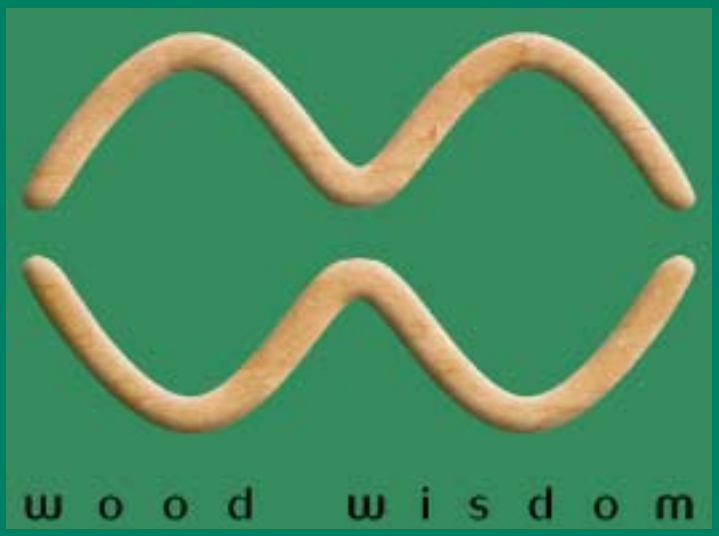
PUBLICATIONS OF THE ACADEMY OF FINLAND 15/02

Finnish Forest Cluster Research Programme 1998-2001

EVALUATION REPORT



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Finnish Forest Cluster Research Programme 1998-2001
EVALUATION REPORT

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Foreword

The Finnish Forest Cluster Research Programme Wood Wisdom was launched in 1998 as part of the Finnish government's additional R&D funding scheme with the aim to strengthen the country's industrial clusters.

The aim of Wood Wisdom was to promote the competitiveness of Finnish forest cluster in the changing operating environment. The emphasis was on research integrating forestry and other parts of the production chain – wood production and procurement, processing, marketing and use of products. Another aim was to train specialists in market-driven production and processing of wood raw material.

Wood Wisdom was co-funded by the National Technology Agency Tekes, the Academy of Finland, the Ministry of Agriculture and Forestry and the Ministry of Trade and Industry. The public funding amounted to some EUR 22 million and the total volume, including private financing, was around EUR 33 million.

The Finnish Forest Industry as well as the forest industries in other countries are facing a change in research appreciation. The concept of "patient money", a prerequisite for carrying out basic research, is getting quite rare. Under these circumstances, basic research carried out – with public money support – in universities and in joint research institutes of the industry, becomes very important. Besides providing postgraduate persons for the renewal of R&D persons it also generates new information from which product, process, service and market innovations can be initiated.

In planning the future technology programmes, the real challenge to the Finnish Forest Industry and to the sponsoring organisations will be to set the objectives for the national research programme. This would make it easy for the participating scientific organisations to identify the decision-making situations in which the industry and/or the political organisations would like to utilise the research results.

The Finnish Forest Industry has had a good opportunity to set objectives for the research carried out in the Wood Wisdom Programme and to monitor the progress of the various consortia and thus keep the work on track.

As the chairman of the Steering Committee of the Wood Wisdom Programme I like to extend my thanks to the funding organisations, i.e the National Technology Agency Tekes, the Academy of Finland, the Ministry of Agriculture and Forestry and the Ministry of Trade and Industry. Special thanks are due to Dr. Leena Paavilainen, Ms. Christine Hagström-Näsi, Dr. Liisa Saarenmaa, and Dr. Anneli Pauli for their persistence and radiant optimism in getting the programme running

Kari Ebeling

Chair of the Steering Committee

SUMMARY

The objective of the scientific evaluation was to determine to what extent Wood Wisdom was successful in establishing a sound knowledge base that would enable the development of market-oriented wood production and procurement, as well as the development of innovative forest-based products. The evaluation was based on the written reports and publications provided by each research consortium, and oral presentations by leader researchers. This was followed by discussions among the members of the panel. The evaluation focussed on the following aspects: (a) the scientific competence, quality of results, and innovations at consortium level, (b) postgraduate studies and expert training, and (c) collaboration between various scientific disciplines, and between researchers and the end-users of research results. The projects related to developmental work were not evaluated.

All consortia demonstrated a high level of scientific competence within the scope of their objectives. The competence was often better in scientific-technological projects than in technological-commercial ones. The results both in quality and quantity were generally impressive, and were widely disseminated. The outcome of the programme represented not only significant incremental progress over what was already known, but in some cases, the results were novel and beyond the current state of science.

In those consortia where universities were involved, considerable effort went into researcher training. This led to many postgraduate degrees. In other cases, the programme contributed greatly to enhancing the knowledge base. All consortia have promoted creative research environments.

Wood Wisdom played a significant role in bringing together various skills in each consortium, thus fostering synergy. Several projects were truly inter/ multidisciplinary. Collaboration and networking among scientists, both at national and international level, was evident and fruitful. The end-users of the research results also participated actively.

Wood Wisdom was a unique, well-structured programme. By supporting basic and applied research, it has contributed greatly to advancing the knowledge base in the forest products industries. Its continuation will be profitable.

1 Evaluation Procedure

1.1 Background

The cluster research programme Wood Wisdom was evaluated the first time after its first year in progress as part of the Assessment of the Additional Appropriation for Research in Finland during 1997-1999, commissioned by the Finnish National Fund for Research and Development Sitra on behalf of the Ministry of Trade and Industry and the Ministry of Education. The evaluation report was published in 2000 (A. Prihti, L. Georghiou, E. Helander, J. Juusela, F. Meyer-Krahmer, B. Roslin, T. Santamäki-Vuori, M. Gröhn: Assessment of the Additional Appropriation for Research. Helsinki. Sitra. ISBN: 951-563-372-9, available on Internet at www.sitra.fi)

The second evaluation of the Wood Wisdom research programme was carried out by the International Management Institute of the Tampere University of Technology and it concentrated on the structure and networking of technology programmes. It was published in 2001 (Ellen Tuomaala, Satu Raak, Erkki Kaukonen, Jyrki Laaksonen, Mika Nieminen, Pekka Berg: Research and Technology Programme Activities in Finland. Technology Review 106/2001. Helsinki Tekes. ISSN: 1239-758X ISBN 952-457-025-454 p, available on Internet at www.tekes.fi.) In addition to these official evaluations, the second Wood Wisdom Forum in December 1999 conducted self-analysis.

