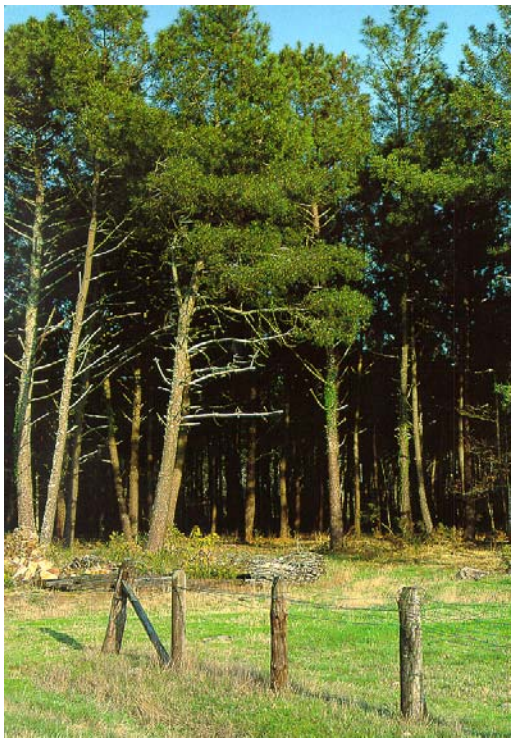
IMACFORD project

"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



FINAL REPORT

Colin A., Orazio C., Carnus J-M.

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Research needs and trends for cultivated forests

Project task coordinated by:
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EXECUTIVE SUMMARY

The objective of IMACFORD task B was to strengthen regional/thematic centres for forestry research with a special emphasis on regional skills and multidisciplinary needs in liaison with interregional sustainable development and links between research, industry and end-users. The aim of this task was to advance co-ordination and prepare interdisciplinary research networks facilitated by inputs from stakeholders. IMACFORD Subtask B 1 concerns the strengthening of the thematic centre on cultivated forests (IEFC) in the context of the sustainable development of forestry-wood chains. The general question which is addressed in this subtask is how scientific progress and technical innovations can contribute to the sustainable development of the forestry sector. Subtask B1 included 3 specific objectives: (i) to improve the research co-ordination at an interregional level; (ii) to provide a platform for dialogue with stakeholders and identification of research needs; and (iii) to elaborate a framework for integrated interdisciplinary research programmes.

The subtask has been conducted successfully in three successive phases, as follows: (1) research network organisation and planning through initial meetings of thematic groups (forest management and modelling, tree breeding and biotechnologies, wood quality and products); (2) regional consultation and identification of research needs (regional workshops held in local languages to facilitate inputs from stakeholders); and (3) preparation of interdisciplinary initiatives through final meeting of all thematic groups. Deliverables have included a database on network research facilities, an interim report at the end of phase 2, and a final report. Other outputs of the subtask include the 7 detailed proceedings of the 3 thematic group meetings and the 4 regional and final workshops and the 3 work programme outlines for the development of interdisciplinary and integrated initiatives. Through a period of less than 10 months, more than 250 people have participated in the meetings and workshops which have been held in the Atlantic regions of Europe in Portugal, Spain, France and Ireland.

Subtask B1 has strongly contributed to the overall objective of Task B and to the strengthening of the thematic centre on cultivated forests. As emphasised by many participants in task B1 meetings and workshops, the main outcome of this project has been the emergence of a dialogue platform and of methods facilitating exchange and debate between the scientific community and the end-users at an appropriate and pertinent trans-national level in link with actors of the development of the forestry-wood sector. For the future, this a very important role and mission for a regional/thematic centre, that must go on.

The specific objectives of subtask B1 have been fulfilled to a large extent, even though the short duration of the IMACFORD project and its timing with 6 FP calls was not ideal for the complete elaboration of new work programmes and interdisciplinary research initiatives. Many priority research topics identified during the subtask, both by end-users and scientists, have been integrated into projects such as EFORWOOD IP proposal for improving the sustainability of the European forestry-wood chains; some other topics have been integrated into initiatives outside 6 FP such as FORSEE interregional project on SFM indicators. However, most proposed research topics and new work programmes elaborated in subtask B1 concern directly three main orientations for the forestry sector in accordance with recent political resolutions agreed in Vienna , April 2003, by the Ministerial Conference for the Protection of Forests in Europe:

- strengthening synergies for sustainable forest management (resolution 1)
- enhancing economic viability and competitiveness (resolution 2)
- preserving and enhancing the social dialogue and cultural dimensions (resolution 3)

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I – Presentation of IMACFORD Task B1

I.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 2 operative tasks.

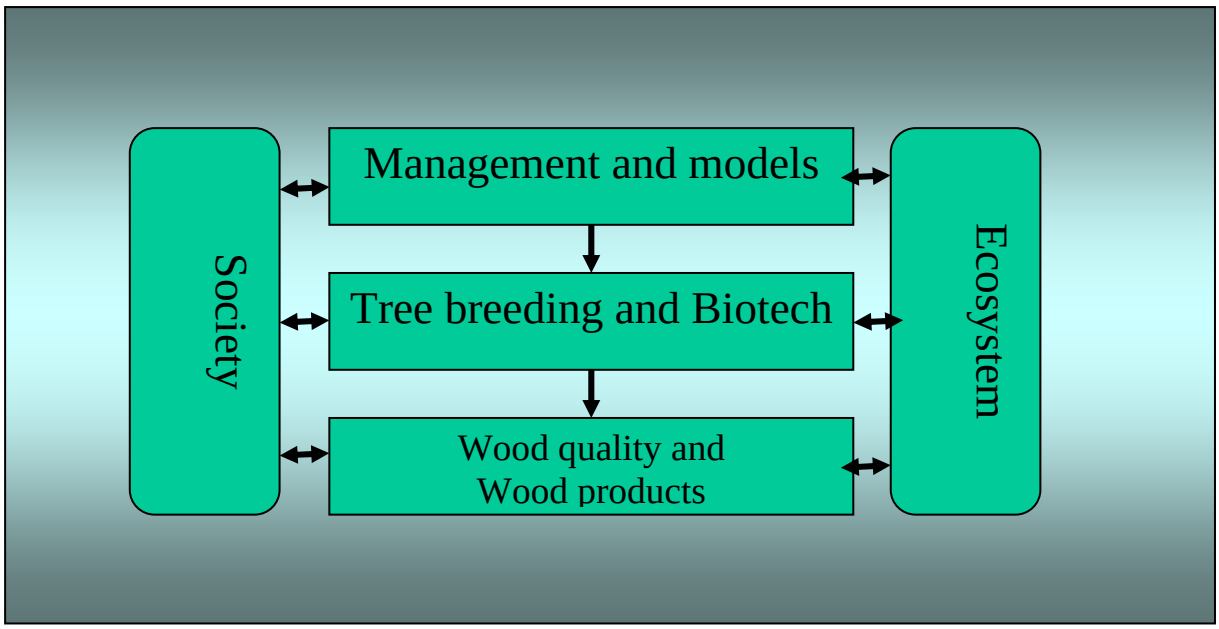
TASK A: Promote dialogue between EU and the forest research community and develop a European network of thematic centres for forestry.

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

I.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. The general research topic of this task is **how scientific progress and technical innovations in the context of plantation forests can contribute to the sustainable development of the forestry sector.**



I.3. Task B1: three phases for developing the research network

Task B1 has 3 separate objectives:

I.3.1. To improve the research coordination at an interregional level (task B11)

The first phase of task B1 investigated 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.
Three thematic groups meetings were hold between September and December 2003. The proceedings of the meetings are available in annexes 2, 3 and 4.

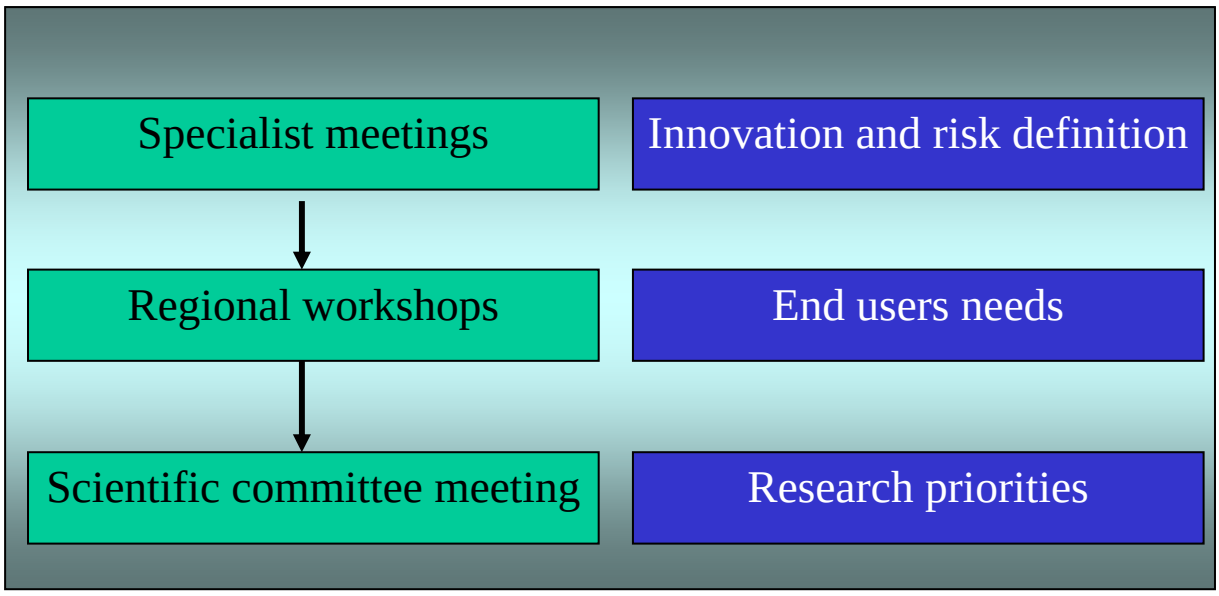
I.3.2. To provide a platform for dialogue with stakeholders and identification of research needs (task B12)

In a second phase, the objective of the IMACFORD task B1 regional workshops entitled "Research needs for the sustainable management of cultivated forests" is to facilitate dialogue with end-users. The output of the consultation is the identification of research needs and the definition of priorities in sustainable forest management and forestry-wood chain related topics.

