

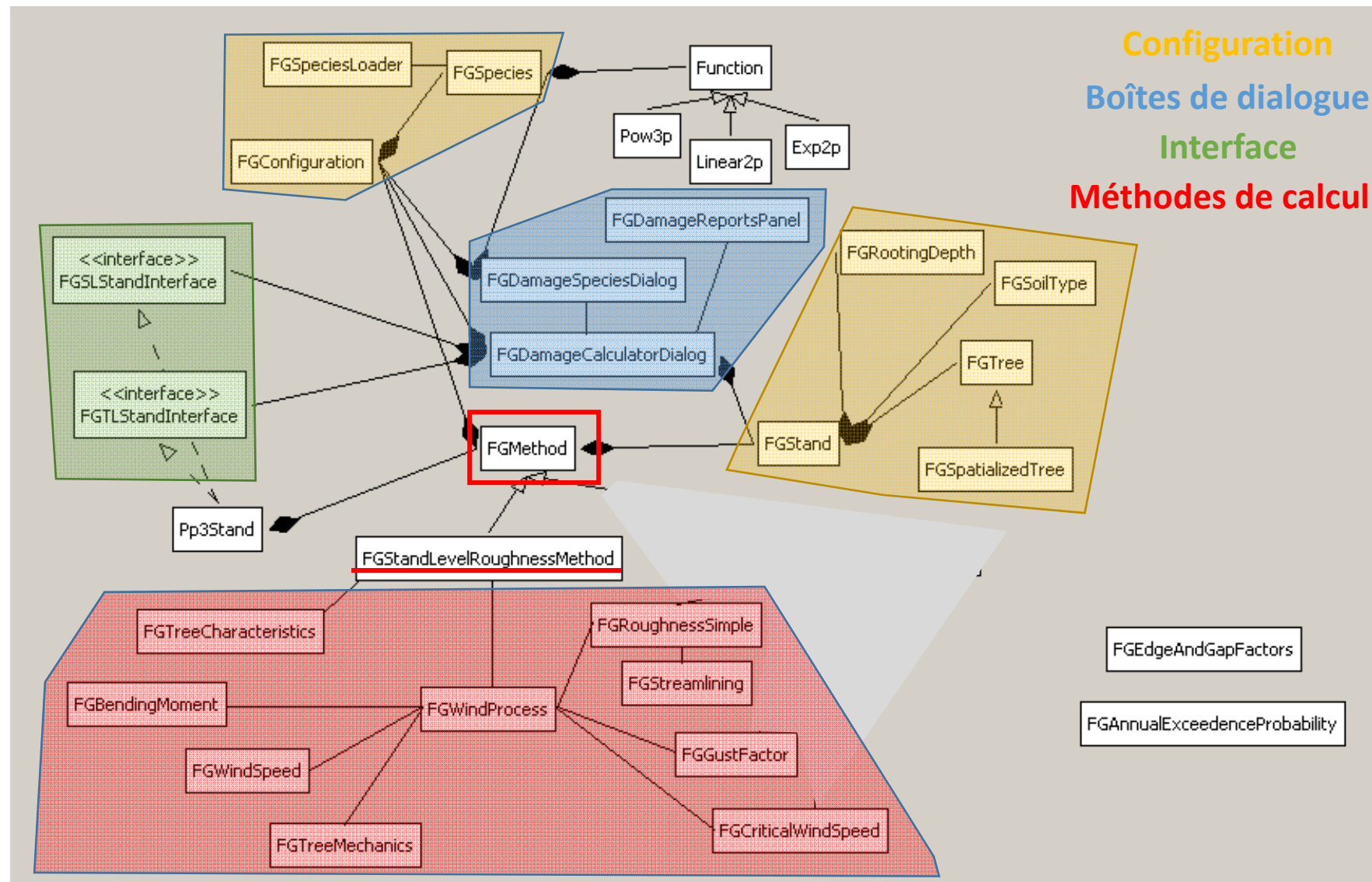
	Shallow < 40cm	Medium 40-80cm	Deep > 80cm
Soil Type A :	294.0	469.0	576.0
Soil Type B :	0.0	0.0	0.0
Soil Type C :	0.0	0.0	0.0
Soil Type D :	0.0	0.0	0.0

