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The Forestry Wood Chain

The impact of EU research (1998-2004)

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The Forestry Wood Chain:

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Contents

Introduction

Thanks to European Union funding under the Fifth Framework Programme's Quality-of-Life Key Action 5 on Sustainable Agriculture, Fisheries and Forestry, pioneering research work spanning the entire forestry-wood chain from forest genetics, forest management, conservation, wood quality and timber processing, through to pulp and paper production, is now coming into its own.

No fewer than 63 forestry and wood chain research projects are being funded by the EU using €80 million under KA5.3 sub-themes on 'Multifunctional management of forests' and 'Strategies for the sustainable and multi-purpose utilisation of forest resources; the forestry-wood chain'. More than 500 researchers are working to sharpen the forestry-wood chain's competitive edge, improving the sustainable production and rational use of Europe's oldest natural resource, as well as developing new technologies and multi-disciplinary, integrated approaches.

Their efforts could provide valuable input for the revised European Forestry Strategy and for current and future environmental, agricultural, rural development and industrial strategies. And important lessons are being learnt for future research, not just for integrating the new Member States into the Sixth Framework Programme (FP6) projects, but also for planning recommendations and guidelines for FP7.

Some of these projects have already finished and many are in their final stages. Taking stock of achievements so far, the Biotechnology, Agriculture and Food Research Directorate of the European Commission's Directorate-General for Research recently singled out 13 projects along the forestry-wood chain and invited the successful project promoters from across the EU to present their findings at a Workshop on Forestry/Wood Chain Research held in Brussels on 3-4 March 2004.

The event certainly provided food for thought, and many ideas and recommendations could be taken up in current and future Framework Programmes. They also provided valuable input for the high-level conference organised by COFORD/InnovaWood (www.innovawood.com) during the Irish Presidency on 'Future Issues for Forest Industries in Europe' in Dublin from 28 April to 1 May.

One message that emerged loud and clear from the workshop is the need for a stronger European vision and effort in research and development through diverse means such as a solid platform for disseminating the results and putting them to work on the ground to help the industry meet the challenges of the 21st century. Beyond mere networking, many experts believe a technology platform linked to a broader strategy is what the industry really needs.

The enlargement challenge

Much of the future growth in wood production in Europe is expected to come from Eastern Europe. When the EU takes in another ten Member States on May 1, its forests will expand by 34 million hectares overnight and timber production will go up by 20% from the EU-15's current annual output of 120 million m³ of softwood (mainly spruce and pine) and over 40 million m³ of hardwood (e.g. oak, beech and poplar). Today, this timber has an aggregate market value of between €6 and 8 billion. Tomorrow, it should be a lot more. Wood production in the new Member States will be very cost-competitive, but some of the questions that should be answered are: will it be sustainable and will it help to make the European timber industry more competitive?

At the moment the market outlook is not too bright. Prices are falling, demand for some products, such as newsprint, is not increasing and many foresters and timber producers are facing difficulties. Jobs are scarce, competition from alternative materials is growing and the search has begun for new types of high-tech, high-quality and more durable wood products.

Markets on the move

In a nutshell, the market for forest products is changing rapidly, as FAO Economist Adrian Whiteman told the workshop. Two major factors that are affecting markets are technology and globalisation.

Technological advances in the use of wood products are shifting markets away from traditional products like sawn wood to new wood-based panels like medium-density fibreboard (MDF), oriented strand-board (OSB) and laminated veneer lumber (LVL). Processing technology is expanding the use of non-forest fibre sources, such as wood residues and recycled materials, and is reducing the demand for high-quality, high-value lumber.

Biotechnology is also starting to have an impact on tree growing. Fast-growing tropical forest plantations in countries like Brazil are very cost-competitive and their products are gaining market share from traditional wood producers such as Canada, Sweden and Finland. Europe's competitiveness in global markets will be affected by the growth in importance of these plantations over the next 50 years.

Globalisation is leading to more international trade in forest products, and Europe as a whole is now a significant net exporter of many wood products. So now it is a question of survival of the fittest…or the most adaptable. Globalisation is also breaking down the traditional link between growing trees and making wood products. For example, Belgium is the second largest European exporter of wood-based panels – not because of its resources, but because of its ability to compete in the export market on the strength of its processing and marketing capabilities. In the EU, Western Europe will face more competition in the future from Eastern Europe and the CIS countries in traditional high-value markets for sawn wood and plywood, because these countries have an abundance of high-quality wood.

Quality control

Emerging changes in wood-engineering technology are leading to new types of wood product coming on to the market, some of which are already big in the US although not yet in Europe. OSB, for instance, is made from what were once considered uncommercial species and is now competing with traditional spruce sawn wood.

So the forestry-processing sector in Western Europe is likely to focus more on high-tech products from low-quality wood and fibre, and growth in demand for wood and fibre will come mostly at the bottom end of the market. "Wood quality is being determined more and more in terms of fibre properties such as fibre length and strength, rather than the size and straightness of logs," said Mr Whiteman.

There is an abundance of wood supply in Europe for the foreseeable future as forest management moves from the traditional forest management models to an agricultural production model focused more on low-cost, volume production and less on growing large trees. For example, high-input, short rotation forestry has already taken hold in places where trees grow fast, such as parts of Southern Europe. But as the CAP (common agricultural policy) has shown, production at all costs is not the answer. "There is significant demand for many different forest outputs such as timber, recreation and conservation, but there needs to be more specialisation if these outputs are to be produced efficiently," the FAO expert insisted.

From supplier to end-user

The family rules

The EU's ability to meet its self-imposed objectives of multifunctional and sustainable management of forests lies first and foremost in the hands of the forest owners themselves. And with the enlargement of the Union, there will be many more to help. Policies will have to be adapted to provide a sound basis for their activities too, Tomas Landers from the Confederation of European Forest Owners explained.

Before enlargement, around 60% of the EU's forests were owned and managed by families. With the addition of ten new Member States, the forestry sector gained another 34 million hectares and 3-4 million additional private forest owners, totalling 15 million family forest owners in the EU-25. This will bring even more attention to the socio-economic problems that exists. The new Member States have even smaller-scale forestry – with an average private forest holding size of just 2 hectares, compared to an average of 5 hectares in the EU-15.

Pay-back time

In the forest owners' view, future research needs lie mainly in 'conservation by management'. The promotion, implementation and development of sustainable forest management and the multifunctional role of forests still remain the main goal. The impact of acid rain on forests may be declining, but instead the trees now have to contribute, helping to reduce greenhouse gases by acting as a renewable energy source and a substitutional raw material for building, etc. Echoing the European Commission's own forestry strategy, the forest owners stress the need for a holistic approach to forestry related issues, taking account of all aspects of sustainability so that the entire forestry and wood chain can be better integrated to promote a 'green Europe'.

Woodworking industries' roadmap to 2010

Sustainability will continue to be the watchword under current and future Framework Programmes, but is the industry itself sustainable? Presenting the roadmap for 2010, Chris Van Riet from the European Confederation of Woodworking Industries (CEI-Bois) described it as "a mature industry, with low margins and too little RTD". It counts around 100 000 firms, employing some 2 million people and generating, in 2002, a turnover of about €150 billion.

The industry is ticking over, but will need to do more in future. CEI-Bois claims that timber products will become the leading material in construction and interior solutions by 2010. At the moment, the market is rather flat in Western Europe for most product groups, though expected to rise especially in Eastern Europe. Growth rates are in general high for specialty wood products like glulam, LVL and OSB (18% in the latter).

The forest-based industry needs to cash in on emerging trends. Timber still needs to draw on its green credentials – although it is perceived as natural and environmentally friendly, it is not considered as strong, safe, durable as modern substitute products such as PVC and aluminium. It is unrightfully perceived as falling short on functional requirements such as durability, insulation, fire- and sound-proofing. "We have to get away from this non-innovative, non high-tech perception," explained Mr Van Riet.

Higher profile

Technical guidance on the use of wood, along with training, are other areas where there is room for improvement. European codes and standards can help but they have to be further developed, according to CEI-Bois. The industry's customers are very individualist which makes standardisation less evident.

The woodworking industry needs to raise its profile and EU-funded research projects are an excellent way to do this. The woodworking industry is actively involved in FP6 but, in future, it wants to see a stronger European approach to R&D and projects that serve the needs of companies. The woodworking industries, nevertheless, argue in favour of smaller research projects as they feel many huge projects involving big companies do not fit sufficiently the needs of the SME-oriented sector. CEI-Bois is also in favour of the development of an industry technology platform, which is supported by the Forest Owners (CEPF), the Pulp and Paper industry (CEPI) and the wood-related research community (Innovawood), too.

The pulp and paper industry

The Research Director of the Confederation of the European Paper Industries (CEPI), Paul-Antoine Lacour, informed the participants that the pulp and paper industry has started a process with the aim of launching a technology platform. He acknowledged that the different partners of the forestry-wood chain have partly different research needs although they do have common interests (contribution to a sustainable Europe) and a common – and renewable – raw material.

He then stated that the European pulp and paper industry also needs to face up to globalisation (with global markets but local costs), changing consumer demands and, more generally, to the challenges of sustainable development. In the coming years, with the "EU target of 3% of GDP for R&D" (Lisbon target) and the implementation of new political instruments (e.g. technology platforms) R&D is likely to contribute even more than today to the challenges listed above.

The European approach

In the European Union (EU), forest policies are implemented by Member States within a clearly defined framework of established ownership rights and with a long history of national and regional laws and regulations based on long-term planning. The forest-based commercial activities fall within the open sector of the economy.

Though forests per se are not dealt with at EU level, there is an increasingly complex array of EU legislation and policy initiatives within different EU sectoral policies that considerably influences the forest policies of the Member States. An EU forestry strategy was therefore adopted in 1998, which puts forward as its overall principles the application of sustainable forest management and the multifunctional role of forests. In line with the principle of subsidiarity, meaning that every administrative decision should always be made at the most appropriate level, taking into account the specific local circumstances, this strategy seeks to establish a coherent framework of forest-related actions at EU level. It also aims to improve the linkages and coordination between different policy areas as well as the coherence with the forest policies of the Member States.

The forestry-wood chain can count on support from EU agricultural, rural development, environmental, industry and research policies, involving several European Commission Directorates-General. Their respective contributions to the forestry sector were explained at the workshop.

Rural development connection

Forestry R&D is becoming increasingly important, Ignacio Seoane from the Directorate-General for Agriculture said when outlining the EU's forestry strategy, now approaching the end of its first five-year review. But it needs to take on a more environmental and socio-economic dimension to better reflect the multifunctional role of forests and the need for more sustainable forest management – the two key objectives of the strategy launched by a December 1998 Council Resolution.

In future, the focus should be on interdisciplinary research, as the EU Member States stressed in their final Declaration at the Fourth Ministerial Conference on the Protection of Forests in Europe in Vienna in April 2003. SFM (sustainable forest management) and multifunctionality are already well reflected in R&D policy and will remain key to future action.

The overall principles of the EU's forestry strategy, e.g. multifunctionality and sustainability, are reflected in the rural development policy of the EU by bringing together economic, social and environmental objectives into a coherent package of voluntary measures and thus giving added value to the implementation of forest programmes of the Member States. The forestry measures of the rural development programmes are, at the same time, seeking to contribute to more global issues such as climate change and biodiversity. Some €4.8 billion has been allocated for forestry measures from the EAGGF under the Rural Development Regulation (CR N° 2157/1999) between 2000 and 2006, accounting for approximately 10% of the total budget for rural development.

EU enlargement brings a 20% increase in forest land and, with it, structural changes in terms of ownership (about 30% of forests in the accession countries are privately owned), restitution of land, and adjustments in employment.

The Commission's Forestry Strategy implementation report, which is now being finalised, questions whether existing EU actions, together with national policies, are capable of meeting cross-sectoral challenges (such as protection of biodiversity and rural development). Are they ready to meet the social impact of enlargement? Can they cope with the growing importance of global issues like climate change and biodiversity?

The general line of thinking is that national forest policies should continue to implement the EU's overall principles of SFM and multifunctionality. In recent years, many countries have started to adapt their policies accordingly. The Commission feels there is a need to adopt a holistic approach to SFM with a 3-D integration of economic, social and environmental objectives, not least to boost the economic viability of SFM. So, in



future, cross-sectoral co-operation will become even more important, as will the conservation of biological diversity.