The first regional workshop was organised in Bordeaux, France on 27-28 February 2003. Its programme and the list of participants can be found as Annex 5.
The second regional workshop was arranged in Obidos, Portugal on 7-8 April 2003. Its programme and the list of participants can be found as annex 6.
The third and last regional workshop will be arranged in Santiago de Compostela, Spain on 15 May 2003. Its tentative programme can be found as annex 7.

I.3.3. To elaborate a framework for integrated interdisciplinary research programmes (task B13)

The third phase include thematic groups meeting and final workshop (proceedings nin annex 8). The objective of this last phase is to elaborate research programmes for sustainable management and utilisation of cultivated forests under changing context. This will lead to a framework for future integration and structuration research within the 6th Framework Programme.



II. Research topics emerging from the research community

II.1. Forest Management and Models

(Presentation in annex 2)

II.1.1. Management of plantation forests: trends and prospective

II.1.1.1. Introductive matter: Prospective study 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 scenarios 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).

Together with the elaboration of 4 possible scenarios for French forests, the results of the prospective study emphasized (1) the relevance of the spatial distribution of forest functions within the territory, and (2) 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's 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.

II.1.1.2. Elements for prospective on regional forest scenarios

One of the main challenge facing scientists would be to elaborate detailed regional forest scenarios.

To do so 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, 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 needs of society, such as 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 regional forest management trends.

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

II.1.2. Growth models and decision support systems for forest management

Scientific forest management has evolved in the last centuries from uncontrolled exploitation and consequent resource depletion. Modern management models embrace both the "ecologically based forestry system" in which sustained production of timber is emphasized and the "social forestry system" in which forests provide a wide range of forest conditions, values and services desired by the society.

In parallel with the development of forestry, the information requirements of the forest managers has 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 criteria 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 decision 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; wood quality is also an important factor to consider in forest inventories in the context of forest wood chain.

(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 now widely accepted 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.

II.1.3. Ecological impact of plantation forests

II.1.3.1. 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.

(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 need 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.

II.1.3.2. 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 may exceed nutrient supplies from the soil, and the increased exports of biomass exportation reduces the volume of organic matter available for mineralization. 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.2. Tree Breeding and Biotechnologies

(Presentation in annex 3)

II.2.1. Overview of tree breeding programmes and strategies in South West Europe

II.2.1.1 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.

II.2.1.2 Breeding trends in Portugal

In Portugal, improvement programmes are developed for maritime pine and eucalyptus globulus.

(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.

II.2.1.3. 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 material from the descendants of trees selected for their site adaptation or stem form qualities. Revigorization of selected adult genotypes is a challenge for Basque tree breeders.

II.2.2. Innovations in tree breeding

II.2.2.1. 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.

II.2.2.2. 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.

II.2.3. Potential impacts of tree improvement regarding forest sustainability

II.2.3.1. 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.

II.2.3.2. 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.

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.

II.2.3.3. 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 high growth rates. In such conditions, the nutrient demands of improved trees selected for their high growth rate may exceed 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 etc.

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.

II.2.4. Research topics

II.2.4.1. 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.

II.2.4.2. 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.

II.3. Wood Quality and Wood Products

(Presentation in annex 4)

II.3.1. Overview of wood quality issues and implications for research

II.3.1.1. 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.

II.3.1.2. 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, silvicultural 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.

II.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.

II.3.2. Market requirements for wood products

II.3.2.1. 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).

II.3.2.2. 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.

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).

II.3.2.3. 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 such as construction. Standardisation of the products and simplification of design rules have to be further studied to make EWP attractive to end-users.

II.3.3. 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.

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.

II.3.4. 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.

III. Research needs expressed by the end-users

III.1. Research needs from the French forestry-wood chains stakeholders

(Presentations in annex 5)

The 50 participants have expressed a great interest in a regional consultation between the forestry-wood sectors actors and the scientific community on research priorities for the sustainable management of cultivated forests.
Three main points of interest have been highlighted by the participants: (i) the identification of end-users expectations for research, (ii) the facilitation of knowledge and technology transfers between the actors of the forestry-wood sectors, and (iii) the developement of an inter-professional frame of communication on the development of forestry with the Society and the media.
Participants suggested the regular organisation of conferences and consultations between the whole forestry-wood chains actors, the scientists and the Society.

The research needs have been by the participants are related to the context of the forestry-wood sector in Aquitaine that includes:

- Important impacts of the storm (December 1999) on the regional forestry-wood chains.
- Globalisation of the wood markets.
- Integration of the sustainable development concept into regional forestry decision making.

III.1.1. Research needs expressed by the forestry and wood sectors – context and expectations

III.1.1.1. Silviculture

The regional sandy forest ecosystem of Aquitaine needs to be better understood in terms of its potential to sustain intensive forest production. An improved understanding of the limits of productivity of the forest ecosystem will help the regional forestry sector to assess the sustainability of the current forest management scenarios and practices regarding essential ecological criteria (soil, water, health).

From a better knowledge of the ability of the regional forest ecosystems to support forest production, technical guidelines for soil and water protection would be useful outputs of the regional forest growth models for the forest managers (Lesgourgues, CRPF). In addition, the identification of adequate fertilisation practices for maritime pine in Aquitaine (what, how, how much, when) has to be improved.

The low profitability of the regional forest production systems, the emergence of new demands for forest products and services from the society and the effects of global change, implies the need to analyse the opportunity of a diversification of forest management scenarios for maritime pine. Forest growth models could assess the ecological and economic viability of the new forest regimes. For instance, in the context of the emerging market of carbon credits, the opportunity to store carbon in the regional forests has to be evaluated and adequate silvicultural scenarios need to be proposed (carbon sink scenarios).
Opportunities for the deployment of broad-leaved species in the current maritime pine forest have to be evaluated as well (Lesgourgues, CRPF). Studies on the profitability of broad-leaves species and their fulfilment of non-wood services under several forest management scenarios have to be continued in Aquitaine.

III.1.1.2. Tree breeding and biotechnologies

In order to have a better control of the quality of reproductive material used in Aquitaine (in the context of the implementation of the European directive 1999/105/CE on the commercialisation of forest reproductive materials), reliable and cheap non-destructive tests need to be developed in order to identify the provenance areas of forest plants (Alousque, DRAF).

Both the regional industrial sector and society demand homogeneous and reliable wood products (Chantre, AFOCEL). Strategies for the genetic improvement of wood quality traits are being conducted in Aquitaine (3rd generation of genetically improved maritime pines in preparation). Taking into account the increasing risk of catastrophic climatic events in the climate change context, the conservation and the improvement of adaptability traits represents a major issue in the tree breeding programmes.

III.1.1.3. Biodiversity

Conserving biodiversity in forest is becoming a relevant issue in Aquitaine since the implementation of Natura 2000 network and the development of the European forest management certification process PEFC. Nevertheless, habitats and relevant species have to be better inventoried and characterised for their sustainable management (Sardin, ONF). Indicators of biodiversity in forest have to be elaborated as well as the methodologies for their periodical assessment.

III.1.1.4. Risk management

FOREST HEALTH

Considering the socio-economic importance of the forestry-wood chains in Aquitaine, the set up of a regional network to monitor forests pests and diseases dynamics has been demanded. How will the European directive “Forest Focus” comply with its objectives at the regional level?

The current strategy to eradicate forest pathogens in Aquitaine is based on the systematic use of chemical pesticides. For the protection of biotic threats, the development of an economic and ecological friendly biotic control approach is needed. Biological control methods have to be proposed and developed in Aquitaine (Alousque, DRAF).

FOREST FIRES

Fires do represent a major threat for the 1 million hectares of maritime pine forest in Aquitaine. Nevertheless, until now, no scientifically based methods (prevention strategies) and tools (models for the understanding of forest fires behaviours) have been developed in the particular context of southwest Atlantic forests (Pinaudeau, SYSSO).

CLIMATE CHANGE

Since December 1999 storm, climate change phenomenon represents a relevant issue for the regional forestry sector.

In order to characterise the risk associated to forest activities, climate change needs to be better understood in terms of its impacts on forest ecosystem functioning (autoecology), forest productivity and tree-forest-landscape stability to extraordinary climatic events (Bosc, INRA). Silvicultural scenarios integrating risk and economic profitability have to be defined and evaluated (Lesgourgues, CRPF).

Considering the changing political and climate context, an analysis on crisis operational management scenarios needs to be conducted.

III.1.1.5. Socio-economic aspects

The forestry-wood chains strongly contribute to the regional income, mainly because of its intensive silviculture. Nevertheless, several studies on the perception of forests conducted at the regional level have shown that most of the citizens do not perceive the economic function of forests as the major one. Considering the increasing awareness of the Society for the sustainable development concepts, the regional forestry sector has to better communicate on its activities (Alousque, DRAF). Strategies to train communicating persons for the forestry sector and to get closer to the non-professional actors

have to be defined and implemented. Research has to further describe the mechanisms of social representation of forests and forestry activities.

Research also needs to better describe the socio-economic mechanisms guiding forest owner decision making. For instance, the comprehension of the sociological processes that conduct the private forest owners to integrate the abiotic risks and the protection of the forest ecological components into their practices could lead to the development of guidelines of sustainable management practices.
In addition, an analysis of the forestry sector organisation would lead to the identification of the criteria to increase the employment in forestry (Picard, IDF).

Considering the low mid-term profitability of forest activities and the increased and diversified demands for forest services emerging from society (biodiversity conservation, soil and water protection, recreation, etc.), funding mechanisms based on a public participation to encourage the private forest owners to enhance multifunctionality and non-market services of forests have to be defined (Picard, IDF). In addition, a market for carbon credits will be opened by 2008 and it may constitute another opportunity for forest managers to diversify their income and to allocate funds to the fulfilment of new forest services demands (biodiversity, recreation, etc.). The economic and energetic viability of the "carbon-sink scenarios" need to be assessed (Bosc, INRA).

At the macroeconomic level, the people in charge of the political and economic decisions for the forestry-wood chains need a scientific basis to objectively understand the evolution of the wood and non-wood products markets (Capes, PEFC Aquitaine).