Ok Annuler Aide

Capsis and ForestGales library in 2014

- **Two scales to compute wind vulnerability :**
 - Stand level: with only one species, with regular spacing
 - Tree level: each tree could be from different species
 - With spatialisation
 - Without spatialisation
- The level of connection with Forest Gales depends on the growth model capabilities to provide more or less complete information on the stand and the trees
 - For example if the growth model is able to provide the weight of the bole sections, FG will then integrate these input data.
 - Otherwise, FG can compute the missing data with or without species dependant relationships.
- For one step of a silvicultural scenario or a complete project

Organisation of Forest Gales Library




What are the inputs from a growth models in order to use Forest Gales library

- Must give a **species name**: for example « Maritime Pine », in order to use **the preferred parameters**
- Must compute tree or stand **diameter**: D_i or D_g
- Must compute tree or stand **height**: H_i , H_g or H_{dom}
- Must give the tree density or **tree spacing**: number of trees per ha
- Optional variables:
 - Length or diameter of the crown
 - Stem volume or stem weight
 - Crown volume or crown weight
 - Stem profile

Non interactive use of Forest Gales Library

```
Commande prompt
Microsoft Windows [version 6.1.7601]
Copyright (c) 2009 Microsoft Corporation. Tous droits réservés.

c:\capsis4>java -cp class;ext\* capsis.lib.forestgales.FGStandLevelRoughnessMethod Inputdata_IFN_v3.txt
```



# ligne de commentaire si besoin													
# ligne vide													
# Identifiant du point IFN	Sol Type	Profondeur de sol	nha	hdom	species	dbh_m	height	crownWidth	crownDepth	StemVolume	StemWeight	CrownVolume	CrownWeight

```
--- Results ---
nha : 258.5776558

spacing : 6.218770117712635

FGTree
  dbh_m: 0.259710505
  diam[0]: [D03f1a6bc7
  height: 15.24528494
  crownWidth: 2.209928629
  crownDepth: 6.153811927064
  stemVolume: 0.324647775
  stemWeight: 270.431596575
  crownVolume: 0.127126513
  crownWeight: 0.34705538049
  speciesName: OAK
  cwsForBreakage: 77.63496458100354
  cwsForOverturning: 51.534755152574434
  probabilityOfBreakage: -1.0
  probabilityOfOverturning: -1.0

ForestGales Stand Level Roughness Method ended successfully
```


The work already done ...