The Programme Steering Committee decided on 13 March 2001 that the final evaluation of the Wood Wisdom cluster programme would consist of *scientific evaluation* stressing on scientific competence, and of so-called *self-evaluation* concentrating on industrial relevance and socio-economic impacts.

Tekes commissioned the self-evaluation from Professor Ahti Salo of the Helsinki University of Technology, System Analysis Laboratory. The self-evaluation was carried out in fifteen advisory group workshops during September and December 2001. The report was published in the Tekes series in August 2002. The funding organisations of Wood Wisdom agreed that the Academy of Finland would take responsibility for the scientific evaluation described in this document.

1.2 Objectives of the scientific evaluation

The objective of the scientific evaluation was to estimate to what degree the Wood Wisdom programme has succeeded in the establishment of a knowledge base enabling the development of market-oriented wood production and procurement, as well as the development of innovative forest-based products. This includes:

- scientific quality of Wood Wisdom
- postgraduate studies and expert training and
- collaboration between scientific disciplines, between research units and with the utilisers of the research results

1.3 Evaluation procedure and evaluators

All research consortia having basic or applied research projects were evaluated regardless of the funding organisation. A list of the projects involved in the programme is given in Appendix 1. The projects having strong emphasis on development work were not included in the evaluation.

The evaluation was carried out on 19-23 November 2001 by an independent international expert group set up by the Academy of Finland. The expert group consisted of seven highly acknowledged persons in the field, each representing specific research areas of the programme:

- Rajinder Seth, Pulp and Paper Research Institute of Canada (PAPRICAN), Chair of the evaluation panel
- Xavier Deglise, Professor and Head, University of Nancy
- Pekka Ilmakunnas, Professor, Helsinki School of Economics and Business Administration
- Robert Kliger, Associate Professor, Chalmers University of Technology Structural Engineering
- Jean-Michel Leban, Dr, Institute National de la Recherche Agronomique (INRA)
- David M. O'Malley, Research Associate Professor, Forest Biotechnology Group, North Carolina State University
- Ulla Westermark, Professor, Luleå Technical University

The assessment was based on written material, consortia interviews and panel discussions. In total, 107 project leaders and researchers representing 43 different consortia or individual projects participated in the interviews.

The experts were provided with:

- abstracts of all research consortia included in the evaluation
- final reports of each consortium in the relevant research area
- as part of the final reports, basic data by subproject, such as funding, research team, degrees, publications and communication of information, national and international cooperation and
- CVs of the main researchers.

Each consortium was allowed to comment on the draft report and correct mistakes.

1.4 Evaluation criteria

The evaluation reflects on the following issues at the consortium level:

- Scientific quality of Wood Wisdom
  - Scientific competence of the consortia
  - Scientific quality and innovativeness of research projects

- Postgraduate studies and expert training
  - Importance of the programme for researcher training

    - Importance of the programme for the development of the research environment

- Collaboration and networking
- Enhancement of inter/multidisciplinarity in research
- Reinforcement of the applicability of research results

And at the programme level:

- Added value of the programme
    - Administrative and scientific coordination
    - Concordance with the objectives of the research programme

- Recommendations
    - Including grounds for the recommendations

2 Wood Wisdom research Programme

2.1 Background

The Finnish Forest Cluster Research Programme Wood Wisdom was launched in 1998 as part of the Finnish government's additional R&D funding scheme with the aim to strengthen the country's industrial clusters. Of the eight cluster programmes started, Wood Wisdom was the most extensive one.

Wood Wisdom is co-funded by the National Technology Agency Tekes, the Academy of Finland, the Ministry of Agriculture and Forestry and the Ministry of Trade and Industry. The organisations responsible for programme coordination were the Finnish Pulp and Paper Research Institute (KCL) and Wood Focus Ltd. (Appendix 2).

2.2 Objectives

The aim of Wood Wisdom was to promote the competitiveness of Finnish forest cluster in the changing operating environment. To be more competitive the forest cluster should take a more customer-oriented approach and pay more attention to producing and developing value-added, quality-competitive, eco-efficient products.
The focal point of the research was market-driven use of Finnish wood raw material in optimal wood and paper products (Figure1). The main emphasis of the programme was on research integrating forestry and other parts of the production chain – wood production and procurement, processing, marketing and use of products. Another important aim was to train specialists in market-driven production and processing of wood raw material. A further objective of the programme was to foster the competitiveness of small- and medium-sized enterprises in the wood products sector.

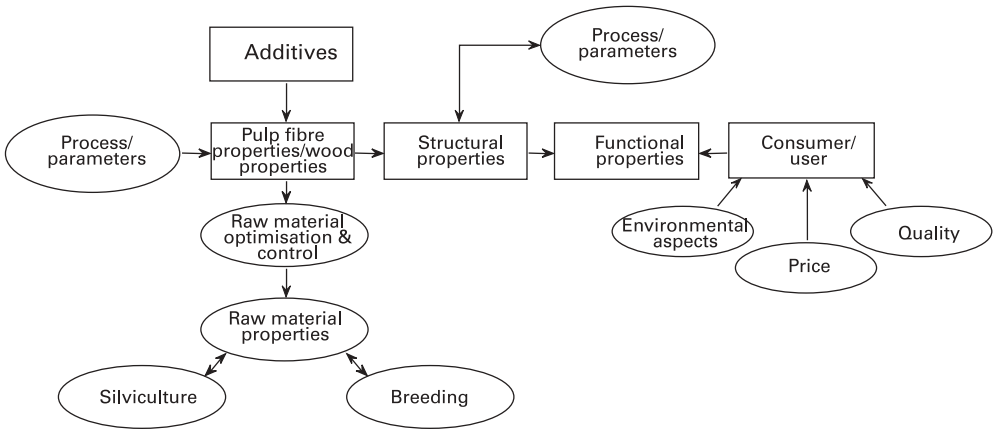

Figure 1. Market-driven approach to research and development in Wood Wisdom.