Since December 1999 storm, the opportunity to optimize the wood sales conditions between the forestry and the wood sectors has emerged. Wood stock platforms were built. Their efficiency in the optimisation of the forestry-wood chains logistic on the one hand, and in the economic enhancement of wood quality for the whole forestry-wood chains actors on the other hand is being evaluated (Lesgourgues, CRPF). Cost studies need to be conducted.

The storm also highlighted the question of the limit of the forest insurance systems in a climate change context (Picard, IDF). Research needs to provide the sociological and economical elements to answer to the question: Is it still possible to insure forests, and how?

III.1.1.6. Sustainable forest management

At the regional level, in order to assess the progress towards sustainability and the impact of forest management practices in terms of forest surface and quality, biodiversity, forest health, climatic and fire risks, the forestry-wood chains require a global forest survey system based on scientifically-based indicators (Lesgourgues, CRPF).

III.1.2. Research needs expressed by the scientific community – research programme opportunities

III.1.2.1. Forest modelling and inventories

In order to better understand forest ecosystem functioning, to integrate the scientific results at regional/national scale or to identify adequate forest management practices, scientists and forest managers need complex process-based and empirical models able to take into account both current and future "natural" (e.g. climate change) and "anthropic" parameters (e.g. demands for new forest services and products) and to provide diverse, reliable and practical outputs (Tomé, ISA).
In term of inputs, the forest models have to integrate the changing "natural" parameters like climate, site characteristics, abiotic risks, forest species natural dynamics, biodiversity, as well as the parameters that can be directly modified by humans like silviculture regimes, genetic pool and biotic risks.
To achieve the objective of multiple and reliable inputs for the appropriate functioning of forest models, forest inventories have to provide new data on trees (biomass, tree mensurations, wood

quality) as well as data on forest stands (biodiversity, carbon, landscape, forest status). Forest inventory methodologies and costs have to be further explored (Gallay, IFN).

In term of outputs for the models, forest managers and the people in charge of landscape planning need to simulate and to assess in an ecological and socio-economic changing context the impacts of their choices on forest ecosystem components (soil, water, biodiversity), forest productivity (wood quantity and quality, non-wood forest products), and microeconomics (profitability of the forest scenario).
One practical challenge lies in transferring the information from detailed scientific models to empirical forest growth models that can be easily used in forest management models. The development of forest growth models in association with GIS will provide decision support tools for forestry practices as well as for policy making.

III.1.2.2. Wood quality and wood products

The main discriminative factor of a broader commercial use of wood products lies in the natural heterogeneity of the material. Wood quality improvement represents a key issue for the economic development of the forestry-wood chains.

In that context, fundamental research activities are currently focused on the comprehension of the processes leading to the formation of wood properties (genetics, site and climate). The results have to be integrated into silvicultural scenarios models in order to identify the forest management regimes and the silvicultural techniques that better enhance wood quality (Castéra, LRBB). Those regimes and techniques would have to be transferred to the forestry sector.

In addition, the forestry-wood-end-products chains need to further integrate the new demands for wood quality emerging from the Society and the markets in their decision making processes. Research has to improve the environmental credibility (low environmental impacts of industrial processes and wood treatments) and the structural reliability of wood products (stability of qualitative parameters in time) by the development of specific tools and techniques.
Moreover, marketing studies would help the wood sector to analyse the relations between the wood products and their markets. Tools are needed to overpass the technical, sociological or economic constraints of the accession of some wood products to the market (e.g. Engineered Wood Products).

III.1.2.3. Competitiveness of the forestry-wood chains

To enhance the competitiveness of the forestry-wood chains at the regional level, the relations between the wood properties and the industrial processes need to be optimized (Chantre, AFOCEL).

In order to reduce the important costs of log transportation, the industrial opportunities of the regional forest resources need to be further evaluated (e.g. mixes of forest tree species for pulp making). To achieve this objective, methodologies and tools to assess wood quality have to be developed (*in vivo* and at the entrance of the factory).
To achieve an adequate territorial management of the regional wood resources (in quantity and quality), logistic tools also have to be developed. For instance, GIS would be useful for the wood sector to optimize the costs of transport.
For the forest contractors as well, the forest operations need to be optimized. To achieve cost reductions, a better correspondence between the harvesting machines and techniques to site characteristics is required (slopes, soil humidity). Good security conditions for the forest workers also have to be further analysed and improved.

CONCLUSIONS OF THE WORKSHOP

Within the presentation of their research needs or during the group discussions, the representatives of the forestry and the industrial sectors have shown a great interest in the role the evolution of the economic, social and climate contexts have on their activities.
The several end-users expressed their needs for new tools (forest models, logistics) and decision making systems (decision support tools for forestry and industrial development) to integrate into their

practices the new demands emerging from the markets and the Society for a qualitative wood production and the achievement of multiple use of forests. They have also demanded technical recommendations in order to properly manage and monitor their forests (e.g. regarding biotic control or soil and water conservation) and their factories in accordance to scientifically-based indicators and guidelines. The forestry-wood sector also expressed expectations for further socio-economic data and new microeconomic models in order to be able to adapt their managerial strategies within a changing context (climate change, internationalization of the wood markets, new societal demands).

To contribute to the achievement of end-user's expectations, research has to identify, describe and predict the mechanisms influencing forest ecosystem functioning, forest productivity, wood quality formation, societal demands, market expectations, forestry-wood chains organisation and economic profitability.
Improved knowledge and technology transfers are required in order to compare the scientific knowledge and tools available on the one hand, and the needs and experiences of the end-users on the other hand, and to propose adequate operational tools for the development of the forestry-wood sectors. In that perspective, the organisation of intersectorial thematic workshops would be useful.

A prioritisation of research needs (Pinaudeau, SYSSO) in Aquitaine could be summed up as below (for further details consult the list of research needs priorities):

- To improve the protection of forests against biotic and abiotic factors.
- To increase the competitiveness of the regional forestry-wood chains.
- To evaluate the sustainability of the silvicultural and industrial practices and to mitigate their negative impacts on the forest ecosystems.

III.2. Research needs from the Portuguese forestry-wood chains stakeholders

(Presentation in annex 6)

Approximately 80 people attended the Portuguese workshop. Representatives of the forestry sector (private forest owners associations, public and private forest companies, forest development organisations), the industrial sector (pulp and sawing companies), the governmental and no-governmental environmental organisations, the national forest authority and the private and public research communities (the full list of participants is given in annex), have demonstrated their interest in an open inter-professional discussion on research priorities for the development of the forest activities in Portugal.

The large participation of the public research community and the forestry sector shows the willingness to bring the national research closer to end-users expectations and to reinforce the cooperation for the transfer of new tools and methodologies from research to practice.

III.2.1. Research needs expressed by the forestry and wood sectors – context and expectations

III.2.1.1. Silviculture, forest planning and inventories

The assessment of the sustainability of the current silvicultural practices (e.g. soil preparation) regarding some essential forest productivity factors (e.g. soil and water) needs to be conducted in order to provide Portuguese forest managers with technical guidelines for the sustainable management of their forest stands (e.g. concrete means to avoid soil erosion). Moreover, research needs to integrate the environmental, social and economic impacts of silvicultural practices into the recommendations provided by decision support systems.
In intensive forestry contexts (e.g. eucalypts plantations), the management of soil fertility is an essential issue and the foresters are interested in the maintenance of forest stand fertility. In parallel, pulp mills produce a high volume of mineral ashes and their destruction is expensive (Araujo, Celbi). The opportunities to fertilize forests with industrial residues have to be further explored. More generally, in order to supply the right quantity of nutrients, research has to better understand the role of soils and silvicultures on tree growth. Furthermore, scientific studies have to be conducted to identify the appropriate fertilization practices (operating conditions, quantity of fertilizers and cost) and the impacts of added nutrients on site productivity and ecological parameters (soils, water, forest health, biodiversity).

Considering the socio-economic demands for wood quality, non-wood forest products (cork, pine cones, resin and hunting) and forest services (e.g. recreation or biodiversity), research has to propose silvicultural scenarios that enhance new forest uses, for both industrial forest tree species (maritime pine, eucalypts and cork oak) and other forest tree species (stone pine, holm oak, chestnut tree, acacia).
For instance, research should explore new attractive forestry schemes in order to avoid the negative environmental impacts of the plantation of eucalyptus in poor soils (e.g. higher biotic risk) and to optimize the economic investments (Sande Silva, LPN).
Furthermore, considering the emerging market of carbon credits, the Portuguese forest managers could be interested in the implementation of silvicultural scenarios to store carbon in their forests in order to diversify their income or to allocate funds to non-wood forest productions. In that perspective, research still has to evaluate the energetic efficiency and the economic balance of "carbon-sink scenarios" within the Portuguese forest context (Calado, AFLOPS).

To contribute to the achievement of the multiple socio-economic demands towards forests, the forest models need to integrate new variables from the forest inventories. It concerns the tree level

(mensurations, wood quality, bark content and wood density) as well as the stand level (non-wood products or biodiversity). Methodologies to collect the new data and tools to map the data on the territory have to be further explored (Tomé, ISA).

III.2.1.2. Risk management

FOREST HEALTH

The understanding of health and vitality conditions of the forest stands (silviculture, site, tree species) is required for the implementation of sustainable silvicultural practices (Calado, AFLOPS). Research also has to propose curative methods to eradicate the Pine nematode (*Bursaphelenchus xylophilus).*

FOREST FIRES

Mainly because of the predominance of unmanaged small scale forest ownerships, forest fires represent a considerable threat to the development of the forestry sector in Portugal. Therefore, forest fires control is a major issue to both private and public forest actors (Rato, DGF).

At the forest manager level, silvicultural practices that enhance forest fires prevention need to be developed. For research, it concerns the identification of preventive methods (pruning, burning), regarding their cost and their efficiency to prevent forest fires (Sande Silva, LPN). The effects of both tree species and stand structures on fire behaviours also need to be better understood in order to provide silvicultural recommendations to the foresters.

At the national level, planning strategies and protection methods are required by the national forest authority in order to fulfil its political commitments on forest fires control (Rato, DGF).

III.2.1.3. Degraded soil rehabilitation

In Portugal, site rehabilitation techniques are claimed by the foresters because of the importance of the erosion process and the large surface of burnt areas (Cunha, Forestis).

