EFORWOOD

Sustainability Impact Assessment
of the Forestry - Wood Chain

Project no. 518128

EFORWOOD

Tools for Sustainability Impact Assessment

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Deliverable PD2.5.3
Report of workshop on "methodologies to improve and extend models for forest sustainability analysis"

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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EFORWOOD

Sustainability Impact Assessment
of the Forestry - Wood Chain

WP 2.5

Deliverable PD 2.5.3
Report of workshop on "methodologies to improve and extend models for forest sustainability analysis”

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Date: September 30, 2007

Abstract

This document reports the presentations and discussions that were held during the workshop organized by WP2.5 in Villanova, Spain. The workshop had three objectives: 1) to analyse the forest growth models available for each one of the Reference forests, in order to assess how well the existing models predict the EFORWOOD sustainability indicators selected in D2.5.2 that can be estimated, either directly or indirectly, with models; 2) to discuss methodologies for the implementation of the selected models into regional simulators; 3) to discuss the methodologies that are planned to improve the existing European simulator EFISCEN and to analyse the possible links and contributions of the WP2.5 partners to EFISCEN. The present document includes the minutes of the workshop and the presentations made during the meeting which were the basis of our discussions.

Executive summary

During this workshop, we clarified questions about the use of growth models in regional and national simulators. First we reviewed terminology concerning forest modelling tools. We agreed about some definitions and about the fact that description of available models should be improved. It was decided that the models should be described in the IEFC database after some modifications, proposed during the workshop, will be made on the database. Second, every partner made a presentation about the selected reference region and the models available.

To start the discussion about simulators, inputs for models were examined. They can be constituted by NFI data; two examples were discussed, in Aquitaine region (France) and Baden-Württemberg (Germany). These examples highlight problems linked to the use of this type of data and possible solutions, as correctives functions, or plots aggregation to deal with discrete information. Solutions for using NFI data as inputs for models and regional simulators will probably be local as data and protocols are heterogeneous, depending on country.

The discussion about regional simulators was centred around two demonstrations, the regional simulators developed for Catalonian forests and the landscape simulator/decision support system developed in Portugal for application at the management unit level. After some discussions around the methodologies that must be used for the development of simulators it was decided that it will be possible to have different simulators in EFORWOOD. It will be good if partners using similar models will develop common systems, but there is no requirement about the methodologies selected by each partner. The only requirement is towards the main functionalities as outputs and links to ToSIA. They should also have common capacities to simulate various scenarios and to produce values for indicators. However all the indicators will be not predicted by every regional simulator, but these tools will help us to identify the possible follows and improvements needed. Simulators should be considered as a valuable method to evaluate the European simulator EFISCEN at the regional level. In this way, the most important thing for EFISCEN is to develop for it volume growth functions.

The present document is constituted by the minutes of the workshop and the presentations made during the meeting which were the basis of our discussions.

Key words: growth models, regional simulators, EFISCEN, input data, NFI data, improvement, scenarios, indicators' values, volume growth functions.

1 Introduction and background

The workshop on "methodologies to improve and extend models for forest sustainability analysis" was organized in the sequence of previous work that identified the indicators of sustainable forest management that can be estimated with the models (Tomé et al., 2006). The objective of the workshop was the planning of the work to be undertaken in order to improve the selected forest models to be able to provide estimates of the indicators selected in Tomé et al. (2006).

The workshop had five sessions:

1. Discussion of terminology to be used under WP2.5
2. Presentation of the models and regional cases
3. Discussion on the development of simulators
   a) Input data for simulators
   b) Regional simulators
   c) European simulator (EFISCEN)
4. Planning of future activities

The list of participants is included as annexe 1.

2 Discussion of terminology to be used under WP2.5

The subject was initiated with a presentation by MT (annexe 2).

<u>Summary of the presentation and related discussions:</u>

- Introduction and objectives of the workshop.

- Discussions about definitions and terminology related to the forest modelling tools: state variables, driving, principal and derived variables; forest growth models, forest growth models modules, sub-modules and components; stand, landscape and regional simulators; decision support systems. Modifications made directly on the ppt file.

- Discussions about the framework for description of models that will be used in the regional simulators: the excel sheet should be modified and resent to the WP partners before the end of the current month (February). IEFC database is too flexible, we need a more strict form to describe the models. Possibility to develop our own database?

<u>Decisions:</u>

- *Corrections on definitions and terminology (already included in annexe 2)*
- *Framework for models description: modifications according to previous forms, more strict forms needed, improved forms will be re-sent to all WP partners, assumptions made for models building will be added as information in the references*
- *Deliverable 2.5.2 should include all the details discussed.*

3 Presentation of the models and regional cases

The objective of the presentation made by each partner was to briefly describe the region, the models that will be used in the regional simulators, identifying the need for improvement in order to assess the indicators selected in PD2.5.2 as well as the planned improvements. The implementation of the models into regional simulators should also be indicated.

3.1 Portuguese production forest region (MBC, SB and PS)

- Description of the Portuguese production forest region (presentation in annexe 3):
  Main species are *Eucalyptus globulus*, *Pinus pinaster*, *Quercus suber* that occur mainly as pure stands; mixed species stands are also present, eucalyptus and pine are mainly even-aged but uneven-aged structures occur for the three species
- Forest growth models: Globulus 3.0 (whole stand model for eucalyptus), GLOB-3PG (process-based model for eucalyptus); Modispinaster (whole stand model with simulation of diameter distributions for maritime pine), Suber (individual tree model for cork oak, also predicts cork yield)
- Planned improvements on models: development of a sub-model for biomass prediction in maritime pine, as well as a sub-model for initialization after clearcut and/or in the plantation of new areas. Development of economic models for eucalyptus and maritime pine
- Weaknesses detected on models: For all models: non-wood goods (except cork) and forest damage are not predicted.
- Problems anticipated for simulators: predicting growth of mixed stands as the models available were developed for pure even-aged stands
- Simulators: stand and regional simulators are available but there is the need to improve them, namely to add modules for the estimation of indicators that can be indirectly estimated.

3.2 Maritime pine in Aquitaine-France (CM and MN)

- Description of the Aquitaine region (presentation in annexe 4):
  Main species is maritime pine, even-aged stands, stands are more and more planted compared to seedling and natural regeneration
- Forest growth models: 4 models for Maritime pine: 1) the whole stand growth model PP1 for south-western of France except the coastal dune area, 2) the whole stand growth model of Lemoine for coastal dunes, 3) the Afocel growth model and 4) the individual tree growth model PP3 for south-western of France except the coastal dune area with the Capsis 4 stand growth simulator. Some additional models exist: biomass

model per compartment, carbon content, wind throw risk model, partly branch, fibre and solid wood models.

- Planned improvements on models: development of branch and wood quality models.
- Weaknesses detected on models: not presented at the workshop
- Problems anticipated for simulators: NFI data has been used: to calculate difference in carbon balance between 2 national inventory dates; however the use of these data as input for the simulators is not straightforward, needs corrective functions
- Simulators: regional simulator must be developed under EFORWOOD

3.3 Baden-Württemberg in Germany (JZ, PD and KT)

- Description of the Baden-Württemberg region (presentation in annexe 5): Most stands are pluriespecific, even-aged and uneven-aged stands
- Forest growth models: Extrapolation of NFI data with the WEHAM model (distance-independent tree model, plot/stand level)
- Planned improvements on models: The intended improvements on this model are closely related to its weakness described below. At present the growth potential is predicted according to yield tables developed for the region. However, diameter increment is not directly related to stand density or other competition measures. Thus, it is planned to include a diameter growth model sensitive to stand density in order to model the impact of alternative forest management regimes.
- Weaknesses detected: No dependency of diameter growth to competition or density measures included in the model. The model is developed in order to predict the timber flows coming from a region for a period of 30 years which is only about one third of the common production period for Norway spruce and about one fourth for European beech, respectively.
- Problems anticipated for simulators: Available data for input are NFI data (Bitterlich plots). There are problems due to differences in protocols between German regions, particularly the size of the grid. The number of plots is high (ca. 13000) but each plot contains few trees, corresponding to a discrete information. It is a problem to use these data for models and optimization. A solution may be to aggregate plots to create an "artificial stand", but the method for aggregation is not yet defined.
- Simulators: There is no regional simulator readily available. The presented model might serve as the basis to develop a simulator within the EFORWOOD project. In this matter it has important advantages since it is already linked to an assortment model and thus allows for basic economic calculations. However, it is required that the addressed weakness in regard to properly reflect alternative silvicultural operations is overcome.

3.4 Westernbotten in Sweden (EV)

- Description of the Västerbotten region (presentation in annexe 6):
  Main species are *Pinus sylvestris*, *Picea Abies* and *Betula Pubescens*, mostly in stands dominated by one of the species; mixed species stands are also present in the region. Detailed description of volume, area and wood production for main species in this region is given on annexe 6.
- Forest growth models: Models are available for all the species and forest types, both stand models and distance-independent individual tree models
- Planned improvements on models: Models for recreation, habitat suitability, climate change, soil carbon and wood quality will be implemented in the new simulator Heureka during 2008 and 2009.
- Weaknesses detected: Risk and effects of forest damages are not implemented in the simulators, i.e. models for storm, wind, insects and fungi.
- Problems anticipated for simulators: All new models not completely tested and ready to use in the simulator until 2009.
- Simulators: the models for forest production have been implemented in simulators, the HUGIN and the HEUREKA systems

3.5 Catalonia in Spain (JJG and MP)

- Description of the Catalonia region (presentation in annexe 7)
  Main species are *Pinus sylvestris*, *Pinus halepensis* and *Quercus ilex*. Wood is not the main forest product, others services as hunting, mushrooms are very important.
- Forest growth models: growth and yield models development was based on NFI data, therefore all the forest types are covered. The approach is an individual tree and stand level approach. Additional models exist: fire risk model (occurrence and damage), mushroom yield model, biomass, scenic beauty.
- Planned improvements: take into account fires to limit the overestimation of growth; moment method to obtain diameter distribution.
- Weaknesses detected: habitat suitability, timber quality, water quality…
- Problems anticipated for simulators:
- Simulators: forest growth models are implemented into the regional simulator ESCEN that projects each individual tree plot. The decision support system RODAL, that uses a distance-independent empirical tree growth model for pluriespecific forest, is also available.

3.6 Scotland (MDL)

- Description of the Scottish region – Craik forest (presentation in annexe 8)

Main species is Sitka spruce, even-aged stands predominate in the area. The simulator will also consider Scots pine, Lodgepole pine and Birch

- Forest growth models: Forest Yield - a set of stand level models suitable for even-aged stands and originally produced as 'look-up' tables
- Planned improvement on models: adapted to allow greater flexibility in interpretation
- Weaknesses detected: difficulty in modelling and/or irregular stands
- Problems anticipated for simulators: Linking to GIS based landscape simulator. Also weaknesses noted above
- Simulators: a landscape simulator for the forest is available for the Craik forest, a GIS based modelling tool that emphasises the relations between forest management and indicators (economic, environment, social). The example presented shows a study of the relations between forest management and presence of an endangered species, the red squirrel, (environmental indicator), the recreation (social indicator) and the timber value (economic indicator).The system allows the study of factors which allow the scattering of the red squirrel, by mapping habitat suitability (connectivity), prediction of potential density of animals. Recreation is studied by mapping intensity of frequenting areas and roads by people. The tool also provides timber value: yield classes, elevation, soils, forecast volume of Sitka spruce, diameter classes, minus by costs,…

3.7 Oak in Lorraine region (JPS and JFD)

- Description of the Oak in Lorraine region (presentation in annexe 9)
  Main species are Fir, Spruce, Beech and Oaks
- Forest growth models: growth and yield models with stand growth and individual tree growth models (Fagacées)
- Planned improvement on models: growth data from both regions are being used to improve existing models
- Weaknesses detected: not yet defined
- Problems anticipated for simulators: not yet known
- Simulators: not existing at this time but a simulator for the Lorraine region will be developed under EFORWOOD

4 Discussion on the development of simulators

After the presentations describing the reference regions as well as the models available, the discussions were focused on the development of simulators. Several problems were discussed, namely:

- How to use NFI data as input for the simulators
- Which variables should be used as drivers
- Methodologies to develop regional simulators
- Methodologies to improve the European simulator EFISCEN

As a starting point to the discussions, two presentations/demonstrations were done by Portuguese (JB) and Catalonian (AT) partners.

4.1 Presentation/Demonstration of the GEIS and SADFLOR simulators (JB)

- Presentation of the Generic Environment Impact Statement (GEIS): a DSS example used for Minnesota. It uses Hoganson-Rose model (Lagrangian relaxation): breaking down of a complex problem into sub component.
- DSS SADFLOR (demonstration): it is a landscape simulator, each individual stand is locally identified into a GIS system. Several management alternatives are simulated for each stand and several optimization algorithms can be used to select the best alternative to each stand in order to achieve pre-determined objectives (maximization of net present value, for instance) while satisfying a certain number of restrictions (maximum and minimum volume harvest, maximum area of harvest, etc). The processes are at stand level

4.2 Presentation/demonstration of the ESCEN simulator (AT)

- Presentation of the ESCEN simulator, developed in collaboration with NFI services. Permanents plots allow the development of individual tree models. For each plot, it can visualize each tree.
- Possibility to visualize the state at the inventory date and future state according to silvicultural options.
- Simulations can be performed according to scenarios at stand level.
- Fire models also included.
- This simulator is not able to propose scenarios according to target values as annual volume to cut for instance (it is not an optimization approach): they have to test various scenarios and compare them.

4.3 European simulator (EFISCEN)

<u>Presentation by IW (presentation in annexe 10):</u>

- Input data for the new EFISCEN are country or regional level data. Data should be spatialized through a 1 km x 1 km grid. Data sources are plot data all over Europe: NFI plots and ICP level I plots. The grid is translated into maps of tree species based on plot data and ancillary data as elevation, soil map, average rainfall. Regression and kriging are being considered as a means to spatialize the data. Each species presence is predicted. In each cell, presence/absence for species.
- Demonstration: mapping per species with NFI and ICP data, presence/absence, randomly remove 10% of the data for validation. The map showed contains some errors as Abies species in Aquitaine! Locally in each cells, the results show some errors but globally the distribution is ok. Prediction of tree number and mean diameter on each cell for even-aged forests from inputs as age and volume is being explored.

5 Conclusions

At the end of the workshop some conclusions, decisions for the future could be found:

- The models selected to be used in the regional simulators should be described in the IEFC database that must be modified according to the conclusions of the workshop. Deliverable D2.5.2 (Tomé et al., 2007), about to be finished, should include a detailed description of the structure of the database.
- There is no need to standardize the regional simulators in what concerns methodologies. But the development of common simulators between partners who use similar models is highly desirable. The standardization among regional relates to outputs and links to ToSIA and also with the possibility to simulate various scenarios and to produce values for indicators.
- Concerning indicators there is not possible to cover all indicators with every regional simulators. The idea is to include as many indicators as possible in the regional simulators. However some indicators, more difficult to estimate, will be exemplified in some cases such as Scotland and Catalonia. One objective for the development of regional simulators is the identification of the indicators that are possible to estimate and plan the research for the future.
- We consider the regional simulators as a valuable method to evaluate EFISCEN at the regional level. The methodology to be used to improve EFISCEN is not yet definitive therefore the contribution of the partners to it has not yet been defined. One idea will be to use local data to develop volume growth functions that can be used for EFISCEN.

6 References

Tomé, M., Meredieu, C., Borges, J., Nabuurs, G.J., Hasenauer, H., 2006. Report on models requirements and outputs. Deliverable D2.5.1 from the EFORWOOD project.

Tomé, M, Baptista-Coelho, M, Meredieu, C. and Cucchi, V. 2007. Framework for the description of forest modelling tools currently available with identification of their ability to estimate sustainability indicators. Deliverable D2.5.2 from the EFORWOOD project.

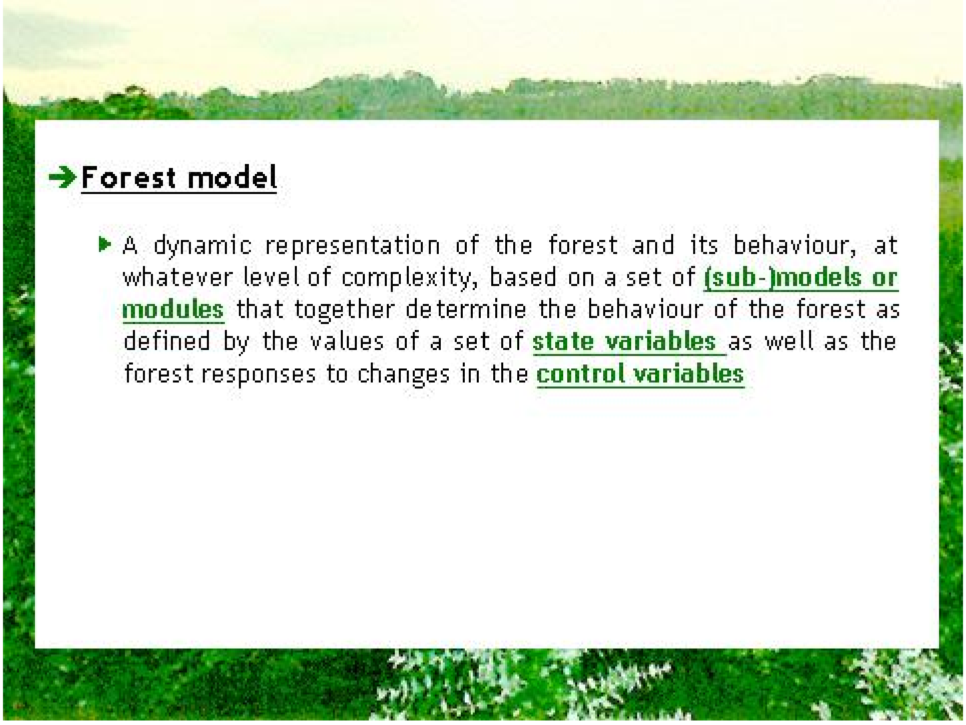
ANNEXE 1 - List of participants

List of registered participants: *– 26 persons*

Names	**Organisation/institution**
Baptista-Coelho, Marta (MBC)	ISA
Barreiro, Susana (SB)	ISA
Borges, José (JB)	ISA
Carnus, Jean-Michel (JMC)	INRA
Cucchi, Véronique (VC)	INRA
De Loanni, Monica (MDL)	FR
Dhôte, Jean-François (JFD)	INRA
Duncker Philipp (PD)	ALUFR
Edwards, David (DE)	FR
Gonzales, José Ramon (JRG)	CTFC
Harou, Patrica (PH)	INRA
Jactel, Hervé (HJ)	INRA
Mason, Bill	FR
Meredieu. Céline (CM)	INRA
Nabuurs, Gert-Jan (GJN)	ALTERRA
Najar, Mohamed (MN)	AFOCEL
Palahi, Marc (MP)	CTFC
Skovsgaard, J. P. (JPS)	KVL
Soares, Paula (PS)	ISA
Spiecker, Heinrich (HS)	ALUFR
Tomé, Margarida (MT)	ISA
Tojic, Karl (KT)	ALUFR
Trasobares, Antonio (AT)	EFI
Valinger, Eric (EV)	SLU
Van den Wyngaert, Isabel (IW)	ALTERRA
Zell Jürgen (JZ)	FVA

ANNEXE 2 – Definitions and terminology


Definitions/terminology related to the forest modelling tools
PROPOSAL
Margarida Tomé


➔Forest model
A dynamic representation of the forest and its behaviour, at whatever level of complexity, based on a set of (sub-)models or modules that together determine the behaviour of the forest as defined by the values of a set of state variables as well as the forest responses to changes in the control variables

➔ State variables

- Set of variables (at stand and/or tree level) that characterize the forest at a given moment and whose evolution in time is the result (output) of the model:
  - **Principal variables** if they are part of the growth modules
  - **Derived variables** if they are indirectly predicted based on the values of the driving variables

➔ Driving variables

- Variables that are not part of the forest but that influence its behaviour:
  - **Environmental** variables (*e.g.* climate, soil)
  - **Human induced** variables/processes (*e.g.* silvicultural treatments)
  - **Risks** (*e.g.* pests and diseases, storms, fire)