The Wood Wisdom programme also promoted the transfer of information between the producers and end-users of new knowledge, as well as the establishment of new co-operation networks among specialists within the forest cluster.

2.3 Funding

The co-operation between the public funding organisations of Wood Wisdom, each having a distinct role in Finland's national innovation system, made it possible to cover the whole chain from the markets to the forest. The cluster approach also allowed combining various kinds of projects into research consortia.

The Academy of Finland supported basic material-scientific research and projects related to the genetics and molecular breeding of forest trees. Projects funded by Tekes are technology-driven and focused on chemical pulping and wood products technology. The Ministry of Agriculture and Forestry and the Ministry of Trade and Industry fund applied research and surveys benefiting the forest cluster as a whole.

The public funding amounted to around FIM 130 million (EUR 22 million) and the total volume, including private financing, was some FIM 195 million (EUR 33 million) (Appendix 3).

2.4 Structure

The research work in Wood Wisdom was carried out in 34 research consortia with 156 projects (Appendix 4) by 789 researchers in 67 research units around the country. Altogether 53 companies and 14 other organisations contributed financially to the programme. The multidisciplinary consortia combined basic and applied research with research and development work targeting specific industrial applications.

The consortia within the programme were divided between four major research areas: Forest industry operating environment, Pulp and paper production, Mechanical wood processing and Raw material questions (Figure 2). Better understanding of the raw material questions and of the changes in the operating environment serves both mechanical wood processing and pulp and paper production.

Comprising the entire value chain, the programme has brought together researchers from different backgrounds and disciplines. New co-operation has been instigated, for example, between microbiology, wood material science and processing technology.

Raw material questions

Raw material questions was clearly the biggest research area by volume, co-funded half and half by Tekes and the Academy of Finland. In this area, the *UniFibre* theme accommodates consortia related to the optimal utilisation of the unique properties of wood and fibres from Finnish forests. The aim is to find out how the chemical and morphological properties of wood affect the properties of paper, mechanical wood products and composites. The theme combines paper and wood products research and is applying and developing new fibre and wood measurement methods.

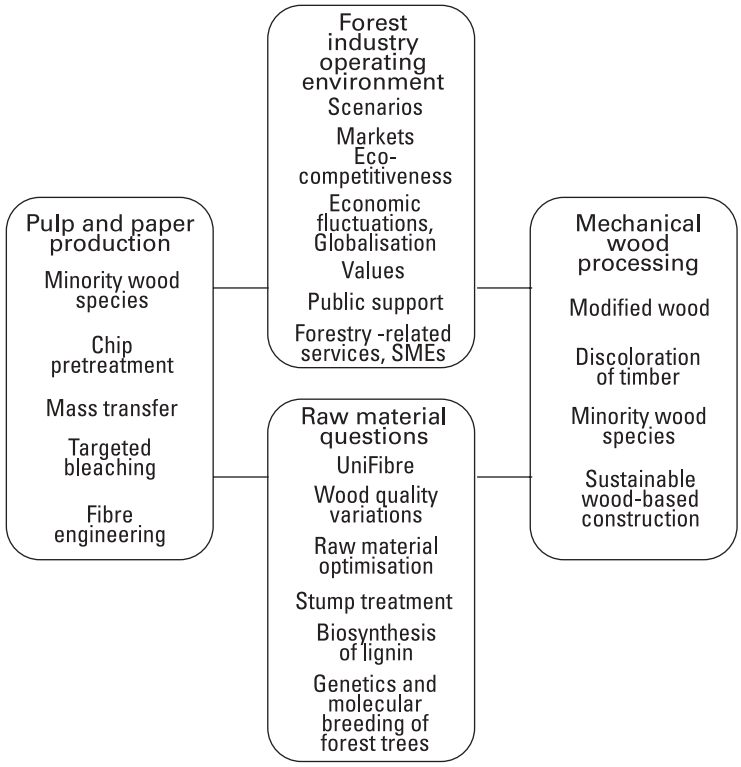

Figure 2. Research areas of Wood Wisdom.

In the *Wood quality variations* theme, the impact of forest management and environmental factors, such as climatic changes, on wood properties and, ultimately, on end-product properties, as well as the genetic variation of decay resistance were studied. Also, the quality and usability of thinnings from post-drainage peatland stands were studied.

Research projects related to *Raw material optimisation and control* covered the entire value chain from the consumer to the forest. The projects aimed at optimising and controlling the wood raw material procurement and flow to pulp production and mechanical wood processing. This theme includes altogether three major consortia.

Molecular breeding of forest trees will soon be possible due to the advances in gene transfer methods. Controlling the amount of lignin was an important goal. In the *lignin biosynthesis* theme, the aim is to isolate and characterise the lignin-forming enzymes and their genes from a spruce cell culture. Projects related to *genetics and molecular breeding* of forest trees were concerned with the functional genomics of birch in order to identify and characterise the genes involved in stress responses, growth and wood formation. The evolution of DNA sequence variation in pines was investigated to produce information on polymorphism of individual genes needed, for example, in the newest methods of gene mapping. In addition, gene transfer methods are developed and applied to production of transgenic trees with important traits.

Mechanical wood processing

As for ***mechanical wood processing***, the key objective is to establish the basic material-scientific preconditions needed to develop more value-added wood products (Figure 3). Within the *modified wood* theme, the chemical and structural changes of wood caused by heat treatment and chemical modification and their impact on the physical properties of wood were studied. The research will create the basis for new, innovative wood products.

The projects on *discoloration of timber* were studying the effect of growth site and timber handling on the properties of wood products. A close look was taken at the chemical changes during timber drying causing uncontrolled discoloration of birch. The aim was to produce high-quality sawn timber by optimising felling times, grading, storage and drying.

In the *minority wood species* theme, the aim was to build up knowledge of the lesser-used wood species in Finland and to promote their industrial processing. The research covered the entire production chain from final product to wood production. The species studied were birch, alder, and hybrid and native aspen.