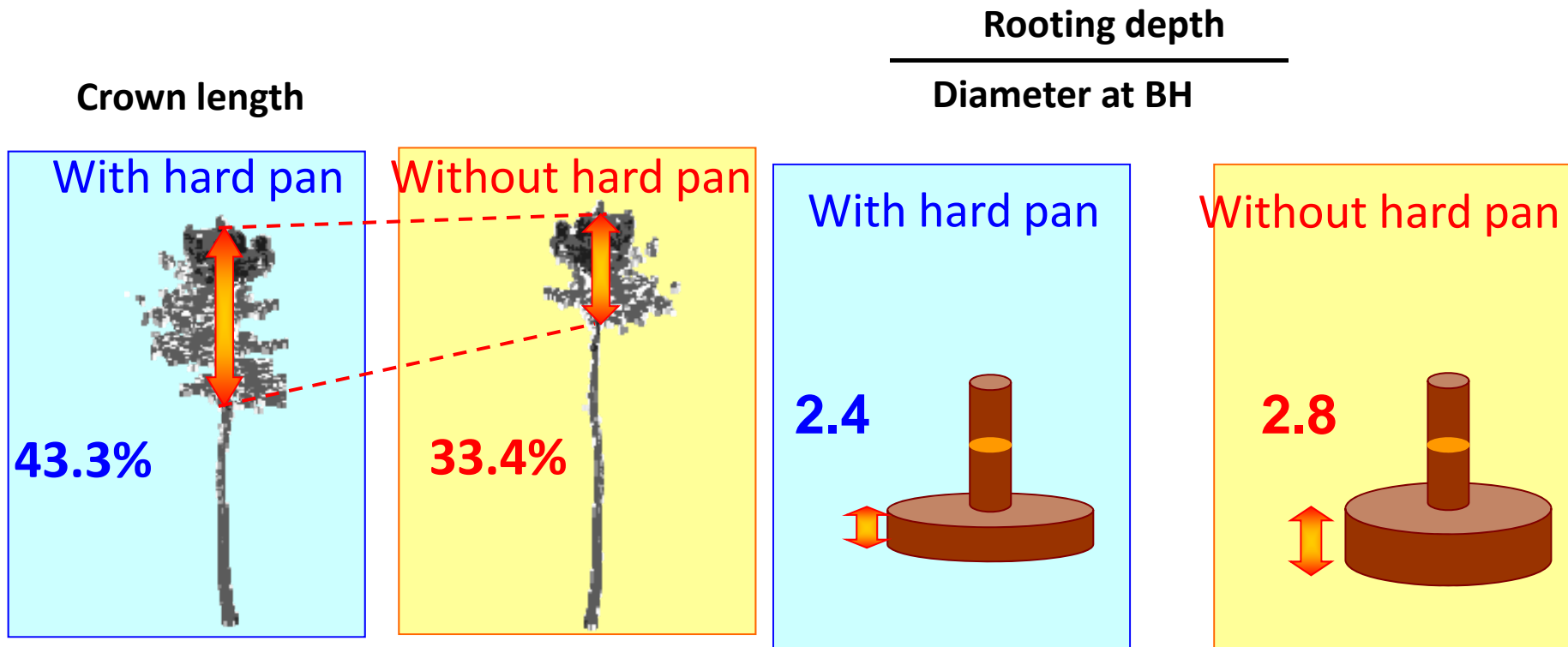
- Implement of two methods
 - A simplified case of critical wind speed calculation (useful for large simulation data: for example landscape scale)
 - The classic method used in 2004: FG Stand level Roughness Method
- We checked the two methods
- Simple connection with PP3: tree density, D_g , H_g for one step or several. *A large majority of models under Capsis could connect the library (but needs species parameters).*
- Computations and display the results in a panel of the dialog box
- Display in a graph of critical speeds versus time.

Work in progress...

1. Additional input data for a mean tree : crown dimensions, stem weight, stem profile – **Analysis of impacts, comparison with Scot pine for example**
2. Activation of the "Tree" interface: sending data of all trees in a stand
3. Choice between (stem weight) and $(Ht \times Dbh^2)$ for anchorage computation
4. How to use stem profile and wood quality ?

In addition the current discussions on anchoring trees ... and their use in Gales

- Impact of soil type: only sand in SW France... but what is the role of hydromorphy?
- Impact of rooting depth : is it relevant for Maritime pine in SW France?