Environmental dimension

Europe's forests face many environmental problems. Apart from biodiversity loss, they suffer from unwise use of exotic species, large-scale drainage problems, acidification, eutrophication, and even the climate change they are supposed to be helping to combat.

The Commission's Environment Directorate-General is keen to stress the multifunctionality of forest use, too, when the EU boasts 136 million hectares of mostly semi-natural forest cover. "Forests have become a cross-sectoral issue," Joost Van de Velde from the Directorate-General for Environment told the workshop. But, he continued, "correspondence with reality and the main objective of the Forestry Strategy, i.e. multifunctionality, is still not good enough", and needs to be addressed in future.

Other future issues to be considered include the declining environmental quality of forests, loss of biological diversity caused by uniformisation and fragmentation, climate change, and the upcoming review of renewable energy source targets (for 2020), competition between stakeholder groups and, in particular, economic problems caused by the SFM objective which has increased costs for foresters who have to support non-material forest functions too. Active intervention is also needed at the landscape level.

Still, EU forestry remains exceptional at global level by maintaining one of the largest single biodiversity reservoirs and continuing to function as a sustainable source of raw material for important economic activities. Reconciliation in the long term of biodiversity preservation, other ecological forest functions and the economic use of wood as a climate neutral energy provider and material is the main challenge that we are facing in an economic environment centred on specialisation and open markets.

Tapping in to other policies

EU water policy opens up another important opportunity for the forest sector. It has a role to play helping to restore wetlands, rain forests, and organic soils, managing carbon sinks and riparian zones, and generally improving the protective function of woodlands. "Much more investigation is needed on links with the Water Framework Directive," said Mr Van de Velde.

And energy policy comes in too. The contribution of forest biomass to renewable energy generation has not been as good as it could have been following publication in 1997 of the Commission's Renewables White Paper and launch of the 'Campaign for Take-Off', with a target of 12% renewables in the EU energy mix by 2010. With this target now up for review and figures of around 22% being put forward, Mr Van de Velde pointed out that just one tonne of forest biomass can produce the equivalent reduction in carbon dioxide emissions from heating oil by 0.53 tonne/CO_2 or by 0.36 t/CO_2 from natural gas. The EU's renewable energy strategy (RES) had hoped for a threefold increase in biomass production but the business-as-usual scenario suggests only a twofold increase, implying there is room for improvement here, too.

Europe's forest-based industries have already developed eco-friendly processes in response to competitive pressures, and pursued new outlets for wood as a renewable energy source or as feedstock for the chemicals industry, while more and more foresters are adopting sustainable forest management practices. However, there is clearly more to be done. The workshop heard several requests for more emphasis on the environmental aspects of forestry in research work.

The economic viewpoint

For DG Enterprise, competitiveness is the watchword. The implementation of the Lisbon Agenda was focused on this and the main role of DG Enterprise's Forest-based & Related Industries' unit is to help maintain and improve the competitiveness of the EU forest-based

industries in a global context. Arguing the case for a genuine forestry-sector strategy for research, development and innovation, Jeremy Wall from DG ENTR began by reminding workshop delegates of the key economic statistics of the sector. The EU-15's forest-based industries have a turnover of €340 billion a year (with added value of €120 billion) and provide jobs for 2.6 million people. Nevertheless, the current outlook is one of stagnation.

The forestry sector as a whole has problems:

* It is very large and diverse, but is fragmented and has few big companies.

* It has low profitability and growth rates (the latter only 1% growth a year whereas e.g. the woodworking industry's 'Road Map' recommends boosting growth to 4% by 2010).

* It suffers from poor communication, weak institutes and lacks coherent strategy.

* It is not capitalising on its 'green credentials'.

* Its expenditure on R&D is well below the EU target of 3% of GDP.

Europe's forest-based industries may have some golden opportunities to start overcoming these disadvantages in 2004, which Mr Wall referred to as "a year of opportunities", with the forthcoming review of the EU forestry strategy, an evaluation exercise of the Commission's first Forest-Based Industries Communication (457/99) and preparations for the Seventh Framework Programme for Research, all in addition to there being a new Commission and European Parliament during the course of the year. In addition, new renewable energy targets may be drawn up for 2020, going beyond the 12% of energy consumption set for 2010. In this context, there would be both challenges and opportunities for the wood-using industries, with biomass boosting its position by offering an alternative market outlet for wood.

Supply and demand for research

The EU forestry sector research has a number of common threads, Mr Wall explained, based on the common, renewable raw material wood. However, on the whole, the forest sector's role in covering R&D does not adequately address society's needs.

As recommended by the Enhanced Use of Wood Working Group – as an input to the Road Map – it should in future focus primarily on market research so as to find out what the clients want and provide solutions in response to that market demand. The industry then needs to be better prepared and equipped to deliver products with predictable characteristics to the supply chain. For this, it is necessary to overcome the traditional disadvantages of wood, such as flammability, durability,

variable performance, limited dimensions, etc. Only when a technically performing and price-competitive product system is in place, with reliable service back-up, can emphasis be put on the ecological advantages of wood as a marketing tool. Sustainable forest management does not necessarily guarantee competitiveness in the market place and "green" wood does not sell itself, particularly when it is in competition with other, more predictable materials. Thus, the forestry-wood chain should try to harness wood's sustainability, including its being a healthy and environmentally sound raw material.

The economic and research outlooks may presently be bleak. So the forest-based industries must join forces with the other essential partners in the sector, researchers, educationalists and authorities, to tackle their common problems, not least in R&D, concluded Mr Wall. Their organisations may have very different structures, but they have a common-source raw material and are very closely interlinked and interdependent, "so the future is to act together".

Networking research

With the main problems spelt out, the policy framework outlined, and the project ideas presented, the debate then turned naturally to the next question: is there life after EU-funded research projects? Once all these valuable research projects have finished, is there a risk of the teams disbanding and the chain stopping dead when the funding runs out? The EU pays for the results to be shared so how do we achieve this in practice?

Several speakers pointed out the practicalities and advantages of networking as a means of R&D capacity-building and the wider dissemination of knowledge. Some valuable projects in this field are already under way.

The Proforest Centre of Excellence

The Proforest Centre of Excellence at the Forest Research Institute in Warsaw (FRIW) is actively promoting integration between forest researchers from accession and EU countries towards the creation of the ERA (European Research Area) which is one of the declared objectives of FP6. It was set up as an Accompanying Measures project towards the end of the FP5 in order to boost networking with both researchers and forestry administration partners, and has set up a local contact point for FP6. It seeks to promote new managerial skills and offers training on several issues such as EU environmental legislation and forest soil classification, water run-off, etc. The Centre's work feeds into a European database of forest research and the Euforgen genetic resources programme.

Real networking

There has already been a big shift in education and training at all stages in the supply and client chains. But what is missing is "the big picture". There is an urgent need to devise a long-term European wood sector RTD strategy and facilitate partnerships and consortia for linked projects.

The InnovaWood Initiative

"Our philosophy is evolution," stated Jos Evertsen from the InnovaWood network for the European forest-wood chain, which started in 2003 and now has more than 80 members, mostly Universities and Research Institutions but also some commercial companies. InnovaWood is a self-funding organisation. It is an example of a platform, supported through various EU projects for generating knowledge and innovation, that is also trying to set up an integrated area for R&D and skills development in the forest-based industries as a springboard for innovation. Seeking to promote excellence and international awareness for the industry and links to suppliers, it has drawn inspiration from its founding European networks, Eurowood, Eurofortech, Eurifi and Eurologna.

Among its practical achievements are the Xyloreach project (see below), a communication e-portal which can serve as a gateway to technical information and services for the forestry-wood sector, research and training inventories, and as a project portfolio for members.

This experiment has highlighted the need to provide a sector-specific innovation and research platform to forge alliances with industry, respond to society's needs, and also to expand into the new Member States. And, of course, to provide input for FP7.

The ERA-Wood Initiative

The need for a technology platform (see below) and coherent sector strategy was also underlined by Andreas Kleinschmit von Lengefeld from the German Society for Wood Research (DGfH) in Munich, which ran a project from October 2002 to September 2003 under FP5, to help the wood industry conform to EU R&D strategies. With the overriding aim of sharpening the competitive edge of the European wood chain, project ideas were selected e.g. in the field of production process technology, knowledge-based material engineering, durability, gluing and coating, and development of new concepts for construction.

ERA-Wood initiative is now funded by industrial federations from Austria, Finland, Sweden, Germany, (Norway and Switzerland are under negotiation to participate soon) but it is widening its partnership to industry groups from other European countries. It prepares and runs R&D projects for the European woodworking industry in close collaboration with industry networks. The Accompanying Measures project under FP5 may be finished, but the initiative is continuing and active, with strong support and funding from industry.

Mr Kleinschmit v.L says there has not been enough groundbreaking innovation in the past but Europe is now facing fierce competition from cheap raw materials and low-labour-cost countries.

The ERA-NET scheme

Like the forest-based industry itself, research suffers from fragmentation at European level. “Each country sets its research priorities independently and there is no systematic approach to avoid duplication and to enable synergy between their research programmes,” according to the rationale of a Concerted Action project called Woodwisdom-Net, under the ERA-NET scheme, that has brought together managers of national research programmes related to wood material from several European countries.

ERA-NET is trying to help here. Marco Weydert from the Commission's DG RTD explained that it has no thematic strategy like the FPs so it is open to all ideas. ERA-NET project members come from research administrations, decision-makers, European agencies, and national and regional organisations. Projects must have three co-participants from three different member countries.

Beyond mere networking, many experts believe a technology platform for the sector linked to a broader strategy is what the industry really needs.

So what is this technology platform that the forest-based industry so badly needs?

Waldemar Kütt from the Commission's DG RTD explained that “although the main objectives of a technology platform is to develop a strategic research agenda for the technology sector concerned, its impact can go beyond that of research, i.e. communicating the importance and benefits of technologies, developing a shared vision among stakeholders and providing information towards policy-makers and regulators”.

The real aim of the technology platform is to boost public and private investment in basic and applied R&D and maximise its impact. But first we need a specific long-term vision about why we need to invest in wood technology.

Perhaps the forestry industry can draw some inspiration from the newly-launched EU Steel Technology Platform, bringing together key European stakeholders including manufacturers, research institutes and user organisations who have prepared their own vision for the sector over the next 25 years.

Summing up

During the general debate and evaluation of the forest-wood chain research projects, several points that emerged during the workshop were discussed in more detail by experts at the grass roots.

Getting the message across

First up was the need to put more emphasis on dissemination of research results and on training. Most of the delegates were in favour of total access to their research work. But what is the best way of disseminating findings to the public: journals or conferences? Is there a problem of systematic under-reporting of research findings? What is the best level of deliverable publicity? Indeed, it seems hard to find the right level of publicity and plug the marketing line.

The main problem seems to be understanding the level of deliverable technology for the industry via the institutions and on a wider community basis. One answer is to do more about training people in management as so much research work ends up in PhDs and theses gathering dust on university shelves. So why is it harder to train management than to do PhDs? National PhD requirements do not always fit EU project requirements, as Jens Emborg from the NATMAN project pointed out.

The main message seems to be that there is simply not enough contact between the R&D world and industry, hence the need for wider networking along the lines of the XYLOREACH project.

The continuity of databases and websites was another issue broached. Many of them simply fold up once the project has finished and the EU funding has dried up. "Databases are more for what everyone is doing at the moment than for what is coming out," said one expert. So there is a need to link up with older databases and keep some sort of chronology. DG RTD Head of Unit Laurent Bocherau summed the problem up basically as: "the fear is that people know they won't have the funding forever so we need to find a mechanism to ensure sustainable follow-up afterwards". But whose responsibility is this and who will pay for the follow-up?

The socio-economic equation

The next problem raised was that socio-economic aspects are not being covered as widely as the Commission would have liked. The Framework Programme is putting more emphasis on this now. But it is still not enough, according to external observers and project promoters alike. Public opinion itself is a source of conflicting views. "We need people to provide information on the economic and social impact," said one external expert from Poland.