A new theme in the programme since 2000 is *sustainable wood-based construction*, in which the possibilities of wood as construction material are studied from a European perspective

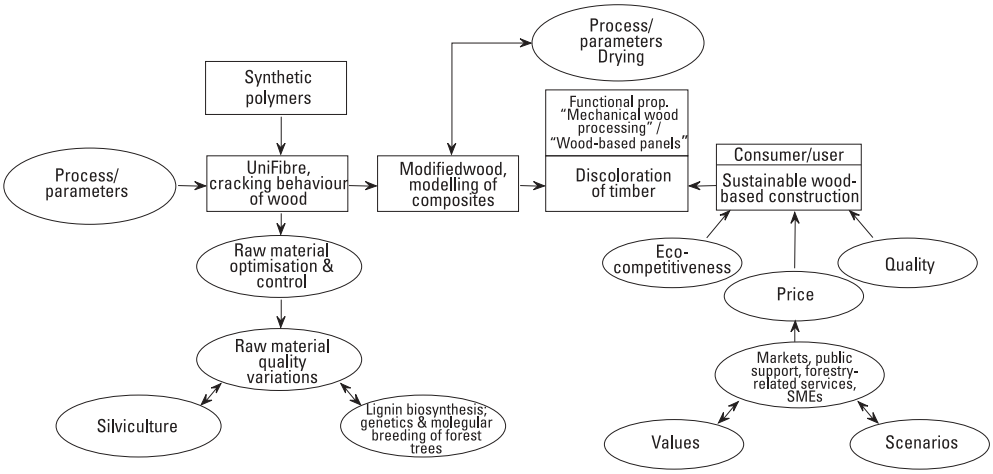

Figure 3. Mechanical wood processing projects in Wood Wisdom - 'Forestry-wood chain'

Pulp and paper production

The projects related to ***pulp and paper production*** are mainly developing methods for producing superior reinforcement fibre for printing papers from Finnish softwood. The latest methods of wood chemistry and paper physics wereapplied in the study of *chip pretreatments*, *mass transfer* in sulphate cooking, *targeted bleaching* and *fibre engineering* for different paper grades (Figure 4). The research area was the second largest by volume.

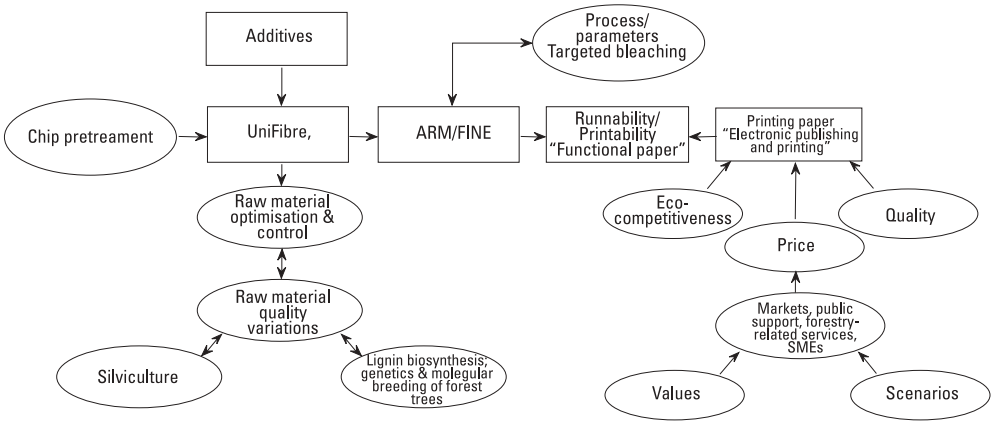

Figure 4. Pulp and paper projects in Wood Wisdom - 'Forestry-wood chain'.

Forest industry operating environment

Tools for predicting the changes in the ***forest industry operating environment*** were developed in the *scenarios* theme, where the central threats and opportunities of the Finnish forest cluster were studied. Also, a model to evaluate the combined impacts of changes in operating conditions on the environment, economy and employment is being developed. Other general research themes studying the forest cluster as a whole were *markets*, *ecological competitiveness*, *public support* and *forestry-related services*. The most recent projects are investigating the *values* related to forests and nature from a philosophical and social-scientific viewpoint, the business operations models of wood-working *SMEs*, the *consolidation and globalisation* strategies of Finnish forest-related industries as well as the stabilisation of *business cycles*.

2.5 Organisation

The programme was led by the Steering Committee of 12 members comprising representatives of forest industry, the funding organisations and the scientific community (Appendix 2). The Steering Committee had on average 4 to 5 meetings a year.

In addition, the group of representatives of public funding organisations arranged 5 to 6 work meetings a year for operative affairs.

The organisations in charge of the scientific and administrative coordination were the Finnish Pulp and Paper Research Institute (KCL) and Wood Focus Ltd (former Finnish Wood Research Ltd). The programme office was constituted by Programme Director Leena Paavilainen and Programme Secretary Sirpa Marttila.

The advisory groups of research consortia had a central role in the management of Wood Wisdom. They followed up the work of the consortia and directed the research when necessary to ensure that the objectives are met. The groups of research consortia (in all 38 with some 400 members) consisted of external experts representing the industry and economy, science, public administration, and trade

and professional organisations (in addition to the representatives of the research groups and the Programme Director). The advisory groups allow an active exchange of knowledge, experiences and opinions between the researchers and those implementing the research results. The groups had on average 2 to 4 meetings a year.

The Wood Wisdom Forum worked as an expert forum for different topics (Wood Wisdom Forum I in 1999 on effective utilisation of Finnish wood raw material; Wood Wisdom Forum II in 2000 on how research can meet the demands of the globalised forest industry). Wood Wisdom coordination office has organised or been co-organiser of 28 seminars with 2350 participants.

3 Outcome of the Scientific Evaluation at Consortium level

3.1 Mechanical wood processing

Scientific quality and innovativeness

It is the evaluators' opinion that all the consortia had a generally high level of scientific competence. The level of scientific competence was often better in scientific and technological projects than in technological-economic ones. Sometimes a consortium lacked specific competence in a certain area. One good example is the "Modified wood" (12) consortium which was working in the fields of chemistry and physics and was aiming to improve certain products but lacked research in some fields of mechanics. The two other consortia, "Discoloration of timber" (13) and "Minority wood species" (14) presented specific properties which were not completely up-to-date. In spite of this, all the consortia demonstrated a high level of scientific competence within the scope of the main aims of the research that had been conducted.