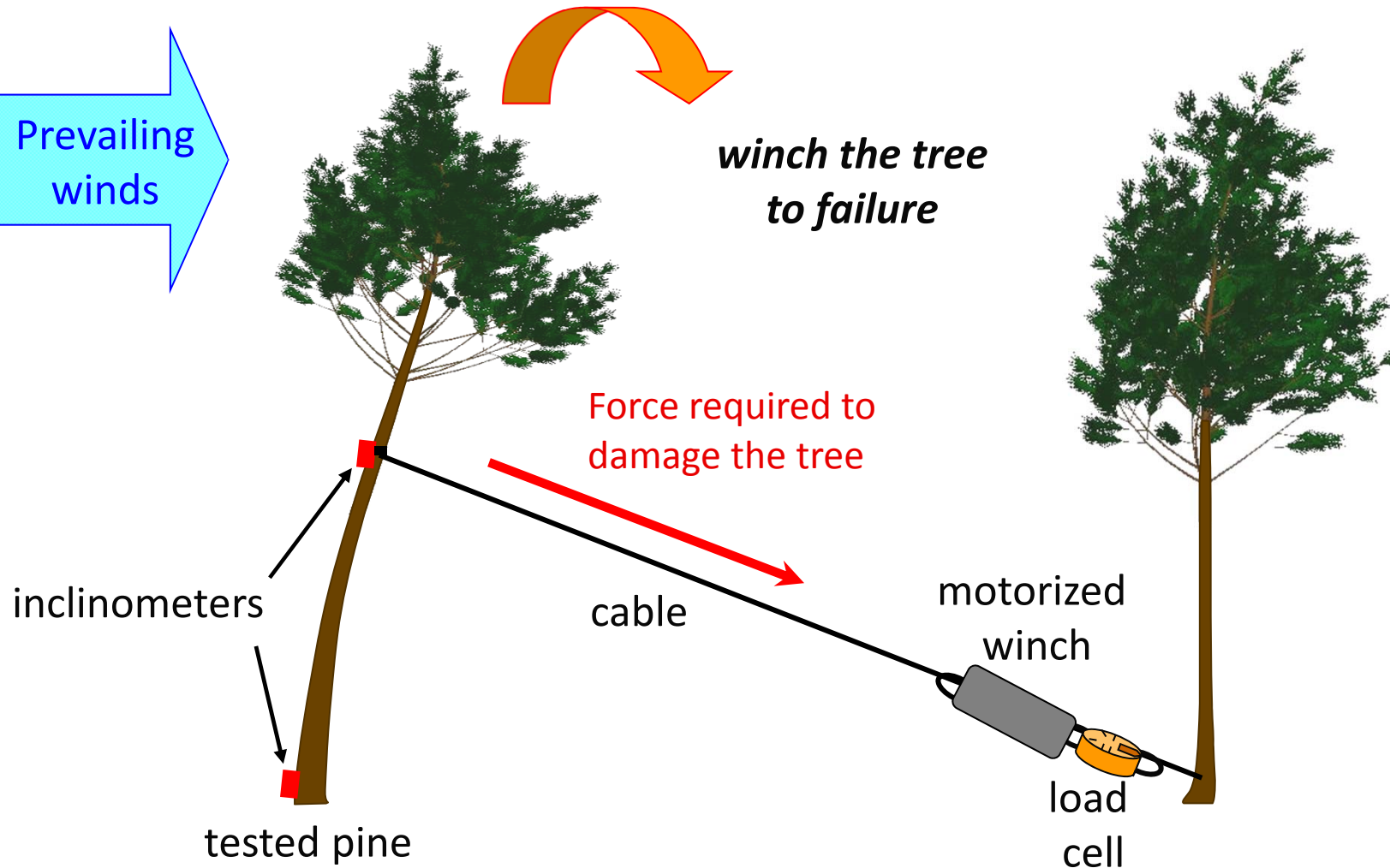


Method : static winching tests in the field

Static winching tests



Mechanical resistance of root anchorage



Sampling of stands

Selection of stands according to **2 podzolic soil conditions**:

with hard pan

Shallow groundwater table
+ presence of an unbroken hard pan horizon
= rooting depth is **very limited**



without hard pan

Groundwater table deeper
+ hard pan horizon broken or absent
= rooting depth is **less limited**



