IMACFORD project

"Improving and Advancing Coordination of Forest Research and Development in Europe"

Task B1 – Sustainable development of forestry-wood chains in the context of fast-growing European forests

Proceedings of the thematic groups meetings: forest management, tree breeding, wood quality

(September 2002 - December 2002)

WORKING DOCUMENT

Project coordinated by:
Institut Européen de la Forêt Cultivée (IEFC) http://www.iefc.net
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Table of Contents

I – Presentation of IMACFORD Task B1

1 – IMACFORD: General objectives and organisation

The objective of this 5th FP accompanying measure is to improve existing and develop new networking facilities in European forest research, and to adapt existing research structures to meet the new demands. The project leader is the European Forest Institute (EFI). The integrated research network will contribute to the emerging European Research Area.

To comply with the general objective, IMACFORD project organises its activities into 2operative tasks.

TASK A: Promote dialogue between EU and the forest research community and to develop a European network of thematic centres for forestry.

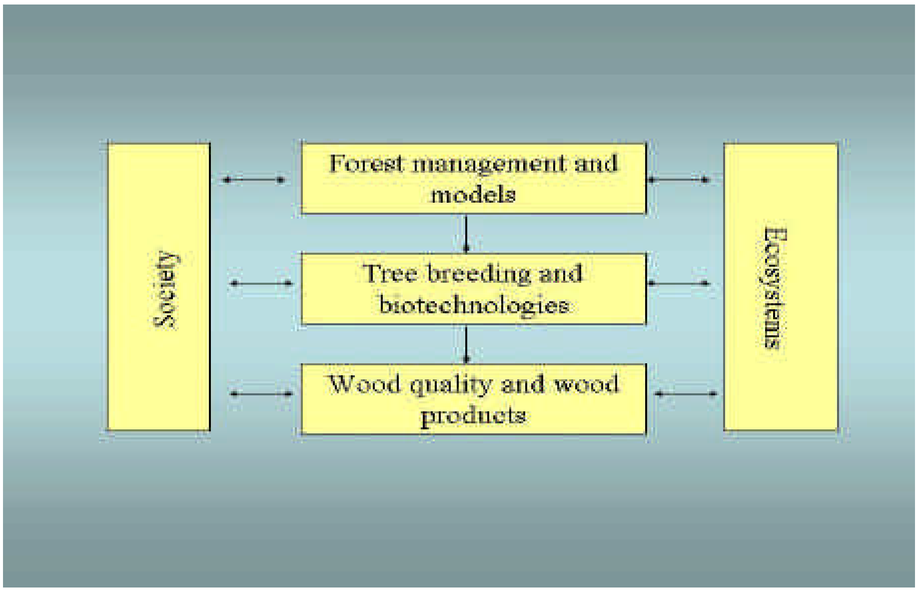
TASK B: Prepare interdisciplinary research excellence networks (one for *Cutivated Forests*: task B1, one for *Mediterranean Forests*: task B2).

2 - IMACFORD Task B1

Task B1 of IMACFORD is coordinated by the European Institute for Cultivated Forests (IEFC).

Task B1 deals with the sustainable development of forestry-wood chains in the context of European cultivated forests and aims at the development of an integrated interdisciplinary research network for the sustainable management and utilisation of fast growing forest resources.

Specific research question that will be investigated :
How scientific progress and technical innovations in the context of plantation forests can contribute to the sustainable development of the forestry sector ?



3 - Task B1: three phases for developing the research network

Task B1 has 3 separate objectives:

(i) To improve the research coordination at an interregional level (task B11)

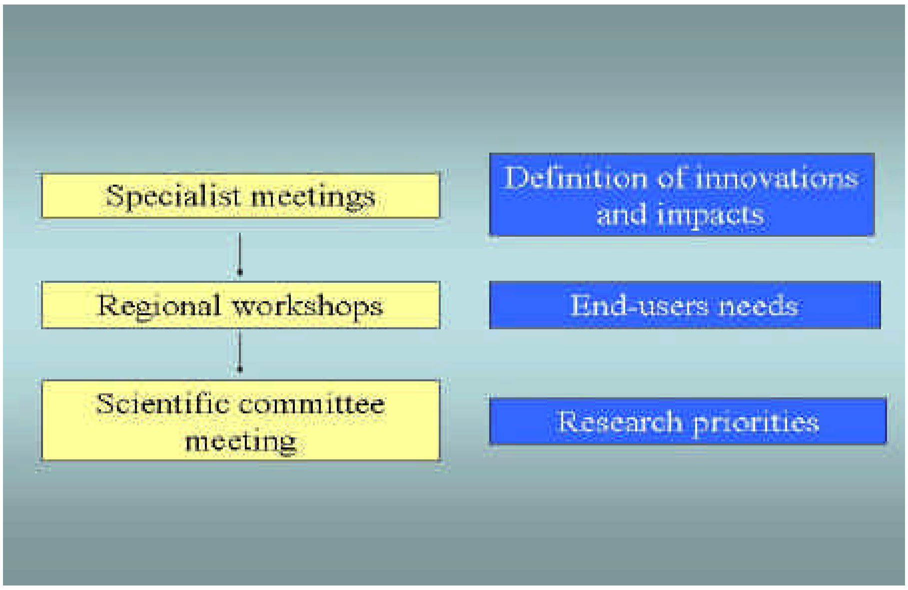
The first phase will investigate the ecological and socio-economic implications for research of technological innovations in (i) forest management and models, (ii) tree improvement and biotechnologies, (iii) wood quality and wood products, and in a changing context.

(ii) To provide a platform for dialogue with stakeholders and identification of research needs (task B12)

The second phase will facilitate dialogue with end-users. It will lead to the definition of research needs and priorities in sustainable forest management and forestry-wood chain related topics.

(iii) To elaborate a framework for integrated interdisciplinary research programmes (task B13)

The third and last phase will elaborate research programmes for sustainable management and utilisation of cultivated forests under changing context. This will lead to a framework for future research within the 6th Framework Programme.



II - Forest Management and Models

1. Management of plantation forests: trends and prospective

1.1. Prospective on the role of forests in France in the context of the forestry-wood chains

In 1998, INRA conducted a prospective study to improve the adequacy of forestry research to new issues related to environmental and socio-economic changes. The aim of the project was to elaborate forest scenarii based on forest management trends and forestry-wood chains, and their relationships with land use policy in France (*Prospective: la forêt, sa filière et leurs liens au territoire,* INRA, 1998). A synthesis of the prospective study are given in annex n° 6.

Together with the elaboration of 4 possible scenarii for French forests, the results of the prospective study emphasized (1) on the relevance of the spatial distribution of forest functions within the territory, and (2) the relationships between the socio-economic actors (forestry and wood sectors).

Considering spatial distribution of forest functions, two basic forest management trends can be described:

(i) Mix of forest functions: Multifunctional forests

In this approach, the forest management regime aims at a supply of multiple forest functions at stand level. Every forest is multifunctional in itself.

Consequently, the territorial functions are all shared between the socio-economic actors. This approach may constitute a compromise with society expectations but there might be some negative impacts on the organisation and the economy of the forest industry sector, and the durability of the whole forestry-wood chain.

(ii) Territorial mosaic of forest functions: Specialised forests

With respect to this approach, every forest function is provided in specific forest stands. All forest functions are fulfilled at landscape level by the addition of the services of each forest stand.

In the wood-production oriented forests, intensive silviculture practices are implemented. Other "function specified forests" are dedicated to the production of services like recreation, biodiversity conservation, water and soil preservation, etc. and management intensity is minimal.

This approach may constitute a compromise between environmental requirements and societal expectations because economic activities can be conducted and the associated economic gain can contribute to the protection of forests and to the fulfilment of their non-wood functions.

1.2. Elements for prospective on regional forest scenarii

To elaborate detailed regional forest scenarii, it is necessary to describe the forest system and its evolution in a historical perspective and to define its functions and its impact factors. This analysis will provide a characterization of the current forest management system in the context of the forestry-wood chain and the national forest policies.

For instance, in the French region Aquitaine (annex n° 7.3) , the stability of the maritime pine forest area in the past century in association with the spatial distribution of the main functions has led to a favourable context for a dynamic forestry sector and the development of strong links with the wood industry. The current dominant forest scenario in Aquitaine can be defined as a semi-intensive sawing regime for timber production.

As a next step, future impact factors on the forest system have to be described and their influence on the stability of the system evaluated. For example in Aquitaine, climate change may have a negative impact on forest stability through a higher number of climatic events or through the proliferation of natural pests and diseases. Also, future society needs like the demands for ecological services and non-wood products, or changing market requirements for wood based products can strongly influence regional forest management trends. Global environmental policy will also affect the regional forest management trends (annex n° 7.4).

Different prospective scenarii can emerge from this type of analysis. For example in some regions, wood production might remain the main forest trend, but specialised forestry areas for biomass production or quality timber production could neighbour new silviculture regimes for recreation or protection (carbon sequestration, biodiversity maintenance…).

2. Growth models and decision support systems for forest management

Forestry has rapidly evolved in the last centuries from a preforestry system characterized by the lack of forest management leading to the overexploitation of forests and their resource depletion, to some more global and complex systems, including the "ecologically based forestry system" in which sustained production of timber is emphasized, or the "social forestry system" in which forests provide a wide range of forest conditions, values and services desired by the society (annex n° 7.5).

In parallel with the development of forestry, the information requirements of the forest managers increased in volume and complexity (for instance from only timber evaluation to the assessment of carbon sequestration in forests) in order to comply with the new ecological, political, economic and social expectations on forest management (concept of sustainable forest management, forest management criterias of the Lisbon conference…).

Practically, to support decision-making regarding forest resources, forest managers require sound predictions on the evolution of the forest under alternative management actions. Growth models and decisions support systems help the user to define the set of actions that optimise their objectives.
There is simultaneously an evolution towards more complex information systems for forest managers and a need for reliable and easily measurable indicators for monitoring forest ecosystems.

(i) The quality of the information collected by forest inventories is essential
Problems with current forest inventories are: (1) the information is usually not available for every stand in the management area, and (2) forest inventories focus mainly on the production functions of forests. Consequently, inventory methodologies should be more intensive and diverse in the data collection; they should be multi-resource. For example, information on the soil (essential for carbon sequestration assessment), the site ecological and physical specificities (rare species for example) and the spatial structure of stands should be collected.

(ii) The need for evolutionary and multi-output growth models
Both empirical models and process based models produce important outputs to better understand forest functioning and to provide quantitative predictions.
Nevertheless, empirical models do not take into account the impact of the changing climate on forest growth (it is admitted that climate change will strongly affect forest growth within the next decades). Also, empirical models do not produce output on the impact of forests and forest management on ecological factors (soils, water, biodiversity, etc.).
On the other hand, process based models need a huge quantity and variety of data that forest inventories do not necessarily provide at the moment. In addition, these models are scientifically-use oriented and silvicultural outputs relevant for forest managers have to be developed.

There is a need for hybrid models combining empirical and process based models; models that would take advantage of the outputs of each one.

3. Ecological impact of plantation forests

3.1. Biodiversity and forest health issues in cultivated forests

Silvicultural operations influence the ecological status of the forest and there is a need to understand their impact on biodiversity (plant, insects, mammals, birds, etc.), as well as on forest pest and disease dynamics. Indicators reflecting the status of forest biodiversity and health are currently investigated by the Scientific community (annex n° 7.6).

(i) Planting and the choice of forest tree species

In cultivated forests, the diversity of forest tree species, their spatial distribution, and consequently the main forest functions and the associated silvicultural regimes, are anthropic inputs. In that context, it is essential to assess the impacts of forest species on diversity (species, habitats) and stability (pests and diseases).

The development of gaps (hedgerows, relict woodlands, amenity plantings) within pure productive stands (often monospecific stands) may constitute a compromise for society expectations towards diverse landscapes. Habitat diversity and complexity will be influenced (ecotone, niche complementation);

Species diversity (birds, insects, plants) and pest and disease dynamics (host accessibility, impact of natural enemies) still need to be evaluated in detail, for example within a network of plantation landscapes with increasing complexity of habitat diversity.

As a response to global warming or industrial needs, exotic tree species can be introduced or developed for wood production. Species richness will be affected and rare species might be at risk. Regarding the forest health issues, the risks of shift of native pests or the invasion of exotic pests needs to be evaluated.

(ii) Stand management

Understorey management in productive stands represents a key issue for its effects on site fertility and biodiversity.

Nevertheless, understorey management will generate some disturbances in the structural diversity and the functional-response of the populations should be assessed at stand and landscape level.

On the other hand, at stand level, the change in vegetation structure and composition will probably influence habitats (host accessibility for example) of natural enemies of forest pests and diseases.

The impacts of varying understorey structure, composition and disturbance regime on natural dynamics need to be assessed.

(iii) Harvesting

In cultivated forests, clear-cutting is the most important factor of disturbance for the associated populations. Alternative methods or improvements of current practices can be considered, such as:

(1) Change in clear-cut design (size, distribution in space and time) would generate fragmentation, connectivity and colonisation that will influence positively population dynamics (metapopulations).

(2) The influence of old trees in stands and their associated species (retention concept) should also be assessed, considering for example the pest spatio-temporal dynamics (genetics and site adaptability) at landscape level.

3.2. Sustainability of forest soils in plantation forests

The role of forest plantations in soil conservation depends on:

(i) site selection: physical and chemical ability of the soil to support forest growth,
(ii) site preparation: logging residues management, fertilization, soil tillage,
(iii) silvicultural management.

Non-adequacy between the soil conditions (supply) and the silviculture regimes (demand) can lead to severe reductions of soils productivity (chemical fertility, structure) that can even be irreversible (erosion).

In cultivated forests, nutrient deficiencies can occur because of the use of improved trees with high growth rates. Nutrient demands of the trees overpass nutrient supplies from the soil, and the higher amount of biomass exportation reduces the volume of organic matter to be mineralized. Moreover, trees growing on poor soil will be weakened and will be more susceptible to pests and diseases. The use of trees not adapted to site conditions can therefore lead to the development of severe sanitary problems.

Long term fertility of forest soils represents a major issue for cultivated forests.
Research is performed on the optimisation of fertiliser use in forest (for water conservation, to avoid soil compaction…) and also on long term impacts on forest soils (humus layer, fertility…).
Research on the consequences of slash and understorey management on the improvement of the fertility and on the physical properties of forest soils is needed.

II – Tree Breeding and Biotechnologies

1. Overview of tree breeding programmes and strategies in South West Europe

1.1 Breeding trends in France

At INRA, research activities in tree genetics are organised in 3 domains: Genomic, Diversity and Selection.
Improvement activities are currently engaged for the 3 main economical forest tree species in France: poplars (*Populus sp*.), maritime pine (*Pinus pinaster*) and Douglas fir (*Pseudotsuga menziesii*), for which specific strategies are conducted and a set of tools established: databases, clone nurseries and seed orchards (for example: 3rd generation of selected trees for maritime pines in Aquitaine).

With regard to the other French forest tree species (walnut, ash, wild cherry, Scots pine, spruces and larch for example), the strategy is to focus research on the characterization and the conservation of the natural diversity, in order to keep the possibility to start improvement programmes if required.

Considering the target traits for breeding, it is relevant to note the historical evolution of the importance dedicated at first to the quantitative (volume) and general (site adaptability) traits and later on to the qualitative (wood quality) and specific (pest resistance) ones.

1.2 Breeding trends in Portugal

In Portugal, improvement programmes are developed for maritime pine and eucalyptus globulus (annex n° 8.3).

(i) Maritime pine (*Pinus pinaster*):
The actual main issue considering breeding strategies in maritime pine in Portugal is the enlargement of the genetic basis in order to provide plants with a better site adaptability (drought resistance) and wood quality. In the context of climate change, for a Mediterranean country like Portugal, the objective of site adaptability is considered as essential.

(ii) Eucalyptus globulus (*Eucalyptus globulus*):
Breeding activities in eucalyptus aim at the improvement of the industrial profitability through a higher pulp yield production and pulp quality, and through a higher wood volume production. To achieve these objectives within a few years, biotechnologies are currently utilized in laboratories.
Interactions between genotypes and environmental factors are analysed in order to enlarge the genetic basis.

Considering the other Portuguese forest tree species (*Quercus suber*, *Pinus pinea*, *Castanea sativa*, *Quercus rotundifolia* and *Cryptomeria japonica*), studies are performed on the genetic diversity (molecular markers).

Current trends in Portuguese breeding programmes are: tree adaptability, improvement of wood quality and public communication for the use of biotechnologies in eucalyptus and pines plantations.

1.3. Breeding trends in the spanish Basque Country

The radiata pine (*Pinus radiata*) breeding programme in the spanish Basque Country is conducted by NEIKER (Basque Institute for Agrarian Research and Development) since 1984. The programme aims at a commercial production of improved cuttings from the descendance of trees selected for their site adaptation or stem form qualities. Revigorization of selected adult genotypes is a challenge for Basque tree breeders.

2. Innovations in tree breeding

2.1. Use of biotechnologies in forestry

In plantation forestry, a scientific challenge is to be able to select and produce trees with interesting traits and to rapidly deploy genetic gains to satisfy end-users requirements.

(i) Multiplication:
Improvement in tissue culture systems (mainly somatic embryogenesis) allows high multiplication rates and the ability to maintain or to restore juvenility when micro-propagation is coupled with cryopreservation. There is an industrial need to develop such techniques for a large number of commercial tree species. Research has to be conducted in order to overcome the clonal effects.

(ii) Selection:
Considering the genomic approach, the exploration of allelic diversity of major genes will greatly improve the knowledge on genetic determinism of important traits. Molecular techniques (mainly marker assisted selection) are also of great help to better manage and characterize the genetic diversity of forest trees as well as to implement quality control at the level of plant propagators (seed orchards, nurseries) and wood suppliers (control of species and geographic origin).