The level of scientific quality was very high, especially when chemistry or chemical physics was necessary for analysis. In some cases, "Chemistry and discoloration of birch wood" (13.1), for example, the proposed work to identify chemical components was too ambitious to achieve results with high level of scientific quality. Sometimes, "Minority wood species" (14), for example, too much time was spent on collecting data which resulted in too little time being left for analysis. In other cases, "Discoloration of timber" (13.2) for example, the scientific quality was very difficult to assess on the basis of the presentation and the short summary of the results. The innovation aspects are perhaps not as clear as they might be in the majority of the projects, but the quality and permanence of the research ensure that this programme is really effective.

More papers should be published at international level, as the results are of good quality and it is therefore important to have them disseminated. In the field of thermo-wood, for example, it is a well-known fact that some good research has been conducted in Finland, but, in spite of this, not too many scientific papers have appeared in recent years. On some occasions, it would be advantageous to develop co-operation at international level in order to avoid re-inventing the wheel.

Postgraduate studies and expert training

In all the consortia in which universities were involved, a great deal of effort had been devoted to researcher training. The number of academic degrees produced within each consortium varied to a large extent. For example, one partner in a certain consortium (VTT) with pure technological aims and financed by Tekes produced no PhDs within the Wood Wisdom programme. Long-term approach in financing of the research is important in order to create a good environment for

researcher training. However, most research projects within the Wood Wisdom programme had a duration of only three years. At present, the minimum time for conducting PhD studies is four to five years. It was very clear that the duration of the Wood Wisdom programme created a problem for some partners to employ a PhD student and not be able to offer funding for the whole period of the PhD studies. A longer duration would be better, especially if VTT or consulting organisations are involved in co-operation with universities.

Collaboration and networking

In almost half the projects there are strong links with end-users, which promotes the dissemination of the research results. Some consortia, such as "Chemistry and discoloration of birch wood" (13.1), published three papers in "PUUMIES" or for " The effect of site and timber handling on quality and end-use value of Scots pine and Norway spruce wood" (13.2) produced a booklet in Finnish for end-users as part of the dissemination procedure. For us, the evaluators, it was difficult to assess the success of publications of this kind. All consortia had the advisory board representatives from the industry. People outside Finland were also included in advisory boards like in the "Evergreen" (15.2). In some projects "Unifiber" (16.1) and "Cracking behaviour of wood" (16.2) there was no collaboration between the researchers and the end-users. The promoters explain that there was a lack of interest from industry and of communication between industry and academic research. In consortia where basic research dominates, it is difficult to involve "Solid wood" industry or other users of the results.

The members of the review panel frequently remarked that the teams appeared to work separately within the consortium. In some cases, "Minority wood species" (14), for example, this was due to the poor coordination and in other cases it could have been due to the geographical localisation of each partner, as in "Chemistry and discoloration of birch wood" (13.1).

3.2 Forest Industry Operating Environment

Scientific quality and innovativeness

By their nature, economic and social research does not easily generate innovations in the same sense that natural sciences or engineering. Therefore publications in refereed international journals is one important criterion for evaluating the scientific quality of the research.

In the field of Forest Industry Operating Environment the share of funding from the ministries (Ministry of Agriculture and Forestry and Ministry of Trade and Industry) was much higher than in the other fields within the Wood Wisdom programme. This has affected the way in which the projects have been chosen and has clearly created tension between policy orientation and scientific orientation in the projects.

All in all, the consortia and projects in this field had therefore very varying degrees of scientific ambition. Some projects clearly aimed to the international level and have

already resulted in publications in refereed journals (e.g. consortia "Short-term forecasts of forest industries' exports and timber trade" (2.1), "Environmental marketing of forest products" (2.2), "Business cycles of the Nordic sawmill industry" (3.3)). On the other hand, some projects were mainly oriented towards the Finnish audience, with research reports written mostly in Finnish and published only in university series or less academic local journals (e.g. consortia "Total value of wood-based products in the forest sector" (1.2), "Human resources and local orientation in forestry" (6.1)). In some cases (e.g. a project in consortium "Forest cluster scenarios for Finland" (1.1)) a lot of effort was devoted to collecting data, with hardly any resulting scientific publications. In some projects the level of scientific ambition could clearly have been raised without harming the aim of doing policy-oriented work.

Collaboration and networking

Another reflection of conflicting goals in research is the tension between researchers and research users. From the industry's point of view, some analyses of the industry environment have been useful in their business planning (e.g. "Forest cluster scenarios for Finland" (1.1)). On the other hand, there were projects where the results were useful to the researchers themselves as inputs in their other work and resulted in international publications (e.g. "Short-term forecasts of forest industries' exports and timber trade" (2.1)), but were regarded as less relevant by the industry. The definition of "end user" of the research results is, however, not always clear. It can be the industry, but also public administration. Therefore it is understandable that all projects cannot serve all end-users at the same time.

In terms of coverage of the forest cluster, the topics in this area covered the whole cluster in scenarios ("Forest cluster scenarios for Finland" (1.1)), whereas in most analyses attention was centered on one aspect (sawmill industry, paper and pulp industry, wood markets, forest use etc.). The whole wood chain was covered in one way or another, although not in a quite consistent way, since different research approaches have been used for different parts of the chain.

Some consortia were very homogeneous, whereas others were more a collection of separate projects. In some cases the project consisted of only one researcher. It seems that it has been very much dependent on the consortium leader how fruitful the co-operation has been. The projects in this area included two cases where genuinely interdisciplinary projects have been achieved (philosophy, sociology and forestry in "Values of forests and nature" (4.1); and business administration and history in "Concentration and globalisation of forest sector firms" (3.2)). Even in these cases this has not been an easy achievement and has required much work from the consortium leaders.

It is noteworthy that topics related to the economic and commercial aspects of the forest cluster have been studied by research teams with varying backgrounds (e.g. business administration, economics, engineering), but mostly in isolation from each other. In some projects it would clearly have been very useful to add to the advisory group strong academic expertise from the other fields, e.g. economics expertise to

research conducted by engineers (e.g. “Total value of wood-based products in the forest sector” (1.2)).