III.2.1.4. Biodiversity

Inventories of the biodiversity associated to Portuguese forest ecosystems are required for the integration of biodiversity conservation into forest management models (Leal, CELPA). Also, technical recommendations for the enhancement of biodiversity in private forests (and multifunctionality in a broader sense) would help the foresters to implement the Natura 2000 network requirements (Calado, AFLOPS).

Studies on the impacts of the invasiveness of eucalypts (as exotic tree species) in remarkable habitats would help landscape planning of the areas surrounding the protected areas (Sande Silva, LPN).

III.2.1.5. Competitiveness of the forestry-wood chains

WOOD QUALITY AND PRODUCTS

The main discriminative factor of a broader commercial use of wood products lies in the natural heterogeneity of the material. Wood quality improvement represents a key issue for the economic development of the forestry and wood sectors (Baptista, SONAE).

To provide their customers with homogeneous wood products and to optimize the cost of the industrial processes, sawmills need tools to classify timber in accordance to simple criteria for wood quality (wood density, log geometry, log quality, decaying rates).

Analyses of the forest products markets (wood products, cork, resin, pine cones, hunting, mushrooms, etc.) also have to be conducted in order to better identify the market opportunities for the whole forestry-wood actors. For instance, is there a niche market for acacia wood products? Moreover, from a better understanding of the forest products markets, the development of an adequate marketing strategy would serve the forestry-wood sectors in anticipating the market demands.

The emerging markets of environmental services provided by forests (carbon, biodiversity, soils and water conservation, recreation, landscape, etc.) also have to be further explored (Leal, CELPA).

FOREST OPERATIONS AND EQUIPMENTS

Key parameters for the improvement of the competitiveness of the forestry-wood chains lie in the optimization of the forest works (costs) and logs transportation (fuel consumption). In that perspective, optimised logistic systems coupled with GIS are required.

To reduce the costs of the logging operations, the forest contractors need tools to identify the right equipments and techniques (Gomes, ESAC) in relation with the forest and site characteristics (surface, slopes, soil humidity, etc.). Furthermore, contractors have to rely on technical recommendations for the integration of environmental constraints in the site preparation techniques (e.g. erosion control).
Applied research also has to develop environmental-friendly and product-adapted (resin, cork, pine seeds) forest operations machines (Araujo, Celbi).

INDUSTRIAL PROCESSES

The pulp companies need to optimize their fabrication processes (better yield and lower lignin content) and, at the same time, to reduce their energy and chemical products consumptions (less chemical inputs and less leachings). Another main issue for the pulp companies is to adapt their industrial process to provide their customer with homogeneous products (Venzeller, Celbi).

III.2.1.6. Tree breeding

To achieve the process and market constraints, the pulp companies require fibres with good mechanical and optical properties. In addition to the optimization of the industrial processes, genetic improvement programmes for better fibre properties are need to be developed (Venzeller, Celbi).

In the context of less intensively managed forests, the quality of forest reproductive material is quite often overlooked by the foresters. In order to improve globally the forest productivity and the wood quality in Portugal, the establishment of rules for seed collection in forests and the improvement of the controls concerning the production of commercial seeds in nursery (towards the certification of tree seeds) are necessary regulatory tools.

III.2.1.7. Socio-economics

In Portugal, the high forest fragmentation implies serious constraints regarding the industrial wood supply (70% of the eucalypts stands are owned by non-industrial private forest owners). Most of the time, small scale forests are not managed and they constitute an important threat for the whole forestry-wood chains (forest fires, sanitary problems).
In that context, the understanding of the private forest owners motivations and decision-making processes represents an essential issue for the development of the Portuguese forestry-wood sectors. Specific forest management tools have to be developed for small scale forestry systems (Araujo, Celbi).

The new economic opportunities for the forest owners to fund the fulfilment of traditional forest productions (wood and non-wood products) and forest services (carbon, recreation, biodiversity, soil conservation) should be integrated within the forest management tools. Also, considering the enhancement at the regional level of multifunctional forestry systems through Natura 2000 network, the viability between conservation values and local forest economies (forestry, hunting, etc.) need to be assessed by the research community.
In addition to those new social demands, the impacts of the forest operations on landscapes have to be scientifically evaluated and landscape management guidelines are required.

III.2.1.8. Sustainable Forest Management (SFM)

Portugal has signed the international commitments on SFM (Rio, Helsinki). To achieve the international obligations and the new market demands for certified forest products (Calado, AFLOPS), the Portuguese R&D sectors need to elaborate scientifically-based indicators of SFM.
The definition of the relevant indicators, the scale for their reliability, the methodologies and the cost of their assessment are still required (Rato, DGF).

III.2.2. Research needs expressed by the scientific community – research programme opportunities

III.2.2.1. Silviculture and modelling

In order to better understand forest ecosystem functioning, to integrate the scientific results at regional/national scale (tree breeding, forest health, edaphology, etc.), or to identify adequate forest management practices, scientists and forest managers need complex process-based and empirical models that take into account both current and future "natural" (e.g. climate change) and "anthropic" parameters (e.g. demands for new forest products and services) and that provide multiple, reliable and pragmatic outputs (Tomé, ISA).

In term of inputs, the forest models have to integrate the changing "natural" parameters (climate, site characteristics, abiotic risks, forest species natural dynamics, biodiversity, etc.) as well as the parameters that can be directly modified by humans (silviculture regimes, genetic pool and biotic risks). In accordance with what has been presented above, the scientific and economic challenge for forest inventories is to provide research with new reliable and cost effectiveness data at the tree and the stand level.

In term of outputs for the models, forest managers and the people in charge of landscape planning need to simulate and to assess, in an ecological and socio-economic changing context, the impacts of their choices on forest ecosystem components (soil, water, biodiversity), forest productivity (wood quality, non-wood forest products), and microeconomics (profitability of the forest scenario).
One practical challenge lies in transferring the information from detailed scientific models to empirical forest growth models that can be easily used in forest management models. The development of forest growth models in association with GIS will provide decision support tools for forestry practices as well as for policy making.

III.2.2.2. Tree breeding

In the Portuguese context, the climate change scenarios are foreseeing that water stress will become a leading constraint to forest primary production. Therefore, tree breeding strategies have to be focused on the improvement of adaptability factors (drought tolerance and resistance to pests and diseases) as well as forest productivity and quality of forest products (market demands).
Nevertheless, strong constraints are limiting the large deployment of genetically improved trees in the Portuguese forests (Almeida, ISA). In addition to the problem of overlooked seeds quality, erratic public financings represent a constraint for the fulfilment of the long-term tree breeding objectives, like for instance the conservation of the genetic diversity of non-industrial tree species (*Umbrella pine*, *Holm oak*, etc.).

For the tree breeders, physiological markers are needed in order to improve the efficiency of indirect selection for adaptability (low genetic heritability). Regarding the development of early selection tests useful in the optimization of the genetic improvement processes, research needs to elaborate molecular markers based on the genetic architecture of the economic traits of interest.

A larger deployment of improved varieties in the forests lies on the diffusion of a reliable and pragmatic information to the foresters. For instance, the integration of the silvicultural requirements of improved varieties (fertilization, thinning, spacing, etc.) into forest models would conduct to provide forest managers with optimized silvicultural recommendations.

III.2.2.3. Forest health

The development of models to predict sanitary risks lies on the evaluation of the density of forest pests and diseases populations in relation with the damages occurred at stand and landscape level. To achieve that objective, a national forest health survey system is required (Branco, ISA).
The understanding of the biotic risks associated with (i) the planning of trees and crops biodiversity at landscape level, (ii) the silvicultural scenarios (tree species, shortening rotation time), and (iii) the

silvicultural management practices (fertilizations, thinning, pruning, understorey management) would lead to the edition of pragmatic silvicultural guidelines for a biotic risk management strategy.

Furthermore, within an intensive forestry system in which genetically improved varieties are commonly used, the evaluation of the susceptibility of those new varieties (e.g. genetically modified trees) to pests and diseases are required by the tree breeders for the integration of biotic risks into their genetic improvement programmes.
Regarding the forest managers, the development of Integrated Pest Management strategies (biological control and use of semiochemicals) would favour an ecologically-friendly and economically-reasonable control of biotic threats. To achieve this objective, studies on the direct (forest productivity) and indirect (forest services) costs and benefits of those strategies need to be assessed. Integrated Pest Management strategies have to be included into decision support systems.

CONCLUSIONS OF THE WORKSHOP

The representatives of the Portuguese forestry-wood sectors expressed the willingness to adapt their current development strategies in order to fulfil the new market and society requirements for forests. In that perspective, they demanded diversified and profitable forestry options through the proposal of new silvicultural scenarios (for both industrial and non-economically traditional forest tree species) to enhance wood quality or to ensure the production of non-wood forests goods and services.
In addition to that, the end-users asked for new development tools to optimize their activities (logistic systems, decision support tools, certified plants) and to achieve the new requirements of sustainable forest management (indicators, technical guidelines).
Furthermore, the socio-economic actors stressed the importance to better protect the Portuguese forests from biotic and abiotic threats through the development of new strategies (forest fire prevention strategies, integrated pest management approaches) and tools (decision support systems that do integrate the multiple risks).

To contribute to the achievement of their requirements, the end-users highlighted the central role of research. Nevertheless, they agreed on the necessary reorganisation of the relations between the research organisations in Portugal. Setting up multidisciplinary teams and national and interregional research networks would avoid effort duplications (Rato, DGF).
The participants also highlighted the necessity to define new financing opportunities for the research sector in order to solve the recurrent problem of erratic public financings and its impacts on the implementation of long term research activities (e.g. tree breeding).

In order to capture all gains, research has to be followed by efficient technology transfers for day-to-day operations. In that perspective, the idea to set up a Portuguese “forest information system” emerged from the discussion (Cunha, Forestis). This intersectorial platform would contribute to the development of the forest activities by the enhancement of exchanges in terms of (i) diffusion of the scientific results, (ii) identification, anticipation and definition of research priorities from end-users and Society research needs, (iii) development of knowledge and technology transfer strategies in order to provide the end-users with the tools and methodologies they require.