On the economic front, competition with the rest of the world needs to be encouraged and Europeans should co-operate on a set economic viewpoint. Europe needs to compare its own economics with countries like Brazil, which is focusing on biotech-based, fast-growth plantations just to chop down and market in a couple of years.

Consumer requirements

The final point in the debate – and perhaps the most important – was the market. Research has become much more interactive, involving specialists from all segments of the industry. And it is aiming increasingly towards the market place. But the general message was that the forest industry's role in R&D is not being covered well enough. As Portuguese external observer Mr Amaral said, R&D needs to be more closely geared towards the material side of things, such as wood properties, imaging, architecture and constitution.

Another external observer, José Vicente Olivier, said there was a need to look at problems throughout the chain and find integral solutions for the sector as a whole. He highlighted the demand for quality and also the need to find the right balance for each element of the wood chain, and that includes the very end of it. The industry still faces recycling problems and more work is needed on biodegradation and composting.

"Have we stopped the chain before the end user?", asked Jens Emborg.

Research Projects

- Forest Genetics, Physiology and Pathology
- Wood Properties and Quality, Treatment and re-engineering, wood waste
- Forest Treatment? Multifunctionnality, Forest policy and Market demand

Forest Genetics, Physiology and Pathology

[QLK5-CT-2000-00960]

OAKFLOW - Intra and interspecific gene flow in oaks as mechanisms promoting diversity and adaptive potential

Genetic conservation of oaks

Home to a rich biodiversity, Europe is a major user of genetic resources in both research and product development. As the EU presses ahead with its own biodiversity strategy, genetic conservation strategies are being put together on the ground. The 20th century witnessed a huge change in the genetic make-up of forests due to intensive use of plantations – a trend encouraged by natural colonisation of abandoned farm land by trees and by the northward migration of species induced by climate change. And the old oak tree is likely to be most affected by these changes. Oaks are particularly susceptible to the effects of gene dispersal as they are highly interfertile and have the capacity for interspecific hybridisation, not only amongst temperate species (like *Quercus robur* and *Q. petraea*), but also between these and Mediterranean species (e.g. *Q. pubescens* and *Q. faginea*). So, the future composition of European oak forests will be faced with new challenges due to the interaction between natural dispersal processes and man-made introduction of non-native, more exotic, material.

OAKFLOW, a 50% EU-funded project running from January 2001 to the end of 2004, is trying to estimate the amount of intra- and interspecific gene flow in European oaks by using genetic fingerprints and applying parentage analysis. It is carrying on the good work from a previous EU shared-cost project on genetic diversity in native oak populations (FAIR PL95-0297). Coordinated by the French national agronomic research institute INRA's UMR BIOGECO unit for Biodiversity, Genes and Ecosystems in Bordeaux, the project promoters are working closely with 13 partners in various European countries, as well as end-contractors, to trace and quantify external gene flow and hybridisation, evaluate genes and assess the impact of gene flow. It has 13 intensively studied plots including sites in Brittany, Northern France, the UK, Italy and Switzerland. Under the project, the UK Forestry Commission, for instance, is studying the extent and time-scale of importation of exotic material into British oak woodlands using established chloroplast DNA patterns.

Rather than focusing on the changes in the distribution and levels of diversity, OAKFLOW is looking at key biological mechanisms that may interact with human interference to generate and modify diversity.

It is drawing on the FAIR project's work using micro-satellite markers to fingerprint batches of trees in each of a range of European oak woods in order to trace pollen movements. The FAIR project's geographic map of highly-differentiated cpDNA markers used to indicate paths of previous natural colonisation is now proving useful to trace past artificial seed transfer.

OAKFLOW has thrown new light on adaptation to environmental change and is contributing to the development of techniques to analyse DNA diversity throughout Europe. Its specialised work packages are developing statistical and molecular tools to detect pollen and seed movement and identify genes that are differentially expressed in each oak species.

Genomic modifications due to the insertion of new genomic segments, as a result of natural hybridisation, are being localised on genetic linkage maps to help identify genomic regions that are "sensitive" to interspecific gene flow. The fitness of interspecific hybrids can be compared to their parents, both *in situ* and *ex situ* (in controlled environments).

The project promoter says this detection and evaluation of gene flow will lead to practical decisions and recommendations on the management of seed and conservation stands in the forestry sector. Computer simulation models have helped to forecast short- and long-term consequences of gene flow on the distribution of diversity in oak stands. End-users (forest services, biologists, population geneticists, conservation agencies) are thus closely associated in testing various implications of gene flow in management and conservation issues.

The OAKFLOW project is of particular importance for implementing conservation measures, and ties in with the genetic conservation strategies that are being devised for native oak species through the European Forest Genetic Resources Programme (EUFORGEN), a collaborative programme among European countries to promote sustainable use of forest genetic resources.

Project coordinator:

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[QLK5-CT-2001-00241]

RESROBS - Resistance of Spruce to Root and Butt Rot Disease

Resistance to disease in spruce forests

Prevention is better than cure. And with vast tracts of conifer forests to manage, European foresters will agree that resistance is the best way to control a disease. But it is very difficult to find, even amongst one of Western Europe's main productive species like spruce, as Steve Woodward from the University of Aberdeen's RESROBS project explained.

This KA5.3 research project, with partners from Sweden, Norway, Italy and Greece as well as Scotland, is testing resistance of Norway and Sitka spruce trees to Root and Butt Rot Disease caused by *Heterobasidion spp*., and trying to throw more light on inheritance of disease resistance based on genetic and biochemical molecular data. These data can now be used to develop methods to predict inheritance of resistance based on experimentally-determined markers.

The RESROBS researchers have inoculated clones, which have often proved hard to find in the case of older plant material, with *H. annosum*, *H. parviporum* or *H. abietinum* and measured the extent of pathogen growth and lesion development. They have developed protocols for early detection of resistant genotypes using monoterpene analysis, and QTL/AFLP maps to determine molecular markers for resistance. Specialised work packages have already come up with proof of differential growth of Heterobasidion in different clones of both the *Picea abies* and *Picea sitchensis* species and have singled out delta 3 carene as a suitable candidate as a marker compound for resistance. So far, 153 AFLP markers have been identified. Another group is applying a novel technique for quantifying pathogen DNA in host tissues so as to measure susceptibility of spruce trees to the disease.

The project is also measuring post-infection responses of clones by localising the accumulation of pathogenesis-related proteins and measuring the rate of development of bark boundary and xylem barrier zones to infection. Inoculations have proved to inhibit bark boundary zone formation in several clones.

Despite awkward timing of the project, which started late in the growing season pushing back the inoculation schedule, the RESROBS project has already confirmed the availability of spruce clones with defined resistance to *Heterobasidion spp*. for planting on badly infected sites.

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[QLK5-CT-2001-00244]

MOHIEF - Modelling of Heterobasidion Infection in European Forests: A Decision-Support Tool for the Forest Manager

Management impact of disease

A parallel EU-funded three-year Concerted Action project run by the University of Aberdeen is tackling the forest management side of the problem by developing a user-friendly computer-based model to predict the incidence of Heterobasidion infection so that foresters can predict the effects of different management inputs.

With some of the same partners as in the RESROBS project, it has brought together a range of experts in forest pathology, forest ecology, modelling of forest systems, and forest managers to prepare a prototype simulation model that can be used to determine losses to Heterobasidion infection and decay in the range of forest types found in Europe. The MOHIEF model has already been tested in all sorts of different forest conditions. The prototype is in an advanced stage of development and has been successfully tested in Poland, Finland and Sweden for example. Work is now concentrating on simplifying the user interface. The project has the support of the US Forest Service, as North America has already developed a root disease model.

This CA is a good example of forward-looking research that can be used in the field. It was conceived as a data-collating and basic model construction prelude to development of a full model and extensive field testing under a future research programme. But it has already shown that there will be a much better understanding of the management impact of disease resistance in spruce forests. In particular, it should help with management of older managed forests that have been affected with the disease in the past.

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[QLK5-CT-2000-01684]

[QLK5-CT-2000-01684] CONTROCAM - Sustainable Control of the horse chestnut leaf-miner, Cameraria ohridella (Lepidoptera, Gracillariidae), a new invasive pest of Aesculus hippocastanum in Europe

Sustainable pest control

Pest control has long been a priority for the forestry sector. But with growing environmental pressure to use fewer pesticides, the arrival in Europe of a new highly-invasive pest whose origin cannot be traced is bad news. In less than 20 years, the horse chestnut leaf-miner, *Cameraria ohridella*, a moth of unknown origin, has spread over vast areas of Europe. It was first recorded attacking *Aesculus hippocastanum* trees near Lake Ohrid in Macedonia in 1985 and was identified a year later as a new species of the genus Cameraria, belonging to the Lepidoptera family Gracillariidae. It appeared out of the blue in Austria in 1989 and by the year 2002, it had colonised major parts of Central and Eastern Europe and also spread to the UK, Spain, Sweden and Ukraine, disfiguring horse chestnut leaves with brown-coloured mines in many areas.

Damage limitation

Wherever it came from, the horse chestnut leaf miner looks here to stay. The source of our childhood playground conker fight is sick. However, a multidisciplinary EU-(KA5.3) funded project called CONTROCAM "Control of Cameraria" under way has concluded it should be possible to bring down the Cameraria moth population to damage-limitation level with suitable control methods.

The CONTROCAM project aims to use integrated pest control as a case study to make recommendations for the future development of common European strategies to tackle the increasing problem of biological invasions of exotic invasive pests in Europe. It is thus developing the basic structures of an integrated pest management (IPM) system for *C. ohridella* that can be used as a generic model across all affected areas of Europe.

The project is split into six work packages, the first of which is looking at the ecology and impact on host trees so as to assess the present and potential future impact of the moth on horse-chestnut trees, both in urban areas in Europe and in natural forests in the Balkans. Field and laboratory tests showed that, besides the European horse chestnut, a few other tree species of the same genus (Aesculus) are also susceptible to the moth, as well as some maple species (Acer spp.). Studies on dieback risks indicated that the defoliation by the leaf miner does not seriously affect the health of mature trees. However, many cities are already removing some of their horse chestnut trees for aesthetic reasons. Furthermore, another study in the Balkans showed that the leaf miners seriously affect the regeneration potential of the tree species in the natural horse chestnut stands.

Another work programme is investigating the potential of different environmentally-safe and sustainable pest control methods including pheromone-based monitoring and control, biological control, and cultural methods. The epidemiology and dispersal of the moth are also being studied. Its origin is still unknown, despite research in North America, China, Japan, and Pakistan. Mortality rates in Europe caused by natural enemies and other factors are still very low, allowing moth populations to develop at outbreak densities in all European regions. CONTROCAM has looked at several pest control methods that have been tried and tested in recent years. These include chemical spraying (with insecticides like Dimilin or Confidor), use of pheromone traps or natural enemies of the moth (parasitoids), and the traditional mechanical method or common or garden leaf collection. It has concluded that spraying trees on a long-term basis is simply too expensive, especially in urban areas like e.g. Berlin where as many as 60,000 trees would have to be treated every year or two, with huge manpower and environmental costs for local municipalities, and with a negative ecological impact. The fate of Brussels' own horse chestnut tree-lined avenues speaks volumes.

Whilst a more suitable pest control system is sought, the rather time-consuming and labour-intensive removal of autumn leaves has been shown to lead to a significant reduction in damage the following year or at least a delay in heavy leaf damage until late summer. The Munich beer gardens offer a good example: autumn foliage harbouring the hibernating pupae is removed every day and leaf damage is extremely low. But then there is the problem of disposing of the diseased leaves in compost heaps, incinerators, etc.

The CONTROCAM project has more work to do to find a way of really reducing leaf damage. For the time being, it could benefit local authorities, foresters, nurseries, private gardeners and even the pharmaceutical industry.

Up to now our natural enemies are ineffective in reducing this invasive pest. It may take many years before an adaptation of the European natural enemies takes place. By then the horse chestnut trees will probably have been replenished in our towns, whereas they may have disappeared in the few natural stands in the Balkans. Thus, it is still of the utmost importance to find the area and host tree of origin of *C. ohridella* to study its natural enemies in this region and select suitable biological control agents for a possible introduction into Europe. This is probably the only long-term solution to the Cameraria problem.