Hypothesis: soil conditions influence tree resistance to uprooting

Sampling of trees

Selection of trees according to **2 positions** in the stand:

inner trees

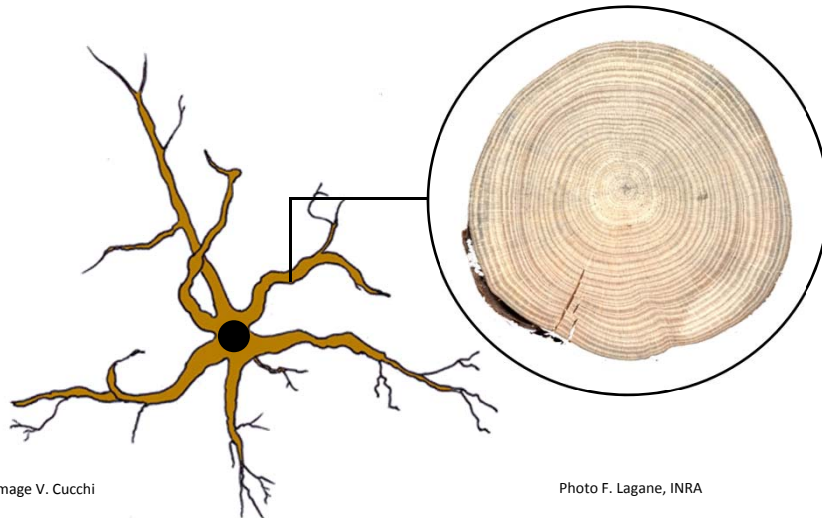
Growing inside the stand
⇒ no repetitive wind loading
= anchorage **not adapted to wind?**

edge trees

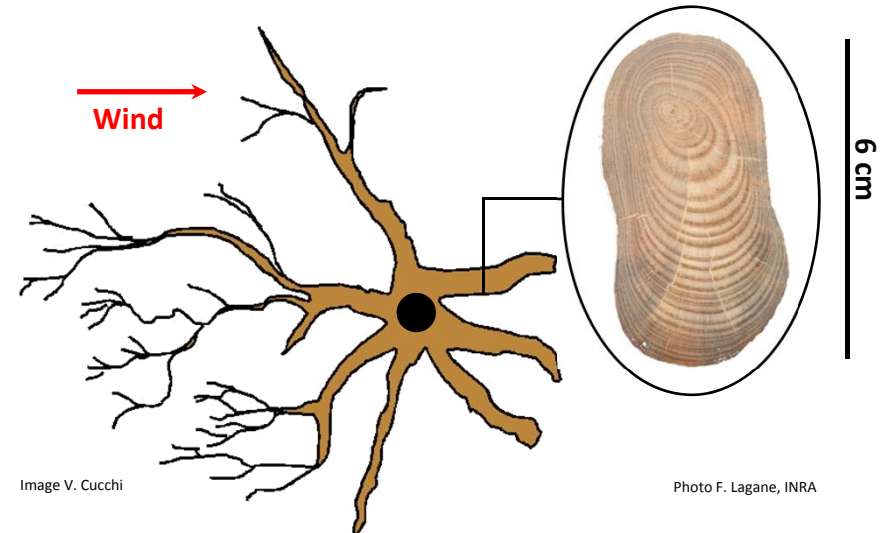
Exposed to prevailing winds
⇒ frequent wind loading
= anchorage **better adapted to wind?***