Portuguese participants

III.3. Research needs from the Spanish forestry-wood chains stakeholders

(presentation in annex 7)

50 forest professionals from the whole Atlantic Spain attended the workshop. Representatives of the forestry sectors (private forest owners associations, private forest companies, public tree nurseries), of the industrial sectors (pulp and paper companies, unions of sawn-wood industries and wood sellers), of the regional forest authority and the private and public forest and wood products research communities (the full list of participants is given in annex), have demonstrated their interest in an open discussion on research priorities for the development of the forest activities in Atlantic Spain.

In Atlantic Spain, the development of the forestry-wood sectors is closely linked with the context of increasing international competition on wood markets, and emerging social and environmental constraints (sustainable development requirements) on the forest and industrial activities.
The end-users research expectations stressed by the participants and presented below are mostly determined by those two factors.

III.3.1. Tree breeding and forest plants production

Genetic improvement requires an important economic investment for the whole Society (public research financing) as well as for the actors of the forestry-wood chains (higher cost of genetically improved plants). In order to capture all gains at mid and long term perspectives, the genetically improved plants need to exactly fulfil the market and industrial demands (wood quality), and to be adapted to the new ecological constraints of climate change (plants with drought or pests and diseases resistances). In that perspective, tree breeders and end-users have to closely identify the relevant traits to be genetically improved (Dans, AFG).

Regarding the pragmatic implementation of the genetic improvement programmes, tree breeders need to enlarge their current improvement basis (selection of plus trees) for the forest tree species of economic interest at the regional level (Ruiz, Xunta de Galicia). In addition to that, the viability and the genetic gains of varieties from foreign provenance areas introduced in the regional ecological conditions have to be tested. Finally, a database of the genetically improved varieties available at the regional level is needed to avoid the duplication of efforts for the tree breeding community and to deploy development strategies with the foresters (Fernandez, CIF).

To optimize the costs of reforestation and to contribute to the production of wood quality, tree nurseries need to provide the foresters with a good quality of forest plants in terms of low juvenile mortality and quick initial growth (Rodriguez, USC).
To achieve those objectives, tree nurseries have to improve their techniques of production (e.g. the adequate type of containers per tree species or the efficient techniques to mycorrhize the substratum). Regional technical guidelines for a qualitative production of forest plants in tree nurseries are required.

III.3.2. Silviculture, forest planning and inventories

In Atlantic Spain, the great diversity of ecological conditions coupled with a complex structural organization of the forest ownership requires specific silvicultural approaches (Ruiz, Xunta de Galicia). In that perspective, regionally understandable forest planning and forest management models and tools are needed.
Furthermore, to fulfil the new socio-economic demands for wood quality, non wood products and forest services, the current silvicultural guidelines have to be updated.

Research has to integrate the new expectations towards forests into the forest models in order to define the more efficient and cost-effectiveness silvicultural scenarios and techniques (soil preparation, initial densities of forest plants, intensity of pruning and thinning, etc.).

Modelling the interrelations between sites and silvicultures on wood quality formation would lead to the definition of industry-oriented silvicultural scenarios for the improvement of wood quality. It could lead to the elaboration of silvicultural recommendations to avoid the formation of reaction wood (Martinez, NEIKER), to a diversification of the industrial uses of *Eucalyptus globulus,* or to develop relevant industrial-focused scenarios for *Eucalyptus nitens* in Galicia.
Reliable silvicultural guidelines (Dans, AFG) are also required to ensure the economic (logging of high economic value timbers) and ecological sustainability of mixed broadleaves forests (conservation of soils and water, protection of biodiversity, etc.).
Furthermore, considering the emerging market of carbon credits, the Spanish forest managers could be interested in the implementation of silvicultural scenarios to store carbon in their forests to diversify their incomes. In that perspective, research still has to evaluate the energetic efficiency and the economic balance of "carbon-sink scenarios" within the Atlantic Spain forest context (Merino, USC).

At the regional level, in order to assess the impact of the forest management practices and to develop sustainable management guidelines for the conservation of biodiversity, carbon storage or soil protection, the forestry-wood chains require qualitative indicators of sustainable forest management (Alvarez, USC)
The definition of the relevant indicators, the scale of their reliability, the methodologies and the cost of their assessment are still required. They should be included into decision support systems.

To reduce the costs of the logging operations, the foresters need tools to identify the right equipments and techniques in relation with the forest and site characteristics (surface, slopes, soil humidity, etc.).

Considering the multiple socio-economic demands towards forests, the forest models need to integrate new variables from the forest inventories (Rojo, USC). It concerns the tree level (mensurations, wood quality, bark content and wood density) as well as the stand level (non-wood products or biodiversity). Reliable and cost-effectiveness methodologies to collect the new data have to be further explored (efficiency of a network of permanent plots?).
Regarding the use of the forest inventory data, the large diffusion of the forest resource characteristics through a database would make the development of new qualitative and quantitative forest growth models and volume tables easier (Alvarez, USC). Furthermore, the development of new volume measure techniques closer to the reality would be facilitated.
The industrial sectors require reliable and updated data on the quality of the wood resource and its geographic localization in order to optimize log transportations and industrial processes. In that context, the rotation between each data recollection could be reduced for the fast growth tree species (Vega, USC).

III.3.3. Nutrition status and protection of forests

SOILS FERTILITY

The main factor impeding the development of intensive forest practices lies in the productivity of the soil. Therefore, managing soils fertility represents a key-issue for the sustainable development of cultivated forests (Merino, USC).
In that perspective, research must provide the forest managers with sustainable forest management guidelines taking into account the physical (ability of soils to sustain mechanized forest operations) and chemical capacities of their soils (ability to sustain intensive silvicultural practices or genetically improved trees).
Regarding the issue of nutrients supplies by fertilization, research has to implement experimental methodologies and to develop operational tools to answer the pragmatic questions of the foresters: What, How much, When and How.
The evaluation of the amount and the nature of nutrients fixed per tree physiological compartments (per ages and per tree species) requires reference data for the realization of nutrients balances at the forest stand level.

Good responses to experimental nutrients supplies and litter management practices (e.g. understorey management, slash management) should orientate management practices for fertilized forestry scenarios.
Studies on the cost-effectiveness and the environmental impacts of fertilization and soil preparation also need to be conducted.

FOREST HEALTH

Considering the socio-economic importance of the forestry-wood chains in Galicia, the set up of a regional network to monitor forests pests and diseases dynamics has been demanded.

In addition to the evaluation of threats, the biotic risk management also lies in the implementation of an integrated prevention strategy (Magan, CIF). The expected outputs will be to provide forest managers with appropriate forest management guidelines and decision support tools integrating biotic risk control (Dans, AFG).
To achieve that objective, research needs to better understand the impacts of the site and the silvicultural factors on the pests and diseases dynamics as well as the susceptibility of genetically improved trees and exotic species to forest pests and diseases. This information is required by forest management models.

Regarding the protection of forests, the development of Integrated Pest Management strategies (biological control and use of semiochemicals) would favour the ecologically-friendly and economically-reasonable control of biotic threats. To implement IPM strategies, reliable diagnostic methods have to be transferred to the forest managers as well as the list of legal biocides available in forestry.

FOREST FIRES

To prevent forest fires, appropriate landscape planning strategies (territorial mosaic of rural uses, management of the interfaces between forests and urban areas, bush management) and techniques (fuel management, silvicultural management, deployment of fire tolerant forest species) have to be defined by research (Vega, CIF-Lourizan). For instance, in order to mitigate the risk induced by silvicultural practices, research has to elaborate predictive models to identify the impacts of trees and stands architecture on forest fires behaviours (considering ground and canopy fires).
Then, the development sector will provide the public administrations and the forest managers with decision support systems and technical guidelines to be implemented at stand level.

Considering forest fires fighting strategies, the elaboration and the cartography of fire risk indices based on the meteorological conditions and the fuel humidity content will contribute to optimize the allocation of forest fire fighting equipments and teams.
Efficient, safer for humans and cost-effectiveness forest fires fighting strategies are required, as well as ecologically-friendly practices and in that perspective, the ecological benefits of fire retardants still have to be assessed.

Within the objective to implement adequate rehabilitation techniques of burnt areas, the ecological effects of forest fires on water, carbon and nutrient cycles, on soil physical status and on the ecological dynamics of surrounding biological populations need to be better understood.

III.3.4. Socio-economics

In Atlantic Spain, the high fragmentation of private forests represents a heavy constraint to the management of forests and to the competitiveness of the wood sector as well (Vilariño, USC).
To raise those limitations, the promotion of private forest owner organizations and the development of specific tools for the collective management of multiple private forests stands are demanded. In that perspective, research will have to provide the decision-makers and the developers with reliable information about the socio-economic characteristics and motivations of the private forest owners.

Moreover, a political commitment to enhance the grouping of forests lands and to get the forestry financial system more attractive to forest activities would also facilitate the development of the forestry-wood sectors in Atlantic Spain.

Considering the weak cash flow of forest activities and the increased and diversified demands for wood quality emerging from the markets, and for forest services emerging from the Society (biodiversity conservation, soil and water protection, recreation equipments, etc.), new funding mechanisms to support the development of the private forestry sector have to be defined. For example, financial means to make thinnings profitable for the forest owners are required.
Market, taxes and public subsidies opportunities have to be further explored. In that perspective, the people in charge of the political and economic development of the forestry-wood sectors need to objectively understand wood and non-wood products markets functioning as well as new forest services markets.

The establishment of an interregional monitoring organisation (Touza, CIS Madera) on the industrial costs would contribute to identify the macroeconomic and juridical measures that would make Galicia more attractive to high value wood transformation manufactures (furniture, moulding, etc.).

In spite of the contribution of the forestry-wood chains to the regional incomes in Atlantic Spain, several studies conducted on the perception of forests by the society have shown that most of the time the economic function of forests is not perceived as important. Given the increasing environmental awareness, there is a need for the regional forestry sector to improve communication with the public. The forestry sector has to get closer to the non-professional actors. Research has to further describe the mechanisms of social representation of forests and forestry.

III.3.5. Competitiveness of the wood sector and wood products

The main discriminative factor of a broader commercial use of wood products lies in the natural heterogeneity of the material. Thus, the segregation of homogeneous wood quality classes represents a key-issue to increase the competitiveness of the forestry-wood sectors (Basurco, ENCE).
To optimize log transportations and industrial processes, pulp mills need to link the products to the processes through the development of non-destructive, quick and cheap fibre quality tests in accordance to practical criteria for the pulp making process (yield, density, chemical composition).
Moreover, logistic systems coupled with GIS are required for the optimization of the forest operations.