Regarding the phenotypic approach, techniques to better assess wood quality in trees, logs and timber have to be developed and non destructive techniques allowing fast measurements on small samples without damaging trees are needed. Among them, suitable correlative techniques (for the construction of genetic indexes) have to be further developed.

2.2. Improvement of conventional selection strategies

In conventional genetic selection, early assessment of interesting traits in improved trees represents the main research topic. Nevertheless, several problems emerge mainly because of the weakness of the heritability of qualitative traits on the one hand, and the fact that the full expression of genotypes becomes only visible after the first floral period (10 to 15 years) on the other hand (annex n° 8.4).

Within an early selection perspective, 2 complementary strategies are developed: (i) elaboration of multi-criteria indexes for specific traits, and (ii) shortening the juvenile period.

(i) Multi-criteria indexes:
Studies are performed in order to elaborate indexes for complex traits. The objective is to assess those complex traits like pest resistance, wood formation or stem and branch habit form through indirect and "easy measurable" criteria with a good genetic heritability. The resultant multi-criteria indexes have to be strongly correlated to the phenotype of interest.

(ii) Late fully phenotypic expression
To resolve the problem of weak trait expression in juvenile trees, flowering stimulation processes and also indexes based on juvenile criteria well correlated with target traits are developed.

Inter-specific and intra-population hybrids can be produced in order to valorise the heterosis effect and to evaluate the complementarities between traits of interest. This research programme can lead to new commercial varieties.

Research perspectives in conventional genetic selection are:

- Development of tools to simulate the management of breeding populations
- Reduction of the negative impacts of juvenile wood increment
- Assessment of genetic diversity and plasticity of improved varieties in a climate change context.

3. Potential impacts of tree improvement regarding forest sustainability

3.1. Economic implications

A study (GIS pin maritime du futur, 2002) based on a retrospective economic analysis of improved pine plantations in South East USA, and also on the analysis of 3 scenarios for maritime pine forest in Aquitaine (rates of improved seeds used in reforestation 0%, 50% and 80%) has demonstrated that the use of improved trees can result in a high economic gain due to a higher wood production.

One of the major issues for the use of improved plants concerns the end-users (nurseries, forest-owners, wood industries) regarding the economic acceptability of improved forest trees. Will the end-users trust this innovation and invest in it for reforestation or afforestation? Social (analysis of behaviours and perceptions) and economic studies (research on the parameters of profitability) have to be conducted.

Also, considering the potential effects of climate change on tree growth and the associated wood properties, as well as the evolution of industrial and market requirements, tree breeders will have to develop improved varieties whose wood properties could fit in different industrial uses.

3.2. Potential impacts on forest health and biodiversity

The use of improved trees may directly (*e.g.* higher tree palatability of improved trees for some insects) and indirectly through silvicultural regimes (*e.g.* higher biomass exportation and the induced decrease in the quantity of organic litter) influence natural pest and disease dynamics. Such changes may constitute a risk for forest health (annex n° 8.5).

Regarding biodiversity, the effects of both (i) genetically improved products, and (ii) associated intensive silvicultural regimes, *e.g.* understorey management, fertilization, use of pesticides, and more generally the reduction of crop diversity, have to be assessed.

More generally, the management of genetic innovations is an essential issue regarding ecological sustainability of plantation forests. The large use of one clonal variety in combination with one silvicultural regime may generate a high ecological risk. A strategy to mitigate such potentially negative impacts is a mosaic management of clonal stands and associated silvicultural regimes at landscape level: this strategy needs to be further evaluated.

3.3. Impacts on soils fertility

There is a need to analyse the effects of improved trees and associated silvicultural practices on forest soils and on trees nutritional balance.

Soils provide trees with the nutrients for their growth. Soil ability to support plant growth is quite different from one site to another and some sites do not allow important growth rates. In such conditions, the nutrient demands of improved trees selected for their high growth rate may overpass the soil supplies.
Moreover, forest soils quality and long-term fertility might be affected by site operations like repeated penetration of forest tractors, harvesting operations…

Also, higher biomass production and exportation will lead to the reduction of the nutrient pool available in the forest soils. This risk may increase in the context of climate change with changes in mineralization processes.

There is an urgent need to evaluate both nutrient demands of genetically improved trees and site supply in relation with silvicultural regimes and practices. More generally, the whole site, silviculture and genotype interactions have to be further studied in order to sustainably manage forest tree species and soils.

4. Research topics

4.1. Diversity and genetic resource management

Among the tree breeders community, fears are expressed about the consequences of the future enlargement of the EU and the implementation of the Council Directive 1999/105/EC on the marketing of forest reproductive material, and consequently the potential use of seeds from new natural areas. It would be relevant to develop a European assessment strategy to analyse all the specificities of the seed varieties that would be sold throughout Europe.

4.2. Tree breeding

(i) Tree improvement

For each species used in forest plantations in South West Europe, the interesting traits for improvement programmes (wood quality, pest resistance, stem form, etc.) and the related research strategies to be implemented might be elaborated.

(ii) Experimentation and demonstration

Since many improved varieties are nowadays available for a production use, research efforts need to be allocated to the evaluation of their behaviour under productive conditions.

In the forestry context characterized by low short term profitability, it is crucial to demonstrate to the stakeholders the benefits of the use of improved materials which represent a high initial investment. Therefore, research programmes concerning the socio-economic aspects need to be reinforced and the decision making process and informed dialogue between tree breeders, forest stakeholders, forest industries, environmentalists and policy makers could be facilitated.

(iii) Integrated models

Research programmes aiming at the integration of genetically improved material in silvicultural models and decision support tools should be initiated.

IV – Wood Quality and Wood Products

1. Overview of wood quality issues and implications for research

1.1. Understanding wood formation and wood material properties

The formation of wood is a function of tree growth, which determines wood density, chemical composition, cell structure, the size and distribution of knots and levels of compression wood.

With the aim to improve and to predict wood quality in trees and logs, studies on functional genetic of wood formation and wood quality (heartwood, durability, etc.) are performed in parallel with research on environmental determinisms of wood formation.
Also, genomics and validation experiments with transgenic materials are useful to understand tree's functioning. For instance, *in vitro* xylogenesis has led to an increased knowledge of wood formation.

1.2. Tree breeding and wood properties

(i) Economic issue
From the identification of the genes coding for the traits of interest to the commercial exploitation of improved trees, improvement strategies of wood quality are long term processes. In that context, the economic acceptability of improved trees may represent the main factor of impediment for a large scale development of breeding programmes on wood and fibre properties.
Taking into account this economic aspect, only for a few forest species specific improvement programmes currently exist for wood quality. Those forest species are intensively managed (poplars, maritime pines or eucalyptus for example) and industrial connections are well developed.

(ii) Strategies to increase the wood volume production and its consequences on wood quality
Because of climatic disturbances and the impacts on forest stability, shortening the rotation period by increasing growth rate may represent a solution for profitability and risk management.
However, wood and fibre quality parameters differ between juvenile and mature wood (micro fibril angle, moisture content, wood density or the importance of reaction wood for example), leading to a decreased quality and limited use.

High variability of wood quality between Douglas fir clones selected on growth rate has been demonstrated by AFOCEL. Qualitative factors such as density of solid wood or fibre length have weak genetic heritability (except for the lignin content for which breeding programmes are engaged) and for that reason those parameters may be strongly affected when breeders only take the quantitative traits into account within the breeding programmes.

Consequently, silviculture regimes with shortened rotation and the use of improved trees with high growth rates may lead to unfavourable properties for both solid wood and fibres.

(iii) Interactions between site, silviculture and genotypes on wood quality
It has been demonstrated that the use of intensively managed forest species (for their higher growth rate or their better pest resistance) can have important effects on wood quality**.** Wood quality is not a strictly phenotypic expression of the genetic pool. It's the result of a combination of genetic, environmental and silvicultural parameters. Studies have to be done on the interactions between site, silviculture and genotypes and their interconnections regarding wood quality (annex n° 9.3).

1.3. Strategies and tools to integrate wood quality into the forestry-wood chain

(i) Integrating wood quality aspects into silvicultural models
Several growth and functional models are now available for scientific use and could be linked with wood quality issues in order to predict intrinsic wood quality according to a set of productivity factors.

For example, OPTIM-OAK developed at INRA LERFOB aims at providing an evaluation of the amount and the quality of present and future oak resources (*Quercus petraea* and *Quercus robur*) through an empirical model simulating tree growth, harvesting, product manufacturing, and considering climate change, various silvicultural regimes, various commercial wood products, carbon and energetic balances, etc.

(ii) Early assessment of wood quality
Within a global wood quality strategy, it is essential to evaluate wood quality in trees and to segregate logs according to the wood quality parameters required by the end-users. The aim is to provide qualitatively homogeneous logs to the industries and thus to enhance their flexibility and competitiveness. Moreover, through the assessment of the quality of their logs, forest owners and entrepreneurs can expect a fair price for their products.

On one hand, models for optimising logistics are being developed; on the other hand, tools to assess wood quality parameters like rigidometers for stems and densidometers for logs are also available.

2. Market requirements for wood products

2.1. Timber quality for construction

There are several factors of impediment for a large use of timber for construction (structural defects of wood, spatial and temporal heterogeneity of wood properties). To overcome this, following objectives (annex n° 9.4) must be reached:

- To improve the reliability of the structural properties (global homogeneity),
- To propose products complying with the concept of “Fitness for purpose” (various sizes),
- To sell standardised (measurements and qualities) and eco-certified products (rationalised use of chemical wood preservatives).

(i) Research on technological aspects:
Industrial processes (drying and storage, sawing and green gluing) can avoid some timber defects like those in relation with the sizes limitations, the stability in time of the structural properties or the stiffness. Consequently, there is a need to better understand those industrial processes and to improve them in order to fulfil builders requirements.

(ii) Research on commercial aspects:
To prevent end-users fears because of wood heterogeneity, strategies to better specify wood quality for specific end-uses should be developed (technical methods and commercial tools).
Also, to enhance the reactivity of wood companies and the image of wood in builder’s mind, market needs have to be better understood.

(iii) Connections with the forestry sector:
Methods cannot work miracles and the enhancement of timber use in construction goes through the offer of a basic grade of starting material from wood suppliers. The issue concerns the raw material supply and consequently the organization of the forestry sector. Finally, customers want ecologically friendly products and the whole forestry sector has to enhance the transparency of its production process (sustainably grown timber, transport, and biodiversity for example).

2.2. Market requirements for fibre products

According to printing companies, “a quality product” is (i) a product with constant and homogeneous properties, and (ii) a product which supports different kinds of printing processes without degrading the product on the technical and esthetical point of views, and (iii) a product with a low environmental impact.
To provide such quality to their customers, pulp and paper mills had transferred the market requirements on the forestry sector. The objective is to have a forest/wood resource well adapted to the

industrial processes. In other words, it's to feed the mills with a good industrial fibre. Such a fibre can be defined as: easy to beat and to bleach, high cellulose content and low lignin and resin content, high fibre strength and flexibility, low MFA and compression wood content (annex n° 9.5).

To comply with the market requirements for fibre products, research and development institutes are leading programmes around 4 complementary areas:

(1) Enhancing the value of the local species (understanding fibre formation and properties, utilization of tree breeding techniques to improve the resource, elaboration of fibre oriented silviculture regimes through short rotation coppices, etc.).
(2) Adapting the forest resource to the industrial needs (log segregation, specific plantations for fibre properties mixes).
(3) Improving the supply chain management and the industrial control (logistics to identify wood assortments and to optimise the wood flows knowing the freshness and the proportion of various origins).
(4) Optimising the industrial process with the wood supply (beating, bleaching).

2.3. Engineered Wood Products (EWP)

EWP are attractive for wood and fibre companies because of their technical properties (better stability than traditional wood for end-uses) and their economic opportunities (new markets). They also actively contribute to the optimisation of the resource ($1m^3$ of product from $1m^3$ of raw material).

(i) Issues concerning the physical properties of EWP:
Until now, no studies have demonstrated the influence of the quality of the raw material (moisture content, durability of the fibre) on the physical properties of EWP. However, this issue should be more and more relevant in the future because of climate change and the development of innovations in forestry in fields like genetic improvement and silviculture.

(ii) Issues concerning the environmental impact of EWP process:
What's the environmental impact of the production processes (like gluing for instance) in terms of emission of pollutants? And what's the energetic balance of EWP considering their whole life cycle?

(iii) Issues concerning the commercial development of EWP:
For the wood sector, EWP represent an opportunity to penetrate new commercial niches like the construction one. Standardisation of the products and simplification of design rules have to be further studied to make EWP attractive to end-users.

3. Life Cycle Assessment (LCA) of forestry and forest products

LCA aims at the evaluation of the environmental balance of a product considering its whole life cycle (emission of pollutants, energy and material consumption). For a given product, the environmental impact of each step of his life is measured, from the forest stand to the end of life of the product through its utilisation as furniture for instance (annex n° 9.6).

The major outputs of LCA are:

(i) To obtain quantified and reliable information for the debate on the environmental impact and benefits of wood products, information to be used by industry and policy makers,
(ii) To improve production and recycling techniques by minimizing steps with high environmental impact or choosing different processing routes to reduce environmental impact or highlighting compatibility between processing,
(iii) To highlight areas where information on the environmental impact of products is still unknown or uncertain,
(iv) To enable comparison between different materials used for the same purpose.

Within the context of sustainable development of the whole forestry-wood chain, LCA represents an attractive integrating tool to measure the consequences of its activities on the environment and to help in the implementation of ecologically friendly operations (silvicultural regimes for instance) and processes (*e.g.* pulp bleaching). With the increased environmental awareness of the Society, LCA results would also be useful for the forestry-wood sectors to dialogue.

Finally, the development of LCA is conditioned by the existence of exhaustive studies concerning the systems (functions, impact factors) used within the analysis.

4. Research topics in relation with Wood Quality issues

To improve the use of wood as a raw material it is necessary to better understand wood formation, how this is affected by environmental conditions and also to understand the relations between wood microstructure and the wood properties of importance to the end user.

There is also a need to for early identification of key-wood properties in order to optimise utilisation and target the most appropriate end-use. The aim will be to provide a reliable material to end-users that is consistently uniform and meets their requirements.

ANNEXES

IMACFORD – TASK B1 coordinated by IEFC

Coordination : Jean Michel Carnus (INRA – Bordeaux) + Antoine Colin (IEFC – Bordeaux)
DRAFT AGENDA – 24 FEBRUARY 2003

TASK B1.1 RESEARCH NETWORK ORGANISATION AND PLANNING

Thematic group meetings : 10 to 15 people meetings/ scientists + invited experts from industry
General objective : networking+ reviewing innovation and research directions + planning

DATES	LOCATION + local organiser	TITLE	LOCAL COORDINATION	Comments
18-19 OCTOBER 2002	LOUSA – ISA	FOREST MANAGEMENT	Margarida TOME	1 day meeting + ½ day group report
15 NOVEMBER 2002	VITORIA - NEIKER	TREE IMPROVEMENT	Enrique RITTER	1 day meeting
12 DECEMBER 2002	BORDEAUX - INRA	WOOD PRODUCTS & QUALITY	Patrick CASTERA	1 day meeting

TASK B1.2 CONSULTATION PROCESS AND IDENTIFICATION OF RESEARCH NEEDS

Regional workshop – by invitations 40 to 50 people
Objective: information transfer (innovations)+ debate on regional issues & priorities

27 -28 FEBRUARY 2002	FRANCE - BORDEAUX	European Research and sustainable development of forestry wood chains	IEFC antenna	+ annual general meeting of IEFC on the 1st MARCH+IEFC soil group meeting
07-08 APRIL 2003	PORTUGAL – OBIDOS	European Research and sustainable development of forestry wood chains	IEFC antenna	+ Scientific board meeting ?
15-16 MAY 2003	SPAIN - SANTIAGO	European Research and sustainable development of forestry wood chains	IEFC antenna	+ visit Galician Interreg site ?

TASK B1.3 ELABORATION OF STRATEGIC FRAMEWORK FOR FUTURE RESEARCH

Thematic groups (3)+ scientific committee meetings : 10 to 15 people meetings (scientists + experts + industry people)
General objective : prepare integrated project for 6th FP
Meetings to be held on 2-5 July 2003, DUBLIN, IRELAND

Final reporting of TASK B1 - AUGUST 2003

Des scénarios d'avenir pour la forêt, l'industrie du bois et leurs liaisons au territoire

Dans le contexte actuel de la globalisation tant des économies que des problèmes d'environnement, la gestion du patrimoine forestier devient un enjeu important du développement durable de la planète, comme l'a souligné la conférence de Rio en 1992. En Europe notamment, le souci de préservation et l'intérêt accordé aux fonctions non marchandes des espaces forestiers vont croissant.
La Délégation à l'agriculture, au développement et à la prospective (DADP) de l'INRA a publié en 1998 un rapport intitulé "Prospective : la forêt, sa filière et leurs liens au territoire"[1]. Cet exercice de prospective, mené en collaboration avec le Ministère de l'Agriculture (Direction de l'espace rural et de la forêt), a mobilisé une centaine de personnes : acteurs économiques de tous les maillons de la filière, administrations, élus, collectivités locales, experts... Commandée par le Président de l'INRA, cette étude avait pour objectif de fournir une base de réflexion pour l'orientation des recherches forestières de l'Institut, mais aussi pour les acteurs de la filière forêt-bois et de l'environnement et l'aménagement du territoire.