A conference "Cameraria and other invasive leaf-miners" was organised by the CONTROCAM project in Prague, March 24-27, 2004. More then 80 scientists from most European countries participated in this meeting, which provided an excellent opportunity to discuss the continuation of the research activities at European level.

Coordinates:

www.cameraria.de

Wood properties and quality, treatment and re-engineering, wood waste

[QLK5-CT-2001-00443]

EDEN - Enzyme discovery in hybrid aspen for fibre engineering

From genetic to fibre engineering

Genetic engineering is opening up new opportunities in the forest wood chain. With an increasingly complex demand side of the equation, forest products will have to be grown to specification. Several of the workshop delegates, including the FAO economist and the European wood-working industry representative, predicted that fibre content will become much more important in future than price and quantity. The EDEN project coordinated by the Royal Institute of Technology in Stockholm, is a good example of how modern biotechnology and information technology can be combined to help develop new wood products.

The project takes its name from its aim of enzyme discovery from 8,000 hybrid aspen EST-sequences, for their eventual use in fibre engineering. This four-year experiment, ending in mid-2005, is using expression profiling to try and identify the function of genes relevant for wood formation in hybrid aspen trees grown in greenhouses. EDEN is using novel bioinformatics to carry out in a confined environment sensitive sequencing and domain organisational analysis of carbohydrate-active enzymes. It is split into several work packages focusing on such things as transcript profiling, protein production, assay development, enzymology, and fibre analysis.

It has a complex selection plan starting with identification of genes highly expressed during wood formation using microarray technology for mRNA expression profiling, then using novel bioinformatics software for sensitive analysis of distant evolutionary relationships and modular structures of selected enzymes and heterologous expression and enzymatic characterisation of selected enzymes. Moving on to fibre analysis, EDEN's promoters are developing Arabidopsis mutants in orthologous genes by reverse genetics and also testing transgenic poplars in Ghent and Umea in Sweden. The last two steps of the project are protein expression, localisation and fibre analyses in transgenic plants and then micropulping of selected fibre samples to correlate the enzymatic activities with final product properties.

EDEN's major success is the database it has set up with 877 putative carbohydrate-active enzymes and 20 full-length sequences of wood-related poplar genes. This could throw a lifeline to researchers as the search for available genes or enzymes is very time-consuming when there are over 40,000 possibilities. For instance, the project has found ten knock-out mutants relevant

to xylogenesis which researchers may not know about. They can now use the database to look for the markers they specifically want to regulate and start to apply the gene to different species, once the fibre length is known. Another interesting option addressed by the EDEN consortium is to identify enzymes for use in post-harvest fibre modification. Such applications have a significantly shorter time from research to market as transgenic plants are not involved.

The EDEN project is a good example of getting new technology to the manufacturing industry. Wout Boerjan of Ghent University has high hopes of new technology-intensive spin-off companies being set up as suppliers of the technology to the wood product manufacturing industry. Indeed, a spin-off company from the Swedish teams has already been set up and is host to over 100,000 listing sequences. He also hopes the EDEN project will lay the basis for future fibre engineering for applications relying on plant raw materials. Future success will of course depend on costs falling and once a full list of genes has been established the EDEN method should become more cost-effective. It may take 20 years but the benefits for the FWC will be worth the wait.

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[QLK5-CT-2001-00345]

Forecasting the dynamic response of timber quality to management and environmental change: an integrated approach

Multi-purpose forest management

Forestry in Europe is taking on a multi-purpose role, with its environment and recreational dimension now matching up to the more traditional requirements of timber production. Forest managers need to diversify their own practice, too, and for that they need guidance from forecasting and decision-support systems.

Seven organisations in five countries – Belgium, Finland, Germany, Italy and the UK – are working closely together under the MEFYQUE project to develop an integrated modelling system to help forest managers, the timber industry and policy-makers forecast timber growth, yield, quality and marketability, and decide whether forest management should be primarily geared towards production, conservation or amenity purposes.

MEFYQUE's promoters have thought of everything with their forecasting system. They have even given it a broader European policy angle to reflect the shift towards more sustainable management, conservation, provision of renewable resources and the role of forests as carbon sinks. This prototype modelling system itself feeds on a regular flow of quantitative data reflecting the current and future range of growth conditions and management practices across Europe's forests. It also incorporates carbon and energy budgeting modules to help with cost-benefit analysis of forest management.

Explaining its goals, the MEFYQUE project says "a fully integrated approach to pre- and post-production activities is required in order to develop a tool suitable for use by both the timber industry and national/international policy decision-makers".

Even the project's choice of sites reflects its diversified outlook. Assessments have been carried out on different sites in Belgium, Germany, Italy and the UK reflecting a full range of factors like soil and climate variation and tree species. The sites, too, are divided into primary sites in managed forests where samples are used for anatomical, chemical and structural analyses to identify climatic, management and treatment effects on wood quality, secondary existing CO_2 and H_2O monitoring sites, and tertiary sites near field research centres investigating the combined effects of higher CO_2 concentrations, temperature and drought conditions on wood quality.

Advance planning

It is a well-structured project made up of integrated components (monitoring forest sites, manipulating conditions of growth, laboratory analysis of anatomical, biochemical and mechanical wood properties, modelling growth, yield and quality at a range of spatial scales). Each component has a set of specialised work packages ranging from the production of stand growth and yield data to the stand-scale model, feeding into the EFISCEN large-scale scenario model developed in Finland which upscales stand features to regional and European levels.

In practice, the project is focusing on the last three years of tree growth and, with its visual log grading models, on the 30% on the surface of the end product which shows up the timber quality as well as physical and chemical stress. It has developed stand growth models using Scots pine trees that can be used to predict accurately the dynamics of growth and "pipe theory" specialised models with simulated biomass of tissue types to try and predict stem straightness and help decide where the tree is best suited.

The project coordinators are integrating all the findings into a model to assess growth of the standing crop and the wood it produces, how the wood is converted through different production lines into different products and how initial quality might affect the end product. It is working on a common standard on the effects of changing environment and climate conditions on tree growth and timber. It has measured CO_2 effects on biomass partitioning, developed a prototype model and carried out regional demonstrations.

MEFYQUE's classification system and the common standard it is developing with representatives from several EU countries are amongst its main achievements. It has links with five other KA5 projects, such as CARBOEurope, and is collaborating closely with the wood chain, which it can greatly help with advance planning of production. But its critical target beneficiaries are policy-makers at regional level as its modelling system may help develop future investment in their basic raw material, as Sam Evans from the UK's Forestry Commission Forest Research unit explained. The project is drawing to an end and an international conference is being staged in Edinburgh in September to take stock.

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[QLK5-CT-1999-01587]

MARWINGCA - Magnetic Resonance Imaging of Wood and its Interface with Glue, Coatings and Air

Understanding movement of moisture in wood

Europe is blessed with abundant rainfall, which may make the trees grow but it can make the wood wet. And this is costing the industry. Wood itself is a sustainable, renewable and versatile material. When processed, dried and protected correctly, it becomes a high-quality and relatively stable material. But it still gets wet when used externally. Not enough is known about the mechanisms of moisture movement in wood when it is initially dried and in service. Wood can be dried to the wrong level. A high moisture gradient can cause it to twist and shrink, for instance. It now faces a new problem with the increasing use of environmentally-friendly, low volatile organic compound coatings which can cause rot in wood panels due to water retention under the coating/wood interface. At the end of the day, moisture ingress into wood bond glue can lead to poor durability, mechanical failure and a shorter product life.

The MARWINGCA project, run by the University of Surrey in the UK, may have an answer. It applied magnetic resonance imaging to measure moisture profiles and used the resultant data to build a surface layer model in order to understand the movement of water in wood. This led to an improved electrical impedance moisture sensor which, in turn, was used to develop an innovative kiln control system which is now available on a commercial basis*. It developed systems using MRI for characterisation of wood surface drying, coatings and glue layers. In a nutshell, the project put the simple human brain scan model (GARfield magnet designs) to work to calculate dry shell thickness and help control the drying process.

MARWINGCA is a good example of a completed project that has expanded understanding of movement of moisture in wood and generated new technology with commercial success which, in turn, has led to substantial further funded R&D and training courses.

** wsab explorer control system and moisture sensor*

Coordinator: Keith Maun, BRE, UK

[QLK5-CT-2001-00749]

RODET - Reduction of Detrimental Substances in Papermaking

Environmentally-friendly pulp and papermaking

The papermaking industry has a hidden enemy within its own ranks in the form of detrimental substances, originating primarily from recycled and wood-containing papers used as raw materials. These substances may interact with the complex chemical additives needed in modern-day paper and board manufacturing. Reduced process performance and serious production failures are caused by neutralisation reactions between these manufacturing aids and anionic detrimental substances, causing deposits on machine parts, specks or holes in the paper, machine downtimes owing to web breaks, etc. This means increased consumption of chemical additives, higher energy consumption and increased loads, of effluents. The end result is not just higher production costs, but also a negative impact on the environment.

Using its €1.67 million EU grant, the RODET project (Reduction Of DETrimental Substances in Papermaking) being coordinated by PTS in Munich, Germany, joins the efforts of research institutes, suppliers and papermakers and is coming up with solutions for more effective control of detrimental substances in the papermaking process. It thus hopes to reduce production costs and makes an important contribution to quality consistency, too.

In a first step, on- and off-line methods were developed in a pilot project, together with two paper mills in Sweden and Spain, to classify deposits and detrimental substances in paper mills to predict the risks of deposit formation or web breaks. Methods newly developed during the project have already been applied in paper mills.

New chemical additives, based on modified minerals (bentonite and talc) and aluminium compounds, have been developed for an improved removal of detrimental substances from the papermaking process. They were tested successfully for their efficiency at laboratory and pilot scale.

Even though the RODET project has another year to run, it has already led to new products that have reached marketing stage. And there is a high probability that they can be marketed, says Reinhard Grenz of PTS in Munich.

This is another success story of research being brought to the market. RODET offers a practical example of how to improve the efficiency of papermaking processes, while making them more environmentally-friendly by reducing pollution from mill effluents.

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[QLK5-CT-1999-01105]

REMPULP - Reduction of air emissions at kraft pulp mills

Knowing NOx reduction potential

REMPULP is another KA.5.3-funded project seeking to develop environmentally-friendly processes that has had some success in finding ways of reducing polluting atmospheric emissions, notably nitrogen oxide, at kraft pulp mills, especially recovery boilers.

This three-year €1.27 million shared-cost project, which ended on December 31, 2002, drew on the expertise of distinguished partners like STFI, KCL and PCG (Process Chemistry Group from Åbo Akademi University) which had experience with other EU-funded projects, to carry out laboratory-scale tests in Sweden, Finland and Portugal to glean detailed information on the formation, distribution and behaviour of different nitrogen compounds in kraft pulping, including both fibreline and liquor cycle operations. It also investigated by mill-scale measurement campaigns how the distribution and behaviour of nitrogen compounds can be affected by modifying conditions during cooking, black liquor evaporation and combustion, smelt dissolving, and white liquor preparation. On the practical front, it assessed different NOx reduction strategies and methods at softwood, birch and eucalyptus kraft pulp mills.

Thanks to the REMPULP project, the NOx reduction potential is now known and several different methods or strategies have been compared. A simulation mill-wide model has been developed, too. The research findings have already been widely disseminated within the European pulp and paper industry and have gone on to benefit the financing companies of KCL and STFI, for instance, as well as equipment manufacturer Andritz Oy.

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[QLK5-CT-2001-70471]

WOODCOMP - In-vessel biological degradation of wood powder from the furniture industry

Turning the dust into compost

The timber industry needs to cut costs or it will all turn to dust. What better way to save money and help the environment than by making a value-added product out of wood waste?

An EU-funded project in the UK called WOODCOMP has taken just 24 months to prove that a highly-rated product for the burgeoning gardening centre market can be made out of wood waste powder from the furniture industry. 95% of these wood chippings normally go straight into landfill tips. But EU countries are bending under the weight of rubbish tips and struggling to respect the new waste landfill legislation. Working closely with local furniture manufacturers and a Dutch company specialising in compost systems, WOODCOMP is seeking to give the furniture industry a more environmentally-friendly profile.