Pulp mills produce an important quantity of mineral ashes and the cost of their disposal represents a constraint in the competitiveness of the wood sector. For that reason the economic and ecological opportunities to supply cultivated forests with industrial ashes need to be further explored.

A better competitiveness of the forestry-wood chains in Atlantic Spain (Touza, CIS-Madera) also lies in the economic and marketing promotion of the forest resources available at the regional level (e.g. develop higher value silvicultures for *Eucalyptus globulus*, investigate industrial opportunities for *Eucalyptus nitens*, propose attractive and reliable wood based products of Maritime pine).

CONCLUSIONS OF THE WORKSHOP

The representatives of the forestry-wood sectors in Atlantic Spain stressed the need to develop management tools specifically adapted to the regional ecological and regulatory conditions in order to better comply with the socio-economic demands and with the conservation of forest productivity factors.

Considering the important growth rates of the industrial forest plantations in Atlantic Spain, the establishment of regional monitoring organisation on the quantity and the quality of the forest resources will facilitate the implementation of prospective studies on wood availability and quantity within the next 15 years (Where are we going?). Pragmatically, those results would serve the wood–

industries and the public authorities in the identification of the best development strategies and forest policy orientations (Toval, ENCE).

Taking into account the new socio-economic demands for wood quality and multiple forest services (biodiversity, recreation, soil and water conservation), the forestry-wood chains require alternative silvicultural scenarios for both industrial and traditionally non-industrial forest tree species. For instance, the issues of biomass production for energy or storing carbon in forests were raised. The forestry sector demanded technical guidelines for the implementation of sustainable forest management and forest operations practices in accordance with the recommendations of PEFC, for instance regarding forests soils conservation.
Nevertheless, the economic profitability of forestry under new silvicultural scenarios (recreation or biodiversity and also wood quality) is essential to encourage foresters to develop new management practices. So new financing opportunities for forest activities have to be explored by research.

In order to capture all gains, research has to be followed by efficient technology transfers for day-to-day operations. In that perspective, the setting of an inter-professional discussion forum on research at the regional level would contribute to identify the research needs and to define the best technology transfers and communication strategies in order to provide the end-users with the tools and the methodologies they require. For instance, the forum would facilitate the development of Integrated Pest Management strategies, identify the relevant traits to be genetically improved, or clarify the strategy of diffusion of genetically improved varieties at the regional level (Ocaña, Tragsa)
Another pragmatic output of the inter-professional forum for research transfer and communication organization would be to develop regional data cooperatives, e.g. on forest resources characteristics (Vega, USC) or on the availability at the regional level of relevant information for indicators of SFM.
In addition to that, the inter-professional discussion will facilitate the diffusion of best forest management and forest operations practices by defining appropriate professional training strategies.
The forum will also provide the basis to a platform of communication on the development of the forestry-wood sectors with the Society.

Finally, the participants highlighted the need to optimize the public financial investments in research and to avoid effort duplications by the set up of multidisciplinary teams and research networks at the national and interregional level.

Spanish participants

IV. Strategic framework for future research

Thirty five people from 5 partner countries of IEFC (Ireland, UK, Spain, Portugal, and France) participated in the final meeting of the IMACFORD task B1 in Dublin. Representatives of EFI also participated. Most of the participants came from the forestry and wood research community; representatives of the private foresters of Western Europe, of the industry sector and NGOs attended the meeting as well.

The objectives of the final meeting of IMACFORD task B1 were (i) to present and discuss the list of research needs that have emerged from the regional consultations with end-users, (ii) to identify priority research topics, and (iii) to prepare work programmes outlines for future research and transfer activities within IEFC framework (meeting agenda and presentations in annex 8).

IV.1. Thematic groups consultation on priority research topics

Thematic groups met the first day in order to identify research priorities for the sustainable management of cultivated forests in the areas of (1) tree breeding and biotechnologies, (2) forest management and modelling, (3) wood quality and products as well as (4) forest ecology and (5) socio-economics. The 5 thematic groups were also asked to identify new project opportunities.

The participants of the thematic groups were provided with the synthesis of the IMACFORD task B1 regional end-users consultations held in Aquitaine, Portugal and Atlantic Spain (Galicia) and the director of COFORD(Irish National Council for Forest Research and Development) expressed the specific research needs in Ireland.
In addition, the Dublin meeting participants were also provided with the list of end-users research needs and priorities that emerged from the 3 regional workshops (annex 9 - also available on IEFC's web page).

The 5 thematic groups reports are summarized below (detailed reports in annex 8.4).

IV.1.1 Priority research topics

IV.1.1.1 Tree breeding and biotechnologies (Dublin group 1):

The group of tree breeders emphasized the general goal to create improved varieties for re-(a)-forestation in an evolving ecological and economic context: minimize risk, maximize quality and quantity. Priority research topics include:
(i) Increase breeding activities for species of intensive silviculture, and develop variety selection activities for species of diversification (Cryptomeria, Ash, Tilia, etc.).
(ii) The choice of the traits to be improved should be based on the dual objective of minimizing risks and maximizing quantity and/or quality.
(iii) Breeding strategies should be optimized providing long term genetic gain and maintaining genetic variability for example through the construction of multitrait selection associating phenotypic value and molecular information.
(iv) Genetic gain deployment has to be further planned and methodologies and tools for a better knowledge/production/utilization of improved varieties are needed.
(v) Analysing the impacts of improved varieties on the environment (ecological and socio-economic impacts) is also a matter of particular relevance.
(vi) For long term activities such as tree breeding, research policies should develop specific strategies at the European scale.

IV.1.1.2. Forest management and modelling (Dublin group 2):

The forest management and modelling group drew up a list of:
(i) Basic research topics aiming at an increased knowledge of.

- Functioning of forest ecosystems
- Ecological characterization of sites and integration of this knowledge into models

(ii) Applied research topics aiming at improving the management of forests from stand to landscape and regional levels (e.g. fertilization practices, soil preparation, stand manipulation, development of indicators of SFM, inventory data) taking into account biotic and abiotic risks and providing integrated models, decision support tools and technical guidelines for:

- Forest management at stand level
- Risk analysis in relation to forest management
- Forest regeneration
- Forest and land-use planning at landscape and regional levels

IV.1.1.3. Wood quality and products (Dublin group 3):

The wood quality and products group identified the following research topics:
(i) Develop a forest production strategy based on end-users product requirements.
(ii) Understand and predict wood formation that controls wood quality and products.
(iii) Analyse market requirements for wood and fibre properties.
(iv) Provide methods and tools for the early assessment of wood properties.
(v) Improve the design methods for timber use in building industry.
(vi) Assess the environmental impact of wood products (life cycle analyses, etc.).
(vii) Analyse the ecological and economic opportunities for biomass exploitation.
(viii) Understand the interactions between forest pests and diseases and wood quality.

IV.1.1.4. Forest ecology (Dublin group 4):

Basic Research Needs

(i) Life history and habitat requirements of forest flora and fauna.
(ii) Interrelation of community structure and biodiversity on the stability, health, productivity and biogeochemical cycling of elements at the forest ecosystem.
(iii) Assess the landscape organisation influences on forest processes and community structure at the stand level.
(iv) Structural and functional biodiversity of soil microbiota and its relation with sustainability of forest systems.
(v) Management impacts on community structure at the stand, forest and landscape level, including the introduction of exotic species and GM organisms.

Applied Research Topics

(vi) Cost effective methodologies for inventory of remarkable habitats at various levels (plot, stand and landscape) for key taxa
(vii) Cost effective methodological tools and indexes for assessing and monitoring forest biodiversity, including, structural diversity in forest ecosystems, and their relationship with stand processes and management objectives
(viii) Tools to evaluate the impact of fragmentation and landscape layout on the forest community
(ix) Integrate biodiversity management in Decision Support Systems, assessing tradeoffs between biodiversity conservation, stability, productivity and global environmental performance of forest systems under alternative management strategies.
(x) Develop management guidelines for riparian areas and ecological corridors
(xi) Development of integrated and biological control of forest pests and diseases

IV.1.1.5. Socio-economics (Dublin group 5):

The socio-economic group has focused on 3 priority research topics at the interregional level:

(i) Identify new funding mechanisms to satisfy simultaneously society demands for wood products and forest services (energy, carbon, recreation, biodiversity, etc.).
(ii) Analyse Society's perception of forests and forest management.
(iii) Understand and characterize forest owners and socio-economic factors influencing their choices and motivations.

IV.1.2 Comparative analysis of research needs and priority research topics

From the exhaustive list of 120 potential research topics (annex 9) expressed by end-users, the thematic groups elaborated a "short list" of 35 priority research topics (Table 1) on the basis of their expertise and current knowledge for the different topics, and taking into account priorities expressed by end-users during the regional workshops. Table 1 shows that each group covered 17 to 26 % of potential research topics as expressed by end-users.

Group number	1	2	3	4	5
Number of priority research topics proposed	6	7	8	11	3
Needs covered	23%	26%	17%	20%	17%

Table 1 :End-user needs and priority research topics

Though proposed research topics don't cover 100% of the expressed needs, it is interesting to notice that all the categories of research needs are covered at least partially (table 2).

Research needs categories	Covered by priority research topic			
	No	Partly	Yes	Total
Non wood products	0%	0%	100%	100%
Wood quality and wood products	0%	14%	86%	100%
Forest inventories	13%	38%	50%	100%
Forest management and modelling	17%	29%	54%	100%
Biodiversity	29%	29%	43%	100%
Tree breeding, biotechnologies and production of plants	29%	6%	65%	100%
Forest operations, logistics and transport	30%	40%	30%	100%
Biotic and abiotic risks	46%	0%	54%	100%
Socio-economics of the forestry-wood chain	60%	7%	33%	100%
Forest policy	73%	9%	18%	100%
Dissemination of knowledge, Communication	100%	0%	0%	100%
Total	**35%**	**17%**	**49%**	**100%**

Table 2: coverage of end-users needs categories

Comments on Table 2: we notice that non wood product potential topics are covered, the two main reasons being that there are only five identified, and all included in the proposal made by the group 5. The wood resource quality issues are also well covered by the priority research topics, it seems that the group 3 used this category to define most of its research topic. With low coverage, dissemination of knowledge, risk management , forest policy and socio-economic.