➔ **Model module**

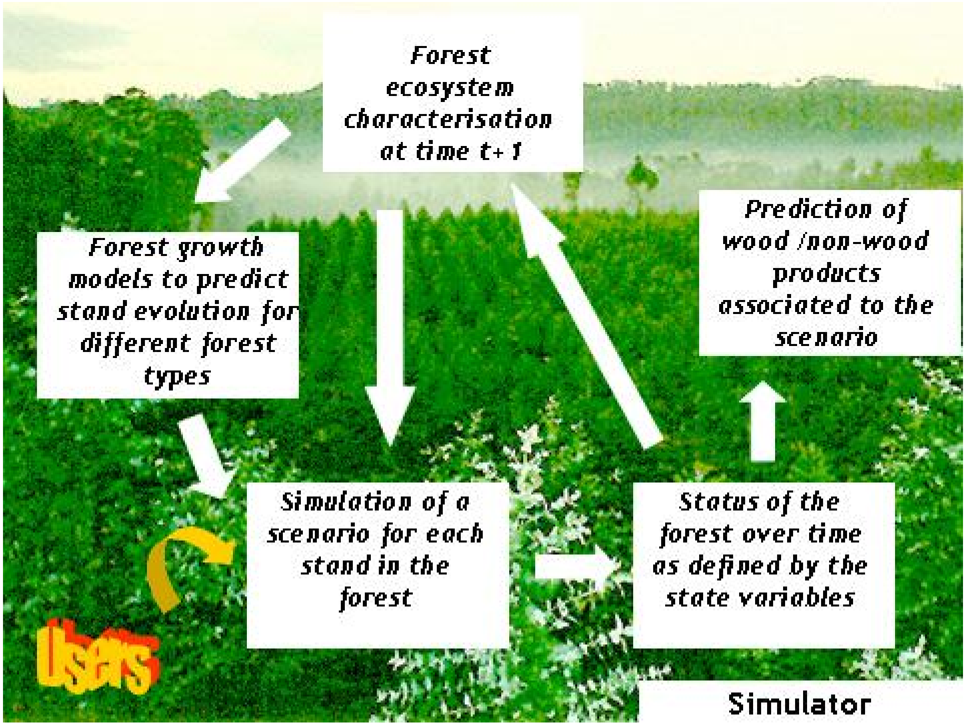
- Set of equations and/or procedures that led to the prediction of the future value of a state variable

➔ **Module component**

- Equation or procedure that is part of a model module

➔ **Forest simulator**

- Computer tool that, based on a set of forest models, makes long term predictions of the status of a forest under a certain **scenario** of climate, forest policy or management
- Forest simulators usually predict, at each point in time, wood and non-wood products from the forest



➔ **Forest management alternative (prescription)**

- Sequence of silvicultural operations that are applied to a stand during the projection period

➔ **Scenario**

- Conditions (climate, forest policy measures, management alternatives, etc) present during the projection period

➔ Stand simulator

- Simulation of a stand

➔ Landscape simulator

- Simulation, on a stand basis, of all the stands included in a certain well defined region in which the stands are spatially described in a GIS
- It allows for the testing of the effect of spatial restrictions such as maximum or minimum harvested areas or maximization of edges

➔ Regional/National simulator - not spatialized

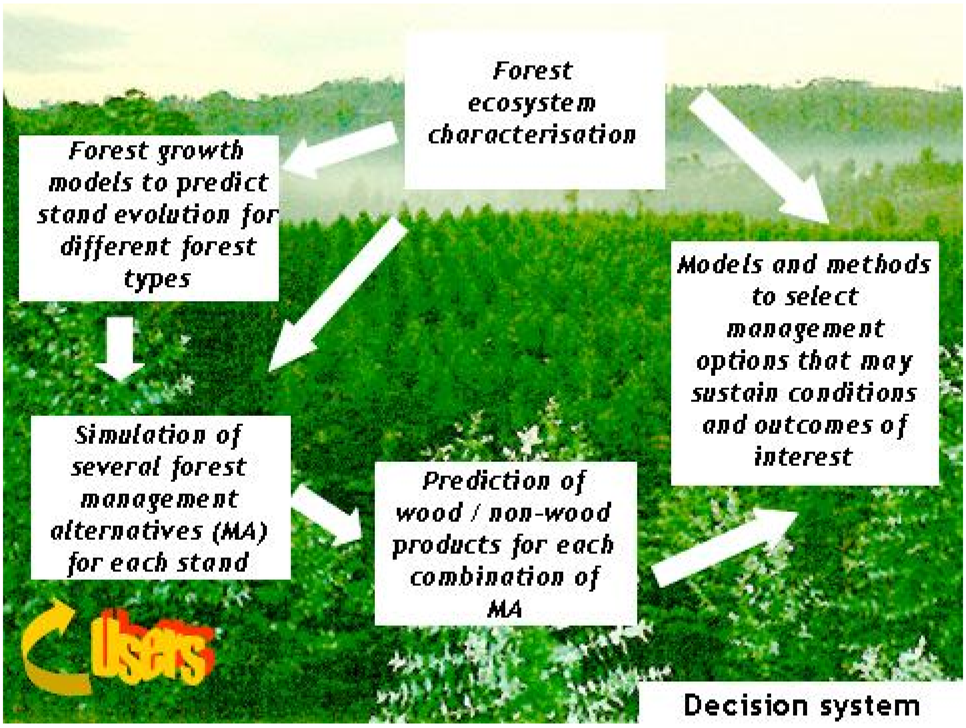
- Simulation of all the stands inside a region, without individualizing of each stand, stands are not connected to a GIS

➔ Regional/National simulator - spatialized through a grid

- Simulation of all the stands inside a region, without individualization of each stand, stands are not exactly located but can be placed in relation to a grid

➔ Decision support system

- Simulator that includes optimization algorithms that point out for a solution - list of forest management alternatives for each stand:
  - Multi-criteria decision models
  - Artificial neural networks
  - Knowledge based systems



ANNEXE 3 – Portuguese production forest region

PORTUGUESE STUDY REGION

Susana Barreiro

Marta Baptista-Coelho

PORTUGUESE STUDY REGION

Region Description

Models Selected

Needs of Improvement

Region Description Models Selected Needs of Improvement

The Region is composed of a set of Nuts III

1st

The set should represent over 80% of the Eucalyptus area

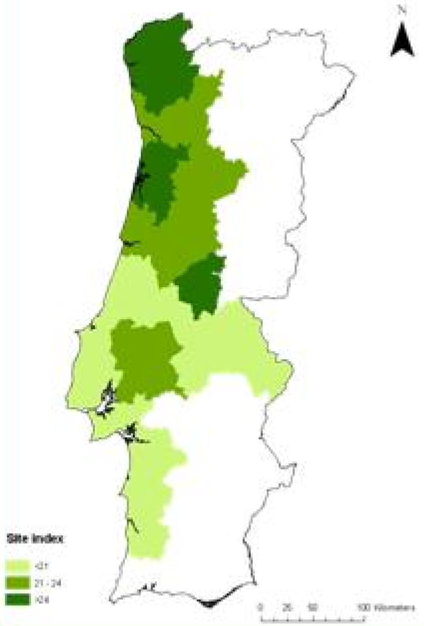
2nd

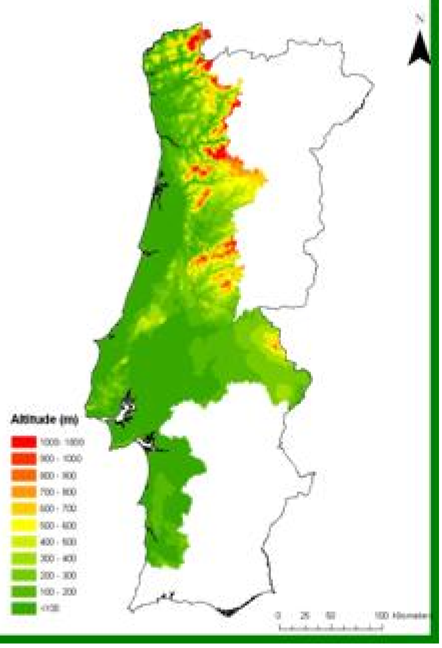
The set should originate a continuous study area

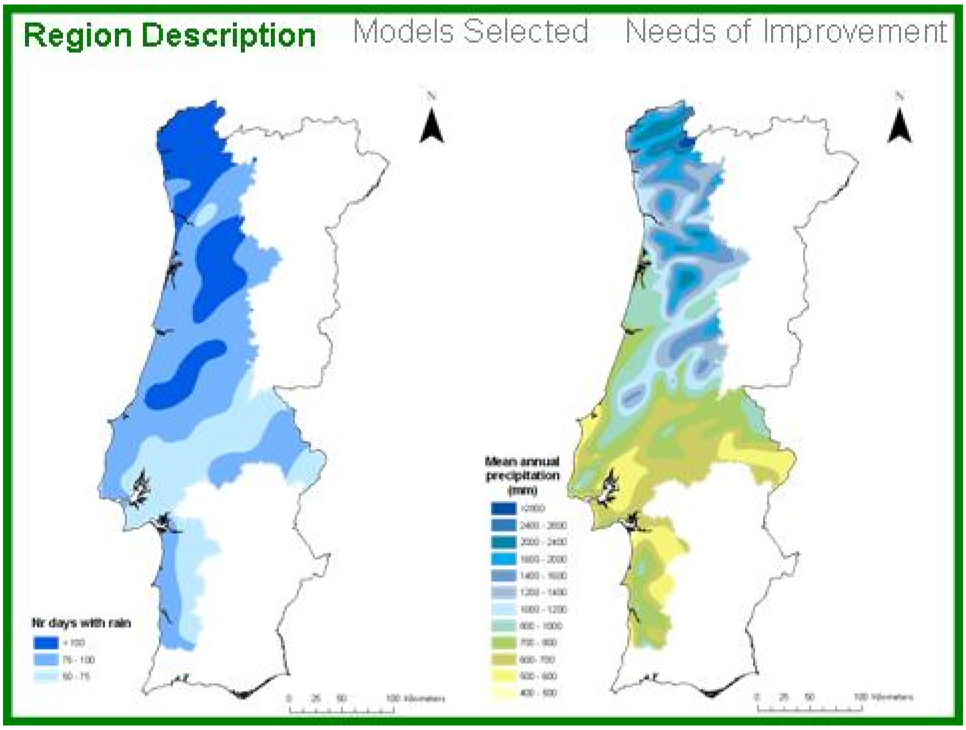
Based on these 2 conditions, as well as on the:

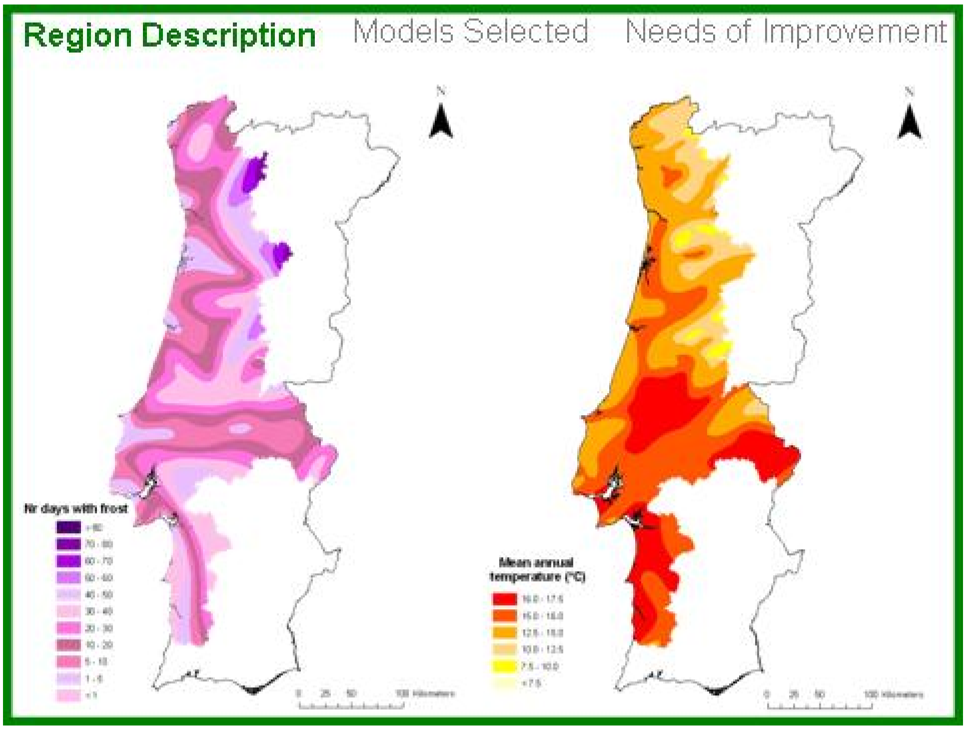
- Mean SI value of Eucalyptus stands for the Nut III
- Number of NFI Eucalyptus plots in the Nut III
- % of Eucalyptus in the Nut III forest area

Region Description Models Selected Needs of Improvement

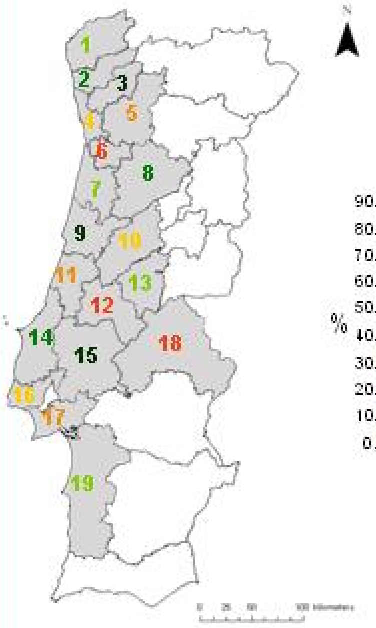


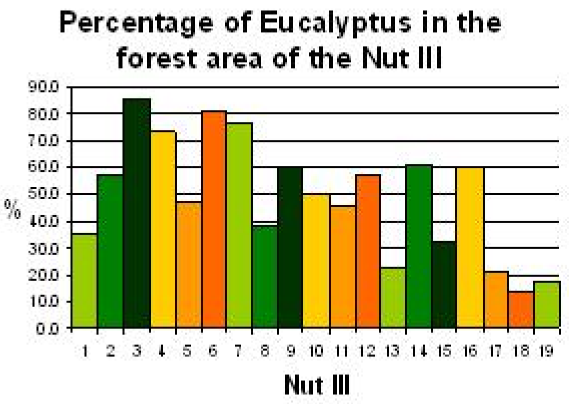



Region Description
Models Selected
Needs of Improvement
Nr days with rain
Mean annual precipitation (mm)
100 Kilometers


Region Description
Models Selected
Needs of Improvement
Nr days with frost
Mean annual temperature (°C)
100 Kilometers

Region Description Models Selected Needs of Improvement





Region Description Models Selected Needs of Improvement

Species representativeness per Nut III:

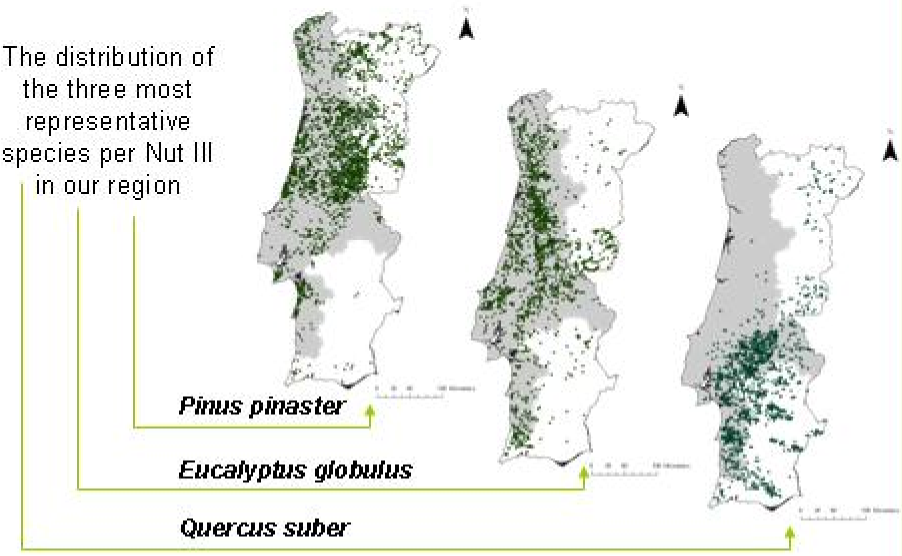
Number of plots per dominant species and per nut III

Sorted the number of plots per nut III, and checked how often each species showed as 1st, 2nd and 3rd most representative species

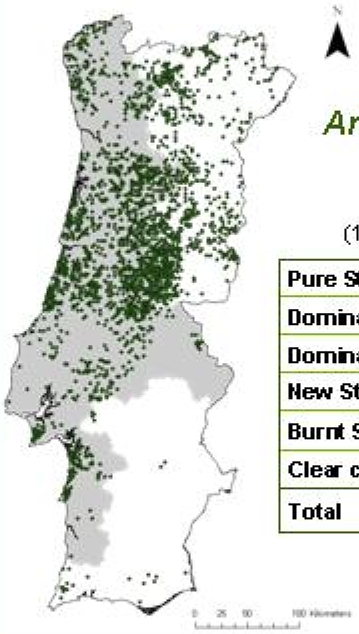
	Pinus pinaster	Pinus pinea	Other softwoods	Quercus suber	Quercus rotundifolia	Quercus spp	Other hardwoods	Eucalyptus globulus	Castanea sativa
1st Species	卌 III			IIII				卌 II	
2nd Species	卌 II		I		I			卌 卌	
3rd Species	III	I		I		卌 II	IIII	II	I
NFI plots	**1445**	5	3	**760**	207	52	25	**1342**	2

Region Description Models Selected Needs of Improvement

The distribution of the three most representative species per Nut III in our region



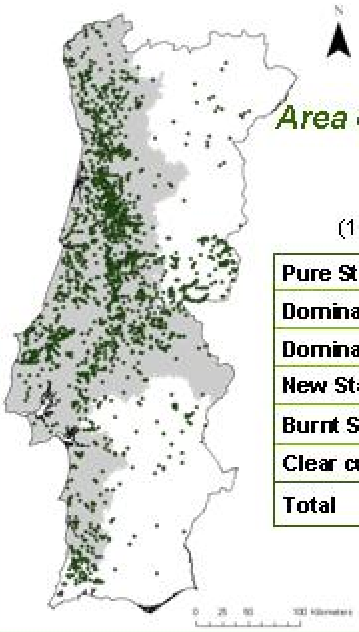
Region Description Models Selected Needs of Improvement



Area of Maritime Pine - Pinus pinaster

(10^3 ha)	Even-aged Stands	Uneven-aged Stands	Total
Pure Stands	230.2	145.7	375.9
Dominant Stands	59.2	68.3	127.4
Dominated Stands	51.7	52.2	104.0
New Stands	11.5	7.9	19.4
Burnt Stands	13.4	9.3	22.7
Clear cuts	4.9	2.0	6.9
Total	370.9	285.4	656.3

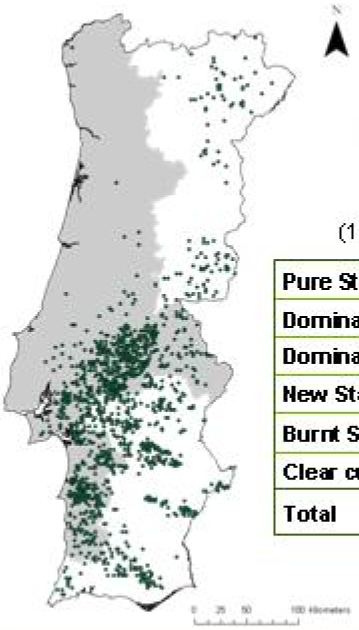
Region Description Models Selected Needs of Improvement



Area of Eucalyptus - Eucalyptus globulus

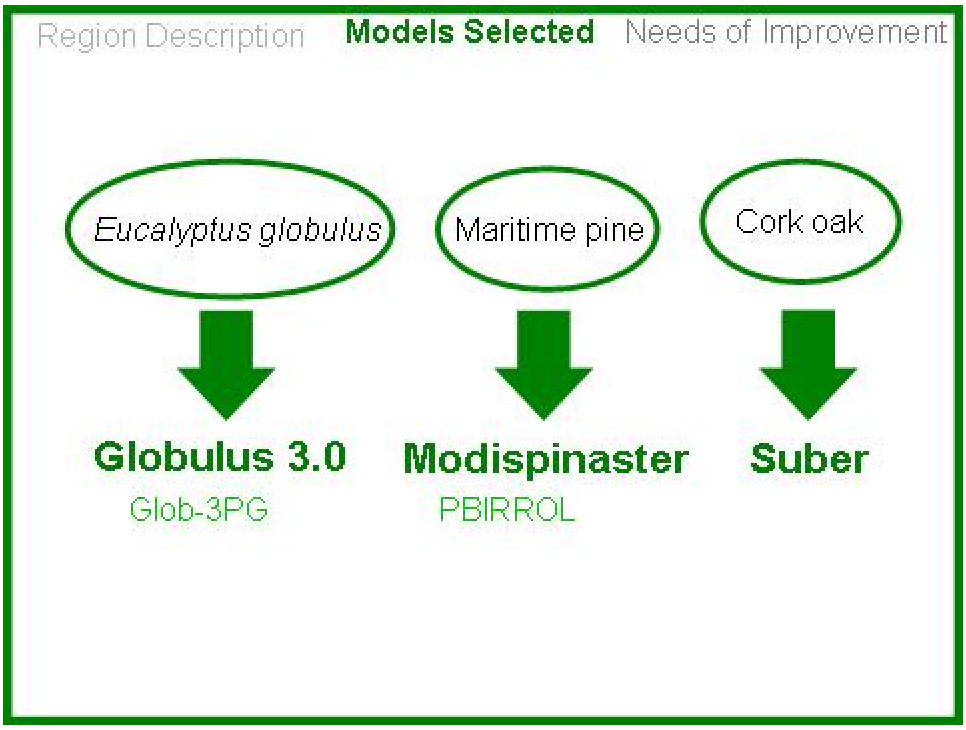
(10^3 ha)	Even-aged Stands	Uneven-aged Stands	Total
Pure Stands	304.9	158.5	463.9
Dominant Stands	46.2	36.0	82.2
Dominated Stands	48.1	48.8	96.9
New Stands	26.1	12.2	38.2
Burnt Stands	23.6	17.2	40.8
Clear cuts	13.0	4.3	17.3
Total	461.9	277.0	738.9

Region Description Models Selected Needs of Improvement



Area of Cork Oak - Quercus suber

(10^3 ha)	Even-aged Stands	Uneven-aged Stands	Total
Pure Stands	129.0	194.2	323.2
Dominant Stands	23.9	47.8	71.8
Dominated Stands	21.2	43.3	64.5
New Stands	4.0	1.7	5.7
Burnt Stands	0.4	0.4	0.7
Clear cuts	0.1	0.1	0.2
Total	178.5	287.6	466.1



Region Description **Models Selected** Needs of Improvement

1. Model Identification

WP member name: ISA (Instituto Superior de Agronomia)

Country: Portugal

Model name: **Globulus 3.0**

Year of publication: 2006

Author: Tomé, M., Soares, P., Oliveira, T.