La prospective n'est ni un exercice de prévision, ni un exercice de consensus : son ambition étant de mieux préparer les décideurs à une large gamme d'éventualités, la méthode consiste à faire apparaître les enjeux socio-économiques et les hypothèses d'évolution les plus différenciés possibles, et à élaborer des scénarios "contrastés" (voire caricaturaux) de façon à susciter la discussion. Pour faciliter la lecture et le débat des acteurs sur les questions cruciales, il est préférable de limiter le nombre des scénarios.
Pour la construction de ces scénarios sur la filière forêt-bois, les hypothèses d'évolution ont été volontairement restreintes au moyen terme (horizon 2020), et l'accent a été mis sur les problèmes internes de la filière, ceux sur lesquels elle peut agir, plutôt que sur les facteurs externes.

De l'identification des enjeux...

L'accroissement de la ressource française
En France, la place de la forêt n'a cessé de croître depuis deux siècles, avec une accélération sensible après la seconde Guerre mondiale, liée à la déprise agricole. Cette progression, d'environ 4 Mha en 50 ans, s'est faite principalement au profit de la forêt spontanée, mais 800 000 ha de terres agricoles ont été plantés dans le cadre du Fonds forestier national. Aujourd'hui, la croissance de la surface forestière est d'environ 25 000 ha supplémentaires chaque année.
La production de la ressource, du fait de cette extension et des efforts accomplis par les propriétaires forestiers, est en pleine croissance : au cours des 10 dernières années, la production biologique s'est accrue de 12 à 15%. Elle est de l'ordre de 85 Mm^3 par an et dépasse donc la récolte forestière, qui s'élève à 35 Mm^3/an auxquels il faut ajouter 15 Mm^3/an de bois de chauffage hors circuits commerciaux. L'exploitation de cette ressource sur pied qui s'accumule constitue un enjeu majeur sur le plan économique puisque les retards d'exploitation peuvent compromettre la qualité du bois, mais aussi sur certains plans écologiques.

Le déficit chronique du secteur
Si l'on part maintenant de la consommation apparente finale de bois, on constate qu'elle est environ de 60 millions de m^3 par an (1 m^3 par habitant). Du fait de la concurrence avec d'autres matériaux, sa progression n'est que de 1,5% par an environ. La forte progression de la récupération et du recyclage couvre aujourd'hui plus d'un quart de ces besoins. Les besoins en bois bruts s'élèvent donc à 45 Mm^3, dont les trois quart seulement sont assurés par les 35 Mm^3/an de la récolte intérieure.
La filière forêt-bois française souffre donc d'un déficit structurel en volume correspondant à environ un quart des besoins en bois brut, principalement dans la filière bois de trituration où existent de fortes importations nettes (pâtes à papier notamment). Ce recours aux importations n'est pas compensé par les exportations dans d'autres domaines, puisque l'on constate un solde constamment négatif de la balance commerciale oscillant entre -15 et -25 milliards de francs depuis 1975.
Ces constats posent la question d'une relative non-adaptation de la forêt française aux besoins de l'industrie.

Les problèmes de compétitivité de la filière bois française
La filière est confrontée, outre la concurrence inter-matériaux, aux possibilités d'importation de bois tropicaux et de bois provenant du nord et de l'est de l'Europe, ayant des qualités spécifiques et un rapport qualité/prix intéressant. Dans ce contexte, les industriels estiment qu'en France, la faible intégration de la filière et la dispersion de l'offre de matière

première (due à l'exiguïté des propriétés forestières, à la taille des scieries et au fonctionnement atomisé de la mobilisation du bois) génèrent des coûts d'exploitation et de transaction trop élevés. Au-delà du prix excessif du bois rendu usine, ils soulignent la disproportion entre la taille des lots offerts et les quantités requises pour des unités industrielles, un manque d'homogénéité des lots, un manque de sécurité et de régularité dans l'approvisionnement. Les industriels signalent également un problème de qualité de la ressource française : qualité des essences mais aussi du bois en rapport avec la sylviculture (ébranchage et problème des noeuds, par ex.), problèmes au séchage.

Quelques chiffres clés

La forêt française :
- 16 millions d'ha en métropole, soit 25% du territoire ; et 8 Mha outre-mer (Guyane essentiellement)
- 0,3% en surface de la forêt mondiale ; 13,7% de la forêt de l'Europe des 15 (25% de celle des 12)
- près de la moitié des surfaces en taillis ou taillis sous futaie ; près de 2/3 en feuillus ; moins de 30% des surfaces sont en peuplements monospécifiques
- 74% de forêt privée, 16% de forêts communales, 10% de forêt domaniales
- 2/3 des 3,7 millions de propriétaires forestiers possèdent moins d'un ha ; 1% des propriétaires possède plus de 25 ha et détient 45% des surfaces
- récolte annuelle de 35 Mm^3 (+ 15 Mm^3 de bois de chauffage n'entrant pas dans les circuits commerciaux)

La filière bois :
- un chiffre d'affaires (HT) de 230 Md F, réparti entre exploitation forestière (3%), sciages (9%), panneaux (10%), menuiseries et parquets (14%), ameublement (30%), pâte à papier (6%), papiers et cartons (28%)
- près de 38 000 entreprises, dont près de 95% de moins de 20 salariés
- 262 000 emplois salariés en entreprise hors commerce et bâtiment, dont 73% en entreprises de plus de 20 salariés
- environ 550 000 emplois salariés et non salariés au total (commerce et bâtiment inclus).

La diversification des fonctions de la forêt

Les préoccupations environnementales et les demandes liées au développement d'une “société de loisirs” conduisent à une diversification des fonctions attendues de la forêt. Cette “multifonctionnalité”, variable selon les régions et les contextes locaux, recouvre à la fois des activités économiques, comme la chasse et la récolte des champignons, et des fonctions non marchandes, comme la préservation de la diversité biologique, la protection des sols et des eaux ou l'accueil du public.

Si l'importance écologique, sociale ou économique de ces diverses fonctions est désormais reconnue, la vente de bois reste souvent, à côté de la chasse et de la cueillette, la principale source de revenus permettant l'entretien pour les propriétaires forestiers.

Le poids croissant de la question environnementale

Les acteurs économiques s'alarment d'une demande environnementale croissante, se traduisant par un niveau de contraintes accru en matière d'exploitation, voire un gel de certaines surfaces forestières. Ces contraintes sont vues comme un facteur de renchérissement du bois, mais aussi d'inadaptation de la ressource aux besoins (trop petite taille et hétérogénéité des lots liées aux objectifs de biodiversité, manque de conifères - dû à l'engouement pour les feuillus). Cette prise en compte de l'environnement se traduit également par la mise en place d'une réglementation de plus en plus contraignante sur les traitements appliqués lors de la transformation du bois.

Cette question environnementale joue à différents niveaux : Au niveau international où, suite à la Conférence de Rio, des enjeux commerciaux majeurs apparaissent autour de l'éco-certification, dont les incidences sur le marché pourraient être très importantes. A l'échelle locale, où l'on observe le poids croissant de divers groupes de pression allant parfois jusqu'à la demande d'une forêt “naturelle” non exploitée, ce qui n'est pas toujours la meilleure façon d'obtenir les fonctions environnementales attendues.

Le contexte européen

L'Europe des 15 ne représente que 2,8% des surfaces mondiales en forêts denses, mais fournit environ 15% de la production mondiale de bois d'industrie. Elle constitue surtout l'un des premiers marchés de consommation. Malgré une exploitation importante, les ressources s'accroissent et l'Europe conserve un potentiel de récolte supérieur à ceux de l'Asie ou de l'Amérique du Nord. La balance commerciale de l'Union Européenne reste cependant déficitaire dans ce secteur. S'il n'existe pas à proprement parler de politique communautaire de la forêt, on assiste à la mise en place de règlements ou de directives, et à l'accroissement des financements européens au travers de programmes spécifiques. L'entrée dans l'Union de la Suède et la Finlande, acteurs majeurs au plan mondial, constitue un élément déterminant pour la structuration du secteur, de même que l'avènement de la monnaie unique. La perspective de l'élargissement aux pays de l'Est, constitue à la fois une chance pour l'Europe d'acquérir un poids plus important et un risque concurrentiel pour les autres filières nationales.

… à la formulation de 2 "axes" d'évolution

A l'issue du débat organisé par l'INRA entre une centaine d'acteurs de la filière ayant travaillé pendant plus d'un an dans des “ateliers de prospective”, deux questions structurantes ont été dégagées :

- Le bois restera-t-il la production principale de la forêt française ?
- La production de la forêt française, et surtout la mobilisation de la ressource, resteront-elles compatibles avec l'évolution de l'industrie, et en particulier avec les besoins de la deuxième transformation ?

La formalisation rigoureuse de ces deux questions a abouti à la définition de deux “axes” servant de base à la définition de la grille de scénario (voir schéma).

L'axe Bois / Non-bois : Quelle orientation politique pour l'usage de l'espace forestier ?

Cet axe porte sur la finalité de l'espace forestier, sur les orientations souhaitées pour la gestion de cet espace par le politique et/ou par la société.

L'option “Bois” correspond à la situation où la production de bois reste la fonction orientatrice principale, la fonction organisatrice de la gestion forestière. Cela ne signifie pas que l'on attende pas de cette gestion, secondairement, d'autres fonctions.

L'option “Non-bois” correspond à la situation où ce sont au contraire les autres fonctions (environnement, aménagement, accueil…) qui deviennent les fonctions principales. Cela ne signifie pas que le bois n'est plus exploité du tout.

L'axe Bois/Non-bois est un axe politique, qui traduit le but poursuivi objectivement par le fonctionnement des institutions, et non la réalité par ailleurs du fonctionnement de l'espace forestier. Ainsi, les institutions peuvent poursuivre l'orientation Bois, alors que dans la réalité du fonctionnement de l'espace forestier, c'est l'orientation Non-bois qui domine, et *vice versa*. C'est le degré de liberté du politique.

Bien que le bois soit encore dans beaucoup de cas la seule production susceptible de rémunérer l'entretien forestier, l'option Non-bois a été considérée sérieusement. Celle-ci est en effet portée par plusieurs phénomènes de fond : la demande par une population en majorité urbaine d'un accès d'usage au territoire rural ; l'artificialisation croissante de l'espace agricole et le report de la demande d'espace naturel sur la forêt ; l'existence de craintes réelles (fondées ou non) pour les équilibres globaux de la planète.

L'axe Découplage / Non-découplage : Quels rapports économiques dans la filière entre forêt et industrie ?

Ce second axe porte sur l'organisation et le fonctionnement de la filière forêt-bois, c'est-à-dire sur des évolutions économiques et technologiques, et non plus sur une orientation politique.

Dans la situation “Découplage”, les besoins de l'industrie (quantité, qualité, régularité, coûts) ne sont pas satisfaits à un niveau suffisant par un approvisionnement provenant de la forêt française. Dans cette situation de recours croissant aux importations, la “grosse industrie” peut finir par se délocaliser. La question est alors de savoir si la forêt française trouve d'autres débouchés pour ses bois (export, meubles, niches haute technologie) ou pour ses autres fonctions (tourisme), et donc les moyens d'un entretien minimum.

Dans la situation “Non-découplage”, les besoins de la “grosse industrie” sont supposés couverts à un niveau suffisant, ce qui la fixe sur le sol national, avec ses emplois et sa valeur ajoutée (beaucoup plus forte dans l'industrie que dans l'exportation de grumes).

Le Découplage en question est analysé à partir de la demande de l'industrie, et non de l'offre forestière : dans la définition adoptée, il y a découplage si l'industrie ne trouve pas une fourniture adaptée à ses besoins en France, et non si la forêt ne trouve pas de débouché pour ses produits, ce qui est différent.

Le Découplage vis-à-vis de la “grosse industrie” n'exclut pas qu'une “petite” industrie du bois locale, accrochée au terrain et rendant d'autres services territoriaux, puisse subsister. Encore faut-il alors envisager de compenser le déficit financier des scieurs qui ne peuvent plus valoriser leurs importants déchets auprès de la filière de la trituration.

Le découplage est la tendance “normale”, en ce sens que l'évolution des structures (parcellaire, essences…) de la forêt française est normalement beaucoup plus lente que la concentration accélérée que connaît l'appareil de production industrielle sous la pression de la concurrence et des fusions mondiales. Rappelons qu'en France, les industries ne possèdent qu'exceptionnellement leurs ressources forestières.

Le non-découplage est cependant possible, au prix d'une action volontaire “contre-tendancielle” des acteurs de la filière forêt-bois.

Ainsi, si le premier axe porte sur le débat entre les acteurs de la filière forêt-bois et le reste de la société concernant les usages de l'espace forestier, le second renvoie les acteurs de la filière forêt-bois à leur propres questions d'organisation, un débat ne devant pas occulter l'autre.

La grille des quatre scénarios

Le croisement de ces deux axes, l'un politique, l'autre économique, détermine quatre scénarios, qui présentent l'avantage d'être clairement alternatifs, puisque résultant d'hypothèses complémentaires, mais qui sont contigus (voir schéma). Cette contiguïté permet de s'interroger sur les conditions du passage d'un scénario à l'autre : en outre, les axes mettent en relief des “variables de commande”, variables sur lesquelles on peut agir, et non des variables d'état (surfaces, etc.) que l'on ne peut que constater.

Scénario I (Bois / Découplage) : le scénario “tendanciel instable”

Dans ce scénario, on part de la forêt, comme productrice de bois, sous contrainte multifonctionnelle (contraintes environnementales et territoriales), et l'on vise avant tout à valoriser cette ressource bois. On est bien dans l'orientation Bois, mais on ne s'intéresse pas directement aux conditions du maintien de l'industrie (celle de la deuxième transformation du moins). Le risque de Découplage existe bien.

Forêt et industrie vivent ici de plus en plus séparées : le pôle forêt, ignorant l'industrie, cherche avant tout à valoriser au mieux et à court terme ses plus belles grumes ou des sciages, en particulier à l'export, comme elle le fait déjà actuellement ; l'industrie se tourne elle de plus en plus vers l'importation, qui lui permet d'acquérir des lots importants, bien adaptés à ses besoins, et au meilleur cours mondial.

Dans la phase de stabilité de ce scénario, le territoire forestier continue à être géré assez activement, puisqu'il est exploité, du moins pour les futaies. Les choses sont plus problématiques pour les taillis. Sur le plan économique, on assiste à une décroissance lente mais certaine des emplois dans l'aval de la filière, avec la fermeture ou la délocalisation partielle d'entreprises. L'amont n'est pas forcément épargné, les scieries souffrant de la disparition des débouchés pour leurs chutes et déchets. Enfin, le bois d'oeuvre, et même le

bois noble, ne sont pas à l'abri de la concurrence étrangère.
Ce scénario semble être fondamentalement instable à moyen terme. Un premier germe de rupture réside dans les risques de délocalisation des industries du bois ; ces risques sont accrus par le phénomène récent (années 90) d'internationalisation du secteur en France et la quasi-disparition des sociétés françaises dans l'aval de la filière ; leur rachat, par des sociétés scandinaves ou nord-américains, qui correspond avant tout à des rachats de parts de marché, ne garantit pas leur maintien sur le sol français lorsque les outils de production seront obsolètes et amortis.
Autre facteur d'instabilité de ce scénario : le jour où, du fait de la tendance au découplage et du départ d'une partie de l'industrie, le bois (qui en majorité, n'est pas du bois noble : taillis, chêne “moyen”…) aurait des difficultés à s'écouler, il perdrait cet avantage, incontestable sur les “autres fonctions”, d'être rémunérateur et de permettre l'entretien de la forêt à titre non onéreux ; rien ne s'opposerait alors au basculement brutal, au sein de la société et de ses instances, de l'orientation Bois vers l'orientation Non-bois.
Ce scénario “tendanciel instable” semble décrire assez bien la situation actuelle au niveau national. Associant des tendances contradictoires, Bois et Découplage, il n'est possible, temporairement, que si le découplage n'est qu'une tendance.

Scénario II (Bois / Non-découplage) : Industrie et multifonctionnalité

Dans ce scénario, on part des besoins de l'industrie du bois. On est, comme dans le scénario I, dans l'orientation Bois, toujours sous contrainte multifonctionnelle. Mais il s'agit ici de produire du “bois-matière première” de l'industrie, et non plus du “bois-ressource noble” : on vise explicitement à satisfaire les besoins de la grosse industrie (y compris étrangère) installée sur le sol français, pour l'y fixer. On est alors logiquement engagé dans l'option Non-découplage, à l'opposé du scénario I.
Ce scénario suppose donc d'abord que la tendance au découplage puisse effectivement être contrée, dans les conditions françaises, par des mesures permettant une meilleure intégration de l'ensemble forêt-industries. Plusieurs types d'interventions sont envisageables : depuis la réforme “douce” de certaines pratiques (passer du système actuel de vente annuelle de bois sur pied à la vente du bois bord de route, créer des centres de tri du bois, contractualisation entre acteurs…), jusqu'au développement de liens en capital, ascendants ou descendants, entre propriété forestière et industrie...
Ce scénario suppose également qu'une gestion multifonctionnelle soit effectivement compatible avec la fourniture de lots adaptés à l'industrie. Or la compatibilité entre les différents objectifs (par exemple la biodiversité, qui demande un mélange des essences, et une exploitation rentable du bois...) n'est pas évidente. La faisabilité d'une telle gestion multifonctionnelle dépend beaucoup en définitive du niveau d'exigence de chaque acteur sur chaque fonction, et de la sévérité du législateur dans la fixation des contraintes.
Ce scénario II permet le maintien, voire le développement de l'emploi. Son financement ne pose pas de problème, et l'activité de la filière, répartie sur l'ensemble du territoire, à la différence du scénario IV, assure spontanément, dans le respect de contraintes réglementaires praticables, l'entretien de l'essentiel de la forêt à titre non onéreux. Scénario le moins coûteux pour la collectivité, et multifonctionnel en principe, il est souhaité par de nombreux acteurs, notamment les élus locaux.