Postgraduate studies and expert training

In many projects one goal was to produce PhD dissertations or Master’s theses. However, the three-year span of the programme has in most cases not been enough for finishing the dissertations. Most of the PhD degrees achieved seem to have been based on work that had actually been started before the Wood Wisdom programme. Although the programme has apparently been helpful in financing the work, it is likely that much of it would have progressed in some form even without the Wood Wisdom programme.

3.3 Raw material questions

The research area ‘Raw material question’ is motivated by the importance and the necessity of studying and improving the entire forestry wood chain from the plant to the plank by (1) taking into account the end-users requirements and (2) by improving information exchanges along the chain.

The contributions of the consortia can be commented dividing them into three categories:

1. The assessment of forest resources in terms of volumes per quality classes of round and sawn wood by taking into account the genetics and silviculture;

   This field was been covered by two groups of consortia. The first one was focused on collecting basic data of the raw material properties in existing forests and in genetic or silvicultural trials. This is crucial to be collected and integrated in data bases. A second group of consortia focused on development of models and simulations tools in order to simulate growth and yield linked with the basic wood properties and to be able to simulate the conversion processes (logging, sawing).

2. The analysis of solid wood and basic fibre properties and their variability (from macroscopic to microscopic properties, with known or unknown genetic origin) as well as their effect on end-product properties;

   At first it must be underlined that efficient investigation tools have been used, adapted and (or) developed, such as (i) micro cracks detection and quantification, (ii) anatomical image analysis tools, (iii) chemical analysis of wood extractives, (iv) electrical impedance spectroscopy for detection of brown rot decay on increment cores, (v) atomic force and scanning electron microscopy for the characterisation of the morphology of wood surfaces. This is not an exhaustive list.

   A lot of original results have been gained and published (wood density variation, modelling branch pattern, microfibril angle for compression wood, fibres

properties etc.). Among several consortia, a good example is the consortium 'Effect of environmental stress factors on chemical and structural quality of Pine and Spruce" (17.2). The chemical properties and structure of wood were assessed for samples taken in trees grown under controlled conditions (nutrients, drought, ozone etc). Such investigation appears to be a very promising research area for a better understanding of relationships between growth conditions and wood formation and properties.

One good example of the relationship wood and end-use properties is the consortium "Cracking behaviour of wood (16.2), which carried out a fundamental and experimental approach in order to describe and model how and why the cracking of wood appears during drying and machining.

3. The analysis and modelling of the processes involved in the conversion chain

Different conversion tools and optimisation algorithms were developed and tested in order to maximise the net income during the logging operation by including the simulation of the sawing. This 'Raw material optimisation and control' theme area was covered by three consortia.

In some cases, the very qualitative information available in the final report and the lack of publications, even in Finnish, made it difficult to evaluate the project like "Monitoring of the wood raw material flow and intelligent control of conversion chain" (18.2). This is probably explained by the confidentiality of the technological improvement obtained throughout this project.

Scientific quality and innovativeness

The evaluators underline that the scientific and technical competence is excellent in all consortia. However, some cases maybe due to the multidisciplinary approach, all research teams were not familiar with the analysis of the wood variability and thus the results do not represent the state of art. One example of this are the results presented by the consortium "Unifiber" (16.1), concerning the solid wood properties variations within the stems. There is a need to analyse the wood variability and its effect on processing, and not only to conclude "that variations were surprisingly large". The consequence is that the excellent results gained by this consortium can rather be appreciated in terms of understanding of the fibres processing than in terms of improvement of the knowledge of the raw material present in the Finnish forests.

Another example are the results of the consortia "Cracking behaviour of wood" (16.2). The results of the effect of the S2-layer microfibril angle on the mechanical and shrinkage behaviour are rather a valuable confirmation of results known than new fundamental knowledge. The consortia in Unifibre theme area seems not to communicate were well with each other especially with the "Modelling of wood composites consortium" (16.3). In such cases the appropriate scientific and technological competence are not fully utilised.

The consortia addressing quantitative aspects and questions of the raw material quality and prices have spent a lot of time in building data bases. Their objective is to answer practical questions for the forest industry. A good example of this is the consortium "Quality and yield of pulpwood in drained peatland forests" (17.5). The originality of the results is in the sampling the peatland stands and in the data base construction. No modelling attempt was made in order to analyse (1) the effects of management on growth and yield and (2) variations of wood or pulp properties within and between trees of each actual or simulated silvicultural treatment. Nevertheless, it is quite clear that all the consortia have demonstrated their scientific competence within the investigated field.

The analysis of the publication scores in international journals shows that many consortia have widely disseminated their results. As expected, the consortia deeply involved in industrial partnerships have lower publication score, while the results are sometimes difficult to disseminate in international journals.

However, even if the evaluators were not able to read all the scientific publications cited in the final reports, it appears that the lack of publication in English is correlated with a limited number of original results presented in the final reports. An example is the consortia "Quality control of wood raw material in the pulp industry" (18.3). A huge amount of data was collected and the results are compiled in 19 reports all in Finnish. It is clear that these results are useful for the industrial partners, but they appear to be mainly valuable confirmation of known results. Maybe in these case the international publications is not the objective.

The consortium involved in "The suitability of methods related to quality and environmental management systems and LCA assessment" (18.5) has produced 13 confidential reports in Finnish. There was not enough elements available in the final report for its evaluation.

The lignin biosynthesis consortia and molecular breeding projects are with high scientific value.

Postgraduate studies and expert training

The number of academic degrees produced varied a lot from none in consortia led by VTT or METLA, for instance, up to five for consortia co-ordinated by universities. On average, there is one Master's degree and 0.7 Doctor's degree 'produced' per consortium. These figures are low for a three-year period. The number of Masters should be doubled and the number of Doctors increased up to one per consortium, on average. This is a key point, because these people will support the scientific and technological development in the future. Furthermore, the evaluators would have appreciated the information of the actual professional activities of the students graduated during the past three years.