The project has several work packages (and subtasks), ranging from materials selection to process development and financial approval to product technology. It has developed a flexible composting system equally capable of degrading wood waste from a single site (20-50kg per hour feed rate) or multi-source waste at a regional level (1000kg-2000kg per hour feed rate). On the practical front, it has carried out successful laboratory demonstrations of a rapid composting process using selected bacterial and fungal species to help rapidly decompose the very sterile and dry material that comes off carpenters' workbenches. The resultant compost that sustained plant growth was produced in just two weeks in some trials.

Composting trials making between 5 and 30 tonnes of compost were undertaken to assess the optimum parameters. They had to find the right amount of nutrients needed to turn the wood waste into compost and also tackle such problems as breaking down the formaldehyde left in furniture waste. Scaling-up presented some problems, not least finding a suitable vessel specification that could replicate the lab tests.

The project promoter, FIRA International Ltd, stresses that if this sort of composting is to become commercially viable in terms of throughput speed, a 28-day degradation period is desirable. But if this proves unrealistic, then the design of the composting system should allow for continual rather than batch feeding.

Thanks to this project, the furniture manufacturing industry has a chance to produce a value-added product and help the environment, thus raising its own eco-friendly profile. The technology has already been demonstrated and should be very interesting for composting vessel suppliers... if, as it claims to be, it is better than other products on the market.

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www.fira.co.uk

Forest treatment? Multifunctionality, forest policy and market demand

[QLK5-CT-1999-01349]

NATMAN - Nature-based management of beech in Europe - a multifunctional approach to forestry

Biodiversity and climate change in natural beech forests

In several European countries, forestry is turning from traditional management to natural, semi-natural or close-to-nature strategies. Greater dependence on natural regeneration has raised the profile of tree response to climate change and enhanced the need for research in this area. Research can help ecologists and forest managers predict the future composition of natural forests. The balance between tree species is changing with the greenhouse effect as a result of the race for the survival of the fittest. Controlled experiments in open-top climate chambers in the NATMAN project show that warmer temperature and higher CO_2 concentration give a strong competitive advantage to ash as compared to beech. In time, this might encourage ash regeneration below old canopy and in canopy gaps. If the greenhouse effect further leads to higher frequency of big storms – and creation of more and larger gaps – ash would gain an even greater competitive advantage.

This is just one of the natural trends that the KA5.3-funded NATMAN project (Nature-based management of beech in Europe - a multifunctional approach to forestry) is looking at. It is primarily an environmental project seeking to promote sustainable forest management by mimicking natural structures and processes in the management practice. Beech forests are an important resource for timber production, as well as for biodiversity conservation. So improved beech management can make an important contribution to the multifunctional use of European forest resources.

Coordinated by the Royal Danish Veterinary and Agricultural University (KVL), the project brings together a multidisciplinary team of scientists and end-users from East and West Europe working to produce new research results. In this project, knowledge from Eastern as well as Western Europe is combined in an extremely integrated working programme. By the end of the project the East/West research team aims to publish a European beech reference book, policy recommendations and nature-based management guidelines for SFM. The work of NATMAN helps the European strive (e.g. Cost Action E4 and E27) to establish a natural reference point for European forestry. NATMAN reviews the history of beech forestry in Europe, looks at pollen records, studies natural beech forest reserves and compares the dynamics of unmanaged forests with contemporary managed forests.

Dead wood and carbon sinks

NATMAN coordinator Jens Emborg says one problem his project is tackling is how to manage the dead wood component in the managed beech forests in the best – and most efficient – way. The challenge regarding dead wood is how to balance wood production, carbon storage and protection of the biological diversity of vascular plants, bryophytes and fungi in the forests.

The project's gap studies in natural as well as managed forests are generating more than just new plant life in big holes in forests left by storms, lightening or senescence – they actually help better understanding of how to regenerate forests.

NATMAN has a strong link to the organisation of European foresters Pro Silva. As a final outcome of the project, a joint NATMAN/Pro Silva conference will be organised in Denmark, 4-8 August 2004. The balance between production and conservation in beech forestry, and nature-based management as a tool for achieving SFM will be discussed among scientists and end-users at the conference.

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[QLK5-CT-1999-01493]

SMALLFORE - Small-scale wood harvesting technology in European forestry and its contribution to rural development

Small-scale wood harvesting technology

It is generally acknowledged that small is beautiful in Europe's highly-fragmented forest-based industry. But even though natural, cultural and socio-economic conditions vary considerably from one country to another, non-industrial private forest owners face common problems. And when it comes to spreading the word on small-scale wood harvesting technology and equipment in the rural environment, a problem shared is a problem halved, as the SMALLFORE project has shown.

This Concerted Action project on small-scale wood harvesting technology in European forestry and its contribution to rural development, coordinated by the TTS Institute (Work Efficiency Institute) in Finland, ran for two and a half years (March 2000-August 2002). It had partners from 13 countries across Europe (Germany, Austria, Italy, Sweden, United Kingdom, Spain, France, Estonia, Norway, Denmark, Belgium, Czech Republic and Finland), with an interesting mixture of technology and research-orientated and resource-based interests. SMALLFORE thus managed to successfully combine the technological and socio-economic points of view when considering common European development needs and possibilities in the field of small-scale wood harvesting technology.

The general objective was to introduce and develop new and feasible small-scale technology-based wood harvesting concepts to boost employment and the viability of forested rural areas in Europe. More specifically, it sought to throw more light on the situation of small-scale wood harvesting technology in Europe, demonstrate local/ regional practices, promote technology transfer and consider development needs and prospects. SMALLFORE pointed up a growing interest in multi-purpose use of forests.

Most of the EU grant was spent on coordinating information from different parts of Europe and on internal and external communication via workshops, conferences and excursions (to see harvesting operations in steep terrain, poplar plantations and fuel wood harvesting sites). All these events helped exchange views on technology and rural development communication between researchers, R&D personnel, rural decision-makers, forest owners, manufacturers and equipment users.

What they all need is reliable and up-to-date information. As was also disseminated in the FAO/ECE/ILO Joint Committee on Forest Technology at a seminar in September 2003, "systematically collected data and statistics vary a lot between different countries, not only in the field of small-scale wood-harvesting techniques but also in non-industrial private forestry as a whole". The SMALLFORE project's most tangible achievement is therefore its pilot database on small-scale wood harvesting technology, SMALLBASE, which is available free of charge on the Internet (www.tts.fi/smallfore/smallbase), features tables and Internet links about products and producers, retailers of equipment for pruning and felling, planting machines, shredders, chainsaws, stump grinders, etc.; the database is particularly useful for forest owners, machinery manufacturers, researchers and rural enterprises. It is a practical success story for small-scale know-how and technology transfer.

But perhaps SMALLFORE's most interesting contribution to European forestry and wood chain research lies in its planning work for future RTD projects. Three thematic groups came up with R&D project ideas such as the COOPFORE proposal to help forest owners improve sustainable management practices while encouraging rural development. It brought together both R&D organisations and practical-level forestry interests from eight countries (Finland, Austria, Spain, United Kingdom, Estonia, Latvia, Czech Republic and Slovenia). Another project idea on "Firewood production - turning tradition into business" was compiled by a working group with members from Sweden, Finland, Italy and Spain. And a third idea of optimising information flow towards small-scale forest owners to promote sustainability in forest management was put together by another working group with members from Belgium, Sweden, Germany, the UK and Spain.

The ideas are living on under FP6 with the STREP project proposal launched in January 2004 to promote co-operation among private forest owners as a means to improved sustainability.

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[QLK5-CT-2001-00608]

XYLOREACH - End-user Access to European RTD for the Forest and Wood Industries Sector

Bridging the gap between research and industry

An essential ingredient of past, present and future research work is networking, as a means of bridging the gap between research and industry. Workshop participants made clear they wanted more opportunities to find information, share experience and know-how, find project partners and ultimately form technology or sector-specific platforms. The last of the projects presented at the workshop rounded the success stories off nicely. The XYLOREACH project is setting up a Thematic Network linking the leading European organisations supporting research and technological development in the forest and wood industries.

XYLOREACH is described by the Irish project promoter as "a sort of editorial process" to collate, assess and disseminate information on results of national and EU-funded RTD in the sector. Its goal is to set up a multi-lingual electronic mechanism whereby the results of RTD projects under EU programmes such as FP4 – FP6 and beyond, and national programmes are accessible to, and understood and used by the SMEs that predominate in the sector. As its name suggests, XYLOREACH has a wide partnership across Europe from harvesting, logging and storage to first-stage processing, sawing, drying and grading and on to finishing and industrial design.

The project consortium's extensive links with the forest-wood industry at European, national and branch levels have been mobilised to produce a far-reaching communication and technology transfer process. Already, the XYLOREACH database has been set up and contains over 900 research summaries, an eight-language web user interface and an effective search mechanism. In addition, 11 thematic groups have been set up with more than 600 researchers from over 20 countries.

And, in 2002, the project won a university-enterprise award from a Spanish network of university-funded enterprises.

An official launch is planned for the April 28 to May 1 Dublin conference on "Future Issues for Forest Industries in Europe".

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Annexes: Expert Report

- Introduction
- The forestry research environment
- EU-funded research in the forestry/wood sector
- Progress review of projects funded in KA5.3
- Thematic coverage and successes
- Coverage of the work programme
- Recommendations for future research at EU and national level

Introduction

An expert review of ongoing Key Action 5.3 projects under the Quality-of-Life programme (1998-2002) took place from 3 to 6 November 2003 at DG Research's premises. 63 projects have been funded under KA 5.3 with its two sub lines, namely, 5.3.1 on "Multifunctional management of forests" and 5.3.2. on "Strategies for the sustainable and multipurpose utilisation of forest resources; the forestry-wood chain".

When green timber is harvested it moves through various stages of processing and then on to manufacture. This production cycle is known as the forestry-wood chain. Because it takes raw material through to the end product, the forestry-wood chain has an impact on a broad range of issues for forest management to industrial competitiveness.

This forestry-wood chain approach is the distinct feature of Key Action 5.3 compared to action lines in other programmes under the Fifth Framework Programme where only certain forestry or wood-related aspects have been addressed in a limited number of projects.

Therefore, the whole range of the forestry-wood chain from forest genetics, forest management (including forest pathology and physiology), wood quality and timber processing, to pulp and paper is covered by Key Action 5.3 projects.

The forestry research environment

Economics background

Timber is one of the EU's oldest renewable resources and still very much in demand. And it is on the rise again, both naturally and thanks to enlargement. In many regions, forest area and material is expanding year by year and most of it is fast-growing softwoods. EU timber production will increase overnight by about 20% when the ten new Member States join in May 2004. Output in existing Member States is also increasing, largely as a result of wide-scale afforestation programmes in Spain, the UK, etc.

The current 15 EU Member States harvest over 120 million m³ of softwood (mainly spruce and pine) and over 40 million m³ of hardwood (mainly oak, beech and poplar) every year, with a total market value of some €4-6,000 million for softwood and €2,000 million for hardwood.

The EFISCEN (European Forest Information Scenario Model) project predicts that even if fellings remain at the current level, Europe's average growing stock will rise from 137 in 1990 to 226 cbm/hectare in 2050. The predicted rise in fellings of just 0.3% a year will do nothing to halt this trend, neither will do the anticipated expansion in (forest) area of reserve from 4 million hectares in 1990 to 11.9 million in 2050, which suggests that more wood can be harvested than in the past with a higher degree of nature conservation.

But timber needs to fight its corner. Forestry risks turning into a loss-making business. Market forces are eroding the financial position of forest owners, as well as the supply of wood to industry. If new and existing material does not meet the required specification when sold, timber will lose its market share. So the aim should be to boost market share and make better use of Europe's natural resources.

The challenge for forestry is to keep producing high-quality, uniform raw material to meet the demands of industry. Improvements can be achieved through advances in genetics, silviculture and biomechanical processes.

Biotechnological innovation

Modern biotechnology tools offer a wide spectrum of investigation in the field of genome analysis, which is being picked up by forest genetic research focusing on studies in genomics and proteomics with biotech applications and on genetic resource conservation. It is working to improve understanding of key features such as adaptation to changing environment, resistance to pathogens, and improvement of quality wood products.