Scénario III (Non-bois / Découplage) : le “tout territorial”

Dans ce scénario, on part du territoire, et de la forêt comme un de ses éléments essentiels, productrice avant tout d'un bouquet “d'autres fonctions”, environnementales et territoriales, et non de bois.
On est donc clairement dans l'orientation Non-bois. On est aussi dans l'option Découplage : plus la gestion Non-bois se confirme, et plus le Découplage d'avec les besoins de l'industrie s'accentue. Inversement, plus le découplage s'accentue, moins la production de bois apparaît comme source essentielle de revenu et d'entretien de la forêt, et plus l'option Non-bois peut triompher. Les deux critères, Non-bois et Découplage se renforcent ici l'un l'autre, à la différence du scéanario I, et l'on entre dans une spirale.
Sur le plan social, on aboutit à un relatif effondrement de la filière bois, y compris dans le sciage et le bois d'œuvre, avec une forte régression de l'emploi dans la filière, baisse qui n'est probablement que partiellement compensée par les créations d'emplois liées aux nouveaux usages de la forêt, puisqu'ils sont dans leur majorité “non marchands”.
Sur le plan territorial, la levée de la contrainte bois ne règle toutefois pas le problème de la faisabilité de la multifonctionnalité et de ses nombreux conflits d'usages (chasse, réserve de biodiversité, espace public...), tel qu'évoqué dans le scénario II. Il peut devenir en outre difficile d'écouler correctement le bois issu de la réalisation même des “autres fonctions”.
Le problème principal de ce scénario est celui du financement de son fonctionnement : la forte baisse de la pression d'exploitation et de la valeur ajoutée créée par la filière fait que la forêt “ne s'entretient plus elle-même”. Deux sous-scénarios sont alors envisageables. Le premier consiste à recourir à un financement par des fonds publics : impôt direct (national ou local), taxe spécifique (prélevée par exemple sur les activités émettrices de CO_2, circulation automobile et industries polluantes...), ou taxe locale (sur les activités bénéficiant de la forêt, notamment le tourisme). Le second accepte l'abandon de l'entretien et le retour à de vastes espaces naturels ; cette option pose toutefois un certain nombre de problèmes sur le plan environnemental (seule une forêt en croissance stocke le CO_2...) et de l'aménagement (la mise en valeur du patrimoine exige un certain entretien).

Scénario IV (Non-bois / Non-découplage) : des forêts spécialisées

Dans ce scénario, on part de fonctions spécialisées, produites par des forêts spécialisées, sur des espaces disjoints et spécialisés. “La” forêt n'est plus considérée comme un territoire global. Dans ce scénario, sur une petite partie du territoire forestier (moins d'un tiers), c'est une fonction bois spécialisée et relativement intensive qui est privilégiée, et qui suffit à satisfaire les besoins de l'industrie : il y a donc Non-découplage. Sur la plus grande partie du territoire forestier, ce sont cependant les “autres fonctions” qui dominent : globalement, l'orientation choisie est Non-bois.

C'est d'abord la fonction production de bois qui se sépare, mais dans l'esprit de ce scénario, à terme, c'est l'ensemble forestier qui éclate, y compris pour les “autres fonctions”, en forêts spécialisées, avec chacune sa gestion spécialisée (forêts de loisir, d'habitat, de protection des nappes, etc.).

Ce scénario de la séparation des espaces et des fonctions présente l'avantage de la simplicité pour les gestionnaires directs, qui n'ont plus à se soucier de concilier des objectifs contradictoires. Mais il reporte en fait la complexité de la gestion à l'échelon de l'Etat, qui devient l'assembleur de ces différentes fonctions - séparées - dans l'espace, s'il veut sauvegarder un minimum de multifonctionnalité à des échelles plus globales. Une telle fonction d'assemblage est d'autant plus complexe, et coûteuse à mettre en oeuvre, que la maille territoriale devant conserver la multifonctionnalité est choisie petite et que le niveau d'exigence pour chaque fonction est choisi élevé.

Le financement du scénario ne pose pas les problèmes relevés pour le scénario III. Le maintien d'une forte industrie du bois sur le sol national offre des débouchés aussi au bois sorti des forêts extensives. Le maintien de l'emploi et des recettes de l'Etat en provenance du secteur autorisent des transferts publics vers le secteur extensif.

Enfin, ce scénario de la spécialisation fonctionnelle est peut-être celui où des fonctions aujourd'hui “non marchandes” pourraient au contraire le devenir à terme. On peut alors s'interroger sur le devenir des forêts éloignées des villes et des investisseurs.

Les conséquences pour la recherche

Ces quatre scénarios fournissent à la recherche publique un cadre de réflexion stimulant, parmi d'autres, quant à l'évolution de ses fonctions et des recherches à développer face aux virages que peut nous réserver l'avenir.

Certaines orientations, comme les approches écosystémiques des peuplements forestiers, la connaissance et la conservation des ressources génétiques, la sylviculture des peuplements hétérogènes, les travaux en économie et politique de la filière... semblent rester pertinentes dans toutes les hypothèses. Mais au-delà, chaque scénario requiert de la recherche des fonctions et des problématiques particulières.

Dans le scénario I, la recherche doit contribuer à valoriser la ressource française, plus que s'occuper de la filière industrielle. Elle doit donc s'intéresser au fonctionnement de forêts semi-naturelles et à leur gestion dans une optique multifonctionnelle, et accorder une attention particulière à la production de bois d'oeuvre de haute valeur et à la recherche de débouchés à l'exportation (qui demande des analyses des marchés internationaux).

Dans le scénario II, l'objectif est d'adapter la ressource et d'offrir un appui aux industries de la filière créatrice d'emploi, quelle que soit leur nationalité. Cette option demande la mise au point d'outils pour améliorer le fonctionnement de la filière et la gestion (plus ou moins intensive et multi-usage) des différents types de forêt. Les recherches sur le matériau bois deviennent prioritaires.

Dans le scénario III, il s'agit de gérer des surfaces très extensifiées. La demande à la recherche porte alors sur l'évolution spontanée des peuplements, sur la mise au point d'une sylviculture minimale permettant de protéger la forêt (contre les incendies par ex.) et de l'adapter à différentes fonctions non marchandes ou d'intérêt collectif, sur les modalités de financement de ces fonctions et sur la place de la forêt dans l'aménagement du territoire.

Dans le scénario IV, la recherche se voit attribuer une difficile double mission : le développement d'une sylviculture très intensive correspondant à la demande de l'industrie, et le développement d'une sylviculture non marchande très extensive. Le premier point exige un effort particulier dans la création (y compris par génie génétique) de variétés adaptées à des usages industriels spécifiques, dans la conduite des peuplements intensifs (amélioration de la fertilité des sols, maîtrise des problèmes phytosanitaires...) et dans l'étude de la rentabilité des investissements forestiers. Le second rejoint les problématiques évoquées pour le scénario précédent.

Enfin, les questions posées par le passage d'un scénario à un autre nécessitent de développer les recherches sur les phénomènes de transition, tant sur le plan économique et politique que biologique (conversion d'un peuplement forestier à de nouvelles fonctions).

• (1) INRA-DADP, 1998. Prospective : la forêt, sa filière et leurs liens au territoire. Tome 1. Synthèse et scénarios. Répercussions pour la recherche (257 p.) ; Tome 2. Rapport des ateliers (130 p.). Sous la direction de M. Sebillotte. Rapporteurs : B. Cristofini, J.F. Lacaze, A. Messéan, D. Normandin.

Contact

• Délégation permanente à l’agriculture, au développement et à la prospective (DADP), INRA - Paris

Grille des scénarios

	Découplage **Forêt / Industrie** *LOGIQUE = TERRITOIRE*	**Non-découplage** **Forêt / Industrie** *LOGIQUE = FILIERE*
Bois **+** **Multifonction** ***OBJECTIF*** ***=*** ***VALORISATION DU BOIS***	**Scénario I :** **Sc. "tendanciel instable"** . Au 1er plan : la ressource forestière . Attentes / forêt : fonction bois, sous contrainte multifonctionnelle dans une approche territoire global . Forêt : bois d'oeuvre et vente de grumes, export croissant . Industrie : import croissant de bois adapté et peu cher . Risque : à terme, perte du débouché bois d'industrie, et délocalisation de certaines fonctions de production ?	**Scénario II :** **Sc. "industrie et multifonctionalité"** . Au 1er plan : la fixation d'industries, d'emplois et de valeur ajoutée . Attentes / forêt : fonction bois, sous contrainte multifonctionnelle dans une approche filière . Exploitation pour le bois de l'ensemble de la forêt, sous contraine multifonctionnelle . Plantations accrues de peupliers et résineux . Exploitation notable pour le bois d'industrie . Possibilité gestion multifonctionnelle si conditions réglementaires adaptées
Non-bois ***OBJECTIF*** ***=*** ***VALORISATION DES AUTRES FONCTIONS***	**Scénario III :** **Sc. du "tout territorial"** . Au 1er plan : la fonction purement territoriale de la forêt . Attentes / forêt : autres fonctions, dans une approche territoire global . Forte régression de l'industrie . Tourisme, aménagement et cadre de vie . Mais difficulté de financement des fonctions non marchandes à grande échelle. D'où peut-être d'immences surfaces "naturelles" peu entretenues : avec recrudescence des incendies, fermeture des accès ? . Arrêt probable des plantations et de la croissance de la surface forestière (parcours, enfrichement sauvage) ?	**Scénario IV :** **Sc. des "forêts spécialisées"** . Au 1er plan : forêts spécialisées. Spécialisation des fonctions et des espaces (bois intensif / autres fonctions) . Attentes / forêt : fonctions spécialisées dont bois, dans une approche filière et territoires spécialisés . L'intégration concerne une partie seulement des surfaces, avec éventuellement des “champs de bois” intensifs et adaptés à la demande industrielle . L'autre partie des surfaces (la plus importante) est laissée aux fonctions non marchandes strictement. Entretien toutefois possible, financé par une taxe sur la filière et une exploitation périodique

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février - mars 2000

Thematic Meeting organised in the framework of
the EU project QLK5-CT-2002-30221 'IMACFORD'

"Future changes and innovations in Forest Management: implications for research"

18/ 19 October 2002
Lousã, PORTUGAL

Friday 18 October - 9 am to 6 pm IMACFORD

Item 1 Presentation

9:00 Overview of IMACFORD project - Presentation of Task B1 : objectives, organisation and planning (thematic groups and regional workshops)
Jean Michel Carnus, Director of INRA Pierroton

Item 2 Prospective on forest management trends

Discussion on trends for alternative forest scenarii within IEFC regions for key species on the innovation and multifunctional point of view

9:15 Methodology proposed for the discussion on prospective forest scenarios
Antoine Colin, IEFC

9:30 Trends for forest management under changing context in Portugal
Américo Mendés (UCP)

9:50 Trends for forest management under changing context in Spain
Inazio Martinez de Araño, NEIKER and Francisco José Lario Leza (Tragsa)

10:10 Trends for forest management under changing context in Aquitaine, France
Jean Michel Carnus, INRA

Item 3 Technological innovation in forest management, links with other forest disciplines

3a) Models for sustainable forest management

11:20 Models for forest management, from research to sustainable forest practices
Margarida Tomé (ISA)

12:00 Technological innovation in forest management: links with wood quality issues
Guillaume Chantre, AFOCEL

13:00 – 15:00 Lunch

Item 4 Impacts in terms of forest sustainability
Discussion on the impacts of changes conditions identified during the morning session

4a) Changes context, silvicultural practices and ecological parameters of SFM

15:00 Possible impacts on biodiversity and perspectives
Hervé Jactel, INRA

Possible impacts on forest health and perspectives
Hervé Jactel, INRA

15:20 Possible impacts on soil fertility and perspective
Agustin Merino, University of Lugo

4b) Changing context and socio-economic parameters of SFM

15:40 Possible impacts of forest management practices on the economic point of view
Américo Mendés, Catholic University of Porto

General discussion about impacts of forest practices on ecological and socio-economic parameters of SFM.

Item 5 Implications of those issues for research in forestry

16:30 -18:00 Discussion on the scientific knowledge needed in order to improve SFM under the changes parameters identified below.

5a) Discussion on interregional research priorities (main fields of interest)
5b) Proposition of research questions (research areas and scales)

Saturday 19 October - 9 am to 12.30 pm IMACFORD

Item 6 Technical session on the following steps of IMACFORD project
Preparation and agenda of the future meetings

Closure of the IMACFORD meeting

Prospective on forest scenarii for Aquitaine

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1

Historical regional perspective

- stability of forest area in the past century
- regional multifunctionnality and diversity
- spatial distribution of main functions
- co-evolution forest < > wood industry: paradigms (resin > timber > EWP?)
- environmental changes (ex: groundwater)
- dynamic forestry and changes in productivity

2

from today forest scenarii ...

- « resin » regime.. ➡ > 60 yrs - sowing - 110 cm - 220 stems/ha
- semi-intensive sawing regime.. ➡ < 50 yrs - sowing or planting - 95 cm - 400 stems/ha
- intensive regime... ➡ 40 yrs - planting - 85 cm - 400 stems/ha

maximal production of good quality sawing timber within the shortest time compatible with ecological constraints

3

.....future climate

- increase in GG concentrations and changes in rainfall distribution, temperatures... regional climatic scenarii
- more extreme climatic events
- changes in atmospheric depositions and fertility
- impacts on living communities and biodiversity

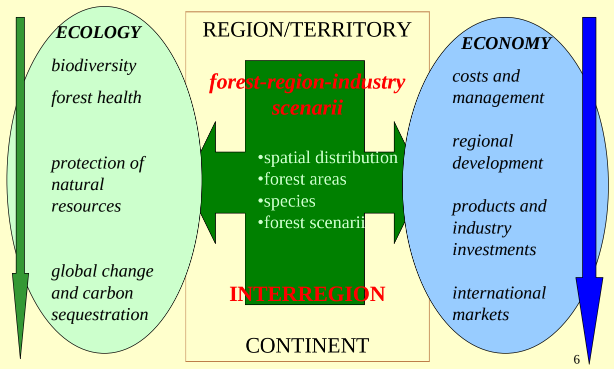
4

... future society needs

- urbanisation and increased demand for ecological services /non wood products
- market demand for wood based products
- ecocertification procedures and increased role of wood as a strategic ressource
- share of information and informed decision

5

....future global context



6

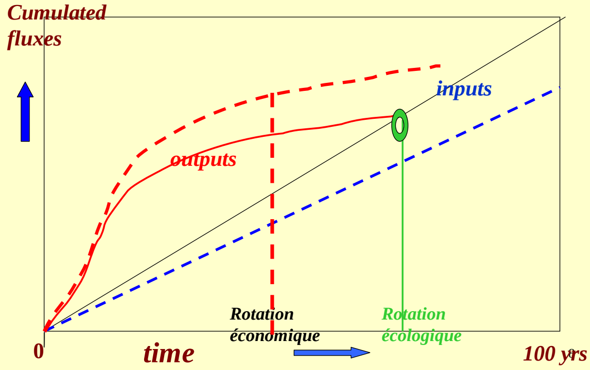
to tomorrow forest scenarii

coupled model/wood function dominant

- specialised forestry areas *(« charts for forested territories »)*
- increase in planted forest areas
- alternative species (*Pinus taeda, eucalypts*..)
- flexible forestry scenarii for wood production *(biomass production to quality timber)*
- new silvicultures for recreation or protection *(CCF,carbon sequestration, biodiversity maintenance)*

7

Scénarii sustainability



Thematic Meeting
FUTURE TRENDS AND INNOVATIONS IN FOREST MANAGEMENT: IMPLICATIONS FOR RESEARCH
EU Project IMACFORD
CTOF, Lousã, 18-19 October 2002

AGRICULTURE AND FORESTRY TRENDS IN PORTUGAL

Américo M.S. Carvalho Mendes
Universidade Católica Portuguesa – Porto
Faculdade de Economia e Gestão

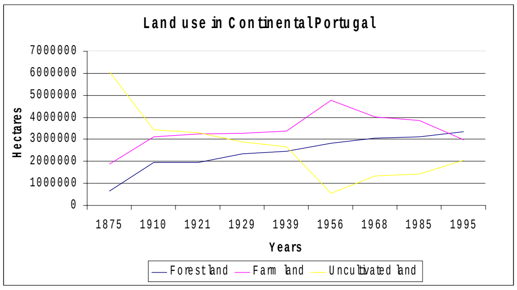
1

A LONG RUN VIEW

- Current trends in land use started in mid 50s

2

LAND USE: 1875-1995



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LAND USE: 1875-1995

- **1875-50s:**
  - Decline in uncultivated land
  - Increase in farmland and forest land
  - Some complementarity farming/forestry
- **Since 50s:**
  - Increase in uncultivated land
  - Decrease in farmland
  - Increase in forest land
  - Increasing separation farming/forestry

4

1875-1950s

- **<u>“Extensive” and “introverted” agricultural growth</u>**
  - **“Extensive” growth**
    - Increase in farmland through decrease in uncultivated land
    - Only small farm outmigration (1536000 farmers in 1890; 1523000 farmers in 1950)
    - Farm labour productivity growth
  - **“Introverted” growth**
    - Population growth (416000 inhabitants in 1878; 7920000 in 1950)
    - Growth in real income (+78,2% growht in GDP per capita between 1875 and 1950)

5

1875-1950s (cont.)

- **<u>“Extroverted” growth of forest production</u>**
  - Increase on forest land through decrease in uncultivated land
  - **Pine** forests increase
    - Public initiative (arborização da dunas e baldios)
    - Domestic market orientation
  - **Cork oak** forests increase
    - Private initiative (proprietários e industriais)
    - Export orientation:
      - Mainly non manufactured cork until the Spanish Civil War
      - Mainly manufactured cork since then

6

1875-1950s (cont.)