2. Parameterization and calibration specifications

Geographical region: Portugal

Site specifications: all sites suitable for Eucalyptus globulus

Species: *Eucalyptus globulus*

Forest composition: Monospecific

Stand structure: Even aged stands

Silvicultural System: Clear cutting+coppice

Range of trees sizes: not applicable

Range of stand variables: until 20 years

Region Description | **Models Selected** | Needs of Improvement

Globulus 3.0

3. Model Classification

3.1 Model type: Empirical growth and yield model

3.2 Model sub-type: Stand model +diameter distribution

4. Primary unit of simulation: Stand

5. Time step: Year

Region Description | **Models Selected** | Needs of Improvement

Globulus 3.0

6. Sub-Models of the growth simulator

6.1Modules for state variables

Driving variables	Inicialization
Age	Not relevant
Cutting cycle	Not relevant
Dominant height	Yes
Stand basal area	Yes
Number trees ha-1	Yes
Number of stools ha-1	No
Volume (Total and merchantable)	Yes

Region Description **Models Selected** Needs of Improvement

Globulus 3.0

6. Sub-Models of the growth simulator
6.1 Modules for state variables

Derived variables
Number of shoots before and after thinning
Total volume over bark
Merchantable volume under bark
Biomass (total and per plant components)

Region Description **Models Selected** Needs of Improvement

Globulus 3.0

6. Sub-Models of the growth simulator
6.2Modules for control variables

Human induced	Environment
Initial stand density (1st rotation)	Site index
Stand density after thinning (coppice)	Climate

Region Description **Models Selected** Needs of Improvement

Globulus 3.0

7. Inputs

Required:

- climate variables (precipitation days, altitude, mean annual temperature, annual precipitation, number of frost days per year) or plot coordinates
- site index
- age
- Initial stand density
- Stand density after thinning
- cutting cycle

Additional: all other state variables

Region Description **Models Selected** Needs of Improvement

Globulus 3.0

8. Software

Stand simulator (excel)

Landscape simulator: GLOBLAND

Regional/National Simulator – no spacialized:

GLOBCARB-agreg
GLOBCARB-plot

Region Description **Models Selected** Needs of Improvement

Globulus 3.0

9. References

9.1 Model references

References	Tomé et al., 2006 – Modelo Globulus 3.0. Publicações GIMREF. ISA
Model equations	Yes
Model modules/components	Yes
Model development methodology	Yes
Methodologies used in validation	Yes
Validation statistics	Yes
Sensitivity analysis	No

Region Description **Models Selected** Needs of Improvement

Globulus 3.0

9. References

9.2 Software references

Reference	GLOBLAND
Interactive use	Yes
Batch-mode use	No
Possibilities of changing control variables	Yes
Interactive changing of equations	No
Interactive changing of coefficients	No
Saving of interim results with continuation	Yes
Potential for continuous updating of input data	Yes

Region Description | **Models Selected** | Needs of Improvement

1. Model Identification

WP member name: ISA (Instituto Superior de Agronomia

Country: Portugal

Model name: **Modispinaster**

Year of publication: 2004

Author: Fonseca, T.

2. Parameterization and calibration specifications

Geographical region: Portugal - Vale do Tâmega

Site specifications: sites appropriate for Maritime pine

Species: *Pinus pinaster*

Forest composition: Monospecific

Stand structure: even aged stands

Silvicultural System: Clear cutting

Region Description | **Models Selected** | Needs of Improvement

Modispinaster

3. Model Classification

3.1 Model type: Empirical growth and yield model

3.2 Model sub-type: Stand model +diameter distribution

4. Primary unit of simulation: Stand

5. Time step: Year

Region Description | **Models Selected** | Needs of Improvement

1. Model Identification

WP member name: ISA (Instituto Superior de Agronomia)

Country: Portugal

Model name: **Suber**

Year of publication: 2007

Author: Tomé, M.et al.

2. Parameterization and calibration specifications

Geographical region: Portugal

Site specifications: sites appropriate for cork oak

Species: *Quercus suber*

Forest composition: Monospecific

Stand structure: Even and uneven aged stands

Silvicultural System: several

Region Description | **Models Selected** | Needs of Improvement

Suber

3. Model Classification

3.1 Model type: Empirical growth and yield model

3.2 Model sub-type: Distance-independent tree model

4. Primary unit of simulation: Tree

5. Time step: Year

Region Description | Models Selected | **Needs of Improvement**

Modispinaster

- Does not have initialization functions for the driving variables – essential to use the model after clear cutting or in new areas
- Does not have a module for biomass – essential to assess Greenhouse gas balance indicators*

Modispinaster / Globulus

- Do not have an economic module– essential to assess economic indicators*
- Designed for even aged stands. Models for uneven aged stands for this region are needed.

*Indicators assigned to be predicted directly or indirectly by growth models according to D2.5.1 Report on Models Requirements and Outputs

Region Description | Models Selected | **Needs of Improvement**

All 3 models:

- Do not have modules to assess non-wood goods indicators* (other than cork)
- Do not have modules to assess Forest damage indicators*
- Do not have Water use modules (for Water indicators*)
- Designed for pure stands. Mixed stand models for this species are needed.

*Indicators assigned to be predicted directly or indirectly by growth models according to D2.5.1 Report on Models Requirements and Outputs

ANNEXE 4 – Aquitaine region

Growth modelling and link with NFI data for Maritime pine in South-West France

C. Meredieu (INRA, Research Unit Ephyse)
V. Cucchi (INRA, Research Unit FBA)
T. Belouard (IFN)
M. Najar (AFOCEL)
Bordeaux - France

EFORWOOD

EFORWOOD, 13 February 2007 - Vilanova

1

Maritime pine in Aquitaine

Forest area in Aquitaine
1.735 millions ha
(41.6 % of the total area)

Maritime pine : 59.7 %
(1.037 millions ha)
Deciduous : 37.2 %
Other coniferous : 3.1 %

2

Maritime pine forest

Gironde
83% of the forest area
Last inventory in 1998

Lot et Garonne
47% of the forest area
Last inventory in 2000

Landes
87%of the forest area
Last inventory in 1999

90 % of maritime pine forest in Aquitaine

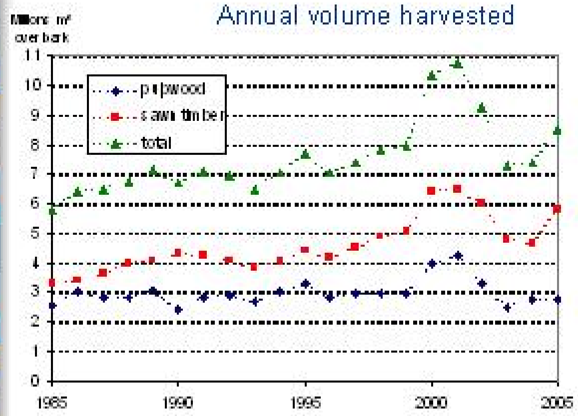
3

Maritime pine forest

Timber stock = 165 millions m³
30 millions damaged by the storm of december 1999

Annual increment = 10.5 millions m³

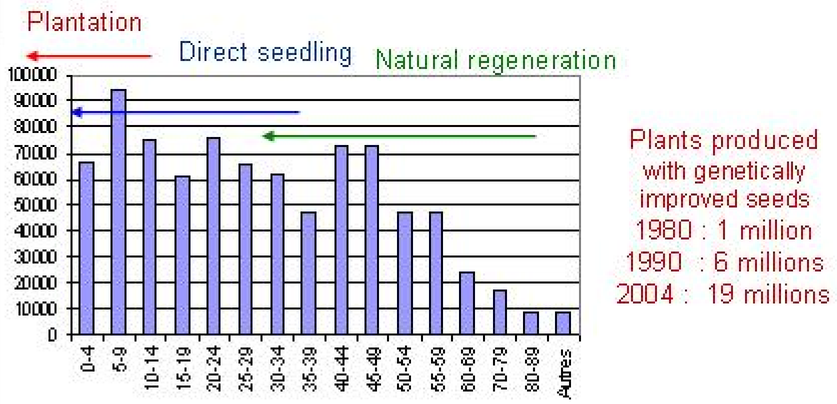
Annual volume harvested



8.5 Mm³ harvested
in 2005

4

Even aged stands of Maritime pine
Reforestation mode



Area of even aged stands by age class

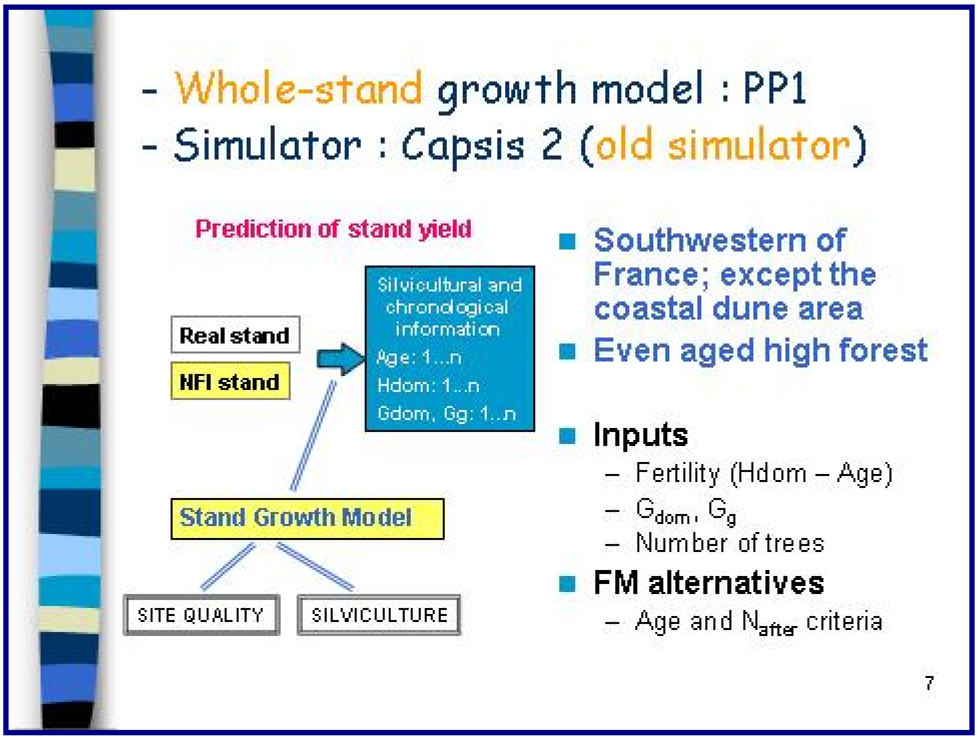
5

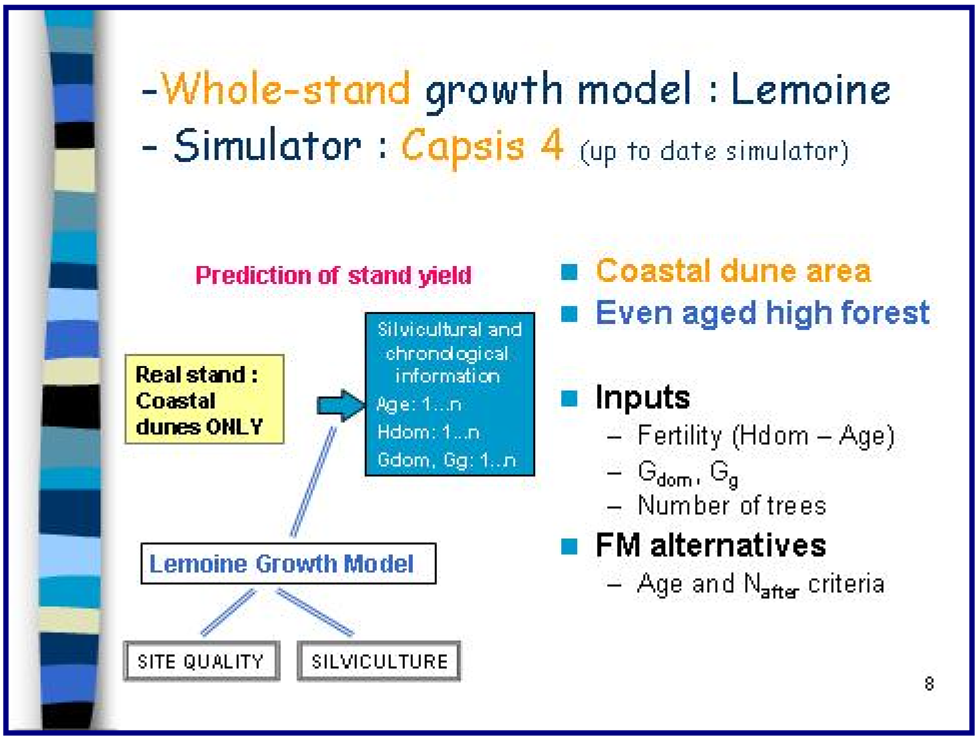
Different types of models for Maritime Pine

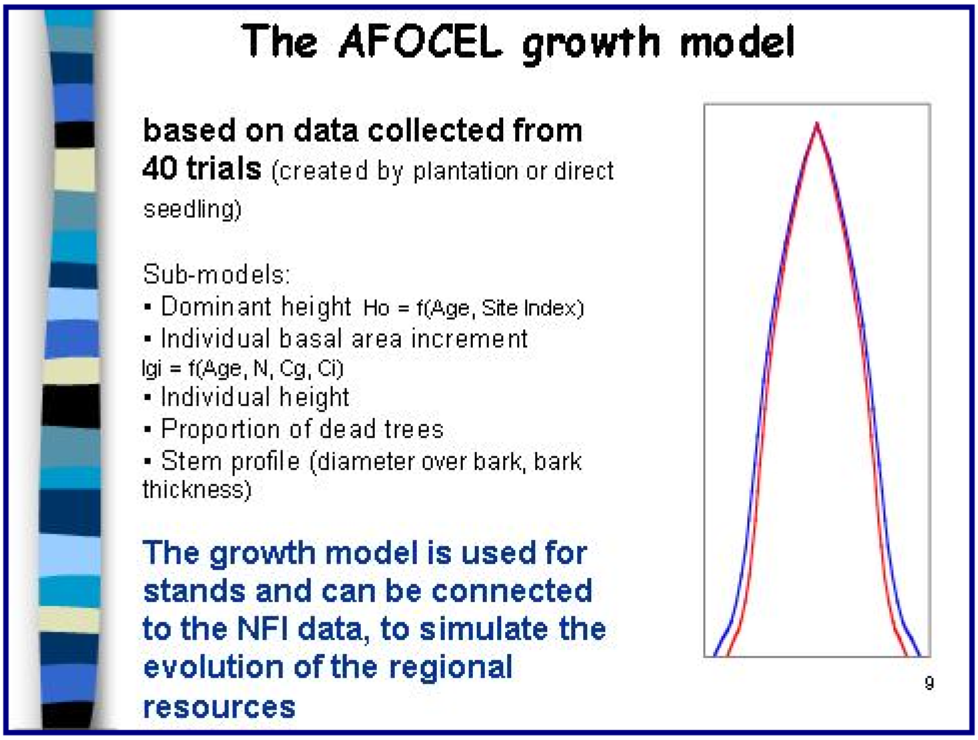
- Whole-stand growth model (ES)
- Individual tree growth model (EDIT)
- Whole-stand Process Based Models (P)

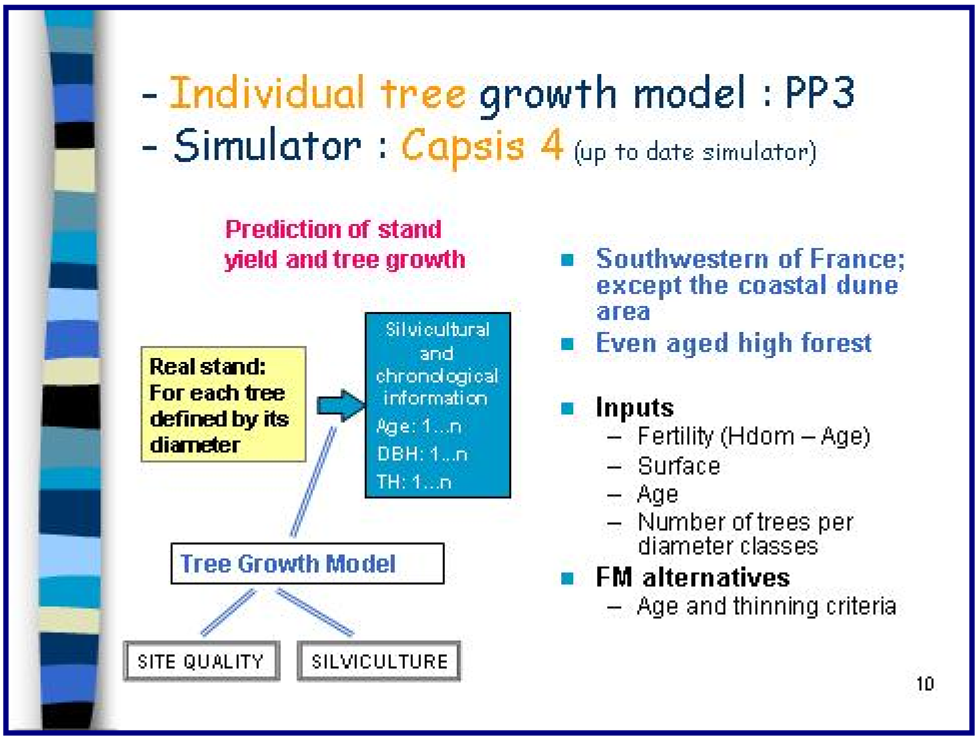
- For different types of Maritime pine stands