For a start, the use of genetic markers offers an opportunity to: i) look into the degree of genetic diversity at both population and species level at neutral and adaptive loci; ii) verify if candidate populations to be protected are autochthonous, and, if they are not, to identify their origin; iii) understand population dynamics, gene flow, and colonisation patterns; iv) reconcile conservation measures with traditional management and with the activities of human populations, particularly agriculture.

Different aspects in relation to differing demands

Another feature of European forests is that each country has its own management culture, different ownership structures and particular societal demands and pressures. This is one of the reasons why European forests are subject to many political initiatives and processes at different levels, which aim at identifying common denominators, necessary actions and integrated approaches.

Forest management across Europe, therefore, varies in intensity and aims, although there is a growing trend to reflect both economic and environmental benefits. Sustainable forest management takes account of various pressures and demands, both environmental and societal, such as climate change, air impurities, land use changes, protection, biodiversity, certification, timber production and water resources.

Issues related to conservation and biodiversity, the social function of forests, environmental changes and carbon sequestration might result in adaptations of forest inventory, management and even harvesting procedures in ways that enable the demands of various stakeholders to be met simultaneously. However, it will often be necessary to design sub-models to cover the variety of European forest management schemes and systems.

One problem with monitoring developments in forest area and land use – vitally important in measuring biodiversity and carbon sequestration – is the lack of comparability between inventories in different countries, especially for changes over time. Remote-sensing technologies and combined approaches may help to assist for continuous and harmonised monitoring of changes in forest area and conditions.

It was largely concern about declining natural forest cover and loss of biological diversity that led to an expanded area of protected forests. Measures have aimed mainly at protecting biodiversity but also take related social and cultural values into consideration. A general strategy has been to expand existing conservation networks, such as the EU's Natura 2000, in order to improve protection of flora and fauna in all regions.

Increasing forest resources in Europe

Nevertheless, the current scenario is one of expanding growing stock despite static timber harvesting levels. However, supply/demand patterns are constantly changing and both market and policy forces can have a considerable impact on felling levels. One factor that is pushing up demand for timber is the European Commission's 1997 Green Paper target of increasing the share of renewable energy, including biomass derived from wood, in the EU energy mix by 50% to 12% of total energy use by 2010.

One of the main constraints to profitability of forestry is the decline in the labour force, so mechanised logging is the prevailing scenario even under mountainous or Mediterranean conditions. Work mechanisation will need to provide a means to cut harvesting costs even further while meeting stakeholders' expectations regarding improved harvesting, measuring and tracking efficiency of forest machinery; reducing the negative impact on the environment; better monitoring to reduce damage and avoid waste; and integrating harvesting of forest residues for energy use wherever possible.

The importance of forest products

The bulk of softwood material is currently used in the building industry in structural components, joinery, furniture, cladding and flooring and in temporary structures. Much of this (beams, roof-truss timber, purloins, studs, glulam timber) has to undergo further treatment to make it fit for use (e.g. to be kiln dried, graded for strength and preservative treated). Hardwoods are used for decorative purposes such as furniture and interior panels. This, too, needs to be kiln dried and graded for appearance. Timber must be fit for purpose and keep its environmentally-friendly image.

EU pulp production weighs in at some 33.8 million tonnes, accounting for 18.8% of world production. Chemical pulp is by far the main grade (20.6 mt), followed by mechanical pulp (11.3 mt) and other pulps (1.7 mt). The EU's major pulp-producing countries are Finland (11.2 mt) and Sweden (11.0 mt). Pulp production will only be boosted by 2.4 million tonnes (7.1%) by the arrival of the new Member States, with Poland contributing 0.9 mt followed by the Czech Republic with 0.7 mt.

The EU also turns out 82.2 million tonnes of paper and board, accounting for 25.8% of world production. The main grade is printing paper (30.8 mt), followed by container board (18.2 mt). Germany is the largest paper producer, followed closely by Finland, Sweden and France. EU paper and board production will go up by 4.7 million tonnes (5.7%) when the new members join, with Poland leading the pack (1.9 mt) followed by the Czech Republic (0.9 mt). Recovered paper has become a very important fibre source within the EU. 41.2 million tonnes of paper (28.3% of the world total) have been recovered and the numbers are going up.

EU-funded research in the forestry/ wood sector

The Fifth Framework Programme for Research (1998-2002) has a multi-theme structure, consisting of four Thematic and three Horizontal Programmes. Research related to forestry and the forest-based industry at EU level has been carried out mainly by Key Action 5 "Sustainable Agriculture, Fisheries and Forestry, and integrated development of rural areas including mountain areas" of the thematic Quality-of-Life programme (QoL), where in Action line 5.3 over 60 research projects involving more than 500 participants at the overall cost of about €128 million and with an EC contribution of about €80 million. Euro are being implemented, addressing important aspects of the forestry-wood chain.

Further projects related to forests and wood fibres in the broadest sense have also been implemented under the Energy, Environment and Sustainable Development (EESD) programme, as well as the Competitive and Sustainable Growth (GROWTH) programme. In the horizontal programmes, the main contributor in terms of funding forestry research has been the dedicated international co-operation programme (INCO).

The overall objective of forestry and forest-based industry research in Key Action 5.3 has been to improve sustainable production and rational use of goods and services derived from natural resources in Europe, with special emphasis on new technologies, including biotechnology ,and multidisciplinary, integrated approaches. This will help boost competitiveness, with direct implications for employment in rural areas; reduce vulnerability of the relevant sectors through diversification; meet societal demands for sound environmental practices and ensure sustainable production of renewable resources.

Subject areas	Number of projects	Total cost [Mill. €]	EC-contribution [Mill. €]
Forest management / biodiversity / carbon research			
QoL – Action line 5.3	29	63.46	40.02
EESD	22	45.82	31.82
INCO	14	16.2	12.17
Forest pathology and physiology			
QoL – Action line 5.3	5	8.59	6.45
Wood processing			
QoL – Action line 5.3	15	25.03	16.03
GROWTH	16	15.93	9.04
Pulp and paper			
QoL – Action line 5.3	12	31.42	17.82
EESD	4	6.43	3.54
GROWTH	5	8.00	4.97
Total	122	220.88	141.86

The vast majority are Shared Cost Research projects (RS) with an EC contribution of up to 50% of total project cost; a few projects are other types such as Concerted Actions, Thematic Networks or CRAFT projects, the latter promoting the participation of small and medium-sized enterprises. Participating institutions comprise universities, public and private research institutes, and commercial and end-user firms.

Progress review of projects funded in KA5.3

A total of 63 projects were funded under Action line 5.3 and reviewed by external experts, covering sublines 5.3.1 "Multifunctional management of forests" and 5.3.2. "Strategies for the sustainable and multipurpose utilisation of forest resources; the forestry-wood chain".

For the purpose of the expert review, the projects were grouped under headings dealing with forest genetics, forest management (including forest pathology and physiology), wood quality and timber processing, and pulp and paper. This grouping reflects the individual experts' in-depth expertise of certain methods and technologies rather than the fields where these methods and technologies may be applied (e.g. biotech for conservation versus selection or breeding).

A questionnaire was filled in by the reviewers to get information about individual project implementation. Information on the qualitative assessment will be provided in the next chapter on "success of funded projects". Meanwhile, an overview is given below covering the quantitative aspects of KA5.3 projects.

It should be borne in mind that information varies according to different start dates of individual projects, thus affecting quantitative data. The number of projects for which the technical annex (TA) was the only source of information is therefore mentioned in each subject area.

FOREST GENETICS (10 projects)

Most projects in this group contributed to subline 5.3.2, in particular to the topic on "Sustainable and diversified forestry production meeting market needs". Three out of the ten were a follow-up of projects previously funded under the FP4's FAIR programme, and another project had roots in a different EC-supported activity. Only one had the TA as the single reference document as it only got off the ground in late 2002.

In a nutshell, the main results at the current stage of implementation lie in generating knowledge, although only two projects were exceptionally strong in publishing results in reference journals and passing them on in training activities, and have gone as far as to file for patents.

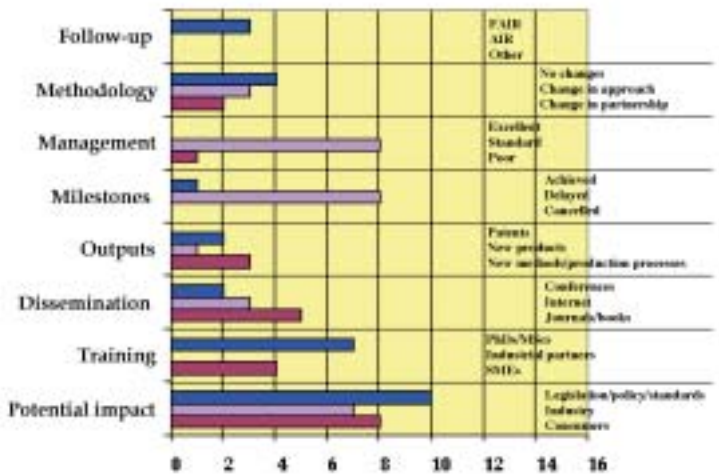
The main beneficiary of the KA5.3-funded forest genetics projects will be industry, not only from improved raw materials but also through higher profitability of businesses in the sector. Five projects have either industrial partners in their consortium or have industrial contacts outside the project.

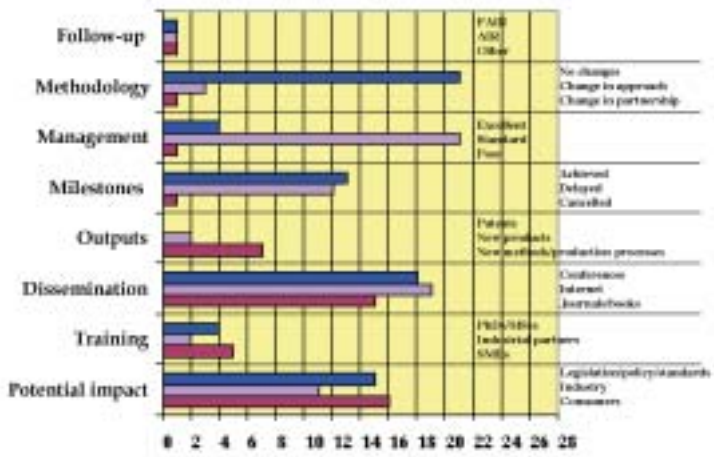
FOREST MANAGEMENT (28 projects)

This group (including forest pathology and physiology) has been the most diverse group in terms of coverage of specific research topics. In only two cases was the assessment solely based on the TA. Quite surprisingly, only two out of the 28 projects produced evidence of previous work supported by EC funding, namely one AIR project (FP3) and one other type of supported activity.

For the 26 projects with annual reports available for the expert review, only one got poor marks for management, but four were considered excellent, being above the standard approach in communication within the consortium and in monitoring project implementation. On the downside, four underwent changes en route, and 11 projects came up against difficulties in delivering the goods. 16 projects fell behind the original schedule for a variety of reasons, but only in five of these is the delay regarded as serious.

At the current stage of implementation, the main output from these forest management projects lies in generating knowledge. But they have also helped develop new prototypes/products (2 projects), new tests/methods (6 projects), new standards (3 projects), new software/codes (4 projects), new production processes (2 projects) and new services (3 projects).





PROCESSING AND WOOD QUALITY (15 projects)

Four projects started recently and their assessment was solely based on the TA. Almost all 15 projects in this area contributed to all three topics of Action line 5.3.2. Like the forest management projects, only a few were based on previous work supported by the EU, namely three projects based on FAIR projects and one based on another type of supported activity.