* Stokes *et al.* 1995, Stokes 1999

Tree root system seen from above



Adapted tree root system seen from above



**Hypothesis: exposure to wind loading
influences tree resistance to uprooting**

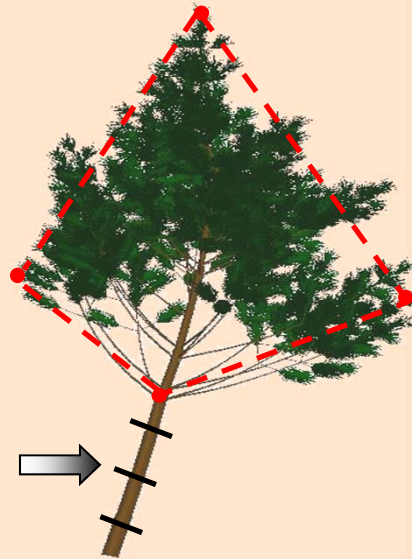
Measurements before and after winching

Aerial part

- Total height and crown height
- Cable attachment height

- Crown area
- Total mass of all living branches

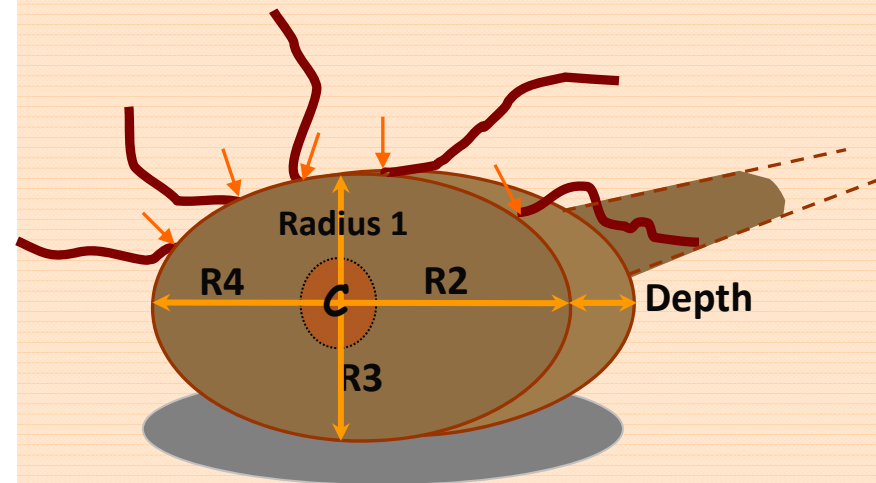
- Stem circumference over bark every 1m



- Dimensions and mass of a 1m long section of trunk

Root system

- Soil-root plate dimensions
- Diameter of all the horizontal roots at the edge of the soil-root plate