6


- Whole-stand growth model : PP1
- Simulator : Capsis 2 (old simulator)
Prediction of stand yield
Real stand
NFI stand
Silvicultural and chronological information
Age: 1...n
Hdom: 1...n
Gdom, Gg: 1...n
Stand Growth Model
SITE QUALITY
SILVICULTURE
Southwestern of France; except the coastal dune area
Even aged high forest
Inputs
– Fertility (Hdom – Age)
– G_{dom}, G_g
– Number of trees
FM alternatives
– Age and N_{after} criteria
7


-Whole-stand growth model : Lemoine
- Simulator : Capsis 4 (up to date simulator)
Prediction of stand yield
Real stand : Coastal dunes ONLY
Silvicultural and chronological information
Age: 1...n
Hdom: 1...n
Gdom, Gg: 1...n
Lemoine Growth Model
SITE QUALITY
SILVICULTURE
Coastal dune area
Even aged high forest
Inputs
– Fertility (Hdom – Age)
– G_{dom}, G_g
– Number of trees
FM alternatives
– Age and N_{after} criteria
8


The AFOCEL growth model
based on data collected from
40 trials (created by plantation or direct seedling)
Sub-models:
▪ Dominant height Ho = f(Age, Site Index)
▪ Individual basal area increment
Igi = f(Age, N, Cg, Ci)
▪ Individual height
▪ Proportion of dead trees
▪ Stem profile (diameter over bark, bark thickness)
The growth model is used for stands and can be connected to the NFI data, to simulate the evolution of the regional resources
9


- Individual tree growth model : PP3
- Simulator : Capsis 4 (up to date simulator)
Prediction of stand yield and tree growth
Real stand: For each tree defined by its diameter
Silvicultural and chronological information
Age: 1...n
DBH: 1...n
TH: 1...n
Tree Growth Model
SITE QUALITY
SILVICULTURE
Southwestern of France; except the coastal dune area
Even aged high forest
Inputs
– Fertility (Hdom – Age)
– Surface
– Age
– Number of trees per diameter classes
FM alternatives
– Age and thinning criteria
10

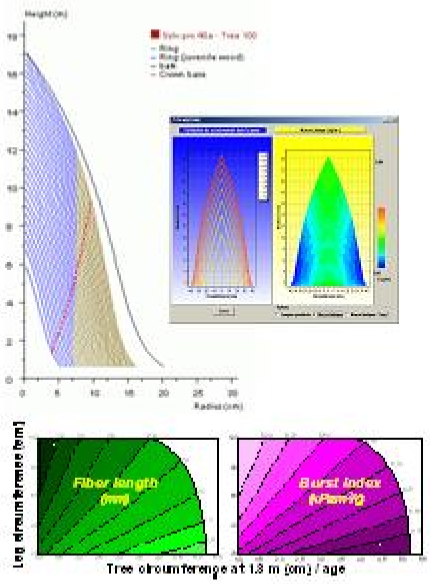
Different types of additional models for Maritime Pine

- Carbon estimation
  - Biomass model per compartment
  - Carbon content
- Windthrow risk

11

Wood quality models

- Branch models (position and characteristics of knot)
  - Existing data base + new data in 2007
  - Should be available at the end of 2007
- Fiber models
  - Fiber length and burst index (Chantre, 2000)
- Solid wood models (wood basic density, stiffness, grain angle, heartwood content)
  - Existing data base

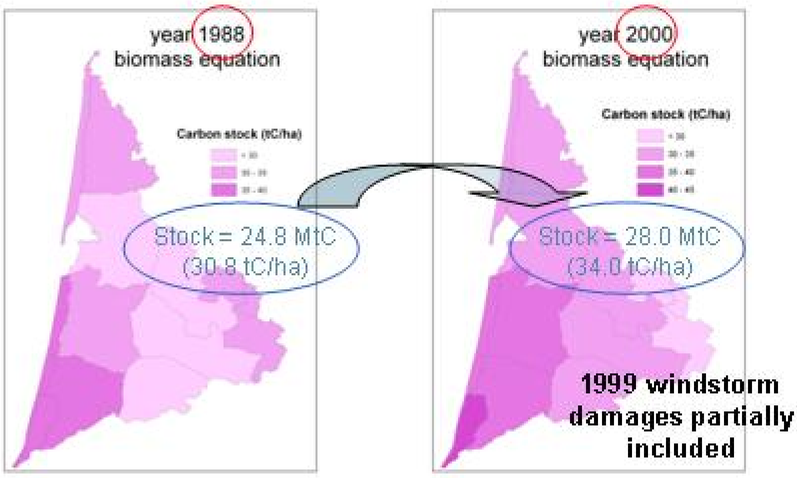


Connection between NFI Data and growth models

- Example between NFI Data and Carbon estimation models
- Example between NFI Data and ES models

13

Example : Calculating the carbon balance of the maritime pine forest and its change over the period 1988 - 2000



Sink = 5.2 MtC (+ 0.43 MtC/year)

14

Regional simulator: Use NFI data as input of growth model

- Test on a whole-stand growth model (PP1)
- Different types of problem
  - Threshold of recensability of the trees (Diameter > 7,5 cm)
    - Use of corrective functions for N and G
    - Stands without any listed tree: contractual data
  - Representativeness of NFI stand description

15

Regional simulator : Calibration of corrective functions in the growth model

- Whole-stand growth model PP1
  - New calibration of the Basal Area Increment IG_{dom} et IG_g
  - New volume functions V_{IFN} (N ; H_{dom} ; G_{dom} ; G_g)

16

Connection between NFI Data and growth models

- Until november 2004,
  - inventory by department
  - every 12 years
- Since november 2004
  - National systematic inventory
  - Annual
  - on a smaller number of points

→ High consequences on growth model inputs

17

Capsis: a regional/national simulator

NFI Data Bases

CAPSIS 4 : Platform

PP3 growth model

Lemoine growth model

IFN increment model

platform which integrate many French forest growth and yield / dynamics models

In construction by French NFI...

18

Conclusive remarks

- Available for Eforwood project
  - Different growth models for *Pinus pinaster*
  - A stand growth simulator : Capsis
  - Methods to connect NFI Data and growth models
- Still to be achieved
  - A regional simulator (available ?)
  - Wood quality models
  - Branch models

19

ANNEXE 5 – Baden-Württenberg region in Germany

Case Study Baden-Württemberg
Germany

Jürgen Zell
Philipp Duncker
Karl Tojic

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Outline

- Overview of currently available **Data**: the National Forest Inventory in Germany
- Extrapolation of NFI-Data with **WEHAM** (including Forest Growth, Harvesting and Prognosis of Assortments)
- **Problems** and further ideas/options

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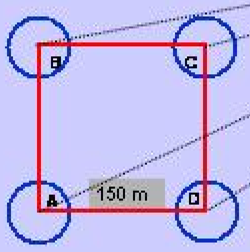
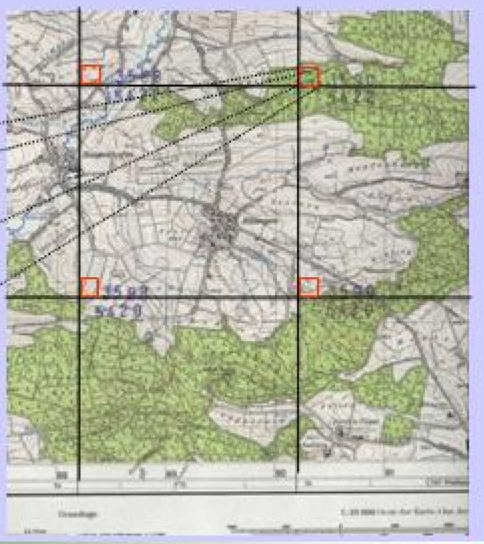
NFI

**National Forest Inventory
("Bundeswaldinventur")**

- Overview on large scale forest condition and forest productivity
- Consistent procedures
- Permanent design: re-measurement

Design | Tracts





Note: the grid covers the total area!

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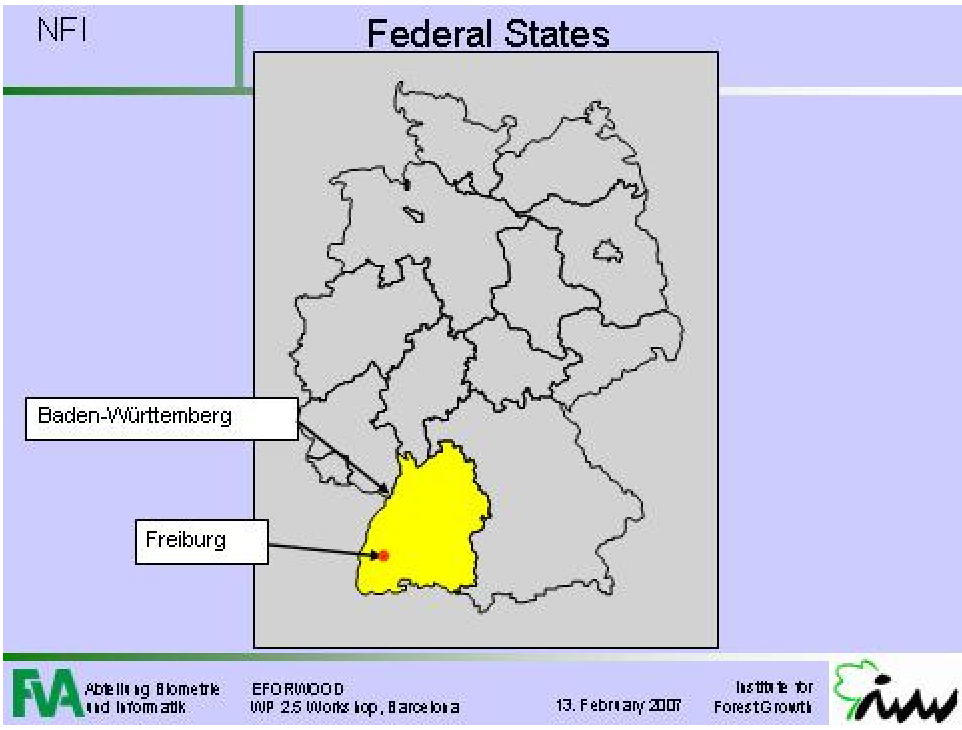
NFI
Federal States
Baden-Württemberg
Freiburg
Abteilung Biometrie
und Informatik
EFORWOOD
WP 2.5 Workshop, Barcelona
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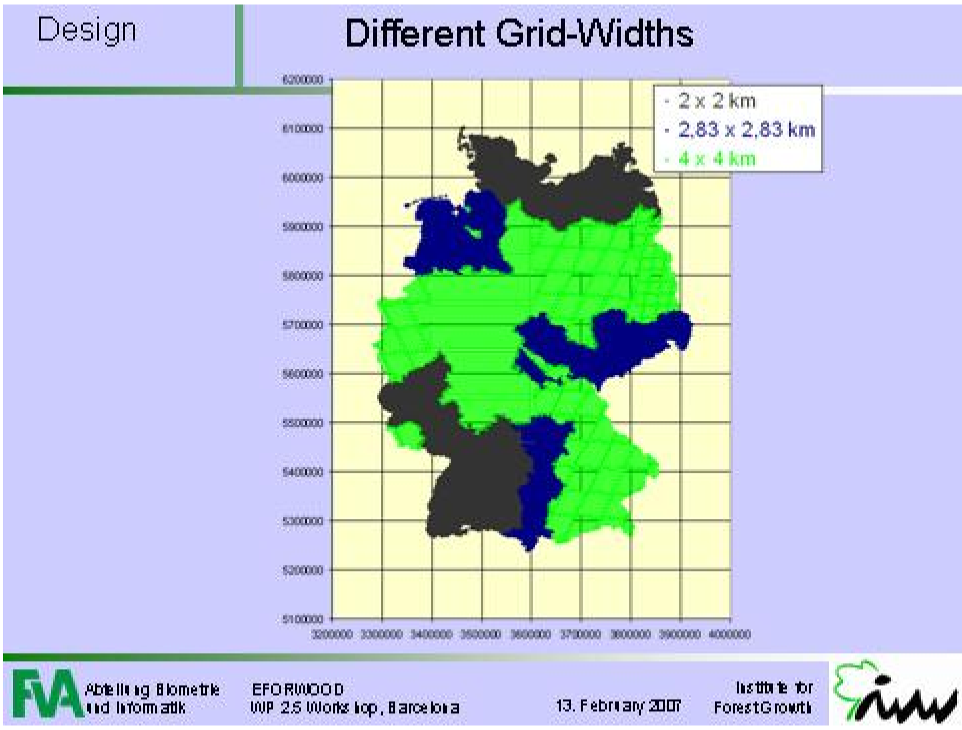
Design
Different Grid-Widths
2 x 2 km
2,83 x 2,83 km
4 x 4 km
6200000
6100000
6000000
5900000
5800000
5700000
5600000
5500000
5400000
5300000
5200000
5100000
3200000 3300000 3400000 3500000 3600000 3700000 3800000 3900000 4000000
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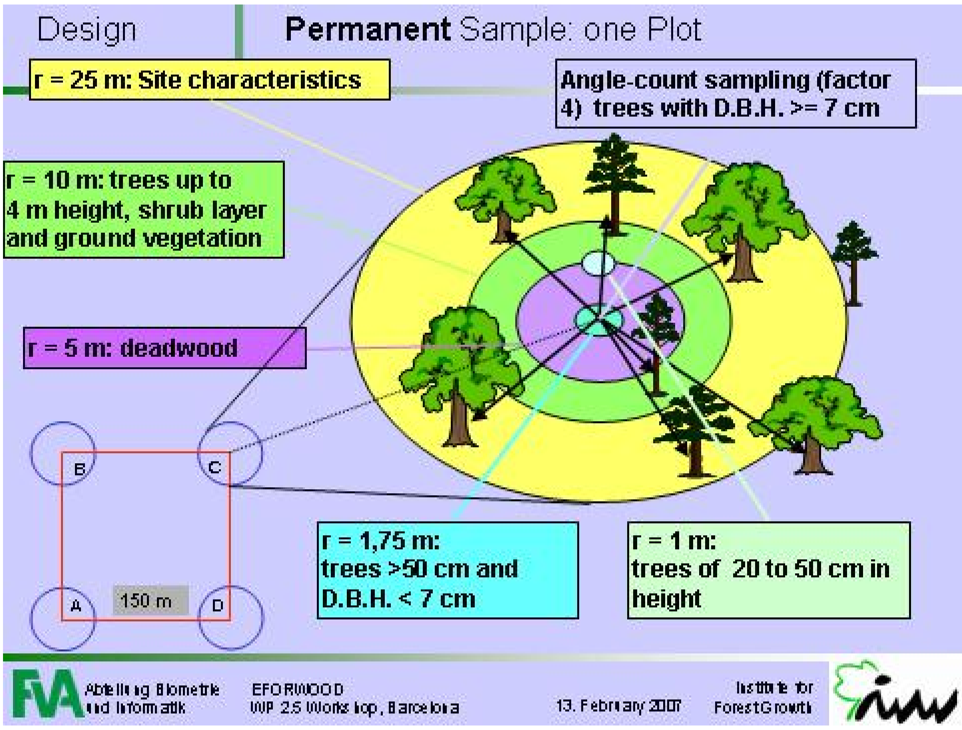

Design | **Permanent** Sample

Permanent plots = retrievable plots

- Permanent **marking** of the plot centre (by metal rod in the ground, invisible)
- Recording of **tree positions** (polar coordinates)
  → assessment of growth and drain at consecutive survey

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Results

Baden-Württemberg

- Total Forest Area: 1,3 Mio. Ha
- 13.228 Permanent sample plots
- ~ 11 Trees/Plot
- ~ 150.000 Measured trees
- 360 m^3/ha Growing Stock
- Increment: (1987-2002): 14 m^3/ha/a
- Drain:13 m^3/ha/a (Cut and Mortality)

WEHAM

Extrapolation of NFI-Data with WEHAM

- Model for
  - Growth
  - Harvesting
- Based on Szenarios
- Comparison of Szenarios

WEHAM

Simulationmodell WEHAM

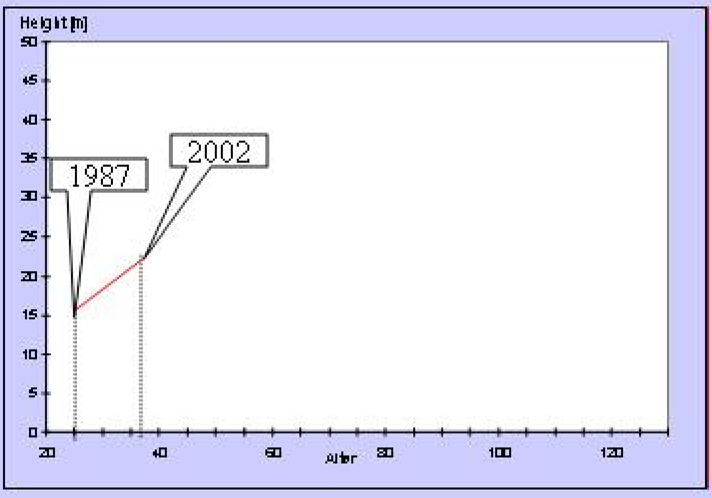
- **Prognosis** of Forest Development and Potential Quantity of Harvest based on NFI
- Timeframe of 40 years
- **Distantance-Independent** Growth-Model

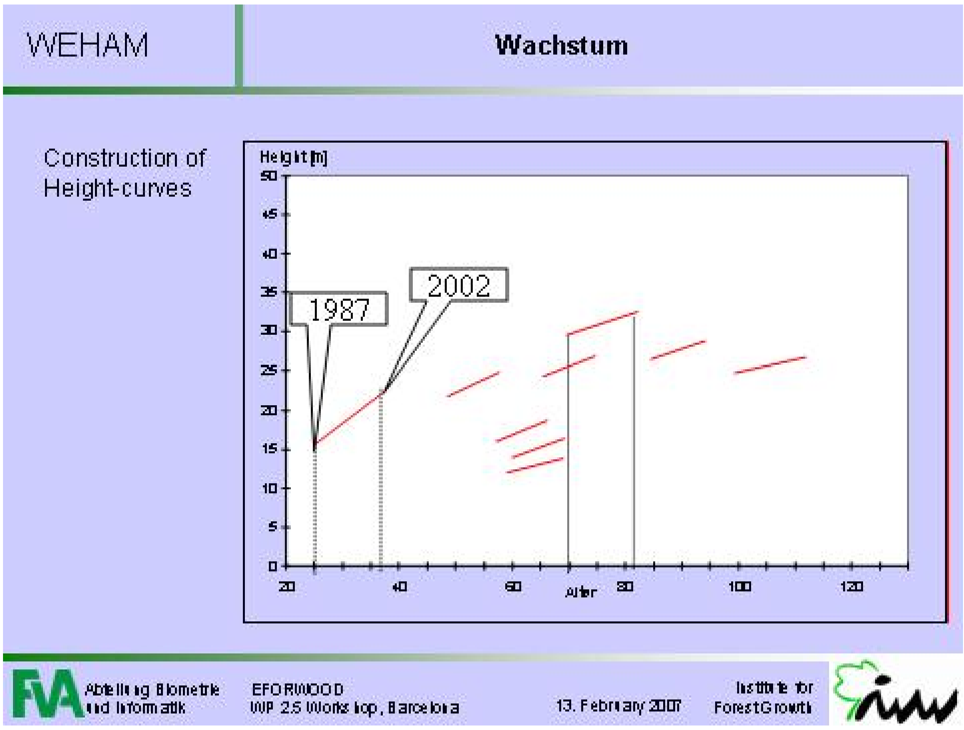
- Problem:
- Stand <-> Plot

WEHAM

Wachstum

Construction of Height-curves




WEHAM
Wachstum
Construction of
Height-curves
Height [m]
1987
2002
Alter
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WP 2.5 Workshop, Barcelona
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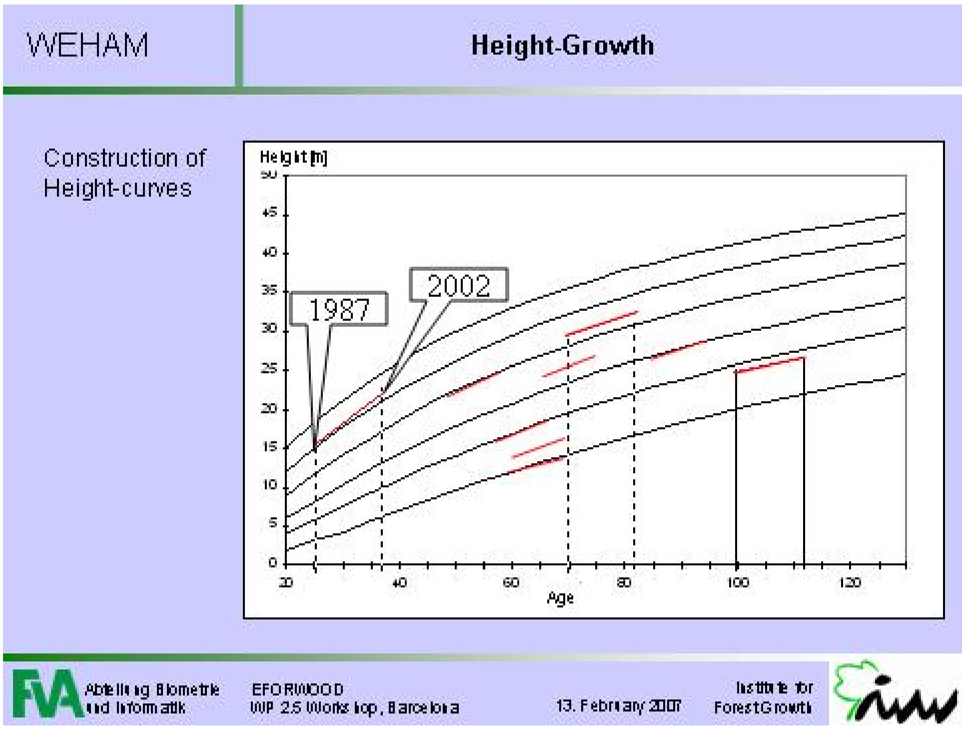
WEHAM
Height-Growth
Construction of
Height-curves
Height [m]
1987
2002
Age
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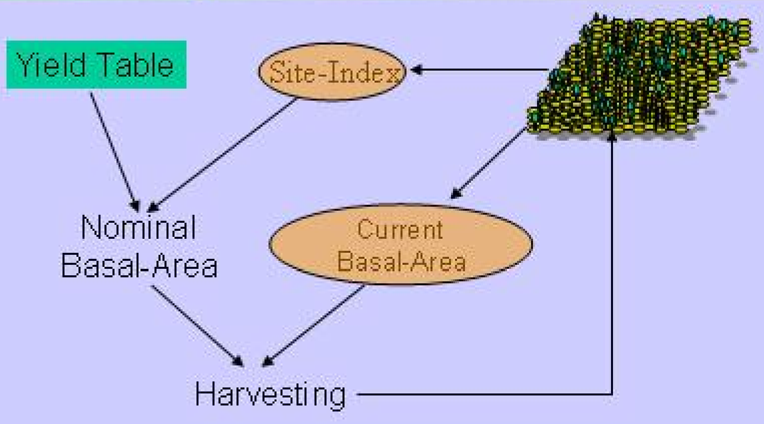
WEHAM