Development of the research environment

The impact of the Wood Wisdom programme on the research environment is quite

evident in main of the consortia. Several consortia were designed by incorporating teams with very different backgrounds and scientific culture. This cooperation should be effective and produce common publications, for example.

Collaboration and networking

Almost all of the consortia had collaboration with researchers outside the consortia in Finland and abroad. There was also an excellent collaboration between the researchers and industrial partners demonstrated and different types of collaboration have been conducted.

Recommendations

Several consortia had built data bases focused on the intra-tree wood property variations. Very often these samples are collected from experimental trials installed and managed by Forest companies or directly by METLA. There is a high risk of data duplication and of waste of time if the collecting protocols are not common between the different groups of researchers involved in the "Raw material questions" research area.

This problem is not specific to Finland and not easy to handle and solve. However, if a research programme in the future is funding such data collection, it can design a general protocol (including the free access to the data base at the end of the projects) for all projects, where the intra-tree mapping of wood properties is proposed. Such decision will enhance strongly the added value of the programme.

The investigated properties were mainly anatomical wood characteristics, wood density and chemical composition. According to the huge amount of data collected within Wood Wisdom, a valuable future contribution could be to construct a national, public data base in preventing duplication of data collection.

For the modelling approaches very few validation work have been carried out. At the moment these approaches are rather academic and not efficient in the industry. However, validation is crucial as soon as the objective of the work is to produce applied results.

In this field there is a lack of statistical modelling to enable to model the variation of the wood properties. The evaluators suggest a deeper involvement in such statistical approaches.

3.4 Pulp and paper production

Ten projects in five different consortia were evaluated in the pulp and paper research area. The consortia included: Chip Pretreatment (7), Mass Transfer (8), Targeted Bleaching (9), Fibre Engineering (10) and Minority Wood Species (11).

Scientific quality and innovativeness

At the scientific level all consortia met their original objectives. Only in one case,

"Pretreatments of wood chips in pulping processes" (7.1), the objectives had to be partly changed from improvement of chemical pulping to mechanical pulping.

Each consortium had impressive outcomes both in quality and quantity.

The methods and procedures followed were generally appropriate and consistent with the objectives. Some could be considered "front-line" or "at the cutting edge". The examples include "Analysis of wood and pulps" (7.1.3), "Chemical microanalysis of wood tissues and fibres" (7.2), "Solid-state NMR studies of cell wall components" (9.1.4), and "FINE Project" (10.1) and "ARMI Project" (10.2) where novel techniques were developed. A few investigators used techniques with questionable results and need rethinking.

The scientific results of the programme represented significant incremental progress over what was already known. Moreover, in some cases they were novel and beyond the current state of the research. For example, the finding of lignans in high concentrations in knots in "Chemical microanalysis of wood tissues and fibres" (7.2) was innovative and may have commercial significance. Both the NMR work in "Solid-state NMR studies of cell wall components" (9.1.4) and the work with enzymes in "Enzymes in the activation of lignin" (9.1.3) were impressive. Other examples included characterization of fibre surfaces, fibre-water interaction, and reinforcement of fibre networks "FINE Project" (10.1) and "ARMI Project" (10.2).

The competence of each consortium, on the whole, was excellent and compared well with the state of the research in the field. However, it was felt that better communication should have taken place among the pulping chemists working on Mass Transfer program elements: "Liquor transfer in sulphate cooking" (8.2), "Fundamental investigations of penetration and delignification" (8.3) and "Impregnation of wood alkaline pulping" (8.4). Furthermore, interaction between these scientists and those working on surface modification of fibres "FINE Project" (10.1) would have been beneficial. The project "Xylem structure and xylem as water-conducting material" (8.1) presented an example where several high-level skills were brought into the project, but the relevance of the findings for the end-use were not apparent. It seems important that when new competencies are introduced in the field of wood science (which is a great merit of the programme) the question to find partners with good knowledge of the wood material should be addressed with special care.

Postgraduate studies and expert training

All consortia have contributed greatly to training researchers at various levels – from postgraduate to postdoctoral. Many degrees have been, or will be granted. All consortia have promoted creative research environments.

Collaboration and networking

It is clear that Wood Wisdom played a significant role in bringing together various skills in each consortium. This has fostered synergy. Some of the projects were truly inter/multidisciplinary. Good examples are "Pretreatments of wood chips in pulping

processes" (7.1.) and "Fibre engineering" (10). Collaboration and networking among scientists both at the national and international levels was evident and fruitful. The users of the research results also participated actively.

Recommendations

For the future, project "Pretreatments of wood chips in pulping processes" (7.1), though risky, should continue; it would be worthwhile pursuing better and effective treatments. We also find further work on project "Aspen in papermaking" (11.1) risky. The present use of aspen is limited and its future use may be uncertain. Considering that it takes 25 years to grow a tree, investment in cultivation appears speculative. We encourage continued work on other projects with vigour, particularly "Chemical microanalysis of wood tissues and fibres" (7.2) for extending the analytical techniques, as well as "Enzymes in the activation of lignin" (9.1.3), "Solid-state NMR studies of cell wall components" (9.1.4), "FINE Project" (10.1) and "ARMI Project" (10.2).

4 Added value of the Programme

The Finnish Forest Cluster Research Programme has been a big investment for future research in that area in Finland. This way of working is unique world-wide and the members of the evaluation panel can see many advantages: obvious synergism in increased competence and innovativeness, and increase of scientific quality as advanced methodologies are spread in different areas. No negative effect of the multidisciplinary research can be seen on the scientific quality.

Combining basic and applied research to one programme can be seen as a great advance. The methodologies and basic knowledge are brought to more practically-oriented research and basic research get more input on issues of important for the commercial utilisation of the material.

The scientific value of industry-oriented research toward high value-added wood products was high. The opinion of the members of the review panel was that this well-structured programme was somewhat unique in global terms, covering many fields in which Finland has impressive expertise and where industrial interest exists.

Good scientific co-ordination, collaboration between partners, many scientific publications and a large number of PhD degrees were the main means of measuring the added value of the Wood Wisdom programme.