Some of the gaps identified in Table 2 can be explained by:

- lack of scientific relevance of certain topics and needs: for example needs and topics such as "promoting forest owner associations" or "elaborating crisis operational scenarios" are more relevant to managers and policy makers than to scientists; dissemination of knowledge concern directly IEFC activities but does not justify specific research programme.

- broad topics such as biodiversity (monitoring), forest health (integrated management), micro-economy (forest profitability) are relevant to all groups and were not elaborated further into research topics by any group.
- lack of scientific expertise in the panel: the range of the needs and topics covered was so large that some competencies where missing in the thematic groups, and no proposal was registered (wildfire prevention, risk economy, forest owner characterisation, …)
- topics that are already addressed in current projects and proposals - such as FORSEE (Interreg project on indicators for SFM) and EFORWOOD (6 FP) - have not been listed by thematic groups

IV.2. Preparation of work programme outlines

IV.2.1. Method

One of the main challenges of the task was to group priority research topics into comprehensive work-programmes and future project proposals, being efficient but not limitative, and relevant to European research and development priorities. The method chosen by the project management team was:

(1) to review and present to participants different RTD project categories and funding mechanisms within FP6 or other sources (Interreg)
(2) to discuss in small groups and elaborate proposals relevant to three main broad categories of issues identified by end-users: multifunctionality of cultivated forests, competitivity of the forestry-wood chain, dialogue between science and society.
(3) to validate at least 3 work programme outlines (WPO) covering most priority research topics

An additional difficulty was that, as the starting date of IMACFORD has been delayed, the first call for projects under the 6th FP occurred in the middle of the consultation process of IMACFORD and some of the topics have already been covered by other initiatives.

IV.2.2.Work programmes overview

Three potential projects (Table 3) for the development of RTD activities relevant to cultivated forests were identified and discussed (work programme outlines detailed in annex 10).

(i) Marie Curie Research Training Network for the multifunctionality and sustainability of temperate Atlantic forests in the context of forestry wood -chains.(6 FP)
(ii) The enhancement of dialogue in forestry between science and society (6 FP).
(iii) Atlantic forestry-wood chains Alliance (Interreg RTD network).

Main issue	Project proposal title	Outlined before 1/07/03	Type	Partners	Research topics (table 4)
Multifunctionality	MUSTAFOR : Marie Curie Research Training Network for the multifunctionality and sustainability of temperate Atlantic forests.	No	Training network for scientists	IEFC Members+ EFI and other RPC's	g1.iii, g2.i, g2.2, g3.i, g3.ii, g3.iii, g3.vii, g3.viii, g5.i, g5.iii
Science and society	Enhance Science and Society dialogue in forestry.	No	Dialogue platform	IEFC Members+ EFI and other RPC's	g1.vi, g5.ii
Competitiveness	Atlantic forestry-wood chains Alliance.	No	INTERREG project	IEFC Members+ Wales university, INOVAWOOD, CIS Madera, LRBB	g1.iv, g2.ii, g3.i, g3.iii, g3.vi, g3.viii, g5.i

pm: projects already proposed or accepted (first call 6FP or Interreg III C – first semester 2003)

Sustainability	*FORSEE :Sustainable FOReSt management : a nEtwork of pilot zones for operational implEmentation*	*Yes*	*INTERREG project*	*IEFC Members*	*g2.i, g2.ii, g4.i-vii, g5.i, g5.ii*
Competitiveness	*EFORWOOD : Improving the sustainability of the forest wood chain*	*Yes*	*6th FP research project*	*>50 partners*	*G1.i-iv, g2.i, g3.i, g3.iii, g3.vi, g3.vii, g3.viii, g4.9*

Table 3: summary of project proposals

IV.2.3.Gaps and overlapping

From the matrix describing relationships between research topics and project proposals (Table 4), it can be seen that most priority research topics are well covered by the work programmes. Nevertheless, some of the research topics are not covered at all by these proposals and will need to be addressed in new initiatives and possibly at other levels (regional or national):

- impacts of improved tree varieties on the environment (ecological and socio-economic impacts).
- Ecological characterization of sites
- Provide method and tools for early assessment of wood properties
- Improve design methods for timber use in building industry
- Develop management guidelines for riparian areas and ecological corridors
- Life history and habitat requirement of forest flora and fauna

IEFC IMACFORD Core group after the Dublin meeting

Table 4 : coverage of priority research topics in proposed workprogrammes and projects

Group	Research topic	*FORSEE*	*EFORWOOD*	Forest-wood chain alliance	MUSTFOR	science society dialogue	
Group 1	(i) Increase breeding activities for species of intensive silviculture, and develop variety selection activities for species of diversification (Cryptomeria, Ash, Tilia, etc.).		Partly				1
Group 1	(ii) The choice of the traits to be improved should be based on the dual objective of minimizing risks and maximizing quantity and/or quality.		Yes				1
Group 1	(iii) Breeding strategies should be optimized providing long term genetic gain and maintaining genetic variability for example through the construction of multitrait selection associating phenotypic value and molecular information.		Yes		Partly		2
Group 1	(iv) Genetic gain deployment has to be further planed and methodologies and tools for a better knowledge/production/utilization of improved varieties are needed.		Partly	Yes			2
Group 1	(v) Analysis of the impacts of improved varieties on the environment (ecological and socio-economic impacts).						
Group 1	(vi) For long term activities like tree breeding are, research policies should develop specific strategies at the European scale.					Partly	1
Group 2	(i) Basic research topics aiming at an increased knowledge of forest ecosystem functioning and site ecological characterization to be integrated into forest models.						
Group 2	– Functioning of forest ecosystems	Yes	Yes				2
Group 2	– Ecological characterization of sites						
Group 2	– Integration of knowledge in models				Yes		1

Group	Research topic	*FORSEE*	*EFORWOOD*	Forest-wood chain alliance	MUSTFOR	science society dialogue	
Group 2	(ii) Applied research topics aiming at improving the management of forests from stand to landscape and regional levels (e.g. fertilization practices, soil preparation, stand manipulation, development of indicators of SFM, inventory data) taking into account biotic and abiotic risks and through the development of technical recommendations, forest growth models and decision support systems :						
Group 2	– Forest management at stand level				Yes		1
Group 2	– Risk analysis in relation to forest management				Yes		1
Group 2	– Forest management at landscape and regional levels	Partly		Partly	Yes		3
Group 2	– Regeneration				Yes		1
Group 3	(i) Develop a forest production strategy based on end-users product requirements.		Yes	Yes	Yes		2
Group 3	(ii) Understand and predict wood formation that controls wood quality and products.				Yes		1
Group 3	(iii) Analyse market requirements for wood and fibre properties.		Yes	Yes	Yes		2
Group 3	(iv) Provide methods and tools for the early assessment of wood properties.						0
Group 3	(v) Improve the design methods for timber use in building industry.						0
Group 3	(vi) Assess the environmental impact of wood products (life cycle analyses, etc.).		Yes	Yes			1
Group 3	(vii) Analyse the ecological and economic opportunities for biomass exploitation.		Yes		Yes		2
Group 3	(viii) Understand the interactions between forest pests and diseases and wood quality.	Partly	Yes		Yes		3
Group 4	(i) Life history and habitat requirements of forest flora and fauna.						0
Group 4	(ii) Interrelation of community structure and biodiversity on the stability, health, productivity and biogeochemical cycling of elements at the forest ecosystem.	Partly					1
Group 4	(iii) Assess the landscape organisation influences on forest processes and community structure at the stand level.	Partly					1
Group 4	(iv) Structural and functional biodiversity of soil microbiota and its relation with sustainability of forest systems.	Partly					1
Group 4	(v) Management impacts on community structure at the stand, forest and landscape level, including the introduction of exotic species and GM organisms.	Partly					1
Group 4	(vi) Cost effective methodologies for inventorying remarkable habitats at the plot, stand	Yes					1

Group	Research topic	*FORSEE*	*EFORWOOD*	Forest-wood chain alliance	MUSTFOR	science society dialogue	
	and landscape level for key taxa						
Group 4	(vii) Cost effective methodological tools and indexes for assessing and monitoring forest biodiversity, including, structural diversity in forest ecosystems, and their relationship with stand processes and management objectives	Yes					1
Group 4	(viii) Tools to evaluate the impact of fragmentation and landscape layout on the forest community						0
Group 4	(ix) Integrate biodiversity management in Decision Support Systems, assessing tradeoffs between biodiversity conservation, stability, productivity and global environmental performance of forest systems under alternative management strategies.		Yes				1
Group 4	(x) Develop management guidelines for riparian areas and ecological corridors						0
Group 4	(xi) Development of integrated and biological control of forest pests and diseases		partially				1
				Yes			
Group 5	(i) Identify new funding mechanisms to satisfy simultaneously society demands for wood products and forest services (energy, carbon, recreation, biodiversity, etc.).	Partly	Yes		Yes		3
Group 5	(ii) Analyse Society's perception of forests and forest management.	Yes				Yes	2
Group 5	(iii) Understand and characterize forest owners and socio-economic factors influencing their choices and motivations.				Partly		1

V. Concluding remarks

This section includes "free" comments received from a representative panel of participants in Task B1 and general remarks on the implementation of this task .

Nature protection NGO representative

Comments about IMACFORD from the point of view of LPN having participated to the last meeting
"I got a good impression about the meeting at Óbidos because it was possible to explain to all participants what is our point of view in what concerns the guidelines of future research on cultivated forests. At the time we have criticised the present policy of forest research in Portugal which is very much conditioned by lobbies associated to pulp companies. For us that was an excellent opportunity since people from different organizations were present, including a heavy representation of pulp companies. From the Dublin meeting I took the opposite impression. We have travelled a long way to meet there and the results were frankly disappointing. Basically I could point out the main deficiencies:
- There was no clear use of the knowledge and experience obtained from the previous regional meetings.
- My working group was not conducted in an objective and clear manner and we have passed two hours trying to squeeze some juice from a quite chaotic discussion. The final conclusions of the group were very much disappointing from my point of view. For example the fact that two entomology/pathology specialists were present at the group has definitely influenced the suggestions in terms of research needs. At the final conclusions the problem of forest fires was practically absent. Ironically we have had in Portugal this year the worst summer ever registered in terms of forest fires. About 400.000 ha have burned, according to the latest estimations!! Who needs to look for pests and diseases after the forest is gone?
- The role of an Environment NGO should have been more transversal and not simply as part of a specific working group. We would like to have expressed our opinion about other subjects but the way things were organised did not allow that to happen.
- The final conclusions of the meeting in terms of guidelines to be pursued were too general and not really reflecting the work done before.
- On the other hand the field trip organised with our Irish colleagues was really interesting, although this was just a marginal event in terms of the results pursued by the Dublin meeting.