Harvesting



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WEHAM

Definition of Szenarios

Szenarios are defined by:

- Growth
  - Depends on Tree-Species (Heigth and DBH differently)
- Harvesting
  - Type of Harvesting
  - Intensity of Harvesting (time steps)
  - Target Diameter-Harvest
  - Rotation Age

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WEHAM | **Output: Standard-Szenario**

Norway Spruce

Growing Stock

- DBH <40 cm Decline of Growing Stock
- DBH >50 cm Increase of Growing Stock

Harvesting

- DBH <50 cm: Drastic decrease
- DBH >50 cm: Increase
- altogether: decrease
- change of assortments -> bigger

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Problems

- Szenarios in WEHAM need **assumptions**
- Can be far away from a „**optimal**" treatment with respect to a given target (mass, volume, value) -> link to WP 2.1
- WEHAM needs input from **Yield-Tables** to define Thinning-Intensities
- 8-12 trees/plot are very **discrete** Information

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Ideas

- Bring together („aggregate") plot information according to
  - Mixture
  - Stage of Development
  - Site Index
- Produce an artifical stand out of the aggregated Information
- Optimise future Harvesting-Decisions based on the aggregated „quasi"-Stand-Information

Thank you for your attention!

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ANNEXE 6 – Västerbotten region in Sweden

EFORWOOD

Basic data for case study Västerbotten, Sweden

Erik Valinger

EFORWOOD

Areas

Forest type	Prportion inland, %	Inland, ha	Proportion coastal, %	Coastal, ha	Total proportion, %	Total, ha
Pine[1]	39.3	730 799	49.3	649 523	43.4	1 380 323
Spruce[1]	27.6	514 170	13.4	176 761	21.7	690 930
Birch[1]	4.8	89 533	3.5	46 182	4.3	135 715
Other[2]	22.1	411 046	27.3	360 722	24.3	771 768
Lodgepole pine[1]	3.9	72 798	2.3	30 017	3.2	102 815
Bare ground	2.3	42 738	4.2	55 203	3.1	97 941
Total, ha		1 861 083		1 318 408		3 179 491

[1]Pine, spruce, birch and contorta dominated forests (>70% of basal area)
[2]Mixed conifer forests (No conifer species >70% of basal area) + Mixed forests (between 40% and 60% broadleaved trees)

EFORWOOD

Cutting classes + definitions

Cutting class	Proportion of area, %	Area, ha	Growing stock, m^3/ha
A	4.2	133130	15
B1	7.9	251617	10
B2 + B3	20.2	642490	19
C + E	36.2	1149856	107
D1 + D2	31.5	1002398	154
All	100	3179491	92

Definitions:
A (Regeneration, bare ground)
B1 (Regeneration, plant forest. Mean height < 1.3 m)
B2 (Young forest. Mean height between 1.3 m and 3 m)
B3 (Young forest. Mean height > 3 m. Dominating and co-dominating trees smaller than 10 cm at 1.3 m)
C (Medium forest. Most dominating and co-dominating of trees larger than 10 cm at 1.3 m)
D1 (Adult forest. Age is lower than recommended clear-cut age)
D2 (Adult forest. Age above recommended clear-cut age)
E (suitable for single tree selection)

SLU

EFORWOOD

Pine

Cutting class, pine	Proportion of area, %	Area, ha	Growing stock, m^3/ha
A	3.1	99366	8
B1	5.4	172350	6
B2 + B3	15.9	505262	8
C + E	26.4	838662	57
D1 + D2	13.4	427569	58
All pine	64.3	2043209	41

Spruce

Cutting class, spruce	Proportion of area, %	Area, ha	Growing stock, m^3/ha
A	1.1	33764	3
B1	2.5	79268	1
B2 + B3	4.3	137228	3
C + E	9.8	311195	27
D1 + D2	18.1	574828	77
All spruce	35.7	1136283	35

Definitions:
A (Regeneration, bare ground)
B1 (Regeneration, plant forest. Mean height < 1.3 m)
B2 (Young forest. Mean height between 1.3 m and 3 m)
B3 (Young forest. Mean height > 3 m. Dominating and co-dominating trees smaller than 10 cm at 1.3 m)
C (Medium forest. Most dominating and co-dominating of trees larger than 10 cm at 1.3 m)
D1 (Adult forest. Age is lower than recommended clear-cut age)
D2 (Adult forest. Age above recommended clear-cut age)
E (suitable for single tree selection)

SLU

EFORWOOD

Year classes

Year class	Proportion of area, %	Area, ha	Growing stock, m^3/ha
0-	4.0	127 160	11
3-	8.4	267 036	10
11-	10.6	336 974	14
21-	10.1	321 079	33
31-	6.8	216 172	64
41-	14.6	464 134	102
61-	10.3	327 437	141
81-	9.7	308 363	140
101-	8.5	270 215	154
121-	8.6	273 394	168
141	8.4	267 036	164

SLU

EFORWOOD

The proportion and area within Site index classes (m^3/ha, year)

Productivity, m^3/ha, yr	Proportion, %	Area, ha	Groving stock, m3/ha
0-	6.2	196 787	74
2-	31.3	996 412	83
3-	39.9	1 270 021	98
4-	18.1	574 052	99
5-	4.1	129 164	102
6-	0.3	8 886	154
7-	0.1	4 169	184

SLU

EFORWOOD

Growing stock per ha for each species within diameter classes

Species	Diameter at breast height, cm									
	0-9	10-14	15-19	20-24	25-29	30-34	35-44	45-	Total	Proportion
	milj. m^3									%
Pine	7.7	17.8	30.8	30.3	21.3	14.1	8.4	0.9	131.4	43.6
Spruce	9.4	17.4	24.0	21.6	15.9	11.3	7.6	2.9	110.1	36.5
Contorta	1.1	0.7	0.1	0.0					2.0	0.7
Betula	12.5	13.6	10.5	5.5	2.4	0.6	0.3		45.4	15.1
Populus	0.1	0.3	0.4	0.3	0.2	0.2	0.3	0.1	1.9	0.6
Alnus	0.3	0.2	0.1	0.0					0.7	0.2
Salix	0.2	0.3	0.3	0.3	0.2	0.1	0.2	0.0	1.6	0.5
Sorbus	0.1	0.0	0.0	0.0					0.2	0.1
Dry + wind-thrown	1.2	1.7	1.4	1.2	0.7	0.5	0.8	0.5	8.0	2.7
All	32.7	52.0	67.7	59.3	40.8	26.9	17.6	4.4	301.5	100

SLU

EFORWOOD

Annual cutting area on forest land and volume/ha

Cutting	Inland, ha	Volume/ha, m^3/ha	Coastal, ha	Volume/ha, m^3/ha	Total, ha	Volume/ha, m^3/ha
Clear felling	11 000	180	18 000	184	29 000	183
Thinning	8 000	43	26 000	70	34 000	63
Cleaning	16 000	4	21 000	6	38 000	5
Others	5 000	44	7 000	33	12 000	39
Total, ha	41 000	61	71 000	75	112 000	70

SLU

EFORWOOD

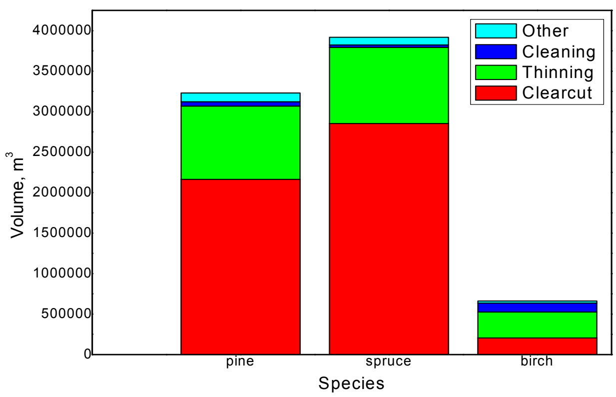
Annual cutting volume

Cutting		Inland, Volume/yr, m^3/yr	Coastal, Volume/yr, m^3/yr	Total volume/yr, m^3/ yr
Clear felling	Pine	527531	1634972	2162503
	Spruce	1281446	1570850	2852297
	Birch	105772	101774	207545
Thinning	Pine	228344	677324	905668
	Spruce	120208	821049	941256
	Birch	16586	301638	318224
Cleaning	Pine	16644	35075	51719
	Spruce	17194	12288	29482
	Birch	32547	78319	110865
Others	Pine	36246	74974	111220
	Spruce	71094	22823	93917
	Birch	16103	9017	25120
Total, m^3/yr		2469714	5340102	7809817

SLU

EFORWOOD

Annual cutting volume



SLU

EFORWOOD

Area possible to use for single tree cutting (spruce)

Potential areas for single tree selection of spruce are when the following criteria are met:

1. Ground vegetation myrtillus or better.
2. Thinning- and Clear-cut forests (Cutting classes C and D).
3. More than 70% of basal area should be spruce.
4. Stand structure. From the diameter of the largest tree in diameter, four diameter classes are created by the construction of the quota dmax/4. The shares of the number of trees (n) within each diameter class are the basics in defining the stand structure classes. Suitable stands are stands with quotas n_1/n_2, n_2/n_3, n_3/n_4 > 1.0, all other are not acceptable.
5. Growing stock > 150 m^3/ha.

SLU

EFORWOOD

Single tree cutting (spruce)

SLU

EFORWOOD

Area possible to use for single tree cutting (spruce), ha

Area	Single tree selection, ha		
	Not suitable	Suitable	Total
Inland	97331	22182	119513
Coast	68650	11025	79675
Total	165981	33207	199189

1% - 6% of the forest land is suitable

SLU

EFORWOOD

Area possible to use for natural regeneration (pine), ha

Potential areas for natural regeneration of pine are when the following criteria are met:

1.Ground vegetation myrtillus or worse.
2.Cutting class D.
3.More than 50% of basal area should be pine.
4.Sites should be situated ≤ 300 m a.s.l.

SLU

Area possible to use for natural regeneration (pine), ha

Potential areas for natural regeneration of pine are when the following criteria are met:

1.Ground vegetation myrtillus or worse.
2.Cutting class D.
3.More than 50% of basal area should be pine.
4.Sites should be situated ≤ 300 m a.s.l.

Area possible to use for natural regeneration (pine), ha

Potential areas for natural regeneration of pine are when the following criteria are met:

1.Ground vegetation myrtillus or worse.
2.Cutting class D.
3.More than 50% of basal area should be pine.
4.Sites should be situated ≤ 300 m a.s.l.

EFORWOOD

Natural regeneration (pine)

EFORWOOD

Area possible to use for natural regeneration (pine), ha

Area	Ground vegetation		Cutting class	
		D1	D2	D1 + D2
Inland	< Myrtillus	24778	28445	53223
	Other	.	1903	1903
	Total	24778	30348	55126
Coast	< Myrtillus	79235	101170	180406
	Other	1242	3245	4487
	Total	80477	104415	184892
Total	< Myrtillus	104013	129615	233628
	Other	1242	5148	6390
	Total	105255	134763	240018

7.5% of the forest land is suitable

ANNEXE 7 – Catalonia region in Spain

WP 2.5 Eforwood Meeting

Vilanova 13-February-2007

EFORWOOD

"Methodologies to improve existing models for forest sustainability analysis at different temporal and spatial scales"

Regional case: Catalonia

Marc Palahí

José Ramón González

Catalonian forests

FACTS

32 000 km2 in the north-East of Iberian peninsula

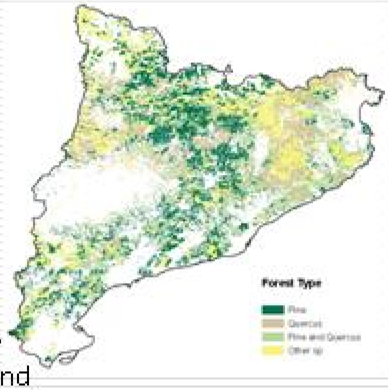
From 0 to over 3000 meters a.s.l

Mediterranean climate with high influence of the altitude

Aprox. 61% forest land

Multifunctional forestry and big Problems of forest fires

Catalonian forests



Approx. 37% forested area
(>20% tree cover)

Dominated by pines and *quercus ilex*.

More than 22% bushland and grassland

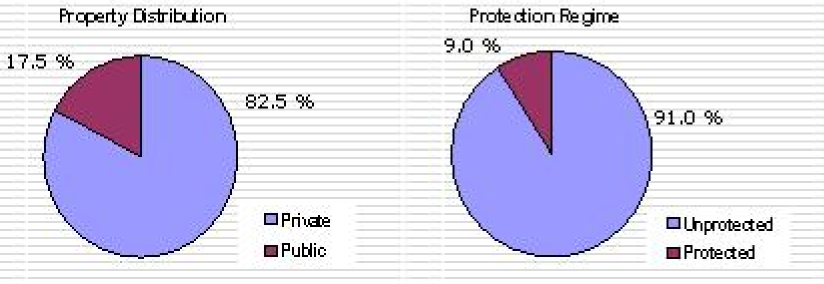
Main species in Catalonia

Species	Presence (ha)	Dominance (ha)	Homogeneus (ha)	Existences (m^3)
Pinus sylvestris	353.777	239.092	170.051	26.262.735
Pinus halepensis	312.407	239.092	198.495	14.477.318
Pinus nigra	233.081	140.627	97.110	12.206.950
Quercus ilex	449.244	184.654	123.310	9.136.284
Pinus uncinata	87.696	54.613	44.808	8.426.346
Fagus sylvatica	61.149	28.726	20.868	5.189.403
Abies alba	26.775	13.346	9.919	4.575.302
Pinus pinea	107.927	36.294	16.892	3.511.616
Quercus suber	116.118	62.937	38.484	3.306.435

Great abundance of mixed and uneven-aged forest

***P. sylvestris* as the regional case species**

Property distribution and protection regimes



Private properties mean size 20 ha, and only 20,7% of private forests have a management plan

Public properties mean size 350 ha

The importance of timber

Forest growth in Catalonia is estimated in 3.600.000 m3/year

Cuttings only reach 621.600 m3/year (Declared 1994-1998)

- Real cuttings estimated to be 30-50% higher

-Timber contribute with less than the 30% of the forest income (>70% hunting, fishing, mushrooms, cork, others)

	1994	1995	1996	1997	1998	1999	2000	2001	1994-2000
Timber	13,[illegible]	19,91	10,11	9,4[illegible]	10,13	7,[illegible]	[illegible]	[illegible]	11,00
Other products	33,[illegible]	39,71	31,31	31,07	34,31	33,11	33,11	33,11	31,10
Sector	[illegible]	49,13	31,17	40,33	44,[illegible]	40,00	40,49	40,79	42,10

In millions of Euros

Growth and yield models available

- Individual tree models:
  - Diameter growth
  - Height
  - Mortality
  - Ingrowth
- Available for the most important coniferous and broadleaves forests:
  - Any-aged
  - Pure or mixed
  - Based on NFI data

Growth and yield models available

- Diameter distribution models
  - Parameter prediction
  - Truncated weibull function
  - Using simple predictors
- Available for the 10th most important tree species
- Based on NFI data

Other types of models available

- A fire risk model for Catalonian forests
  - Fire occurrence model
  - Fire damage model
- A mushroom yield model
  - Only available for Pinus sylvestris
  - Work in progress for other tree species
- Biomass expansion factors
- Coming soon:
  - Scenic beauty models

Most models are available in publications

Need for improvements

- Timber quality
- Water-forest interactions
- Habitat suitability models
- ...

Decision support systems

The models presented above have been programmed by Timo Pukkala (foreco technologies) into different systems:

- RODAL
- MONTE
- ESCEN (utilizes fire risk model to avoid overestimation)

- Possibility of adapting ESCEN to other regions by Timo Pukkala.

Adapting ESCEN to other regions

Requirements

Requirements, Individual tree approach

- Even-aged
  - Hdom=f(SI,T)
  - id = f(...)
  - h = f(d,Ddom,Hdom...)
  - survival = f(d,competition,..)
- Uneven-aged
  - id = f(G,d,BAL,..., NO SI)
  - h = f(d,BAL,... NO HDOM)
  - survival = f(d,BAL,G...)
  - ingrowth N(in) = f(G,N,..)

Requirements, Stand-level approach

- Hdom = f(SI,T)
- N2 = f(N1,SI,T1,T2,Hdom,...)
- G2 = f(G1,T1,T2,Hdom,....)
- model for aritmetic mean diameter
- Then Weibull distribution can be derived with the method of moments to get individual trees (parameter recovery technique) or parameter prediction models can be used.