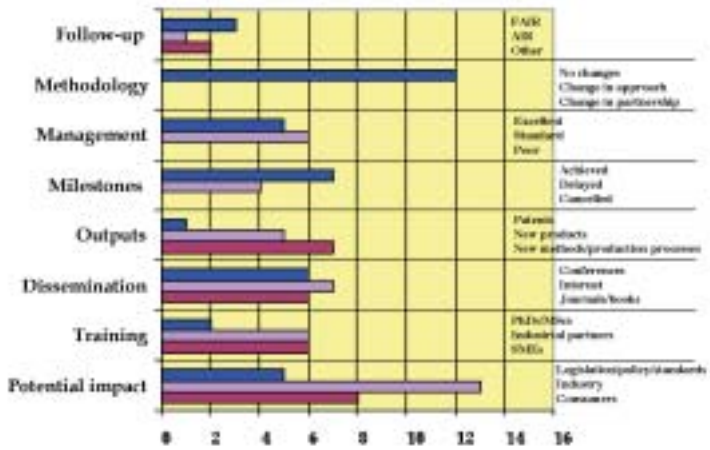
So far, only one project has undergone changes during implementation. Otherwise, project promoters encountered few difficulties in producing the required milestones and deliverables. In two cases, there was a change of partnership for legal reasons and one of these hit scientific problems.

The main output from the projects has been patent applications (1 project), new prototypes/products (5 projects), new tests/methods (5 projects), new production processes (4 projects) and new services (3 projects).

The number of projects investing in training has been very low, with only two projects reporting PhD students covering project work. But industrial participation in the projects has been quite high, with large industrial partners in 11 projects, SMEs in six and industrial contacts outside the consortium in three of them. So industry will reap the main benefits through changes in practices/processes (11 projects), new uses/markets for existing products (8 projects), new products (8 projects), improved raw materials (6 projects) and higher profitability (9 projects).

The number of projects investing in training has fallen behind expectations, as only two reported PhD students, two others MSc students and visiting experts were interested in another two. Big industrial partners have only been involved in two projects and SMEs in five, bearing in mind that two projects in this group were CRAFT projects. Nevertheless, five projects did at least have industrial contacts outside their consortium.

The main beneficiary will be industry via changes in practice/processes (4 projects), new uses/markets for existing products (4 projects), new products (4 projects), improved raw materials (3 projects) or improvement in profitability (2 projects). Society at large should benefit, too, through improved viability of rural communities (6 projects), environmental improvements (10 projects), access to information (5 projects), improved working conditions (2 projects), while the world of science should gain from validation of previous research findings (11 projects), start-up of new research projects (19 projects), improvement in existing communication (11 projects) as well as other scientific aspects (4 projects).

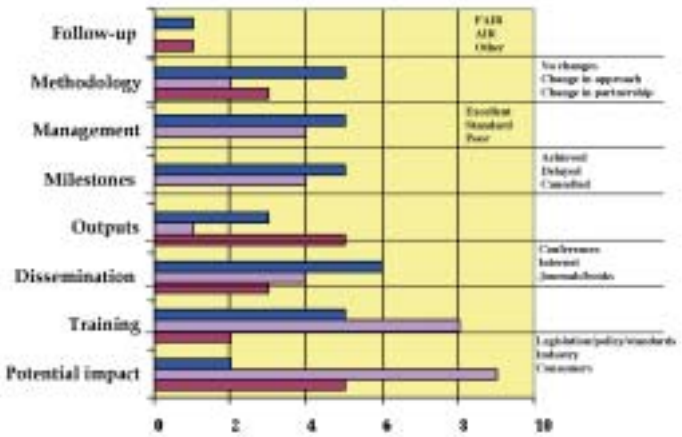


PULP AND PAPER (10 projects)

All ten projects under this sub-heading contributed to the specific topic on "Environmentally friendly and efficient processes". One of them came under the topic "Sustainable and diversified forestry production..." and another under "Market requirements". Only one was based on a previous FAIR project and one alone had just the TA to go by.

On the ground, five projects have stuck to their original plan and schedule. The others are lagging behind a little. In terms of output so far, apart from the general dissemination of knowledge, three projects have given rise to patent applications and four to the development of new tests/methods. Six projects have been very active in disseminating findings through conferences, but only three have managed to publish results in reference journals and communication via the Internet has been sorely lacking. Five reported follow-up training via PhDs (3 projects) and MScs (3 projects).

Nine out of ten projects had industrial partners, with SMEs in only three cases. So the main beneficiary is industry through changes in practice/processes (9 projects), new products (1 projects) and improved raw materials (3 projects).



Summarising remarks on the overall implementation:

- The vast majority of projects reviewed have either been completed or are progressing satisfactorily;
- Some projects started only recently and will shortly produce their first annual report, but this should not change the overall KA5.3 project implementation picture;
- Important topics have been successfully addressed;
- Management has been mostly standard. Delays, where they occurred, may have even been avoided through improved communication and management in general;
- There is a need to put more emphasis on dissemination of findings;
- More effort needs to be put on training, so far limited to pulp and paper;
- Medium-term continuity of databases or websites is no longer guaranteed once the projects have ended, so perhaps specific action is needed to keep some excellent examples going.

Thematic coverage and successes

In summarising the thematic coverage and highlighting the success stories it has been considered appropriate to look at all projects from a problem-oriented perspective; that is from the "raw material" through to the end product and with an impact on a broad range of issues from forest management to industrial competitiveness. The topics multifunctionality, forest policy and market demand are responding to societal demands other than timber production.

A) Forest genetics, physiology and pathology

Application of modern biotechnological methods has opened up new ways of analysing physiological processes, of understanding population dynamics, and investigating neutral and adaptive genetic diversity.

The ultimate goal of two funded projects in this area is to obtain improved material, resistant to drought and salinity stress, for example, and to be used in plantations [**Establish**], and improved winter hardiness and dormancy [**Coldtree**].

Adaptability and drought-tolerance are also issues dealt with in a project investigating ecophysiologial traits [**Creoak**].

Standardisation and quality control to certify plant material is important to guarantee appropriate plant material [**Manchest**] for sustainable management of chestnut stands.

Highly-sophisticated genetic technologies are being used to identify the origin of trees, populations, and plant material as well as to quantify gene flow and the level of interspecific hybridisation. This is being done with respect to the natural variation of the test material [**Oakflow**]. Another project [**UHT-Map-of forest species**] aims to construct an ultra-high density linkage map of *pinus pinaster* which will allow marker-assisted selection or breeding.

Further projects funded in the subject area of physiology and pathology brought together researchers and end-users (mainly SMEs) to develop new and more efficient production systems for forest material, combining traditional approaches (provenance and progeny trials) with molecular techniques (certification of material, species discrimination), and methods for producing micro-propagated plants and somatic embryos [**RAP**] or new innovative methods for producing clone material for reforestation [**SEP**]. Traditional breeding approaches were chosen to develop more efficient methods for large-scale broad-leaved species production in nurseries [**Broad-Tech**] and to overcome related problems with dormancy [**Tree Seed Performance**].

To improve the vitality of forest stands and tree individuals all over Europe, both traditional and very innovative methods have been developed. Pest and disease control [**Controcam / Resrobs / Mohief / Fireguard / Promoth**] have been carried out by simulation models, decision-support systems, GMO techniques, or remote-sensing on non-biotic traits, while traditional measures have been used to tackle improvement of vitality aspects [**Sustman**].

Another aim is to develop scientifically-verifiable methods of Pest Risk Analysis and design quarantine measures. This is being addressed in one funded project by using pinewood nematode [**Phrame**].

Research on drought resistance is also an important aspect in the context of climate change [**Adaptability**].

One of the main non-biotic threats to European woodlands comes from forest fires, especially in the Mediterranean area. The only project tackling this subject, by looking at fire detection via remote-sensing techniques,

Genetic conservation of oaks

The oak tree is likely to be affected by climate-induced changes in the genetic make-up of forests and some species could be migrating northwards. Oaks are particularly susceptible to the effects of gene dispersal as they are highly interfertile and have the capacity for interspecific hybridisation, as the OAKFLOW project has shown. It is trying to estimate the amount of intra- and interspecific gene flow in European oaks by using genetic fingerprints and parentage analysis. OAKFLOW is looking in particular at key biological mechanisms that may interact with human interference to generate and modify diversity. The computer simulation models it has developed will help foresters forecast short- and long-term consequences of gene flow on the distribution of diversity in oak stands.

Resistance to disease in spruce forests

Prevention is better than cure. And with vast conifer forests to manage, European foresters will agree that resistance is the best way to control a disease. The RESROBS project is testing resistance of Norway and Sitka spruce trees to Root and Butt Rot Disease caused by *Heterobasidion spp*. and trying to throw more light on inheritance of disease resistance based on genetic and biochemical molecular data. These data can now be used to develop methods to predict inheritance of resistance based on experimentally-determined markers.

Managing the impact of disease resistance

Turning to the forest management side of the problem, a Concerted Action project under the name of MOHIEF has built up a user-friendly computer-based model to help foresters predict the incidence of this *Heterobasidion* virus. It can be used to determine losses to infection and decay in a range of forest types found in Europe and has already generated a better understanding of the management impact of disease resistance in spruce forests.

Sustainable pest control

The horse chestnut leaf-miner, *Cameraria ohridella*, a moth of unknown origin, is another pest that has spread over vast areas of Europe in the last 20 years and the CONTROCAM project is trying to find out what or who is responsible for it and how to keep it under control. The project promoters claim it is possible to bring down the Cameraria moth population to damage-limitation level with suitable control methods. So they have put together the basic structures of an integrated pest management (IPM) system for *C. ohridella* that can be used as a generic model across all affected areas of Europe.

B) Wood properties and quality

The quality of European wood is an important issue and is not only linked to plant material but also to forest treatment, which often determines the properties of timber and improved processing. Knowledge of the genetic control of wood formation and the impact of the environment on this process is valuable for further improvement of quality and yield. A strong interaction between geneticists and physiologists is needed. This often leads to highly innovative approaches, such as the identification of genes that are differentially expressed under various CO_2 concentrations and involved in wood formation [**Popyomics**] or the analysis of metabolic pathways involved in wood formation [**Eden**] or the development of cheap and reliable methods for measuring wood quality and for selecting elite trees [**Gemini**]. But development of new screening tools to engineer transgenic poplar [**Popwood**] might be hampered by current national and EU regulations on GMOs.

More eco-friendly production chains can be designed from new processes using better raw materials or less chemicals [**AEP, Eurofiber, Pitch**] and optimising printing processes on different paper qualities [**Tona**].

Now and more so in the future it is going to be very important to match end products to the timber quality of the growing trees, so as to use the material more efficiently. Some funded projects are working on this important issue of matching raw material and end product, focusing either on certain aspects such as a specific tree species [**Superwood**], timber defects [**Compression Wood**], novel techniques to improve the fitness for purpose of constructional timber [**Straight**], or the general problem [**Lineset**] and [**Mefyque**] which estimates with modelling and simulation tools the impact of forest management on the wood quality for end-users.

Last but not least, wood needs to compete successfully in future with other materials where the impact of moisture content on coating and gluing [**Marwinga**], durability and load-bearing capacity under external conditions [**Plybiotest**], and testing standards for fitness for purpose and quality control [**Panels / Plybiotest**] are of utmost importance.

Biotechnology-based fibre engineering

Genetic engineering is opening up new opportunities in the forestry industry and helping it to meet the ever-increasing demand for new products, which can now be grown to specification. The EDEN project is using modern biotechnology and information technology to try and identify the function of genes relevant for wood formation in hybrid aspen trees grown in greenhouses. Its speciality is expression profiling to single out carbohydrate-active enzymes and it has already fed nearly 900 of them into a database, along with 20 full-length sequences of wood-related poplar genes. This pioneering work could throw a lifeline to researchers looking for just the right gene or enzyme.

Magnetic resonance imaging of wood

The timber industry faces a new problem with the increasing use of environmentally-friendly, low volatile organic compound wood coatings which can cause rot in wood panels due to water retention in the coating/wood interface. At the end of the day, moisture ingress into glue can lead to poor durability, mechanical failure and a shorter product life. The MARWINGCA project has applied magnetic resonance imaging to measure moisture profiles and used the resultant data to build a surface layer model to improve electrical impedance moisture sensor which, in turn, was used to develop an innovative kiln control system which is now available on a commercial basis.

Multi-purpose forest management

Forestry in Europe is taking on a multi-purpose role, with its environment and recreational dimension now matching up to the more traditional requirements of timber production. Forest managers need to diversify their own practice, too, and for that they need guidance from forecasting and decision-support systems. The MEFYQUE project, coordinated by the UK Forestry Commission, has put together an integrated modelling system to help forest managers, the timber industry and policy-makers forecast timber growth, yield, quality and marketability and decide whether forest management should be primarily geared towards production, conservation or amenity purposes.