I realise that it is not easy to synthesise the opinions of such a broad range of specialists and representatives but I think we could have gone much further both in quantitative as in qualitative terms.

Anyway we LPN have very much appreciated to have been invited to participate at the IMACFORD workshops and we look forward to continue collaborating, since this is our mission. In what concerns the next steps to be pursued I think that really concrete research networks should be implemented. The two basic concerns should be the minimisation of negative ecological impacts of forest management and forest fire prevention. That's what the future needs from us."

Joaquim Sande Silva LPN (Portugal)

University Professor

My university, University College Dublin, was not a partner in IMACFORD. My role was one of the scientific advisers to the project. As such, it is understandable that the main focus of the project should be in south-west Europe dealing with issues, the specifics of which are not of immediate concern in Ireland.

My involvement in the project was to some extent, hampered by the limited time frame in which it could be organised. As a result of this, the notice available for the thematic meetings was short and I was precluded, through other duties, from attending any of them. I did manage to attend two of the three regional meetings, but as these were, quite correctly, held mainly in the local language, opportunities for my participation were limited.

Despite these limitations to my participation, I was impressed with the organisation of the project and in its achievement. For me, the most satisfactory element of it, was the interaction between end-users and scientists which, I believe, is very important for the accomplishment of that most difficult of tasks, namely, developing relevant research questions.

IMACFORD provided me with the opportunity to strengthen contacts within IEFC, which has already given rise to further research cooperation. This is a very important outcome in that it extends the reach of collaboration within the IEFC family.

I was slightly disappointed that I did not have the opportunity to meet with the other scientific advisers to the project. The exchange of views with other scientists who were somewhat removed from the core activity of the project could have been very valuable.

I anticipate that as a result of IMACFORD, cooperation between researchers will be strengthened, communication with end-users improved and the issues surrounding the sustainable management and multifunctional use of forests addressed with increased effectiveness.

Tef Farrell, Forest Ecosystem Research Group, University College Dublin.

Forest Regional Organisation director

"IEFC project has been considered as a very good initiative by the Regional Centre for Private Ownership (CRPF). The dialogue established between scientists, managers, producers, and stakeholders initiated a real progress. CRPF focused mainly on the more applied topics and should build some joined project in a close future. This initial consultation will help for a better definition of the incoming partnerships.
The other benefit of that kind of events is in the international dimension, that we consider as essential nowadays.
Seeing the great diversity of topics, it seems suitable to plan other meeting focusing on one or two main topics.
At the end, we consider the IMACFORD project as very profitable"

Yves Lesgourgues, CRPF director (France).

Forest owners association director

"The Asociacion Forestal de Galicia, a regional forest owner association which participated in the IMACFORD project considers it was of great interest to participate at this event. The regional workshop in Santiago de Compostela has been very fruitful permitting to:

- Know the workplans of forest investigation in north of Spain, and the recent results obtained by many organisations.
- Express the needs of research for the private owners,
- Learn the difficulties of the research centres,
- Confront ideas between scientists and forest sector.

May be the conclusions of the regional workshop should have been made within a more collaborative process, to better reflect the ideas coming from the different parts.
We consider that this project should go on to establish regular contacts between the forest sector and investigation world. The result of this project should be disseminated to all the public authorities and to the administration responsible for research."
Francisco dans del valle, AFG, Espagne

Pulp and forestry research organisation director

Somme comment from Bordeaux AFOCEL director :

What was good?

- The idea of such a consultation is a good thing,
- Working groups are good opportunities to strength link between partners involved in the process,
- Conclusions are good and real issues, even if some are still missing,

What was bad?

- In Bordeaux regional workshop industrial wood sector did not send enough representatives compared with Portugal or Spain,
- Enquiries and interviews should have been done before the meetings to make people more attracted by the debate
- Scheduling: IMACFORD has been delayed for 6 months. So we have been obliged to submit EFORWOOD project to the 6th FP, before the end of IMACFORD. It reduced the interest of the consultation.
- More intersectorial was needed.

Guillaume Chantre, AFOCEL, France

Government representative

Some comments on the IMACFORD Project - "Improving and Advancing Co-ordination of Forest Research and Development in Europe"; Participation: "Research needs for the sustainable management of cultivated forests" Óbidos, Portugal, 7th - 8th April 2003. The comments are organised in two groups: the first one focused on the objective of the Project and the second one deals with the organisation of the meeting:

- Objective of the Project: in my opinion it is meritorious and always in time to contribute to a better communication between the research community and end-users, as it provides a platform for dialogue with all stakeholders (a wide variety of end-users). Their needs and expectations should be taken into account by Research. And one output should be emphasised: Research should be able to give advice or even solve or help solving the practical problems presented. But, what about the following steps? What are the consequences of these sessions? What shall be done with the outputs and recommendations?

- Organisation of the meeting: although having attended only Óbidos' session, it seemed to me that some aspects could have been different, namely:
  - The meeting lasted two days - the first one fully dedicated to presentations - it seemed to me too long! And some of presentations were not clearly focused on the subject. In addition, a lot of people missed the second day, when discussion-groups took place. That is, on the one side, the expected wide change of ideas did not fully happen and, on the other side, regretfully the representation of the several parties was not as balanced as during the first day.
  - Concerning the discussion-groups - each one should have had someone from the organisation to allow a clear and complete picture of what went on. The moderators and reporters should have been informed in advance of their roles.

For me, the initiative's assessment is clearly positive. In fact, meetings focused on a clear subject and that provide a platform for dialogue of all interested parties are always welcome. But, in the end, the gaps identified and the recommendations produced should be seriously taken into account and presented to the right people, that is, to the people that can take the adequate decisions to implement or, at least, facilitate the implementation of the necessary measures to fulfil those gaps and, consequently, proceed successfully towards Sustainable Forest Management.

Graça Rato, Ministry of forest, Portugal

IEFC Chairwoman

"What was good?

IMACFORD was a very good opportunity:

For the scientists:

- to identify the research needs from the "real" world of research results users
- make the state-of-the-art on each one of the subjects related with the fulfillment of the users needs, namely to identify needs on basic research in relation to this fulfillment
- to have the opportunity to present to the users some of the most important and recent research results as well as the objectives of on-going projects
- to increase the connections with society
- to identify opportunities for future international collaboration, namely in the preparation of proposals to the 6th EU framework

For the stakeholders

- to express their needs directly to the researchers
- to discuss with the scientists the priorities of their needs
- to identify opportunities for direct collaboration with the researchers for the implementation of the results of research or for direct participation in on-going projects
- to increase the connections with the research "world"

What was bad?

Generally, the biggest problem with IMACFORD was that it had to run in a very short time and it was not an easy task to coordinate the organization/participation in so many meetings with the current work-load of the researchers. But it is difficult to find out how could this have been as such, as the research teams are not that big. Maybe more "man-power" funded by the project?

For this same reason, we were not able to attract some very relevant researchers to participate in the meetings.

Another problem was related with funding. It is very difficult to organize a project with a very limited funding available (it was there but coming too late)

Benefits for me and my institution

Personal and institutional benefits were related with:

- the satisfaction of the users to participate in the regional workshops
- the possibility to plan for future applications to calls for research projects or other type of projects, such as INTERREG, that will take into account the conclusions of IMACFORD project in relation to research and users needs

Next steps

Go on with the preparation of new proposals that will join researchers and end-users from different EU-countries with a common objective: sustainable and multifunctional management of plantation forests"

Margarida Tomé IEFC Chairwoman

General remarks

The project implementation was largely successful and followed the initial plan. During the first phase, we could define and review very thoroughly the research activities and current programmes dedicated to cultivated forests and identify trends and new developments not only for forestry but also for forest science. This part of the project helped us to prepare very well the regional workshops.

In the second phase, the forest sector and end-users were able to express their needs in a structured environment. The result was an open, frank exchange of views and a clear statement of research needs from the users' perspective.
The third phase of the project consisted in prioritizing needs and elaborating new projects. Many reasons can be put forward to explain why it has been criticised by participants:

- compromise is always a difficult exercise and some of the participants may consider that their own point of view wasn't taken into account,
- there was insufficient time available for open discussion and participants were required to digest a lot of information in a very short time (reports of the regional workshop, end users needs, funding opportunities, identified opportunities, …)

One of the key issues mentioned by participants is the degree to which individual representative is both representative (of it's organisation and of the workgroups) and objective. Does the summary presented embrace all the expectations and comments expressed, or is it skewed towards the individual's own interests? It can be said that most of the participants tried to contribute objectively, but the dominance of scientists at the last meeting has influenced the results.

Having projects outputs related to funding opportunities make the project very valuable not only as an intellectual exercise, but also for short term cooperation. We can imagine that if some of ours proposals are accepted, it will clearly be of benefit to the whole forest sector after such a consultation process.

The opportunity for stakeholders to express their expectations from scientific research and to discuss their research needs was clearly much appreciated. In fact, we realize that even if some of the scientists have opportunities, from time to time, to meet forest managers, it is usually in the narrow context of a project or a funding proposal or project. This project afforded the opportunity for dialogue between scientists and end-users, both at operational level.
This status will encourage us to maintain this link at regional level as much as possible, and to disseminate our "idea" box built during the project. In short, we can consider that, even if everything was not perfect in the implementation of all phases, task B1 of this project has been successful. Every one agrees on the fact that this process of regional concentration between scientists and stakeholder will have to continue and that Task BI consolidated IEFC network and provided all partners concrete outputs and concerted project proposals for the future.