In all cases it is required

- Tree-level volume functions or taper functions
- Biomass estimates can be obtained with the following species-specifc parameters
  - proportion of bark of stem volume
  - basic density of wood
  - expansion factors for: bark, branches, leaves, (roots)
- No programming needed, just parameter files

ANNEXE 8 – Craik forest in Scotland

GIS based modelling tools (GISMT) are used to assess the relationship between the

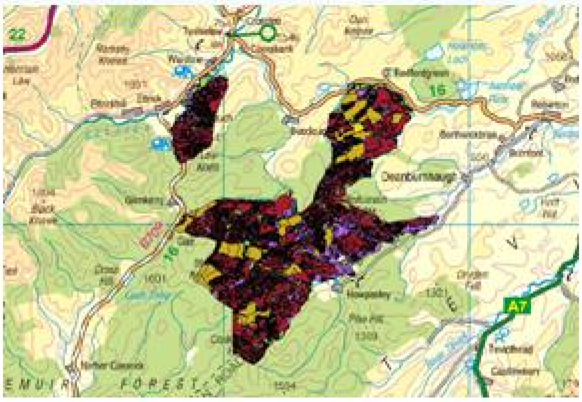
- Economic
- Environmental
- Social

Aspects of the forestry wood-chain and how these relate to the Eforwood indicators

Forest Research

Using ***Craik Forest*** in the Scottish Borders these relationships are explored and then applied as an aid to management decisions

Economic
Environmental
Social



wood-chain Eforwood indicators

Forest Research


Test area
Craik Forest
EDINBURGH
Glasgow
Forest Research


Forest Research

This allows for the spatial prioritisation of

- **Biodiversity**
- **Production**
- **Recreation**

At the forest scale

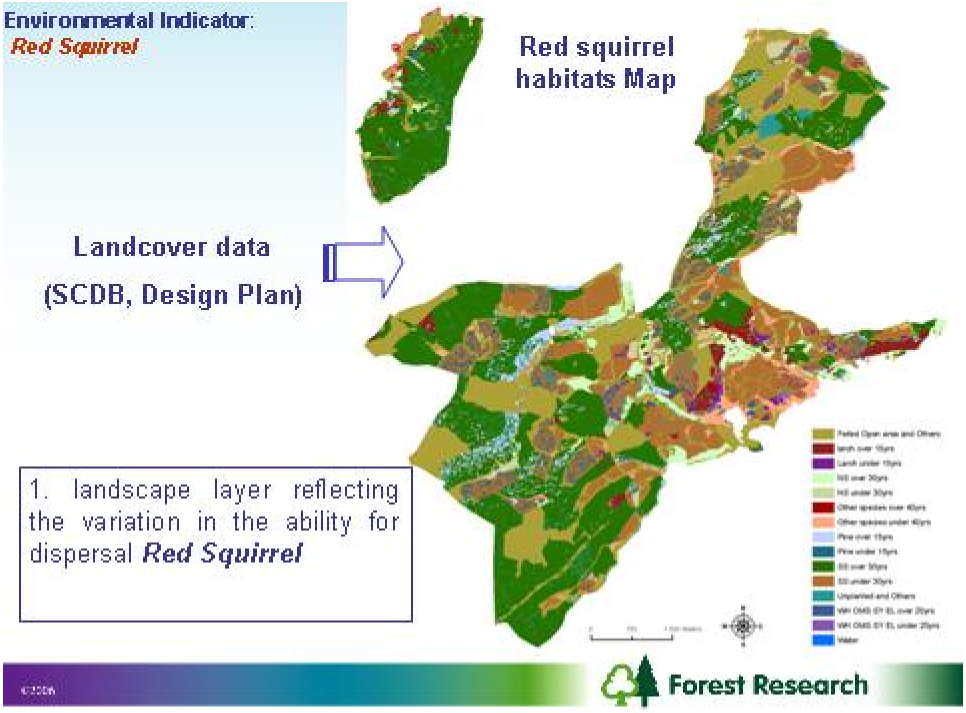
Sustainable forest wood-chain modelling Indicators*

Economic: ***Timber***

Social: ***Recreation***

Environmental: ***Red Squirrel***

*selected for modelling simulation in GISMT



Environmental Indicator: *Red Squirrel*

2. Potential Red Squirrel densities used to identify areas of Habitat
(results based on fieldwork study)

3. Score values for cost distance friction analysis in (GISMT)

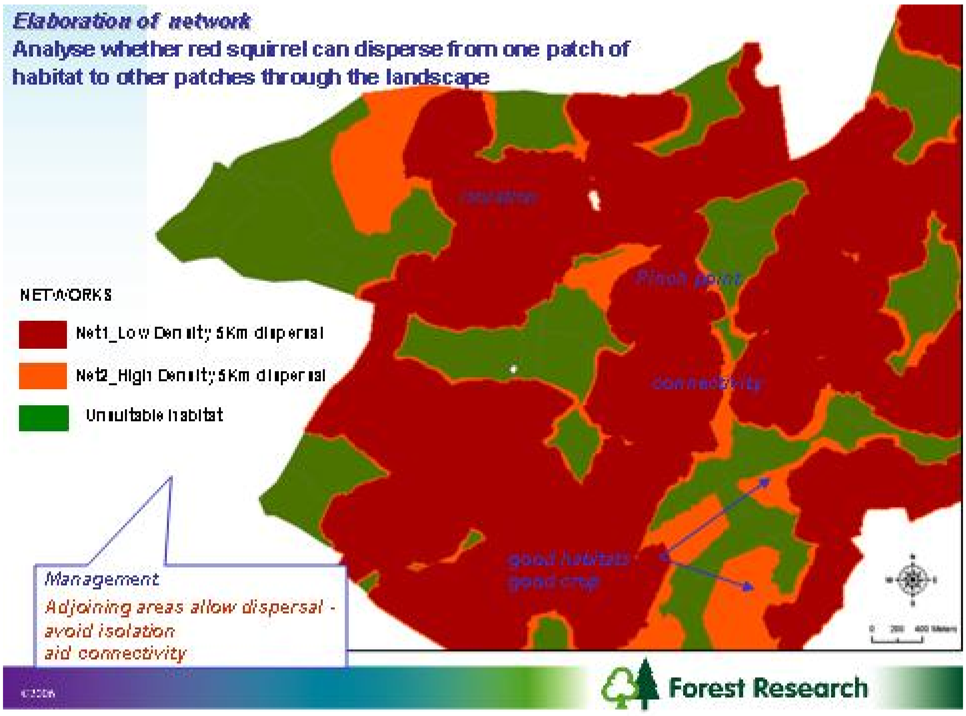
Red Squirrel Habitats			Red Squirrel density (ha^{-1}) Low	High
Pine	over 15 years	Age Good crop	4	0
Sitka spruce	over 30 years		9	4
Pine	under 15 years	Age bad crop	20	20
Sitka spruce	under 30 years		20	20
Other Species			9	9
Felled - Open Areas - Others			50	50

Cost scale
0 (higher density)
50 (lower density)

4. GIS-Modelling tool (beetle) → Networks

areas of habitat that are functionally connected

Forest Research

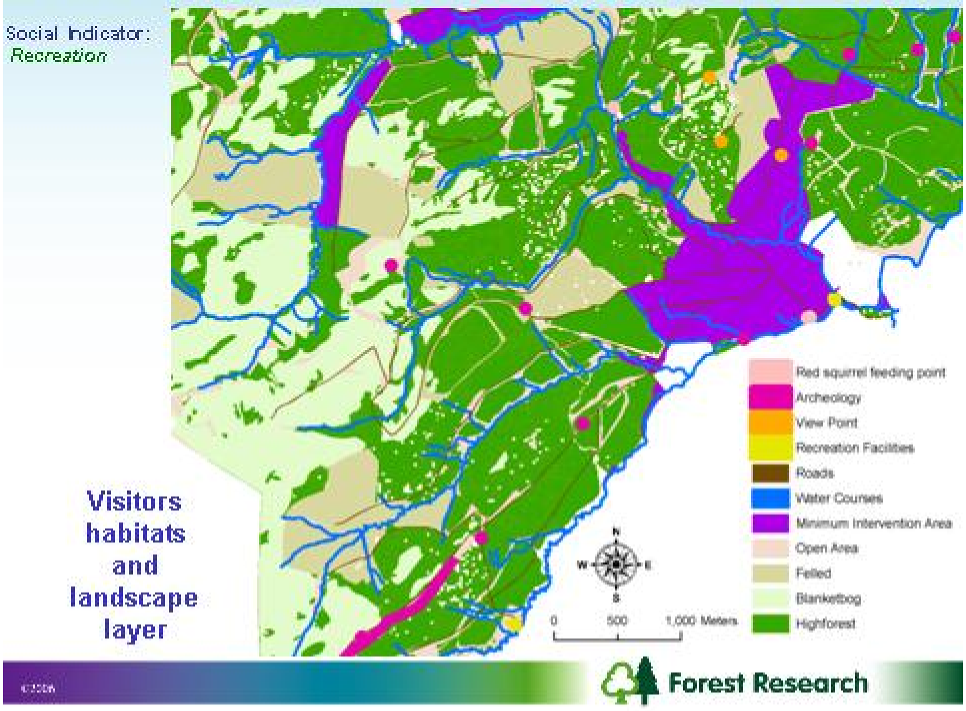


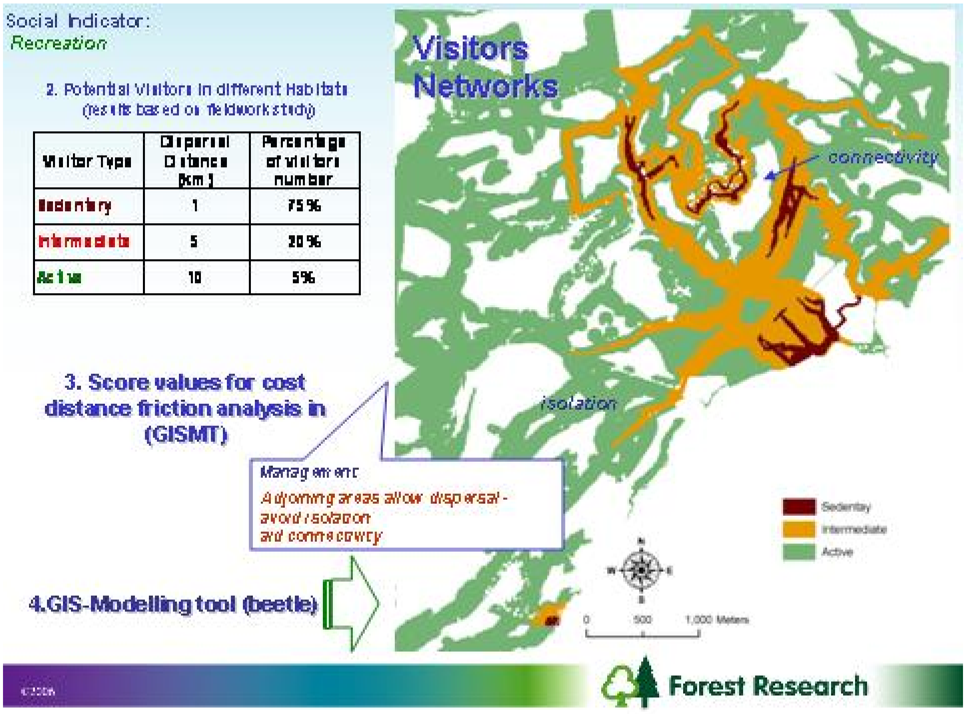
Social Indicator: *Recreation*

People
visitors of the forest

Visitor 1	Visitor 2	Visitor 3
Low	**Intermediate**	**High**
Dispersal Ability	Dispersal ability	Dispersal ability

Forest Research

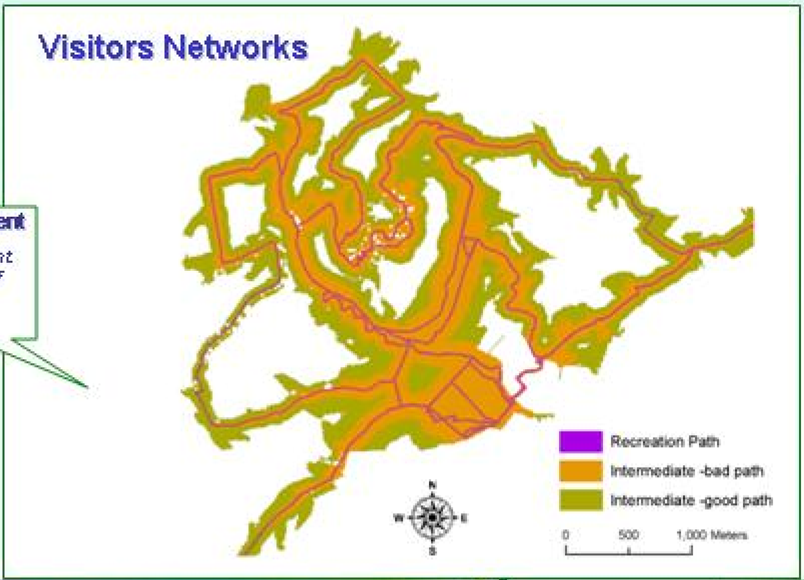

Social Indicator:
Recreation
Visitors habitats and landscape layer
Red squirrel feeding point
Archeology
View Point
Recreation Facilities
Roads
Water Courses
Minimum Intervention Area
Open Area
Felled
Blanketbog
Highforest
0 500 1,000 Meters
Forest Research


Social Indicator:
Recreation
2. Potential Visitors in different Habitats
(results based on fieldwork study)
Visitor Type | Dispersal Distance (km) | Percentage of visitors number
Sedentary | 1 | 75 %
Intermediate | 5 | 20 %
Active | 10 | 5%
3. Score values for cost distance friction analysis in (GISMT)
Management
Adjoining areas allow dispersal - avoid isolation and connectivity
4.GIS-Modelling tool (beetle)
Visitors Networks
connectivity
isolation
Sedentay
Intermediate
Active
0 500 1,000 Meters
Forest Research

Social Indicator:
Recreation

Quality of Recreation Path/Visitor network

Management
improvement of quality of recreation Paths -



Forest Research

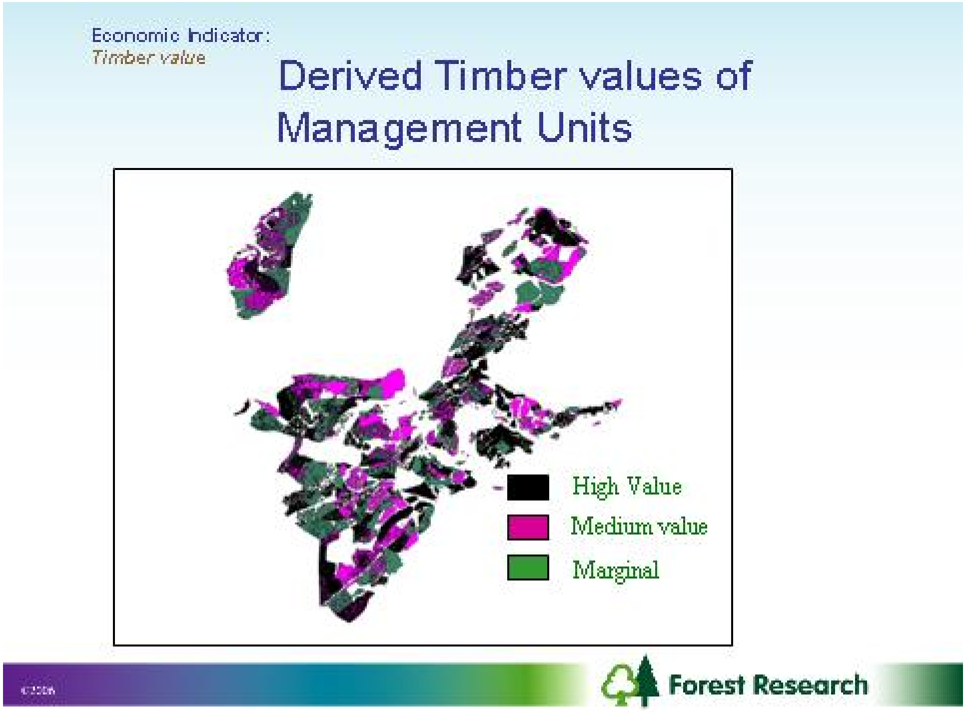
Timber value/Ha
(proportion of Pulp, Green and red logs) derived from:

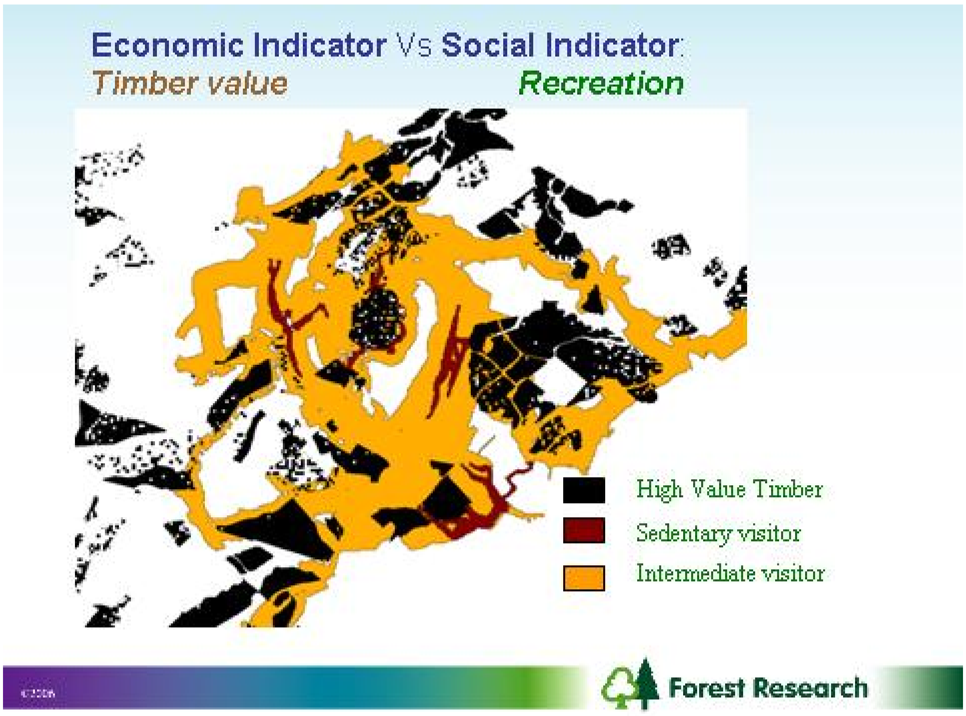
- Yield class
- Elevation
- Soils

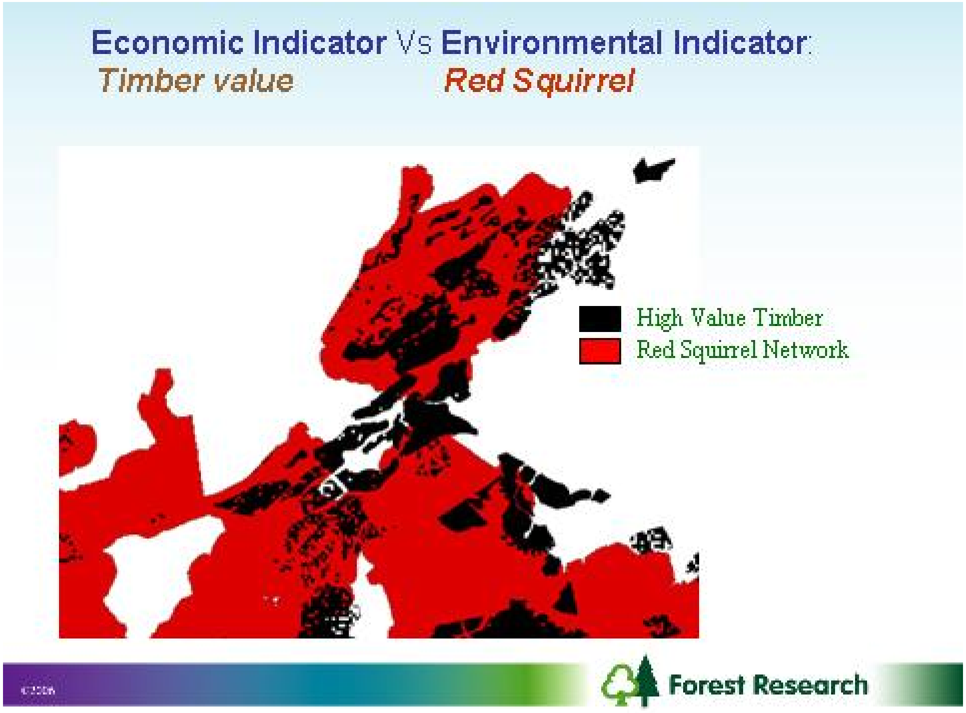
Less
- Harvesting
- Extraction
- Haulage
- Restocking

Costs

Forest Research


Economic Indicator:
Timber value
Derived Timber values of
Management Units
High Value
Medium value
Marginal
Forest Research


Economic Indicator Vs Social Indicator:
Timber value
Recreation
High Value Timber
Sedentary visitor
Intermediate visitor
Forest Research


Economic Indicator Vs Environmental Indicator:
Timber value
Red Squirrel
High Value Timber
Red Squirrel Network
Forest Research


MOUNTAINS
EDINBURGH
Glasgow
Forest Research

ANNEXE 9 – Oak in Lorraine region

Jens Peter Skovsgaard and Jean-François Dhôte
University of Copenhagen / INRA

Danish growth models for forest management alternatives for oak in France

EFORWOOD meetings at Vilanova/Barcelona
13-15 Feb. 2007

Major tree species in Denmark

- Norway spruce – 135,000 ha
- Beech – 80,000 ha
- Oak – more than 45,000 ha

Danish forest growth models

- All of our models are calibrated on long-term silvicultural experiments covering most classical thinning practices as well as an even wider range of stand treaments, including extremely heavy thinnings