- **Exports in 1875:**
  - Total: 23407 contos
  - Agricultural products: 20000 contos (85,4%)
  - Forest products: 1369 contos (5,8%)
  - Export/Import ratio: agricultural and forest products (116,9%)
- **Exports in 1946:**
  - Total: 4587000 contos
  - Agricultural products: 1110544 contos (24,2%)
  - Forest products: 1189147 contos (25,9%)
  - Export/Import ratio: 50,5% for agricultural products and 1020,5% for forest products

7

SINCE 1950s

- **"Intensive", "introverted" and slow growth in farm production**
  - **"Intensive" growth**
    - Decrease in farmland
    - Decrease in farm labour force (1523000 farmers in 1950; 771300 in 1991)
    - Intensive animal production and increase in agricultutal imports (corn and soybeans for feedstuffs)
  - **"Introverted" growth**
    - Population growth (7920000 inhab. in 1950; 9327000 inhab. in 1991)
    - Growth in real income (+ 455,9% growth in GDP per capita between 1950 and 1991)
    - Income elasticities of food products between 0,5 and 0,7 in the 50s and 60s
    - Increase in demand for animal food products

8

SINCE 1950s (cont.)

- **"Extroverted"growth of forest production**
  - Increase in forest land through decrease in farmland
  - **Pine** forests decrease
    - Decline in public initiative
    - Rural outmigration and worsening in risk of forest fires
    - Exports of sawnwood for palets
  - Decrease and then increase (since mid 80s) in **cork oak** forests
    - Private initiative (forest owners)
    - Export orientation
  - **Eucalyptus** plantations increase
    - Private initiative (forest owners and industries)
    - Export orientation
  - Big change in **regional allocation of public funds** since EEC acession (shift from North to South)

9

1981-1999

REGIONAL SHIFT IN ALLOCATION OF PUBLIC FUNDS TO FORESTRY

Distribution by species of afforestation and stand improvement

	World Bank	1st EU programme	2nd EU programmes
Maritime Pine	49.3 %	34.1 %	26.7 %
Eucalyptus	28.8 %	4.9 %	0.3 %
Cork Oak	1.4 %	36.0 %	38.1 %
Other	20.5 %	25.0 %	34.9 %

10

SINCE 1950s (cont.)

- **Exports in 1981:**
  - Total: 256.913.000 contos
  - Agricultural products: 22.100.000 contos (8,6%)
  - Forest products: 46.100.000 contos (17,9%)
  - Export/Import ratio: 20,4% for agricultural products and 342,5% for forest products
- **Exports in 1999:**
  - Total: 4.647.800.000 contos
  - Agricultural products: 273.151.000 contos (5,9%) – <u>7th position</u>
  - Forest products: 489.247.000 contos (10,5%) – <u>4th position</u>
  - Export/Import ratio: 36% for agricultural products and 135,3% for agricultural products

11

FUTURE PERSPECTIVES (cont.)

- **Agriculture: need for "extroverted" growth**
  - Population growth: 0,1% per year
  - Growth in real per capita income: 2% per year
  - Income elasticity of food demand: 0,25

⇓

  - Expected growth in domestic demand for food: **0,6% per year**

⇓

  - Need to increase exports
  - Need to increase non food agricultural production
  - "Quality strategy"

12

FUTURE PERSPECTIVES (cont.)

- **Forestry**
  - "Natural" increase in forest area
  - Decrease in export/import ratio since mid 80s
  - Current system of public finance may not be sustainable after 2006
  - Opportunities to set up a better public finance system may be lost (1996 Forest Law, tax reforms, CAP Reform, etc.)
  - "New on the kids on the block": forest owners' associations
  - Forest contractors: currently having equipment in excess capacity

13

FUTURE PERSPECTIVES (cont.)

- STRONG PREDOMINANCE OF **NON INDUSTRIAL PRIVATE** FORESTRY

	TOTAL	CONIFERS	EUCALYPTUS	CORK OAK
NIPF	**76.9%**	**66.1%**	**60.3%**	**90.4%**
Communal	11.7%	26.5%	3.8%	0%
Industrial	7.6%	2.2%	35.9%	3.8%
Public	2.6%	5.2%	0%	0%
Others	1.2%	0%	0%	5.8%

14

FUTURE PERSPECTIVES (cont.)

- **HIGH RISK** OF FOREST FIRE (especially pine forests)
  - Between 1981 and 1998:
    - **877 804 ha** of forests burnt (48 767 ha/year)
    - 764 204 ha of shrublands burnt
  - MORE THAN THE AREA REFORESTED AND AFFORESTED (**820 890 ha**)

15

FUTURE PERSPECTIVES (cont.)

- FOREST STILL ONE OF THE **MAIN SECTORS** IN THE PORTUGUESE ECONOMY:
  - **2.6%** of the GDP
  - **5th** major employer (225000 workers)
  - **4th** major exporter (was 2nd for several years)

16

FUTURE PERSPECTIVES (cont.)

- **Forestry (cont.)**
- Eucalyptus:
  - Need for renovation of 4th rotation stands
  - Competition from overseas
- Pine:
  - Problems from previous period get worse
  - Need for collective organisation of forest owners to reduce the high risk of forest fires
- Cork oak:
  - Competition from synthetics
  - Some changes in location patterns for industry
  - Supply shortages
  - Vitality problems in some stands (sudden death of trees)

17

FUTURE PERSPECTIVES (cont.)

- PREDOMINANCE OF **SMALL SCALE** FORESTRY

Average size of forest holding	% total forest land
1.35 ha	6.3 %
2.3 ha	**37.6 %**
5.1 ha	**22.8 %**
12.3 ha	8.2 %
86.3 ha	25.1 %

18

FUTURE PERSPECTIVES (cont.)

- Forest and rural development is essentially an **organisational and human resource issue**: who is going to take care? With whom?
- Opportunities and need for **voluntary collective action forms** (forest owners associations and others)
  - "Extroverted" growth
  - "Quality strategy"
  - Land ownership distribution
  - Increasing separation farming/forestry
  - Risk of forest fires
  - Absenteeism problem
  - Multifunctionality problem
  - Increasing "environmentalisation" of public policies
  - Increasing outsourcing of public functions
  - CAP Reform (decoupling)
  - Conservation value: willingness of the owner to pay for conservation of his property

FUTURE PERSPECTIVES (cont.)

- **How?**
  - Joint provision of public goods and **private services**
  - **What kind of private services**?: technically and economically complementary of forest owner's activity on the forest and farm holding (**"conservation" motive**)
  - **What kind of private services**: opportunities for **complementary "specialisation"** (within the same forest and farm holding): "intensive" forest management + "conservative" land management

FUTURE PERSPECTIVES (cont.)

- **But ...**
  - "Natural" extensification (spontaneous forests) and "natural" degradation (fires); need for **conservation of the resource**
  - Also need for **"conservation" of industrial base** (keep forestry/industry coupling)
  - Breakdown of **total economic value** of forest production (1998 prices)
    - Wood: 29,9%
    - Cork: 26,6%
    - NWFP: 33,0%
    - Indirect use value (carbon storage, watershed management): 5,8%
    - Conservation value (to owners and others): 4,7%

FUTURE PERSPECTIVES (cont.)

⇓

"Fragmented" and "regionally differentiated"

industry & multifonctionality scenario

(pine, eucalyptus, cork oak)

- Increase in "spontaneous" and planted forests (eucalyptus, cork)
- More broadleaved species (aesthetic value)
- Grazing (if CAP payments for moutain areas and livestock remain)
- Recreation, hunting

FUTURE PERSPECTIVES (cont.)

- **But ...**
  - **Forest income:**
    - Very weak **profit motive**
    - Highly concentrated **income distribution**:
      - Only for the size classes above **50 ha** forestry might generate an income equal or above the salary of a worker with an elementary school educational level
      - This corresponds to **1% of the number of NIPFO**, **61% of the total forest area of NIPFO and 80,3% of the value** of total forest production of NIPFO

FUTURE PERSPECTIVES (cont.)

- **But ...**
  - **"Fragile equilibrium" problem**:
    - weak (but non zero) forest owners' willingness to pay for intensive management (mainly "conservation" motive) + "fragmented" local awareness (special interests of local authorities, firemen associations, etc.) + no long term commitment from the Central Government
    - High risk of loss from forest fires and other risks
    - Increasing opportunity costs for forest management
  - **"Critical mass" problem**: absence of sufficient critical mass at local level for sustained and good leadership

Models for forest management from research to sustainable forest practices

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- **Forestry**
  - Forestry is the science, art, business, and practice of conserving and managing forests and forest lands to provide a sustained supply of forest products, forest conditions, or other forest values desired by the forest owner and the society in general

    (Ford-Robertson, 1971)
- **Forest management**
  - Forest activities imply decisions about the relationship between man and the forest, in particular about the way man modifies the forest in order to achieve its objectives - forest management

---

- Forest management occurs at different scales of spatial resolution:
  - stand
    homogeneous forest area
  - management unit
    set of stands with a common management plan
  - watershed
  - region
  - country
  - continent
  - globe

Foresters and private owners (stand, management unit)

Politicians and public administrators (region, country, continent, globe)

- Growth models and decision support systems
  - To support decision-making forest resources administrators (politicians, public and private land administrators, foresters, etc) require sound predictions on the evolution of the forest under alternative management actions
  - Growth models and decision support systems help the users to define the set of actions that optimise their objective goals and criteria

Stand →	Growth models
Management area →	Decision support systems
Landscape →	Decision support systems

EVOLUTION OF FORESTRY

- Development of forestry (Kimmins, 1997)

	Stage of development	Result
Preforestry	Exploitation ↓	→ Resource depletion
Forestry stage 1	Administrative forestry ↓	→ Failure to achieve conservation and sustainability goals
Forestry stage 2	Ecologically based forestry ↓	→ Sustained production of timber and other conventional products
Forestry stage 3	Social forestry	→ Ecologically based forestry that sustains a wide range of forest conditions and values desired by society

Increasing information needs (Lund & Smith, 1997)

- The information requirements of the forest resources administrators increased in parallel with the development of forestry

1950's	1960's	1970's	1980's	1990's	2000's
Timber	Timber	Timber	Timber	Timber	Timber
	Multiple resources	Multiple resources	Multiple resources	Multiple resources	Multiple resources
		Biomass	Biomass	Biomass	Biomass
			Global warming	Global warming	Global warming
				Ecosystems, biodiversity, non-wood products	Ecosystems, biodiversity, non-wood products
					Other´s lands?

Sustainable forest management:

- The stewardship and use of forests in a way, and at a rate, that maintain their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems

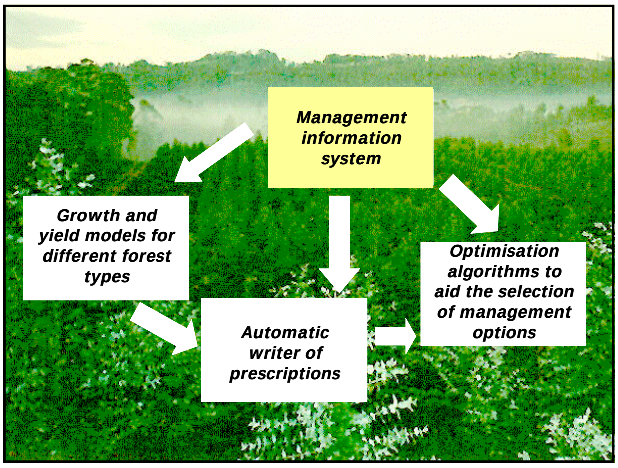
source: MCPFE, 2000

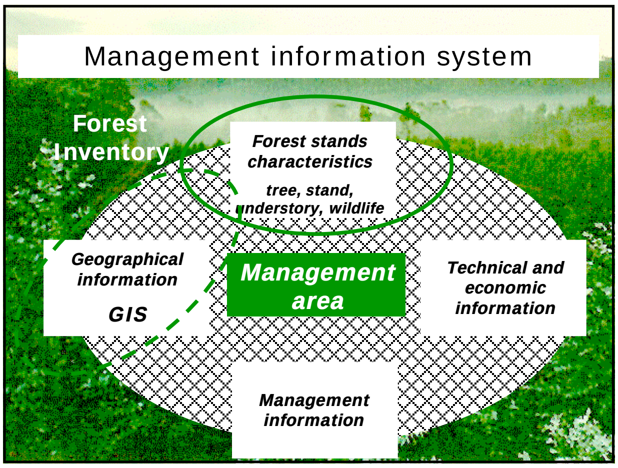
Pan-European criteria and guidelines for sustainable forest management (Lisbon Conference, 1998):

Maintenance and enhancement of ...

1. Forest resources and their contribution to global carbon cycles
2. Forest ecosystem health and vitality
3. Productive functions of forests (wood and non-wood)
4. Biological diversity in forest ecosystems
5. Protective functions in forest management (soil and water)
6. Socio-economic functions and conditions

DECISION SUPPORT SYSTEMS

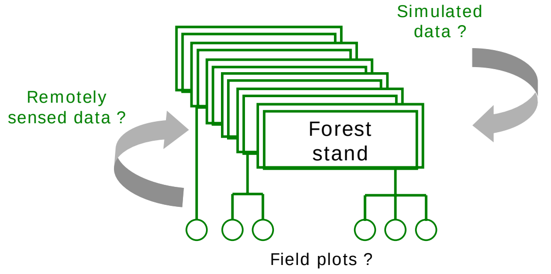




THE NEEDS OF FOREST MANAGEMENT UNDER CHANGING CONTEXT

- Problems with Forest Inventory methodologies used at present:
  - Information is usually not available for every stand in the management area

Information for each stand – how?



- Problems with Forest Inventory methodologies used at present:
  - Information is usually not available for every stand in the management area
  - Present forest inventories focus mainly on the production functions of forest
    - Can multiple functions of forest functions – biodiversity, recreation, carbon sequestration, species mixtures, etc – be assessed on the basis of the sampling scheme that is used for volume assessment?
    - NO!

- The need for more intensive data collection on Forest Inventory methodologies used at present:
  - Other information than just on trees
  - Vertical structure of the stand
  - Herbal plants, bushes
  - Soil information (essential for carbon sequestration assessment)
  - Data to be used for modelling

- The need for new approaches for multi- resource inventory
  - Adaptive cluster sampling for assessment of rare species
  - Ranked set sampling for point-to-plant distances assessment
  - The use of modelling (e.g. habitat modelling, site productivity modelling)
  - The use of hyperspectral data for classifying tree species
  - Landscape indices (area metrics, patch density metrics, edge metrics, etc)

see *e.g.* (Köhl, 2001)

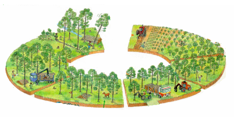
- Problems with growth models used at present:
  - Presently used models (empirical models)
    - do not allow for the simulation of forest growth under a changing environment
    - concentrate output on the development of trees (do not give output on the impact of forests and forest management on soils and water use, on biodiversity, etc)
    - Do not simulate the impact of genetic improvement
  - Process based models
    - do need too much input data, usually not available from forest inventory
    - do not give all the output needed for forest management

- What do we then need?
  - We need a "mariage" between empirical and process based models in order to obtain hybrid models that
    - can work using forest inventory data as input, even if forest inventory data is slightly intensified
    - simulate the effect of global change on tree and stand growth
    - provide information of the effect of different silvicultural alternatives not only on tree growth but also on other forest uses
  - The question that remains:
- Is that possible?