Assessment on the tested trees

100 tested pines: 12 - 56 cm DBH, 15 - 56 year-old

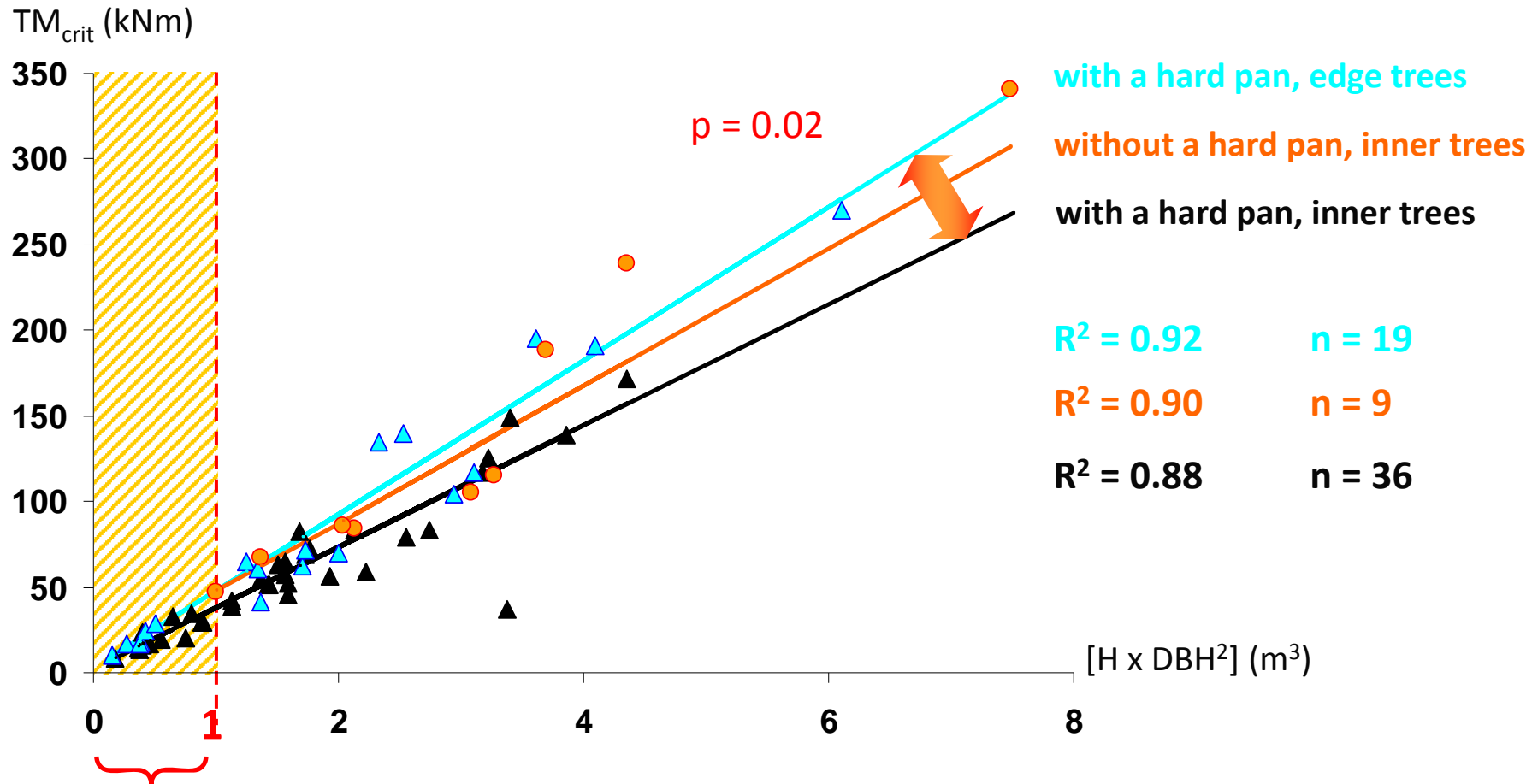
- **71** pines were **uprooted**
- **27** pines **failed in the stem**, with different types of breakage