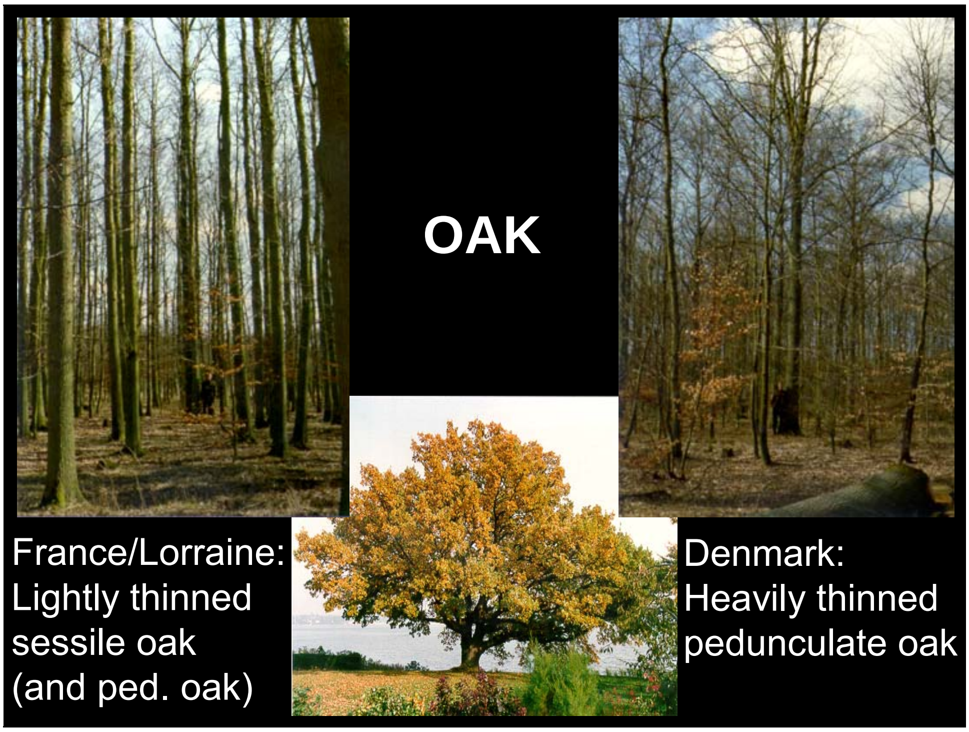
Model concept

- Dynamic state-space approach
  (a so-called adaptive model)
- System of simultaneous difference equations incorporating site productivity, tree growth, stand dynamics, management effects and possible interactions directly in model parameters (one-year time steps)
- Stand or plot-specific calibration

Key variables and parameters

- Stand height (H_{100}, m)
- Stand basal area (G, m^2/ha)
- Stem number (N, 100/ha)
- Tree diameter (d, m)
- Tree height (h, m)

- Site rate constant (***a***)
- A set of additional, global parameters



Stand growth model for oak

$$\Delta H_{50} = \boldsymbol{a_1} H_{50}{}^{a_2} \exp\left(-a_3 H_{50} + a_4 G\right)$$
$$\Delta G = b_{10} \left(\boldsymbol{a_1}\right)^{b_{11}} G^{b_2} \exp\left(-b_3 G - b_4 H_{50}\right) + FV\left[G\right]$$
$$\Delta N = -c_1 N^{c_2} \exp\left(c_3 \sqrt{N} H_{50}\right) + FV\left[N\right]$$

Stand growth model for oak

$$\Delta H_{50} = \boldsymbol{a_1} H_{50}{}^{a_2} \exp\left(-a_3 H_{50} + a_4 G\right)$$
$$\Delta G = b_{10} \left(\boldsymbol{a_1}\right)^{b_{11}} G^{b_2} \exp\left(-b_3 G - b_4 H_{50}\right) + FV\left[G\right]$$
$$\Delta N = -c_1 N^{c_2} \exp\left(c_3 \sqrt{N} H_{50}\right) + FV\left[N\right]$$

Stand growth model for oak

$$\Delta H_{50} = \boldsymbol{a_1} H_{50}{}^{a_2} \exp(-a_3 H_{50} + a_4 G)$$
$$\Delta G = b_{10} (\boldsymbol{a_1})^{b_{11}} G^{b_2} \exp(-b_3 G - b_4 H_{50}) + FV[G]$$
$$\Delta N = -c_1 N^{c_2} \exp\left(c_3 \sqrt{N} H_{50}\right) + FV[N]$$

Stand growth model for oak

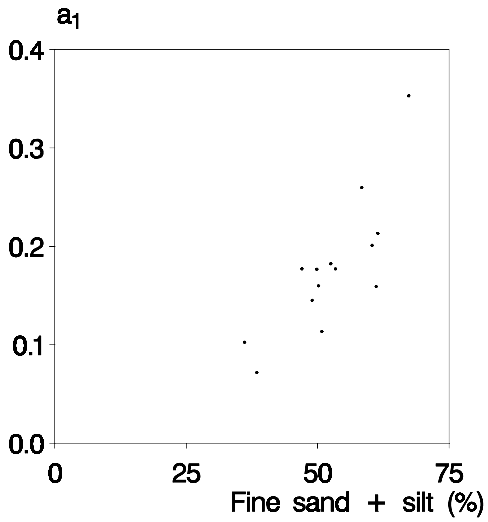
$$\Delta H_{50} = \boldsymbol{a_1} H_{50}{}^{a_2} \exp(-a_3 H_{50} + a_4 G)$$
$$\Delta G = b_{10} (\boldsymbol{a_1})^{b_{11}} G^{b_2} \exp(-b_3 G - b_4 H_{50}) + FV[G]$$
$$\Delta N = -c_1 N^{c_2} \exp\left(c_3 \sqrt{N} H_{50}\right) + FV[N]$$

Individual tree growth for oak

$$\Delta d = \alpha_0 \boldsymbol{a_1}^{\alpha_1} d^{\alpha 2} \exp(-\alpha_3 d)\exp\left(-\alpha_4 G^{1.5} N^{-0.5} d^{-1}\right)$$

$$\Delta h = \beta_0 \boldsymbol{a_1}^{\beta_1} h^{\beta 2} \exp(-\beta_3 h)\exp\left(-\beta_4 G^{0.5} N^{-0.5} d^{-1}\right)$$

Site parameter ***a*** vs. soil texture



If you don't trust us
– then please trust our models,
their quality is (almost) unbeatable

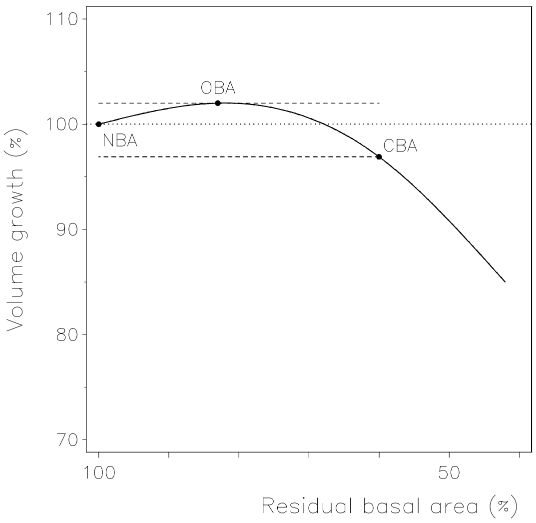
At best, reality is only an approximation to our models

Main scenarios

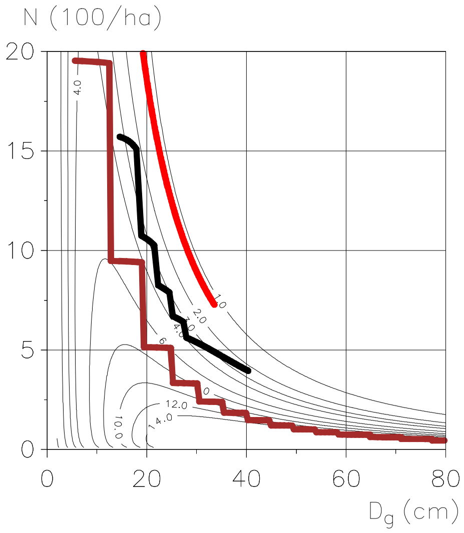
- Max. dendromass
- Max. timber volume
- Max. timber value

- and what about exogenous factors such as the oil price?
- or alternative 'exogenous', management objectives?

Optimizing timber volume and value



Classical management scenarios



The oil price beyond US$ 100?

Other, ’exogenous’ factors?

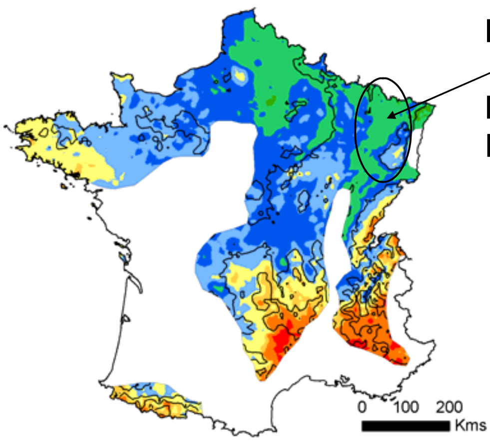
During more than 1000 years
forest management or forest exploitation
in Denmark was ’optimized’ for
naval oak timber

Other, ’exogenous’ factors?

It’s not my fault - it’s the lumberjacks’

Regional Case :
Oak - Lorraine

- France = a land of Oak and broadleaves, OK !
- High present productivity, esp. in North-East
- A challenge : resource use, opportunities/tensions
- Oak-Lorraine as an example
- Using model Fagacées under CAPSIS
- Work planned (2007)

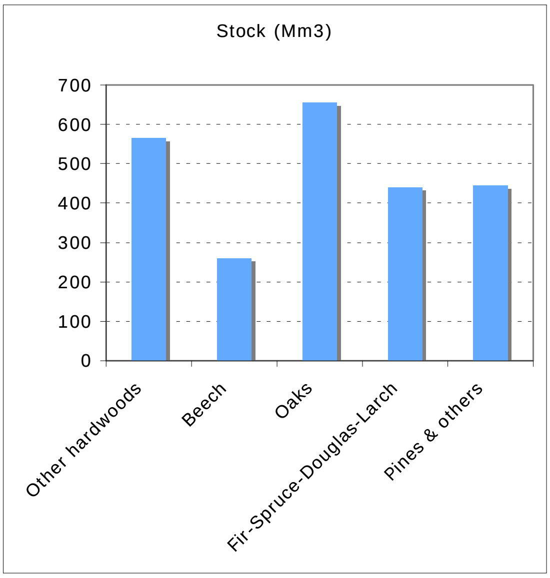


Lorraine is there !

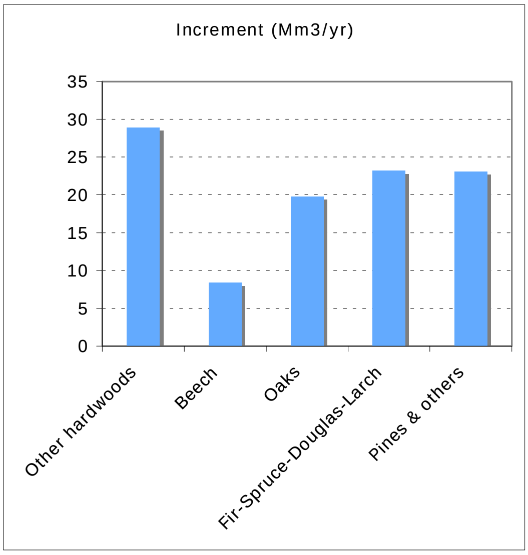
Main species :
Fir, Spruce, Beech, Oaks

Beech Site Index mapping :
Use of NFI data bases (ecological, mensurational)

French NFI :
2005 figures
Whole country

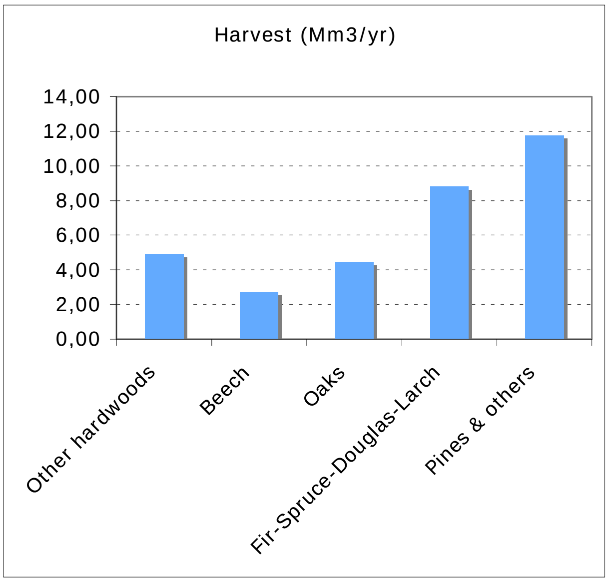


French NFI :
2005 figures
Whole country

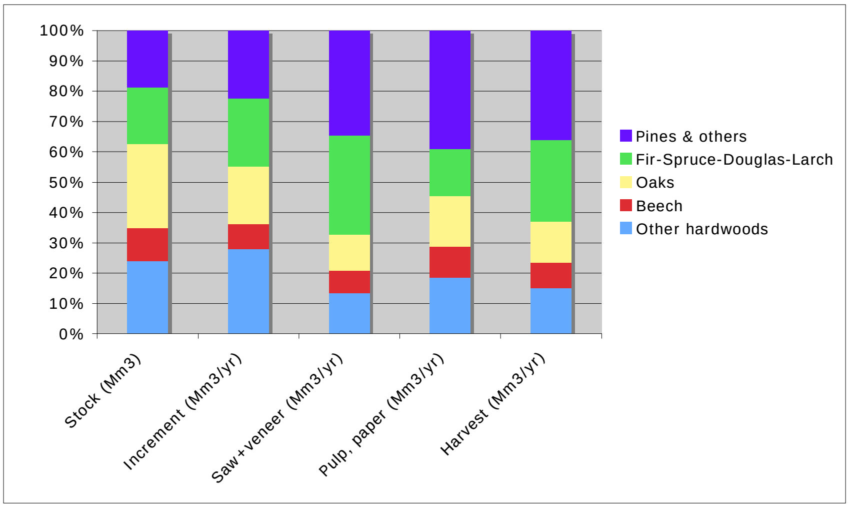


French Industrial statistics :
Whole country,

Average 1993-2004,
Excl. 2000-01

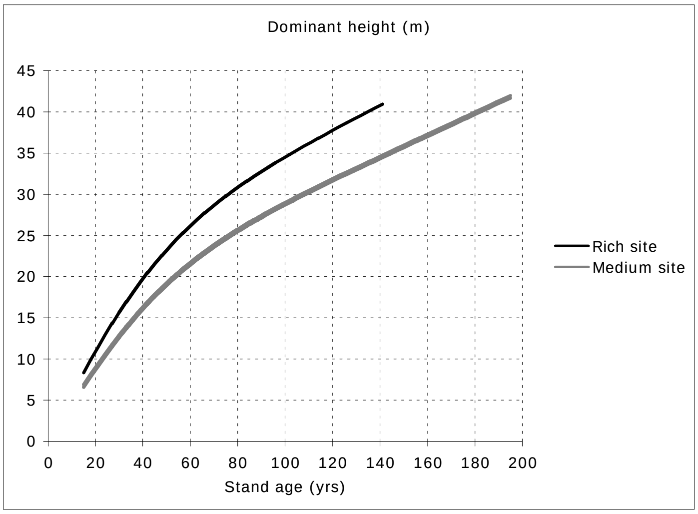


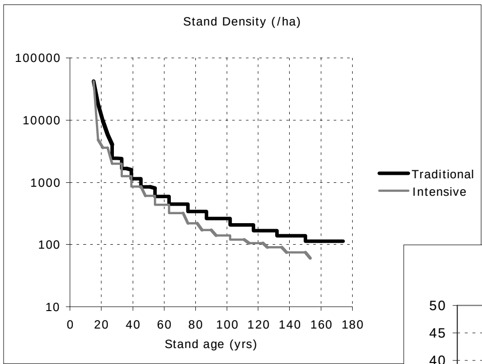
French NFI :
2005 figures
Whole country

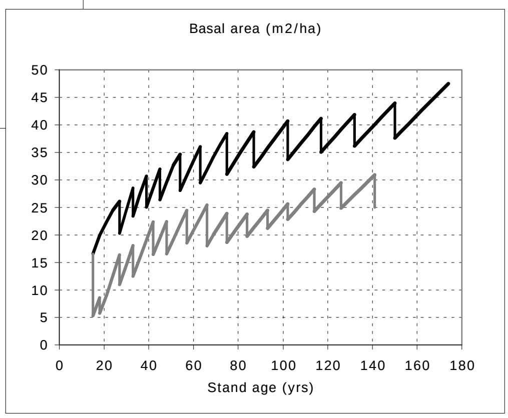


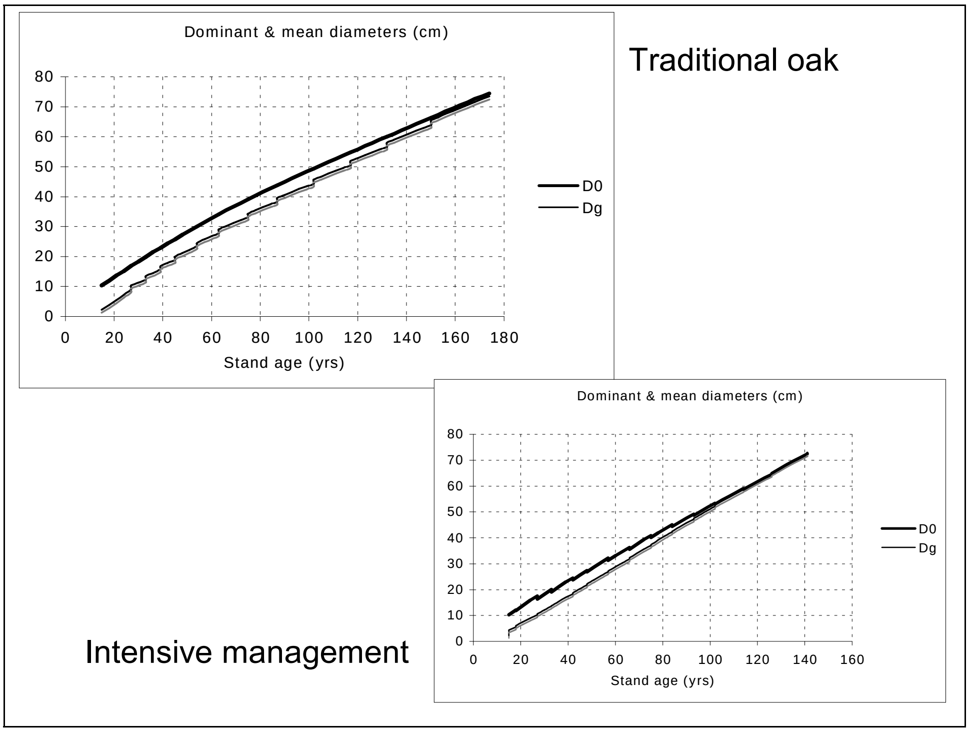
Typical height growth in Lorraine (model Fagacées) :