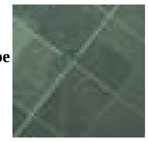
Future changes and innovations in Cultivated Forest Management

Possible impacts on biodiversity and forest health
Implications for research

1. ***Temporal scale**: a cutting cycle*



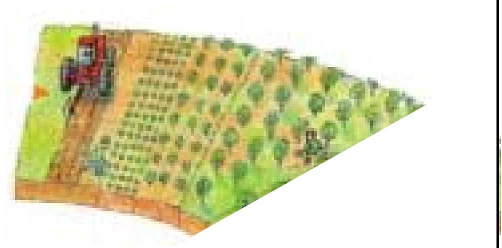
2. ***Main issue***
   - **Hypothesis (scenario)**
   - **Spatial scale: from stand to landscape**
   - **Main processes**
   - **Indicators**
   - **Experimental design**



Hervé JACTEL
INRA Pierroton
69 route d'Arcachon
F – 33612 Cestas

1

1. Planting



2

1. Main issue # 1: **tree/plant species diversity**
2. Hypothesis:
   - still pure productive stands but ...
   in the gaps: hedgerows, relict woodlands, amenity plantings
3. Impact and research implications

	scale	*process*	*indicator*
Biodiversity	stand to landscape	- habitat diversity - habitat complexity (ecotone, niche complementation)	Species Assemblages (bird, insect, plant)
Forest health	stand to landscape	- host accessibility - impact of natural enemies - associational susceptibility	Populations Metapopulations (pest, disease)

4. Experimental design

   Network of plantation landscapes with increasing complexity of habitat (tree species) diversity

3

1. Main issue # 2: **exotic tree species**
2. Hypothesis:
   - introduction/development of exotic tree plantations
   as a response to global warming or industrial needs
3. Impact and research implications

	scale	*process*	*indicator*
Biodiversity	stand to landscape	- invasion, wilding - habitat diversity	Species Assemblages (bird, insect, plant)
Forest health	stand	- shift of native pests - invasion of exotic pests	Populations (native, exotic pest)

4. Experimental design
   - Network of plantation landscapes with varying proportion of exotic tree stands
   - Pair comparison exotic vs. native plantations

4

2. Stand management

5

1. Main issue: **understorey management**
2. Hypothesis:
   - understorey preservation in pure productive stands
   (weeding, fertilising, draining effect on understorey)
3. Impact and research implications

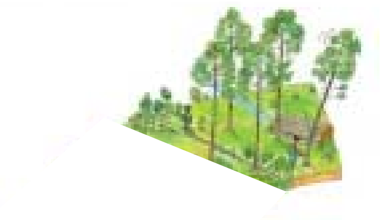
	scale	*process*	*indicator*
Biodiversity	stand to landscape	- structural diversity - disturbance regime	Functional-response groups
Forest health	stand	- plant competition - impact of natural enemies - host accessibility	Populations (pest, disease)

4. Experimental design

   Manipulative experiments with varying understorey structure, composition and disturbance regime in pure stands

6

3. Harvesting



7

1. Main issue: **clear-cutting**
2. Hypothesis:
   - change in clear-cut size, distribution in space and time
   - retention concept (old trees, associated species, logs)
3. Impact and research implications

	scale	*process*	*indicator*
Biodiversity	landscape	- spatio-temporal dynamics (fragmentation, connectivity, colonisation)	Metapopulations
Forest health	stand to landscape	- retention & pest spatio-temporal dynamics	Metapopulations (pest, natural enemy)

4. Experimental design
   Network of plantation landscapes with varying size, patchiness and frequency of clear-cuts (or manipulative experiments)

8

Thematic Meeting organised in the framework of
the EU project QLK5-CT-2002-30221 ‘IMACFORD’

“Future Changes and Innovations in Tree Improvement: Implications for Research”

15 November 2002
Vitoria, SPAIN

Friday 15 November – 10 pm to 5 am **IMACFORD**

Item 1 Presentation

10:00 Overview of IMACFORD project - Presentation of Task B1 coordinated by IEFC: objectives, organisation and planning

Overview of priority V22a) within the draft Work Programme of the 6th FP, role for IEFC within its network
Jean Michel Carnus, INRA Bordeaux

Item 2 Prospective on tree improvement trends

National prospective on forest genetics and biotechnologies

10:30 Trends for tree improvement in France
Jean Charles Bastien (INRA Orléans) and Guillaume Chantre (AFOCEL)

11:10 Breeding trends in Portugal
Maria Helena Almeida, ISA

11:40 Coffee break

Item 3 Technological innovation in tree breeding and biotechnologies areas

Discussion on technological innovations in tree improvement and their links with other disciplines

12.10 Biotechnologies in forestry
Luc Harvengt, AFOCEL

12.30 Conventional genetic selection
Jean Charles Bastien, INRA

Discussion on tree improvement trends in relation with regional forest contexts.

13:30 – 15:00 Lunch and visit of the genetic labs in NEIKER Arkaute

Item 4 Potential impacts of tree improvement regarding forest sustainability
Discussion and review of potential ecological impacts and socio-economics implications of those innovations regarding forestry/wood chain sustainability

4a) Impacts of technological innovations on socio-economic parameters of forest management, regarding long-term forest sustainability

15:00 Economical implications of the utilisation of improved material, acceptability for forest owners
Jean Charles Bastien, INRA Orléans

4b) Impacts of technological innovations in tree improvement on ecological parameters of Sustainable Forest Management

15:20 Potential impacts of the utilisation of highly improved seeds on forest health and biodiversity
Hervé Jactel, INRA Bordeaux

15:50 Utilisation of highly improved trees and its potential impacts on nutrients cycle
Inazio Martinez de Araño, NEIKER

Item 5 Implications of those issues for forestry research

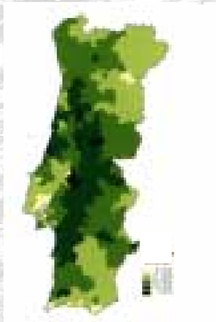
General discussion on relevant research programmes to implement within the 6th FP.

17:00 Closure of the meeting

ISA / DEF

Breeding Trends in Portugal

Maria Helena Almeida
ISA
Tapada da Ajuda
P- 1349 017 Lisboa



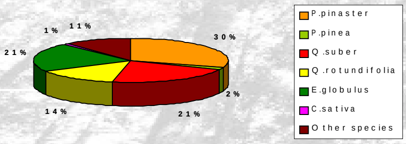
Forest area proportion

Forest covers around 3 300 000 ha in the Continent and 25 970 ha in Azores (DGF 2002).

Ecomic value of forest production is higher than 562 000 000 € per year, representing 34% of the National Gross Domestic Product, excluding the recreation value (CESE 1998)

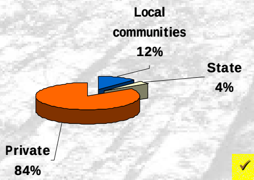
Export/import balance contributes positively to the national economy. Forest products exports (2.7 millions €) represented 11% of total exports in 2000 (DGF 2002).

Species composition



- In continental Portugal, *P. pinaster* and *Q. suber* are the most important autochthonous species.
- *Eucalyptus globulus*, an exotic species, has an important role in pulp and paper industry

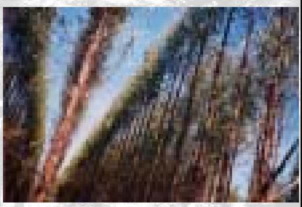
Forestland ownership



✓ More than 400 000 forest owners

✓ In the North and Central part of the country average forest property area is lower than 5 ha

Traditional silviculture ⟷ Clonal forest



Challenges to the forest ecossystems in the XXI Century:

- Increase of human influence over forest ecosystems
- The need to adequate forest multiple use with wood production
- Improve forest products quality to the end users
- Competitive cost against alternative products
- Increased Public awareness of environmental issues
- Need to guarantee economic, social and environmental sustentability
- Certification: Control of production conditions

Breeding Trends in Portugal

ISA / DEF

Climate change scenario*:

* Had RM - Haddley Center' model downgraded to the Iberian Peninsula

- Longer, more frequent and more intense drought periods are expected. Water stress will therefore be a leading constraint to primary production.
- The combined effects of drought and high temperatures will bring about further decreases in carbon assimilation in some aereas.
- Species distribution will mainly depend on stress caused by the expansion of arid and semi-arid climate throughout the country.
- In some regions winter warming with CO_2 fertilization will be beneficial (North).
- The South and interior regions may be inhospitable for some of present species (cork oak,Pinus pinaster).

7

Breeding Trends in Portugal

ISA / DEF

Pinus Pinaster Ait

Objective: To increase de productivity and the wood quality

Deployment: Production of 10 kg of seeds/year with a genetic gain of 10% in volume and 17% in stem straightness

8

Breeding Trends in Portugal

ISA / DEF

Pinus Pinaster Ait

Foreseen activities:

- Enlargement of the genetic base of breeding population
- Establishment of the 3rd generation
- Ensure that improved seed has adequate genetic diversity
- Deployment of improved propagules for a sustainable forest
- Evaluation of wood quality
- Evaluation of the adaptability

9

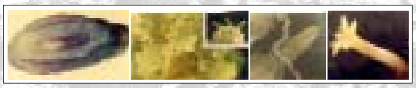
Breeding Trends in Portugal

ISA / DEF

IN VITRO CULTURE-Goals/Competences

Support to the breeding program

- Vegetative propagation
  - Axillary multiplication
  - Adventitious regener.
  - Somatic embryogenesis
- Criopreservation
- Genetic transformation



10

Breeding Trends in Portugal

ISA / DEF

MOLECULAR BIOLOGY

- Genetic stability of in vitro cultures
- Evaluation of the genetic diversity of the breeding population as compared to that of the metapopulation
- Pollen contamination in seed orchards and studies of consaguinity
- Adaptive genetic diversity in natural populations
- Functional genomics

11

Breeding Trends in Portugal

ISA / DEF

Eucalyptus globulus Labill. Celbi - Storaenso

Objective: Breeding for pulp yield production, pulp quality and diversity evaluation.

Strategy: Nucleus breeding.

Production Population: 14 full-sib families

Deployment: 15 kg full-sib seed $year^{-1}$

Plantations area established with improved seedlings: 5 000 ha

Biotechnology:

- Evaluation of genetic diversity through molecular markers.
- Vegetative propagation: Micropropagation and Somatic Embryogenesis

12

Breeding Trends in Portugal

ISA / DEF

Eucalyptus globulus Labill. **Raiz - Portucel and Soporcel**

Objective: **Increase the value and vitality of the eucalyptus plantations.**

Strategy: Rolling-front.

Production Population: 15 clones

Deployment: 1 new clone year^{-1}(2000 - 3000 mother-trees);

new clone genetic identity certification; evaluation of genetic diversitty

Clonal Forest area: 14 000 ha

13

Breeding Trends in Portugal

GENETIC IMPROVEMENT

Increase plantation value, vitality, sustainability

Trait selection ⬅ **Candidate genes**

Breeding ⬅ **Genetic diversity estimates**

Deployment ⬅ **Fingerprinting**

RAIZ

14

Breeding Trends in Portugal

ISA / DEF

Improvement of Statistical Models for Estimating Genetic Merit

- **Quantifying the importance of dominance relative to additive genetic effects in non inbred populations**
- **Accounting for site variability in field tests by using spatial analytical methods**

Evaluation of Genotype by Environment (G x E) Interactions

- **Analysis of G x E interactions in Portugal**
- **Evaluation of G x E interactions using different sets of genetic material**
- **Analysis of G x E interactions across Portugal and Australia**

15

Breeding Trends in Portugal

Studies on genetic variability:

- *Quercus suber*
- *Pinus pinea*
- *Castanea sativa*
- *Quercus rotundifolia*
- *Cryptomeria japonica*

Through genetic tests and molecular markers

16

Breeding Trends in Portugal

ISA / DEF

Adaptability evaluation is linked to physiological process

Improvement of wood traits is a target in breeding

Biotechnology is recognized as a tool in breeding activities

17

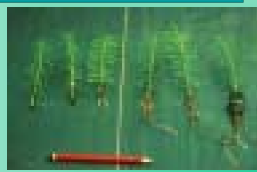
Conventional Breeding Strategies and links with tools and process

Jean-Charles BASTIEN

INRA
Unité Amélioration, Génétique et Physiologie Forestières
Ardon - 45166 OLIVET - France

1


Most of forest tree varieties in use at present are fruit of conventional breeding strategies and allow genetic gains for volume production and adaptability of ≈ 15-20%

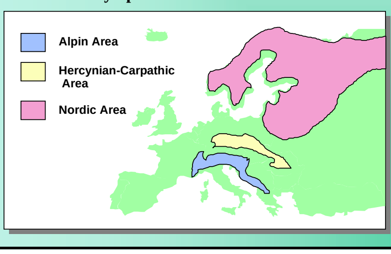



2

Characteristics of conventional forest tree breeding strategies

- *High level of genetic diversity over large areas*
- *Most of genetic variability within populations*

Norway Spruce Natural distribution area



Large breeding populations to evaluate

3

Characteristics of conventional forest tree breeding strategies

- *Long lived species with late sexual maturity*

Late evaluation


Late recombination

4

Characteristics of conventional forest tree breeding strategies

- *Increasing size of individuals*
- *Heterogeneity of environmental conditions*

Constraints in forest trials : thinning, heterogeneity control

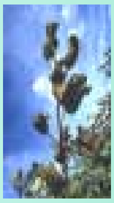

Large genotype archives

5

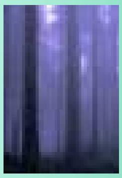
Characteristics of conventional forest tree breeding strategies

- *Selection objectives = complex and cumulative traits*

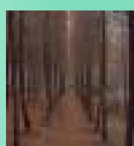
Adaptation (climate, pests)



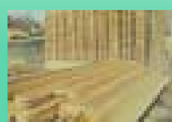
Volume production



Stem form



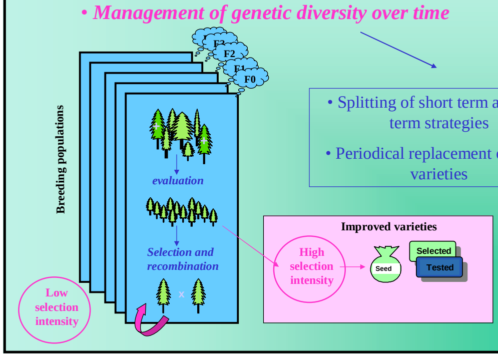
Wood quality



6

Characteristics of conventional forest tree breeding strategies

• *Management of genetic diversity over time*



• Splitting of short term and long term strategies

• Periodical replacement of forest varieties

7

Characteristics of conventional forest tree breeding strategies

• *3 main constraints : time, space, multitrait objectives*

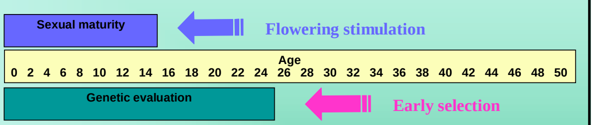
Experimental costs

• *3 main questions to tree breeders*

• Improve early selection
• Explore hybridisation between species or between populations
• Improve mass deployment methods of the genetic progress

8

Objectives of early selection in forest tree breeding



- **Shorten the evaluation period and generation interval**
- **Improve precision of genetic evaluation for mature age**
- **Increase selection intensity**
- **Reduce field testing size and experimental costs**

9

Present perspectives of early selection for forest trees : Adaptation to changing environments

Autumn and Winter Frost resistance

• Efficiency of artificial freezing test at juvenile stage for resistance to autumn and winter frost

Pinus sylvestris : autumn frost , 1 yr-old seedlings , (Aho, 1994 ; Norell et al. 1986, Nilsson & Eriksson, 1986)

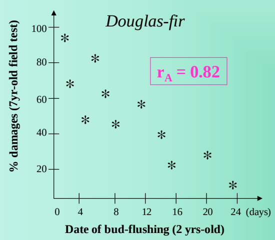
Pinus contorta : autumn and winter frost, 1 yr-old seedlings (Jonsson et al. 1986)

Pseudotsuga menziesii : autumn and winter frost, 7 yr-old shoots (Aitken &Adams 1996)

11

Present perspectives of early selection for forest trees : Adaptation to changing environments

Late Frost resistance : an easy indirect early test



• Efficiency of indirect selection for resistance to late spring frost through earliness of bud-flushing

Picea abies (Hannerz 1999), *Pseudotsuga menziesii* (Heois 1994)

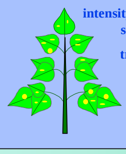
12

"Downward" Decomposition of pest resistance
(Poplar rust resistance Melampsora ssp.)

Field evaluation

natural inoculation :

mixture of races, several cycles of infection



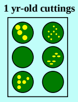
1 trait

Laboratory

16h 15-19°C

artificial inoculation :

5 races E1, E2, E3, E4, E5



3 epidemiological components :
latent period
nb. uredia
size of uredia

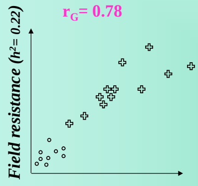
susceptibility index

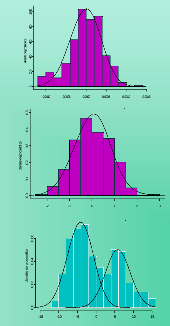
15 traits

h^2 = 0.2-0.3 → Higher h^2 ?
Selection of more durable resistance ?

12

"Downward" Decomposition of pest resistance
(Poplar rust resistance Melampsora ssp.)



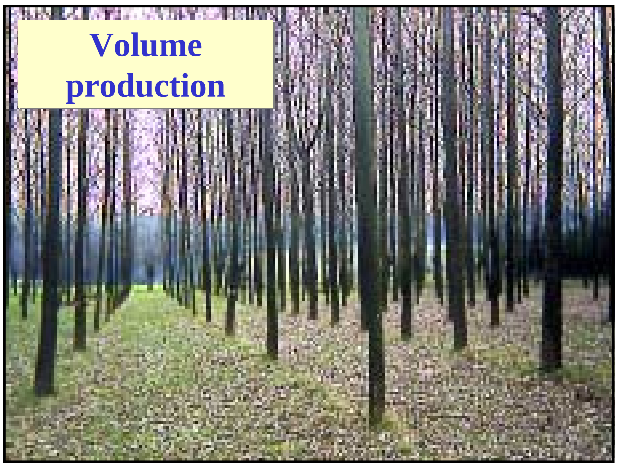


Latent period
CV_G = 15-20%
h^2 = 0.35 - 0.55

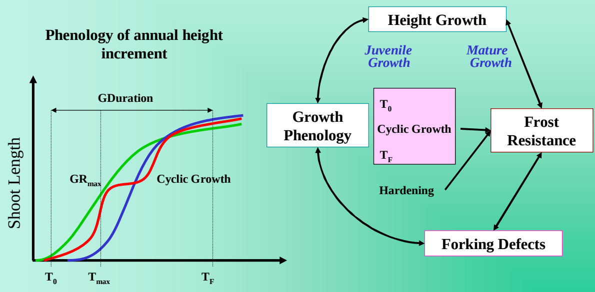
Nb. Uredia
CV_G = 25-40%
h^2 = 0.40 - 0.65

Size of Uredia
CV_G = 30-45%
h^2 = 0.77 - 0.89

14



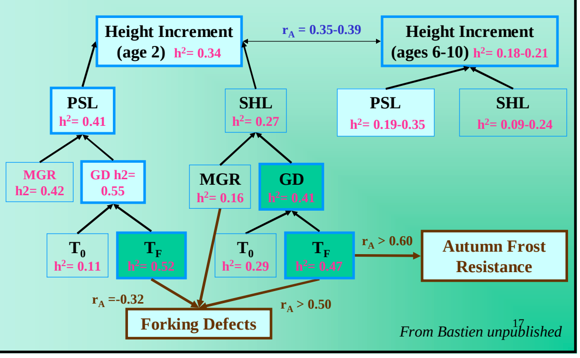
"Downward" decomposition of Volume production
Dynamical decomposition of volume growth



Pseudostuga menziesii, Picea abies

16

"Downward" decomposition of Volume production
Dynamical decomposition of Douglas-fir height Growth



From Bastien unpublished

17

Optimal age of early selection for volume growth
(Synthesis for forest trees)

After validation in retrospective early tests

Species	optimal selection age	Mature age	References
Pinus taeda	3-4 yr-old	23 (35)	Gwaze et al. 1997
Pinus contorta	6-7 yr-old	20 (60)	Xie & Ying 1996
Pinus pinaster	10-12 yr-old	25 (45)	Magnussen & Kremer 1994
Pseudotsuga m.	3 yr-old	15 (45)	Bastien & Roman-Amat 1990
Populus delt.	3-4 yr-old	10 (15)	Pichot 1994
Juglans nigra	8 yr-old	20 (50)	Rink & Kung 1995
Eucalyptus sp.	1.5 yr-old	8 (8)	Pereira et al. 1997

18

Branching Habit

Stem form

Early Evaluation of form

Larix eurolepis Stem Straightness

Stem form
=
complex trait difficult to evaluate before age 10

difficult to measure

strongly exhibited at young age

Interest of juvenile explanatory predictors ?