C) Wood treatments and re-engineering

Research and development in this category of projects is crucial to the future use of all qualities of European hardwoods and softwoods by helping them to compete with other timber material on the world market and more homogeneous non-wood products, like UVPC which is used to make windows and doors.

In the search for treatments to produce more consistent, durable and eco-friendly material, all funded projects promise to make a major contribution, albeit through different strategies, such as developing an environmentally-friendly method to make non-durable wood durable without loss of strength [**Ecotan**], designing a new eco-friendly system for wood preservation [**Hydrophob**] and addressing surface coatings and developing new techniques which will enhance the finish on wood and contribute to greater use of wood joinery products [**Prime**].

Re-engineering existing production processes is another way of developing more efficient practices. Minimising the need for detrimental chemicals in combination with high-quality products like pulp and paper is the goal of several funded projects [**Rempulp / Rodet / Oxydelign / Novacell / Biotech Control**].

Adding value by re-engineering wood is another method of improving consistency and compatibility of wood. The adaptation of current raw material machining techniques and equipment to low-hardwoods in order to process short-length timber more efficiently and cheaply [**Shortlength**] is another example of re-engineering in this sector.

Removing detrimental substances from papermaking

The efficiency of the papermaking process may be reduced by detrimental substances originating primarily from the fibres used as raw materials. The RODET project, which stands for reduction of detrimental substances in papermaking, has shown how they can be kept at bay to improve the efficiency of papermaking processes while reducing the load of paper mill effluents. It has been working on a pilot project to develop on- and off-line methods to classify deposits and detrimental substances in paper mills in order to predict the risks of deposit formation (causing specks or holes in paper) or web breaks. The project has already led to new products that have reached marketing stage.

Environmentally-friendly pulping processes

Another EU-funded project seeking to develop environmentally-friendly processes that has had some success in finding ways of reducing polluting atmospheric emissions, notably nitrogen oxide, at kraft pulp mills is the REMPULP project in Finland. Thanks to the different NOx reduction strategies and methods it has developed at softwood, birch and eucalyptus kraft pulp mills, the N0x reduction potential is now known and a simulation mill-wide model has been developed. And it is already being put to use in the European pulp and paper industry.

D) Wood waste for value–added products

Research in this field is essential to use as much of the available material as possible and to reap the benefits of wood-processing waste. When recycled, it has a high value as a substitute raw material [**ScreenClean**], as top-quality sawdust-based compost [**Woodcomp**] or for medical outlets, using bioactive compounds in wood fibre, like bark and knots [**Cerberus**]. Projects like Cerberus are also important in order to seek every possibility for the use of wood fibre.

Biodegradation of wood dust

The wood-based furniture industry has to cut up a lot of timber and it leaves a lot of waste. Waste disposal is both costly and often environmentally-unfriendly. The WOODCOMP project on in-vessel biodegradation of wood powder has shown how to produce a value-added product from waste by making high-quality compost from wood chippings in no time.

E) Forest treatment

Guidelines for sustainable forest management will be helpful both for protecting biodiversity and for timber production in Europe's beech forests [**Natman / Dynabeech**].

Some aspects of forest treatment related to timber quality and its assessment by inventory techniques are being investigated [**Mefyque / Compression Wood**].

Environmental interaction between soil and machine [**Ecowood**], work safety aspects of harvesting operations [**Ergowood / Ecowood**] and development of new and feasible wood harvesting concepts for small-scale operations [**Smallfore**] have also been subjects for research funded by the EU.

Methods of harvesting storm-damaged forest material to safeguard its economic value while providing a steady supply to the timber industry [**Stodafor**] may become even more important in future due to the effect of climate change.

And a specific ecological-economic model has been put together to help protect, restore and afforest cork-oak woodlands [**Creoak**].

Biodiversity and climate change in natural beech forests

Europe's forests are turning from traditional management to more natural strategies. Greater dependence on natural regeneration has raised the profile of tree response to climate change and enhanced the need for research in this area to help forest managers predict the composition of future natural forests. The NATMAN project is developing a multifunctional approach to sustainable beech forest management.

Small-scale wood harvesting technology

The European forestry industry is highly fragmented and small firms abound. The main objective of the SMALLFORE project was to introduce and develop new and feasible small-scale technology-based wood harvesting concepts to boost employment and the viability of forested rural areas in Europe. With its pilot database on small-scale wood harvesting technology, it has shown how spreading the word on small-scale wood harvesting technology can make a valuable contribution to rural development.

F) Multifunctionality

Planning tools to assist in the multifunctional management of riparian forests, with a strong emphasis on water management, have been developed by one project [**RipFor**]. And an old concept of multifunctional land use – agroforestry – has been reintroduced by combining crops with widely-spread tree cover, under another research project [**Safe**].

The protective function of forests has been covered by two projects, focusing on rock fall risks [**Rockfor**] and protection against slope instability [**Ecoslopes**].

The role of forests as a biodiversity reserve and potential conflicts with competing uses have also been looked into [**Hibeco**]. Forests are gaining an increasingly recognised societal function by acting as buffer zones for N-, CO_2 cycles [**CNTer**], and as carbon sinks as climate change and CO_2 sequestration become ever more important research issues [**Mefyque**]. The socio-economic and biological impact of wood energy use is another increasingly topical research issue that has been addressed in one project. But, naturally, it has only been able to tackle a limited number of issues, such as the impact of spreading wood ash in forests, with less emphasis on the wider socio-economic impact [**Wood-en-Man**].

The socio-economic impact of pest-management measures has been investigated in another project to serve as a basis for future decision-making [**Promoth**].

G) Forest policy and Market demand

Applied IT-technology for the transport logistics should make it possible to track and trace timber from the forest to the processing industry [**InforChain**].

The management of urban surrounding forests needs to be given specific treatment so as to fulfil the diverse functions that are requested by communities [**NeighbourWoods**].

Community policies and strategies related to forestry have been analysed in one project which has produced useful databases on forest infrastructure, policy and implementation on national levels [**Effe**].

Establishing a network of relevant institutions in the forest/wood chain sector is a basic requirement for exchange of knowledge to strengthen the ERA (European Research Area) through the InnovaWood initiative [**Xyloreach**].

End-user access to European forest research findings

An essential ingredient of past, present and future research work is networking, as a means of bridging the gap between research and industry. The XYLOREACH project run by InnovaWood has put its EU grant to good use by setting up a Thematic Network linking the leading European organisations supporting RTD in the forest and wood industries. As its wide-reaching name suggests, the project has a wide partnership across Europe from harvesting, logging and storage to first-stage processing, sawing, drying and grading and on to finishing and industrial design.

Coverage of the work programme

As detailed in the work programme (which is appended to this document along with the overall objectives and deliverables of Key Action 5), research funded by Key Action 5.3 is supposed to address and to contribute

• **to the pan-European forestry policy processes and strategies for the implementation of international commitments;**	**NOT COVERED**
• to develop instruments for the sustainable development of forestry and its contribution to rural development at European and at international level;	COVERED
• to the prevention and control of forest fires, as well as on quarantine and harmful organisms posing a threat to the free movement of products;	**PARTLY COVERED**
• to explore forest ecosystem restoration and reclamation techniques including **afforestation** and vegetation rehabilitation techniques;	**PARTLY COVERED**
• to a better understanding of the role of forests on water management, erosion control, **desertification and prevention of avalanches and landslides;**	**PARTLY COVERED**
• to assess the impact of climate change on forests and the forests' potential as carbon sinks;	COVERED
• to develop further systems for agroforestry, cork and energy production, as well as urban forestry;	**PARTLY COVERED**
• to serve the industrial need for the supply of high-quality and uniform raw material through the assessment and management of genetic resources taking advantage of biotechnological methods;	COVERED
• to develop environmentally friendly and efficient processes, recycling technologies and improved value-added products;	COVERED
• to understand the impact of wood properties on processing and the material specifications of the fibre, its characterisation as well as fibrous networks, with the aim of developing new or improved end products;	COVERED
• **to explore market requirements and final product characteristics;**	**NOT COVERED**
• **to assess the forest-based industry's contribution to rural development.**	**NOT COVERED**

The main gaps observed between the work programme's objectives and the work done, and which may be considered in some future research agendas regarding forestry:

- Economic and social aspects related to forestry were not covered as widely as the work programme's objectives called for;
- Forest industry markets and consumer requirements as well as forest industry's role in rural development were not covered at all;
- Forest policy aspects were not covered as widely as suggested in the work programme => consideration for future research;
- Forests' role in erosion and water management and prevention of land desertification was not covered as widely as in the WP objectives suggested.

Recommendations for future research at EU and national level

The experts who participated in the project review concluded that although tremendous work has been done and a variety of important research topics have been addressed through research projects funded under the Quality-of-Life and other programmes of FP5, there is still a need for further research in various subject areas related to the forestry-wood chain, both at national and EU level.

The topics listed below are broken down by the categories in the previous chapters. However, one should keep in mind that the topics mentioned are a snapshot of individual expert's views and should not in any circumstances be regarded as representing an official view of the European Commission.

A) Forest genetics, physiology and pathology

- investigating population genetics for conservation of genetic resources and ecosystem stability and adaptability to climate changes including tracing and quantifying gene flow and hybridisation;
- developing improved Pest Risk Analysis (PRA) techniques and monitoring pests along new European borders including the assessment of the appropriateness of present quarantine regimes and their improvement;
- studying effects of urban forestry and related physiological processes on quality of life in highly populated urban areas.

B) Wood properties and quality

- investigating the effect of different forest management schemes on wood quality;
- linking log conversion patterns and sorting procedures to select material which can be dried to low moisture contents without causing excessive distortion;
- enhancement of pulp and paper's functional properties by better selection of raw material.

C) Wood treatments and re-engineering

- improved processing techniques for hardwoods, softwoods and recycled timber, and promoting sustainable construction and transfer of construction methods;
- developing new materials based on modified wood (timber/concrete composite, timber/steel composite) including service life predictions for all wood and wood composite materials;
- developing new materials based on cellulose and other chemicals derived from wood, as well as new processes for fibre modification (e.g. fibre fractionation).

D) Wood waste for value–added products

- investigating new possibilities for re-engineering sawdust, chips and other process waste;
- investigate possibilities for utilisation of hardwoods of lower quality;
- research into new uses of wood fibre and use of its attributes to promote this important environmentally sound material.

E) Forest treatment

Environmental cost benefit analysis in relation to changes in forest management by forest owners to respond to the multiple demands on forests;

- development of management rules for forest biomass production, taking into account economic and environmental impacts;
- development of machinery and mechanised methods for forest fire preventive treatments and firefighting.

F) Multifunctionality

- developing best forest management practices related to the EU-directive on water management;
- developing best forest management practices for protection management and disaster prevention, responding to the effects of weather extremes (e.g. storms, floods and fires);
- energy production (e.g. wood residues as local renewable energy source) and its contribution to rural development.

G) Forest policy and Market demand

- proper analysis of the forestry measures including CAP-funded afforestation on abandoned agricultural lands, and their overall impacts on forestry rural development competition;
- socio-economic analysis of forestry and forest industry to rural development for policy and decision-making;
- analysis of market and end-user demands for wooden and paper products, as well as forest-based energy and recreational services, including the perception of society in relation to the aesthetic and recreational values of forest ecosystems.

Useful links

QoL projects are summarised at the following web addresses:
http://europa.eu.int/comm/research/agriculture/index_en.html
http://www.cordis.lu/life/src/proj_browse.htm

INCO projects are summarised at the following web address:
http://www.cordis.lu/inco/src/projects.htm

EESD projects are summarised at the following web address:
http://www.cordis.lu/eesd/src/projects.htm

GROWTH projects are summarised at the following web address:
http://www.cordis.lu/growth/src/projects.htm

Co-operative research (CRAFT) projects are summarised at the following web address:
http://www.cordis.lu/innovation-smes/src/projects.htm

COST Actions are summarised at the following web address:
http://cost.cordis.lu/src/home.cfm

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