21 of the 27 stem failures occurred on dry Lande



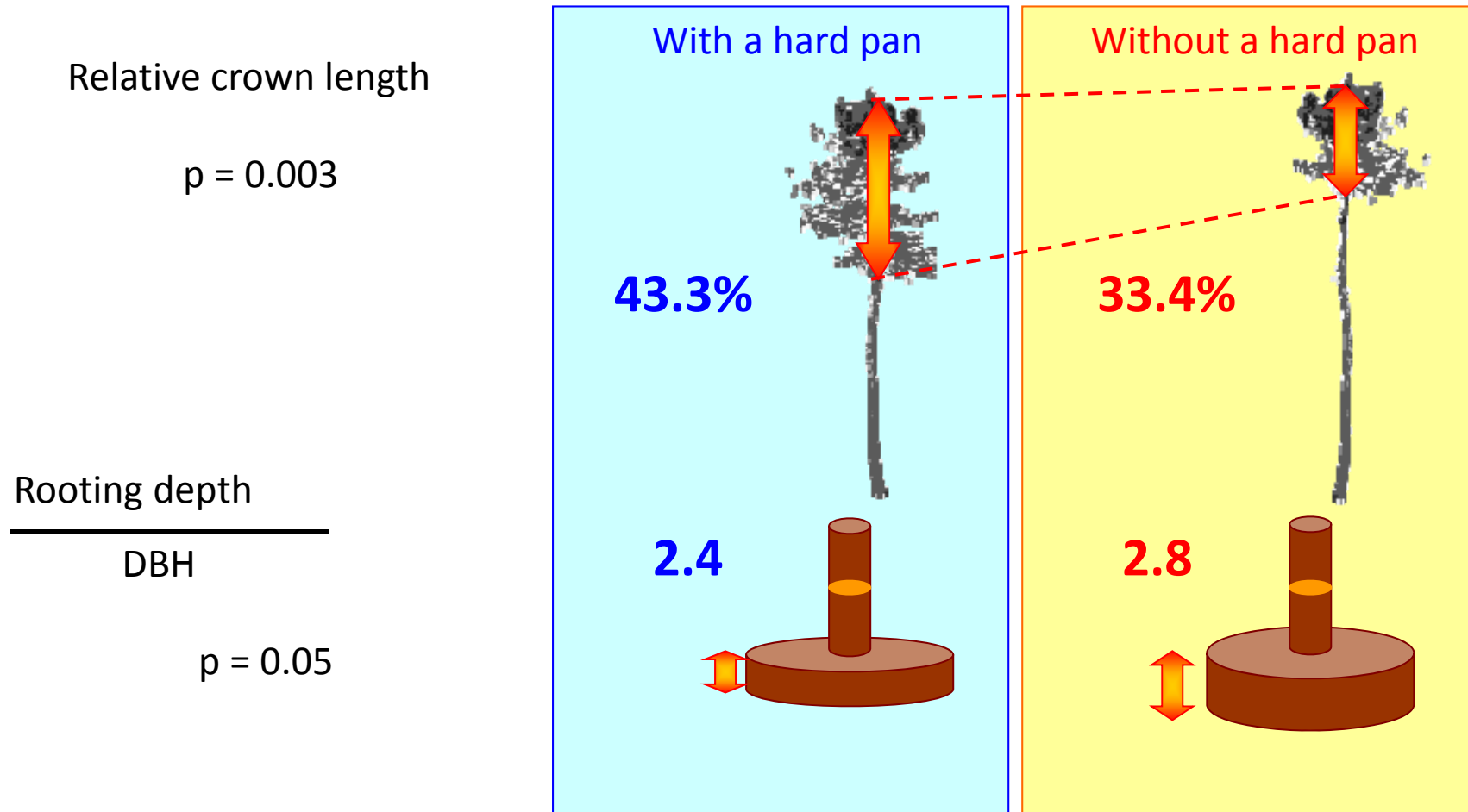
Anchorage strength

Best predictive variable of the TM_{crit} is $[H \times DBH^2]$ with $R^2 = 0.94$



We cannot predict the TM_{crit} for trees beneath $1m^3$ growing on dry Lande due to the high frequency of stem breakage

Differences according to soil conditions



=> Effect of soil conditions on aerial and underground parts

Differences according to tree position

Vertical asymmetry
of soil-root plate:
stem shifted sideways

$p = 0.001$

Soil-root plate volume

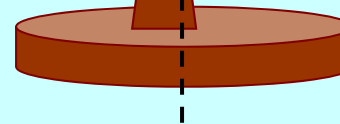
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Stem volume

$p = 0.044$

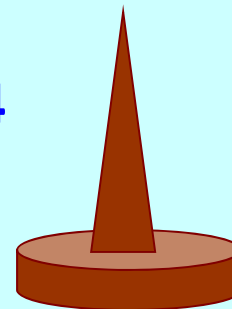
Inner trees

← Prevailing wind

+6.9%



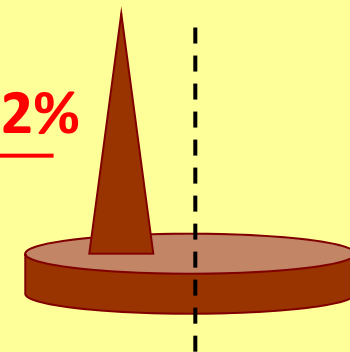
2.4



Edge trees

← Prevailing wind

+20.2%



3.6