20

Early Prediction of forking defects

(*Pseudotsuga menziesii*, Bastien et al 1998)

% Plants with Forking Defects

- **a major stem defect in 10-15 year-old Douglas-fir plantations in fast growing conditions (forking trees frequency 40-60%)**
- **unfavourably linked to height growth ($r_G > 0.4$)**
- **with significant genetic variation but strongly influenced by environmental factors (low h^2, GxE interaction)**

21

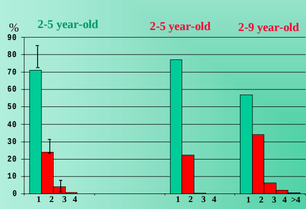
Frequency of top forking defects in Douglas -fir

Annual frequency of trees with top forking defect

Farm-field tests 2-5 year-old	Forest site 6-9 year-old
6-40%	3-15%

Repetition of top forking defects over years

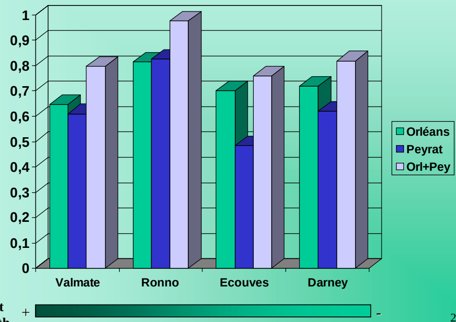
Significant progeny effect



22

Prediction of Douglas-fir forking in farm-field tests

Predictors = % polyc. trees + % SSL/ASL + Nb. yrs with defects
4-5 yr-old / 4-5 yr old / 2-5 yr-old



23

Prediction of Douglas-fir forking in farm-field tests

% forking trees at 10-15 year-old in fast growing conditions

Adaptive traits :
- earliness of budflushing
- polycyclism ability

Repetition over years

Advantages of early prediction in farm-field tests

- *homogeneity* **of environmental conditions**
- *better evaluation* **of polycyclic ability at juvenile stage 2-6 year-old**
- *intensive measurements* **at a** *lower cost*
- *combined selection* **for adaptation, growth and stem form**

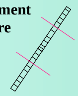
24

Wood Quality

Early Evaluation of wood quality

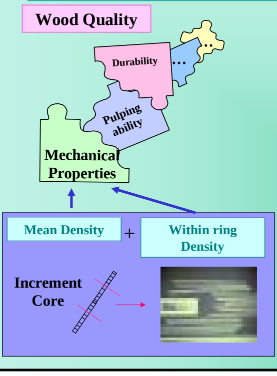
- Wood quality
  - Mechanical properties → Wood density → Within ring Wood density
  - Peeling ability → Within ring Wood density
  - Pulping ability → Fiber Length …
  - Durability → Heartwood formation

Increment core

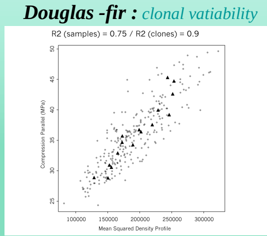


Optimal age of early selection for wood density

(Synthesis for forest trees)



Douglas -fir : *clonal vatiability*



☛ Good prediction of behaviour in compression through within ring density

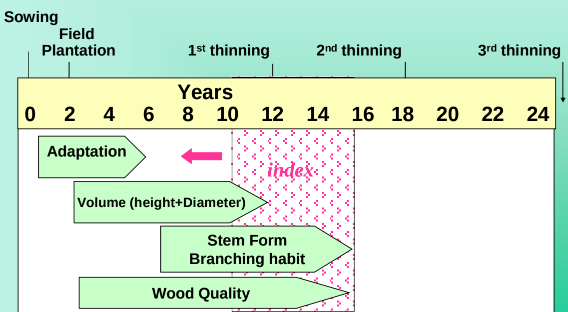
Optimal age of early selection for wood density

(Synthesis for forest trees)

Estimation from age-age correlations

Species	Additive age-age correlation	Age range	References
Pinus taeda	0.76-0.9	2-50 yrs	Williams & Megraw 1994
Pinus radiata	0.79	5-20 yrs	Cown et al. 1992
Pinus sylvestris	0.88	8-33 yrs	Hannrup & Ekberg 1996
Pseudotsuga m.	0.83	6-13 yrs	Woods et al. 1995
Picea sitchensis	0.95	5-17 yrs	Lee 1997

Optimum Selection Ages
One Step : index selection



Relative efficiency of two-stages selection with Lodgepole pine

(from Wu 1998 Silvae genetica 47,2-3, 146-152)

First stage selection : 2 yr-old basal diameter in greenhouse
Second stage selection : 9 yr-old total height in field test
final selection of 11 families from the 110 families tested in the field

Base population size	110	122	138	157	183	220
Nb families culled at early stage	0	12	28	47	73	110
Efficiency $E_{xy.y}$	1	1.051	1.096	1.135	1.185	1.239
Gain increase	0%	5.1%	9.6%	13.5%	18.5%	**23.9%**

Inter-specific or inter-population hybridisation

- Get a good *complementarity* between traits
- Valorise heterosis when it exists

Hybrid vigour (% of average parent) in hybrid Larch

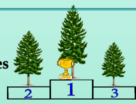
diallel 18 x18 — 4 years — 1 site

%	Hybrid Vigour at :		
	Specific level	Family level	
		min.	max.
Total Height	12,9	-4	31,1
Strightness	-6,1	-24	9,5
Flushing	14,2	-20,4	53,1

Prediction of inter-specific SCA still remain dificult !

Improve transfer of genetic gain

Selection of Elite varieties



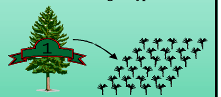
By seed
Mass production of seed in controlled conditions

Mass production

By cuttings
Propagation of the best genotypes

Supplemental pollination of the best genotypes

- More *flexible* structures of production
- More *specific* varieties
- Reduced *production costs*



High multiplication rate

Seed

Rooted cutting

Seedlings for reforestation

Research perspectives

- Multi-generation management of breeding programs : structuration of breeding populations (simulation).
- Application of MAS to create clonal varieties of Poplar resistant to rusts.
- Reduce negative effects linked to increased proportion of juvenile wood.
- Evaluate relationships between genetic diversity and plasticity (in space and time) of improved varieties.

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Use of improved or genetically modified trees
Potential threat to forest health and biodiversity

Hervé Jactel
INRA Pierroton
69, route d'Arcachon
F – 33612 Cestas

1

Introduction

- **Advantages of improving trees:**

- reduction of pest damage
- reduction of insecticide application
- quicker response to invasive species
- decrease pressure for timber on natural forests

(Forest health; biodiversity)

- **Ecological risks associated with improved or GM trees**
  - ethical and technical problems
  - main impediments to the use of improved tree varieties.

2

FOREST HEALTH

1. Evolution of resistant biotypes in pest insects

Mechanisms

- natural selection process operates in an accelerated and directed fashion
- high selection pressure due to
  - ➔ lower tree diversity
  - ➔ narrow genetic resistance traits
  - ➔ long-term transgene expression
  - ➔ uniform transgene expression

Effects

- loss of tree resistance efficiency
- resistant biotype potentially more damaging
- cross resistance to other pesticides or natural plant defence chemicals
- resistant biotypes in polyphagous pest damaging other crops
- reduction of the efficacy of environmentally friendly insecticide like Bt

3

FOREST HEALTH

2. Adverse effects on natural enemies

Mechanisms

- Cascade of magnified adverse effects in the upper levels of the food-web
  - ➔ fewer preys and host
    - ➔ higher cost of host finding and handling
      - ➔ lower reproductive capacities

Effects

- collapse of natural enemies populations
- lower biocontrol efficiency
- emergence of secondary pests

4

FOREST HEALTH

3. Side effects on herbivorous species

Mechanisms

- Secondary pests released from competition with target pest species
- Secondary pests evolve more quickly resistance
- Unexpected effect of transgene insertion in the host tree genome
  increase tree susceptibility to other pest insects
- Breeding for unrelated plant properties (vigour, wood quality...)
  increase tree susceptibility or palatability to other pest insects
- Lower genetic diversity in (clonal) plantation reduces adaptability,
  e.g. direct pest resistance or effect of climatic change on tree resistance
- Diversion processes

Effects

- Increase damage from primary pest preferring GM or improved trees
- Outbreaks of secondary pests
- Increase damage on other tree species or unimproved nearby plantations

5

FOREST BIODIVERSITY

1. Off-site effects: - dissemination of GM trees
- transgene transfer

Mechanisms

- Spreading of modified pollen & cross hybridation
- Gene transfer to unrelated species via bacterial vectors
- Movement of propagules, vegetative reproduction, escape of transgenic trees
  adapted to a wider range of site or climatic conditions, with faster growth…
- Generalisation of improved varieties (highly productive, best quality)

Effects

- Introgression with related species
  - ➔ modification of plant diversity's quality
- Weeding behaviour of GM trees (invasive organisms)
  - ➔ threat to qualitative and quantitative plant biodiversity
- Simplification of plant diversity
  - ➔ loss in associated flora and fauna, via food web interactions
- Simplification of crop diversity
  - ➔ change in land use and associated diversity

6

FOREST BIODIVERSITY

2. Local effects: ➢ improved traits

- Insect resistance
  - ➔ reduction in herbivorous diversity
  - ➔ cascading effects on associated fauna via food-web interactions
- Tolerance to adverse soils (dry, acidic, saline)
  - ➔ competition with native flora
- Fungi and virus resistance
  - ➔ toxic effects on decomposer and soil biodiversity
- Quality traits (lignin / cellulose)
  - ➔ effect on palatability to xylophagous animals
- Growth traits
  - ➔ enhance tree competitiveness with native flora
  - ➔ greater water and nutrient demand w. decline of site productivity
- Sterility traits
  - ➔ loss of species feeding on flowers (nectar, pollen), seeds, fruits

7

FOREST BIODIVERSITY

2. Local effects: ➢ plantation management

- Intensive use of herbicide associated with GM herbicide tolerance
  - ➔ destruction of native woodland flora and depending fauna
- Reduced tree diversity, monotonous structure of plantation
  - ➔ lower species richness
- Shorter rotation
  - ➔ change in plant succession

8

Conclusions

- Effects of both products (improved or modified traits) and processes (transgene insertion and plantations practices)

- Long list of ecological risks associated with the use of genetically improved or modified trees

- Risk: potential rather than observed problems
  few documented ecological impacts in forest
  due to moratorium or secret application

9

How to evaluate the ecological risks ?

1. To experiment:

- Genetic diversity and global biodiversity
- Ecological research in complex and long-term interactions between GM (improved) trees and food-web related species

2. To develop Risk Assessment

- GM crops in agriculture
- Pesticide application
- Traditional tree breeding
- Introduction of beneficial organisms
- Invasion by alien species
- Conservation of genetic diversity and conservation biology

10

Programme
Thematic Meeting organised in the framework of
the EU project QLK5-CT-2002-30221 'IMACFORD'

Future changes and innovations in wood quality and wood products: implications for research

12 December 2002
Bordeaux, LRBB, France

Thursday 12 December - 9 am to 5 pm **IMACFORD**

9.00 - 13.00 Morning : introductory presentations

Opening of the meeting by the chairman of the session
Patrick Castéra (LRBB)

Item 1 Overview of IMACFORD and FP 6

Preparation of the 6th FP, current initiatives in forest, pulp and wood sectors
IMACFORD project - Presentation of Task B1: objectives, organisation
Jean Michel Carnus (INRA)

Item 2 Trends in wood quality issues

Tree Breeding and Wood Properties, a strategy
Philippe Rozenberg (INRA Orléans)

Evolution of wood quality in planted forests: today issues and tomorrow trends
Guillaume Chantre (AFOCEL),

SUSTAINWOOD, a proposal for the 6th FP
Barry Gardiner (Forest Research),

Optim-Oak, a proposal for the 6th FP
Frédéric Mothe (INRA Nancy)

Item 3 Market requirements and wood-based products

Interactions between innovations in wood-based products and quantitative and qualitative requirements

Engineered Wood Products EWP
Patrick Castéra (LRBB),

Timber quality for construction
Dennis Jones (BRE),

The School of Agricultural and Forest Sciences, University of Wales Bangor
Callum Hill (University of Wales)

Interactions between innovations in "fiber products" and quantitative and qualitative requirements
Guillaume Chantre (AFOCEL)

13.00 LUNCH

Item 4 Life Cycle Analysis, end of life, re-use and risk management

Life cycle analysis of wood based products. From the seed to the product, environmental and economic aspects
Emmanuel Bucket (CTBA)

Item 5 Discussion Groups – research topics for FP 6

Constitution of 3 groups
Taking into account the issues presented during the morning session (Items 2,3,4), the 3 groups will discuss their implications for research activities in the area of wood quality and related domains.

Reports on group analysis by each one of the 3 group leader

Final discussion

Item 6 Next steps of IMACFORD project

Next steps, agenda , final group meeting planning, preparation of 6th FP

Closure of the meeting

Tree Breeding and Wood Properties: a Strategy

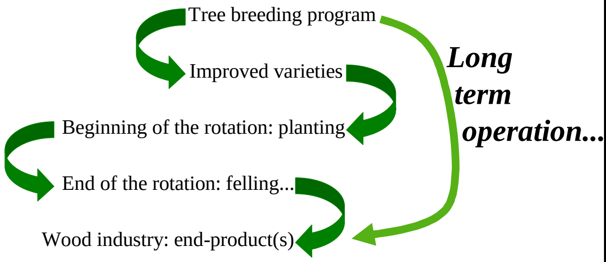
INRA Orléans possible contribution to an European Union research project

Pierroton, 12 December 2002

Philippe Rozenberg

1

Breeding for end-product properties



Up to what length is it an economically acceptable operation?

2

Breeding for end-product properties

- Very small number of end-products
- Very small number of related basic properties
- Expressing genetic gain in €
- Feedback from the wood industry
- Long term relevance

3

Breeding for end-product properties

- Is this strategy adapted to all forest species?
  - Length of selection cycles and rotations
  - Multiplicity of end-products
  - Estimable genetic gains
  - Evolution of industrial processes
  - Traditional adaptability of the wood industry
  - Interest of the wood industry
- Poplars and maritime pine

4

Plantation Forestry

- Modification of environment
  - combination of species and sites
  - sylviculture
- Modification of plant material
  - selection (provenance choice)
  - genetic improvement

5

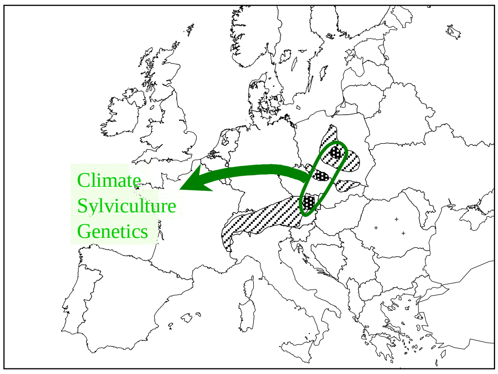
Consequences: *multiple changes*

- Changes in biotic and abiotic resistances (adaptation)
- Changes in growth speed
- Consequences on
  - cambium activity,
  - wood quantity,
  - wood basic properties… WOOD QUALITY

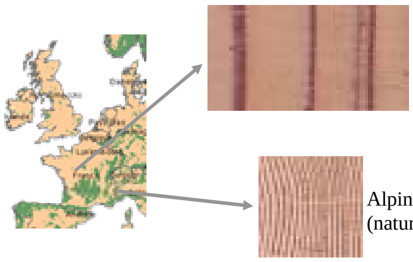
6

Wood Quality Studies

- Consequences of the changes induced by plantation forestry
  - climate changes related with species introduction
  - sylviculture changes
  - *genetic changes related with breeding*
  - *interactions...*



Illustration



Alpine larch (low elevation fertile site)

Alpine larch (natural range)

Growth Increase… Consequences on Wood Quality ?