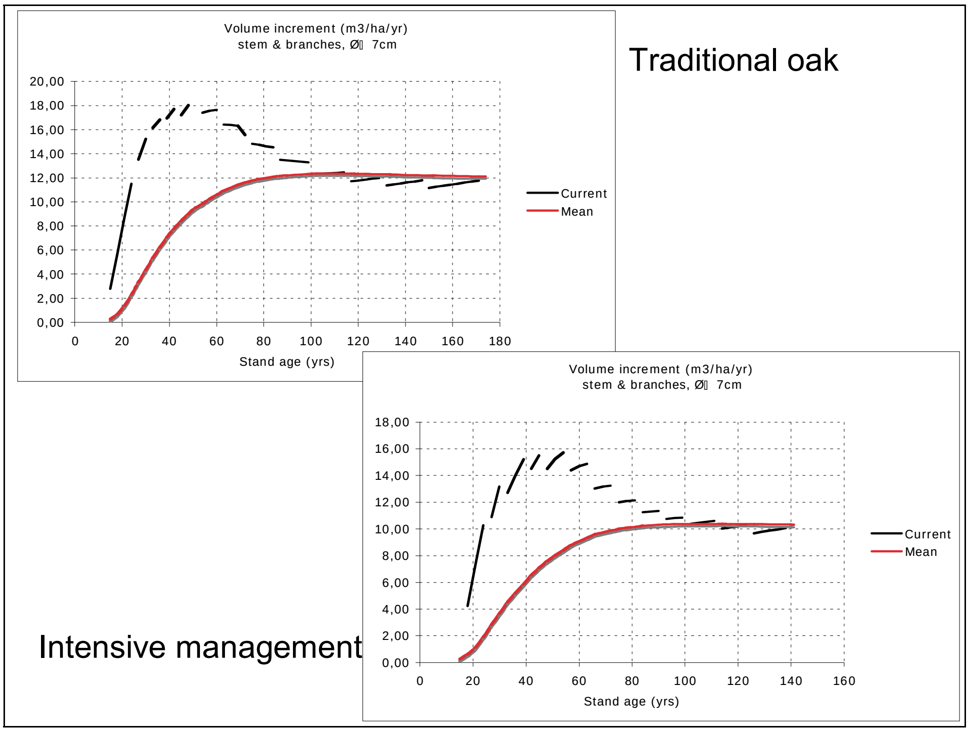
<u>for young stands (40 to 80 years)</u>



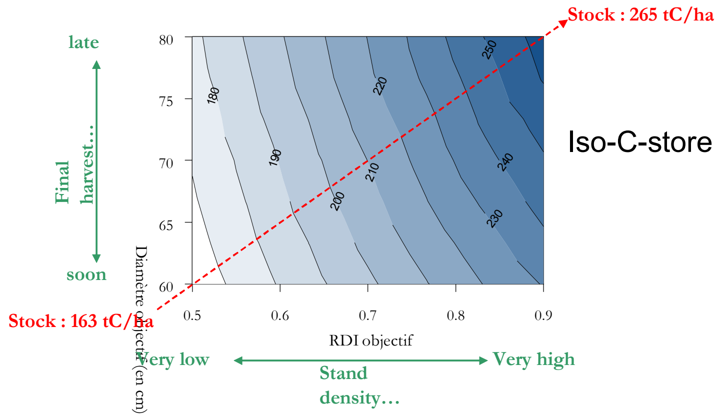





Dominant & mean diameters (cm)
Stand age (yrs)
D0
Dg
Traditional oak
Dominant & mean diameters (cm)
Stand age (yrs)
D0
Dg
Intensive management


Volume increment (m3/ha/yr)
stem & branches, Ø 7cm
Stand age (yrs)
Current
Mean
Traditional oak
Volume increment (m3/ha/yr)
stem & branches, Ø 7cm
Stand age (yrs)
Current
Mean
Intensive management

Average carbon stock / one rotation :
sensitivity to silvicultural strategies



Iso-C-store curves

Use of model Fagacées, under plat-form CAPSIS, batch-mode
Source : PhD thesis of Patrick Vallet (2005)

Work 2007

- On stand growth models : test JP's model on French sessile Oak data
- Enlarge range of scenarios
- Together with AFoCel : create a regional model
- That's all !
- Thank you…

ANNEXE 10 – Improvement of the EFISCEN model

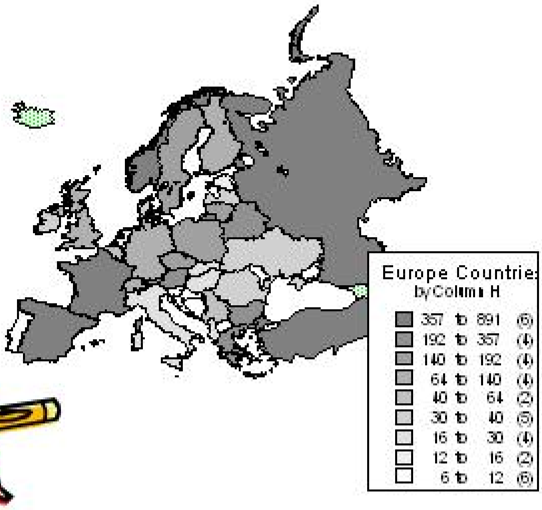
Developing EFISCEN-SPACE

Eforwood WP 2.5 workshop
13 February 2007

What is EFISCEN ?

- European Forest Information Scenario Model
- Is a forest resource model
- Under assumptions for demand and forest management, it shows how the resource will develop up to 60 years in future
- 'What if' scenarios
- Projections in terms of NAI, GS, age classes, fellings per province; biodiv aspects as dead wood, carbon etc.

Level of detail in input data



Number of forest types per country: total 5579

What are the main improvements?

- spatially explicit coverage of Europe on a grid basis (1 km x 1 km)
- simulate forest development for anticipated types of / changes in management & environment
- (make possible to) calculate forest sustainability indicators (wood quality, biodiversity,…)

Data sources: plot data over Europe

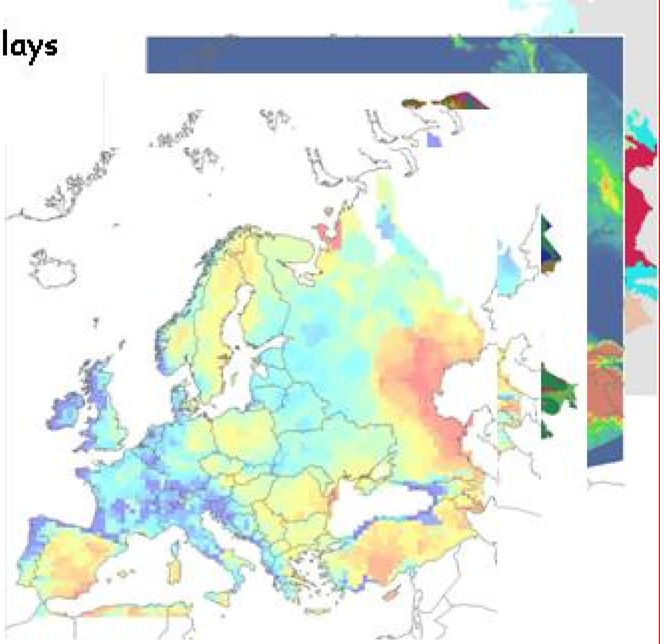
- NFI plot data
- ICP level I plots

General approach

- Put 1 km^2 grid over Europe (9.5 10^6 grids)
- Develop tree species maps based on plot & ancillary data (regression, kriging)
- Assign tree species to each grid
- Assign initial stand age and volume to each grid

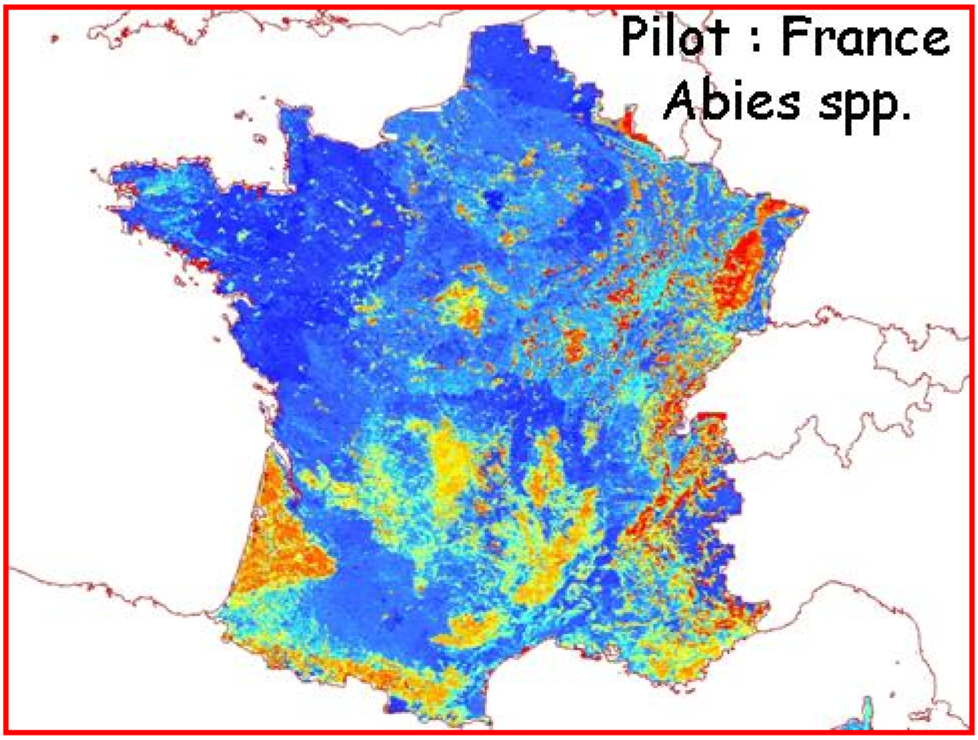
Ancillary data: overlays

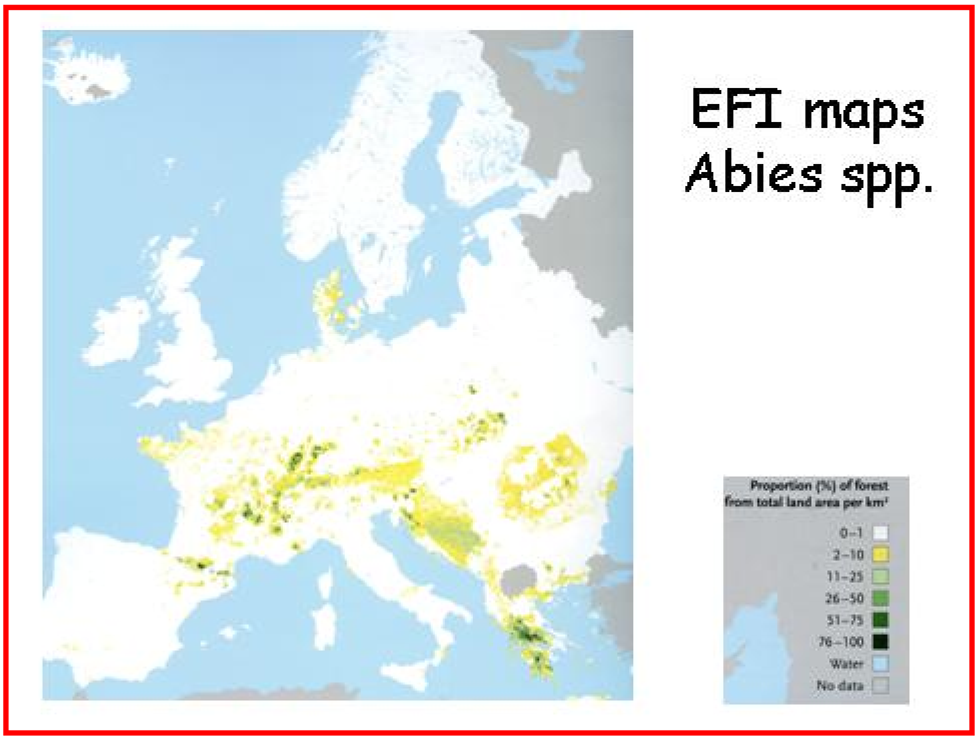
Biogeographic regions
Elevation
Soil map
Forest cover map
Average rainfall
Average temperature
Average radiation
Country
(XY-Coordinates)

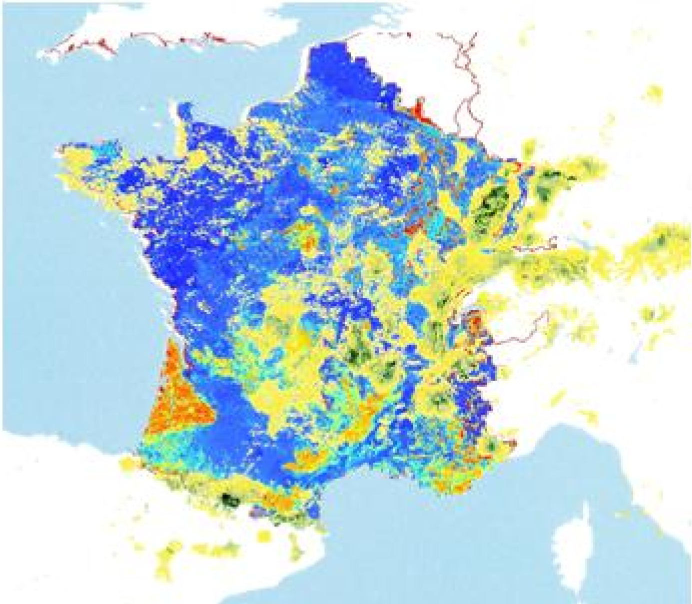


Mapping per species

- Combine NFI & ICP data
- Unique locations: presence/absence
- Randomly remove 10% for validation
- Binary logistic regression on ancillary variables (continuous & categorical)
- Calculate chance per grid cell
  $P(xy)=\beta_0 + \beta_1 Var_1(xy) + \beta_2 Var_2(xy) + \ldots$


Pilot : France
Abies spp.


EFI maps
Abies spp.
Proportion (%) of forest from total land area per km²
0–1
2–10
11–25
26–50
51–75
76–100
Water
No data

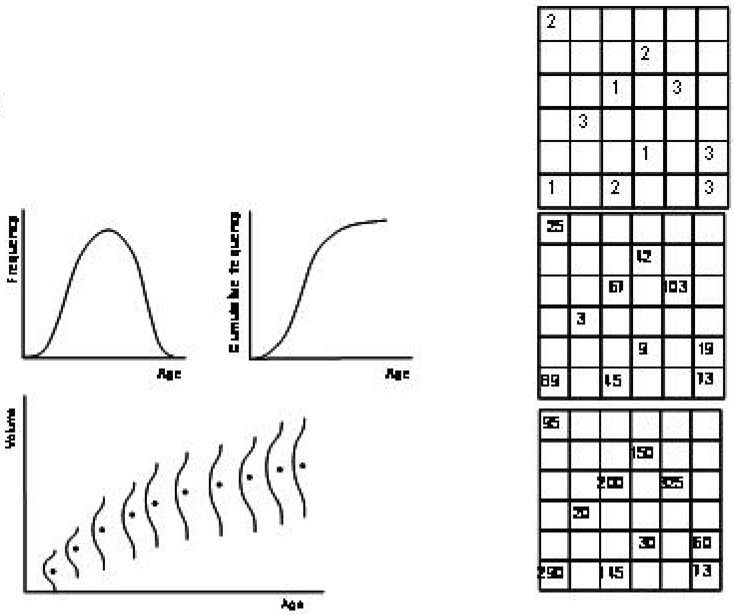


Requirements

Tree species map

Stand age

Volume



Contents of database

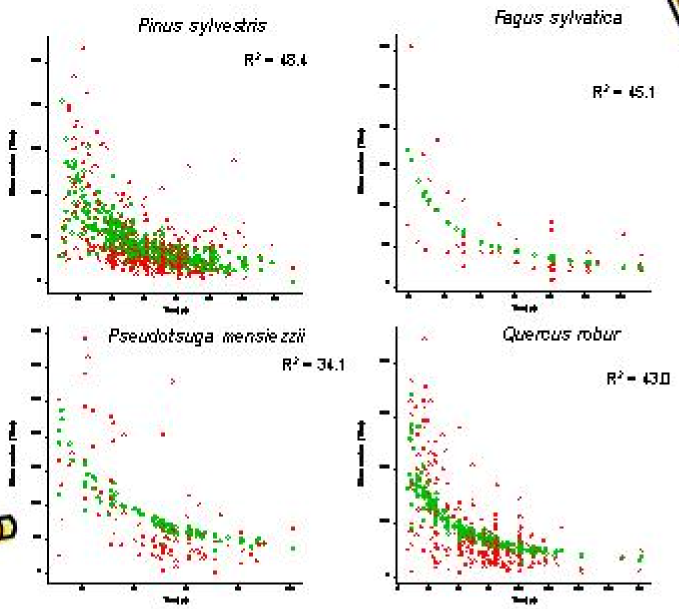
East West	North South	spp	age	rec y	mean H	mean D	min D	max D	stem nr	BA	GS	vol dead	NAI	harvested vol.	area of rep
16300	6465600	Pinus sylve	17	1999	1.5	7.9	5.5	10.4	229		4.1	0	0.34	0	631.1
16300	6465600	Pinus sylve	57	1999	12.5	24	8.4	39.3	1600	35	441.5	0	16.68	0	270.5
11100	6472300	Pinus sylve	79	2000	16.8	19	5.7	41.6	440	17	90	0	2.53	0	901.6
14900	6477900	Betula spp.	64	2003	13.5	12.9	5.1	32.8	1760	21	131.3	0.5	3.85	0	901.6
17900	6477500	Temporarily		2003	0.5							0		0	901.6
15300	6480900	Betula spp.	62	2003	10	9.2	5.1	15.6	1920	12	55.2	1.9	1.8	0	901.6
-3900	6495600	Betula spp.	67	2002	9.2	10.3	5	15.9	1840	12	67.2	0	2.28	0	450.8
2000	6494800	Betula spp.	47	2002	12.9	13.1	5	24.5	1200	10	89.5	3.8	2.81	0	901.6

Slight differences in reported variables

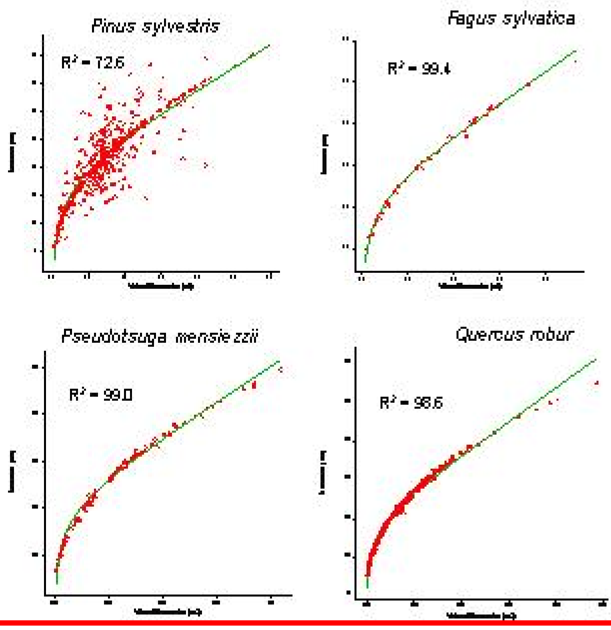
One harmonised dbs has been made

Use data to fit other stand characteristics…
4 tree species in
The Netherlands

$$N = \beta_1 \cdot T^{\beta_2} \cdot V^{\beta_3}$$



$$D = \gamma_1 \log(e^{\gamma_2 V/N} - 1) + \gamma_3$$



Simulation of forest development

- dW/dt = Growth + Regeneration – Mortality – Harvest

- unevenaged and mixed forests
- anticipated (changes in) management regimes
- anticipated (changes in) growth conditions
- changes in forest area and tree species

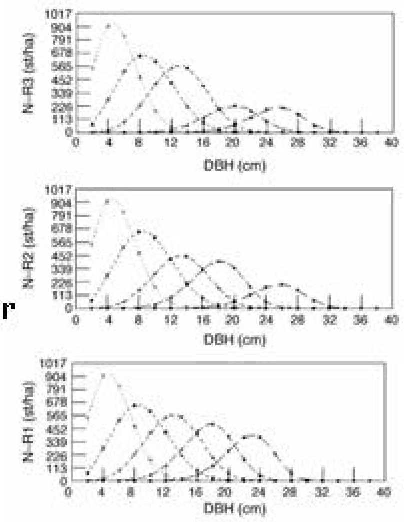
- applicable to large areas
- data available (NFI plot data)

- desired output: (input to calculate) sustainability indicators

AVERAGES ⇔ DISTRIBUTIONS

Combining SDMD & diameter distributions

- **Parametrize Weibull PDF for diameter distributions**
- **Develop parameter prediction equations based on stand characteristics**
- **Incorporate parameter prediction equations into modelling framework**



Newton et al., 2005

Relation with other models

- Diameter (and height ?) distribution parameter prediction equations
- Physiological responses to climate change: effects on parameters
- Responses to new management
- Competition indices – mixture effects

Output to ToSIA

- Response functions (e.g. forest characteristics versus wood demand)
- Indicators:
  - carbon sequestration in live & dead wood biomass, harvested products and forest soils
- Input to other modules (indicators):
  - *Amount & quality harvested products*
  - *Management applied (cost calculation)*
  - ...?