INRA Orléans possible contribution

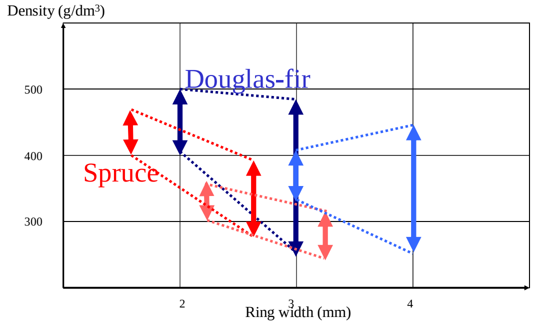
- Consequences on wood quality (basic wood properties) of the changes induced by genetic improvement on 1) biotic and abiotic resistances 2) growth speed 3) form in planted temperate species
- abiotic resistance, climate, changes and simulations...

Another example (Douglas-fir and Norway spruce)

- Consequences of radial growth change on wood density

Consequences of an improvement of growth conditions :

1mm increase of ring width



INRA Orléans expertise

- Main species of interest:
  - broadleaves: poplars, cherry tree, ash, walnut...
  - conifers: Douglas-fir, Larches, Scots pine, Norway spruce...
- Plant material (multi-site networks of genetic field tests) available for many species: several hundreds of genotypes

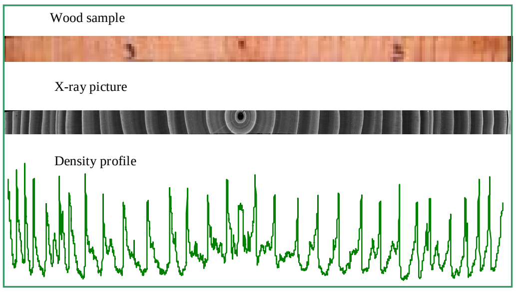
13

INRA Orléans

- Wood laboratory:
  - sample collection and processing
  - indirect X-ray microdensitometry
  - shrinkage
  - clear sample modulus of elasticity
  - standing tree modulus of elasticity (“Rigidimeter”)
  - wood chemistry
  - wood anatomy, including “quantitative anatomy”

14

Microdensity



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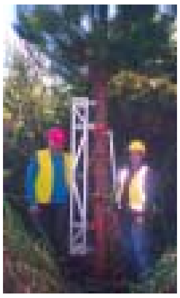
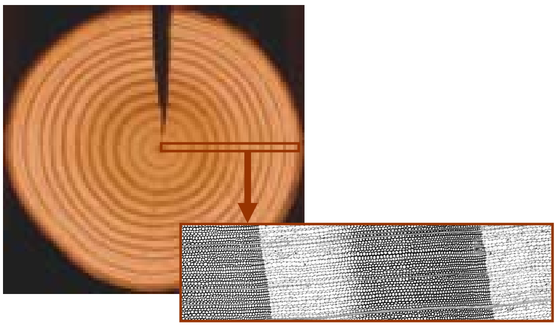
Rigidimeter



Second Prototype
(squared tubes)
New-Zealand
July 2001

16

Wood anatomy profile



INRA Orléans

- Scientific axis related with wood studies:
  - genetic improvement of wood quality (including marker assisted selection)
  - genetic and environmental determinism of wood formation, application to tree breeding
  - functional genomics of wood formation: cambium activity, lignin, cellulose, reaction wood, heartwood
  - physiologic and genetic components of heartwood formation and natural durability

18

BRE

Timber quality for construction

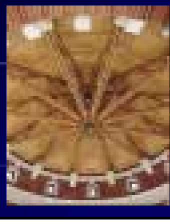
Dr. Dennis Jones
Senior Consultant
Centre for Timber Technology and Construction

FRS

BRE

Construction; Key drivers

- Whole life costs
- Process
- Modular construction
- Avoiding defects
- Environmental aspects



BRE

Timber quality

- Supply of material
- Sizes
  - Reengineered wood
- Strength (defects etc)
- Standards and quality control

- **Mainly consider softwood**

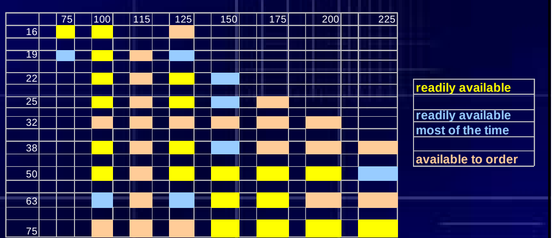
BRE

Softwood- key issues

- Reducing rejects
- Better consistency
- Fitness for purpose
- Certification/environment

BRE

Timber sizes available (Scandinavia)



BRE

Drying

- Better drying conditions
- Produce timber with lower m.c.
- Better quality timber less prone to check/warp/split

Sawing

- Produce a material that is more uniform
  - Avoid heartwood/sapwood in same piece
- Better cutting reduces risk of warp

Green gluing

- Recognised way of removing defects from timber
  - More uniform product
  - No limitation to number of joints or overall length

Green gluing

- Way of producing quality timber from lower grade material
  - Cut out defects
  - Use off-cuts

Solutions

- Better specifications
  - Economy - use for low grade applications
  - Standard - use for timber construction
  - Premium - use for high value production
- Better suppliers
- Storage/handling - avoid mould/staining
- Selling/training
- Information

Upgrading timber

- Improved treatments for wood
  - Modifications
  - Use of new preservatives
  - Incising techniques
- Methods cannot work miracles
  - Need basic grade of starting material, inferior wood cannot be made 'fantastic'
- Manufacture of composites for the construction industry

Environmental aspects

- Certification
- Environmental performance
- Levies
- Wood is best!

Conclusions

- Understand market needs
- Innovation is taking place
  - Specifications
  - Handling/storage
  - Supply
  - Upgrading

Wood-based composites

Key outcomes

- ***Environmental***
- Sustainably grown timber
- Environmental impacts
- Waste, recycling, reuse
- Transport
- Energy
- Biodiversity

- ***Economic***
- Competitiveness, innovation and promotion

- ***Social***
- Local communities
- Health and Safety

Interactions between innovations in “fiber products” and quantitative and qualitative requirements

G. CHANTRE

AFOCEL

- **What are the market requirements?**
  - **Products with constant and homogeneous properties,**
    - **The homogeneity is possible through process adjutments which cost are difficult to evaluate (energy, fillers, DIP / virgin fibers…)**

– **Increasing requirements on pulp especially for**

•Wet physical properties (machinability) or dry physical properties (to increase the DIP%, decrease the starch content…),

• optical properties (brightness, opacity…)

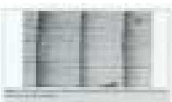
•Maintaining physical and optical properties for the same basic weight

•Printing ability (rugosity…)

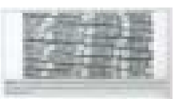
•Various impurities (DCN, pitch…)

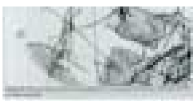
–The environmental impact (water, energy, COD, AOX…) and traceability, chain of custody…

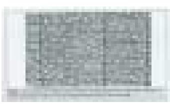
From wood to fibres


Softwood microscopic structure


Softwood fibres (Scots pine)


Hardwood with wide earlywood vessels


Fibres and vessels (thin + wide) (Elm)


Hardwood with thin vessels


Fibres and vessels (poplar)

The process optimization is possible only if we know the fibres

the right « Wood Quality » = forest / wood resource well adapted to the process

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Specifications??
What are the interactions between wood and process?

7

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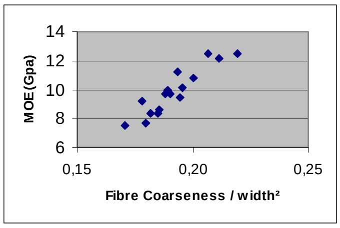
Wood and fibre properties are often correlated



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Enhancing the value and the specificities of the wood raw material and the wood fibres

- **WOOD :**
  - Ratio Resistance/ Weight
  - Insulation properties (heat, fire…)
  - Aesthetics
  - Renewable / re-useable
  - CO_2 storage to control the nursery effect
  - …
- **FIBRES**
  - As resistant as steel
  - Easy to beat, to bleach…
  - Highly valuable in chemistry
  - Renewable, abudant natural resource and molecules
  - …

9

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- Increasing cellulose content and decreasing lignin + resin content
- Increasing fibre strength and flexibility
- Decreasing MFA and compression wood content

- HOW ?
- Adapting the forest resource to the industrial needs with log segregation or specific plantations
- Enhancing the value of the local species
- Improving the supply chain management and the industrial control
- Optimising the process (beating, bleaching) with the wood supply

10

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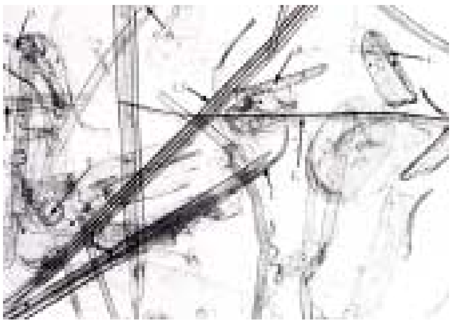
STRAW



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MARITIME PINE

12

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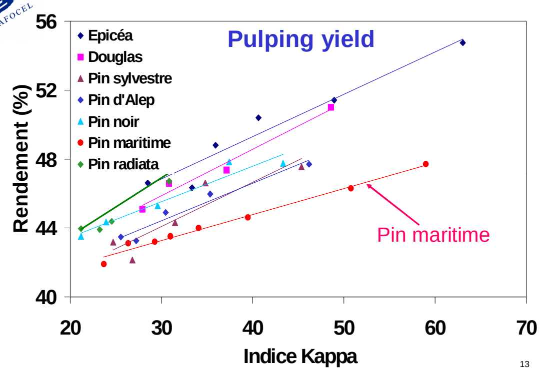

13

Source : AFOCEL

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Physical properties

SPECIE	BURST index kPa.m²/g	TEAR index (mN.m²/g)	BREAKING LENGTH (km)
Pin maritime	*5.6*	*9.9*	*9.6*
Pin d'alep	4.3	10.6	7.2
Pin noir	4.7	12.1	7.4
Pin sylvestre	4.8	10.8	7.7
Pin taeda	5.3	8.0	7.2
Pin radiata	5.7(4.7)	10.0	10
Douglas	4.7	13.9	7.8
Epicéa	5.5	10.2	8.9

14

Source : AFOCEL

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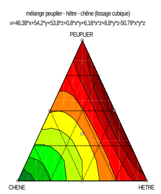
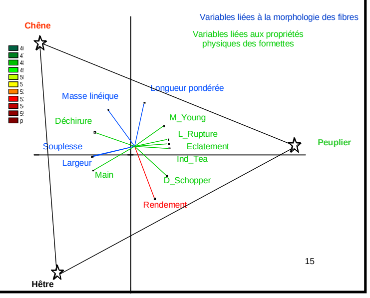
Optimising the mix





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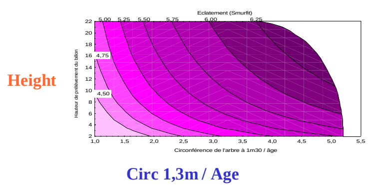

16

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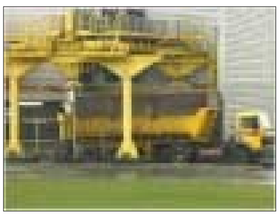
Controlling the wood supply

- On the wood yard



17

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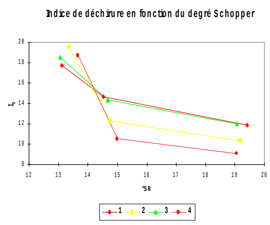
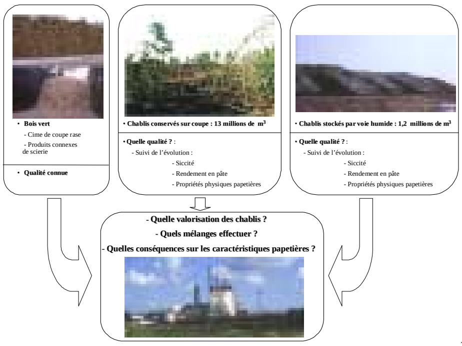
Controlling the supply



Fournisseurs différents de PCS

18

Analysing the forest resources

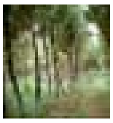


Optimising the wood chain management (logistics)

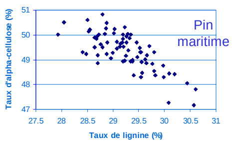
- Identifying wood assortments
- Optimising the les flows (freshness, proportion of various origins)

Modifying the resources

unimproved



improved



Analyse du Cycle de Vie du bois lamellé-collé

Emmanuel Bucket
INRA-CTBA
69, route d'Arcachon
F- 33612 Cestas

Principe de l'Analyse du Cycle de Vie

Bilan quantitatif des émissions de polluants et des consommations d'énergie et de matière d'un produit sur son cycle de vie et traduction en terme d'impacts environnementaux.

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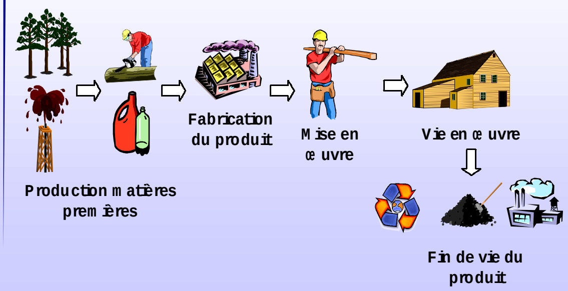
Analyse du Cycle de Vie du bois lamellé-collé

Le Cycle de Vie de la poutre en bois lamellé-collé



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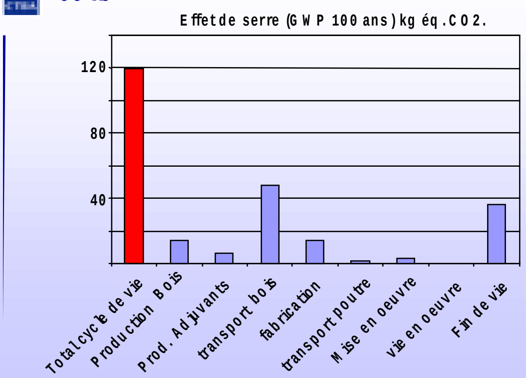
Analyse du Cycle de Vie du bois lamellé-collé



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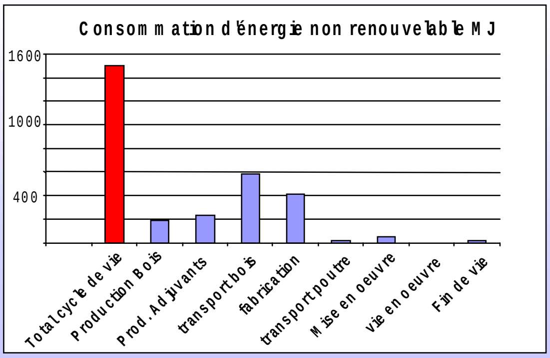
Analyse du Cycle de Vie du bois lamellé-collé



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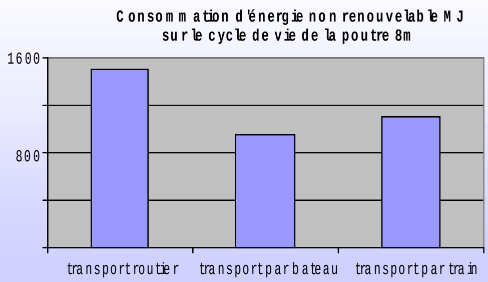
Analyse du Cycle de Vie du bois lamellé-collé



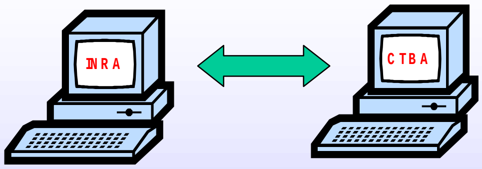
9

Les protagonistes

- UNITE FORESTIERE INRA DE PIERROTON
  Équipe Croissance et Production
- Laboratoire des Ressources Forêt-Bois (LERFOB)
  Équipe Qualité Bois
- CTBA - Pôle Construction
  Équipe environnement

EBPC/CTR 2-10-2002 2

Concept du projet



• modèles Fagacée (Chêne), Lemoine (Pin Maritime)...

volumes de bois et qualité des bois en fonction de scénarios sylvicoles

• ACV de produits bois dans la construction

bilans environnementaux (flux et impacts) avec des scénarios sylvicoles simplifiés (moyennés et figés)

Les objectifs

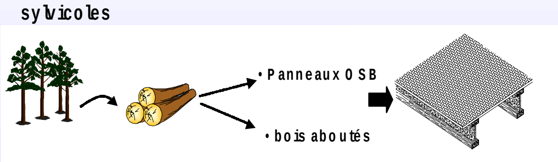
• Développement d'une méthodologie
—raisonnement ressources forestières associées aux produits manufacturés

• Formater les données de sorties des modèles de croissance pour les rendre utilisables dans les ACV

• 2 applications : Chêne et Pin Maritime

Application sur la sylviculture du Pin Maritime

Bilans environnementaux d'un système plancher poutre en I/panneaux OSB issu de différents scénarios sylvicoles

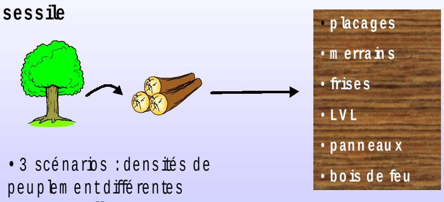


• 3 scénarios = nb d'éclaircies différents
• modèle Lemoine = volumes de bois
• + carte de la qualité des bois

• données sur la transformation
• conception du plancher en fonction de la qualité des bois
• réalisation ACV 1 m² plancher

Application sur la sylviculture du Chêne

Bilans environnementaux forêt - produits bois de scénarios sylvicoles contrastés appliqués au Chêne sessile



• 3 scénarios : densités de peuplement différentes
• 200 parcelles
• volume de bois + qualité des bois

• données sur la transformation
• prise en compte des différentes durées de vie des produits