Administrative and scientific co-ordination

The multidisciplinary research was very positive in most of the consortia, and new co-operation networks have been established. Researchers with different scientific backgrounds learned to collaborate in order to realise their goals. This kind of multidisciplinary research is very fruitful and effective and the enhancement of inter/multidisciplinary approach in research depends to a large extent on the leadership of the co-ordinator. It also provides the best value for money for the funding body.

During the oral presentation of the results gained by each consortium, all the consortium were represented by several participants. The researchers have explained clearly the links and interactions between the subprojects. In addition of the information available in the final reports, this illustrates effective scientific co-operation.

However, the number of participants per consortium was sometimes quite high. As a consequence, there were researchers with a very low number of person-months. Our opinion is that a minimum person- month contribution should be proposed for future application.

From a general point of view, very innovative research has been carried out in this programme and the leadership of several Finnish teams is recognised world-wide especially in different IUFRO and COST research groups

The role of the consortium co-ordinator is very important to reach added value in the programme. Many consortia were working very well. The programme had the ambition to bring new skilled research groups into the forestry cluster. It is important that these kinds of groups can be included in consortia with very strong and experienced leaders. That was a good way to work.

In general, the administrative co-ordination of the programme was excellent. It seems to be small and efficient, and the amount of paperwork appears to be healthy low. The programme has been very lucky to have a co-ordinator with good understanding of both science and industrial development. The co-ordinator has pushed the key issues of co-operation and viable consortia but with great respect to the scientists. The co-ordinator seemed to be well aware of weaknesses pointed out by the evaluators and has tried to correct them in a reasonable way, still with respect to the individual scientists.

Concordance with the objectives of the research programme

Addressing the whole forest wood chain is a scientific and technical challenge for high-level scientific groups of researchers, and it can be pointed out that the Wood Wisdom research programme was an appropriate and key support for the necessary knowledge integration within this chain. The examination of the results has illustrated a very good concordance with the objectives. The results of the programme are delivered/presented efficiently: workshops, final report, and theses and articles.

However, the duration of the programme (three years) was actually too short to produce a doctor and this have caused problems in some cases. Universities usually have very good record in the researcher training while research institutes do produce very few PhDs.

5 Recommendations

1. We think that a joint programme such as Wood Wisdom generates much added value both for innovations and for the scientific quality. We recommend a second stage for the programme where the fruits of Wood Wisdom I can be fully exploited. International co-operation will make the concept even stronger.

2. The key issue for the success of the programme is to look for scientifically competent and enthusiastic co-ordinators for the consortia.

3. It is important to continue the development and use of the frontline methodologies used in the programme, such as analytical chemistry, surface chemistry, solid state NMR, x-ray analysis and enzymology.

4. More papers should be published at international level, as the results are of good quality and it is important to have them disseminated. In many fields, it would be advantageous to develop co-operation at international level in order to avoid re-inventing the wheel.

5. The scope of the programme, which was 'optimising the value chain in the forest-based industries' is very important. There is enough knowledge of natural fibre variability but not enough knowledge how this can be effectively used in industry. High priority should be put on research developing new research areas, such as material science, or to find new industrial use of wood-like wood composites.

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APPENDIX 2

ORGANISATION OF WOOD WISDOM

STEERING COMMITTEE

Kari Ebeling, UPM-Kymmene Oyj, Chairman of Steering Committee
Christine Hagström-Näsi, National Technology Agency Tekes
Matti Heikurainen, Ministry of Agriculture and Forestry
Sauli Jämsä, Kuution Palat Oy
Markku Karlsson, Metso Corporation
Ilkka Kartovaara, Stora Enso Oyj,
Jyrki Kettunen, M-real Oyj,
Paavo Pelkonen, University of Joensuu,
Mauri Saarelainen, Honkarakenne Oyj
Reima Sutinen, Ministry of Trade and Industry
Juha Tuominen, Vapo Timber Oy
Leena Paavilainen, Wood Wisdom, (Secretary of the Steering Committee)

CONTACT PERSONS OF PUBLIC FUNDING ORGANISATIONS

Ilmari Absetz, National Technology Agency Tekes
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Matti Heikurainen, Ministry of Agriculture and Forestry
Jaana Roos, Academy of Finland
Reima Sutinen, Ministry of Trade and Industry

PROGRAMME COORDINATION

The organisations in charge of the scientific and administrative coordination are the Finnish Pulp and Paper Research Institute (KCL) and Wood Focus Ltd (former Finnish Wood Research Ltd).

Programme Office:

Leena Paavilainen, Programme Director, Dr. (Tech.)
Sirpa Marttila, Programme Secretary

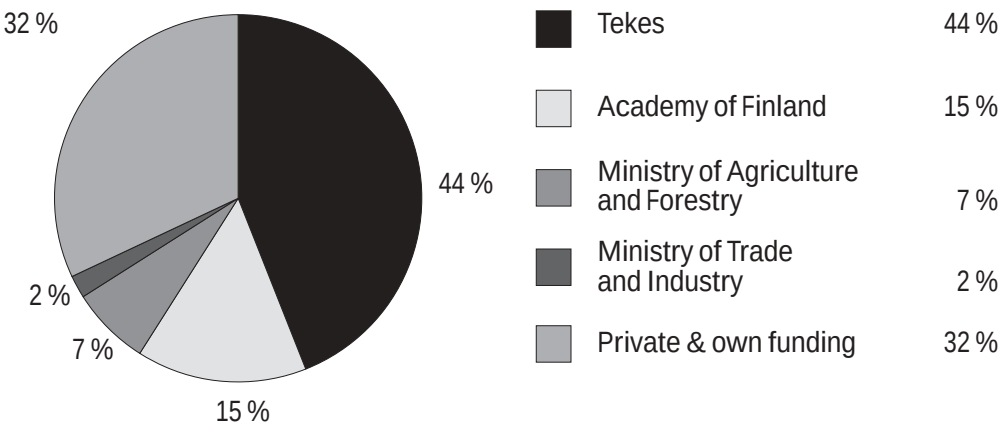
ADVISORY GROUPS OF RESEARCH CONSORTIA

The advisory groups of research consortia (in all 38 with some 400 members) consist of external experts representing the industry and economy, science, public administration, and trade and professional organisations (in addition to the representatives of the research groups and the Programme Director).

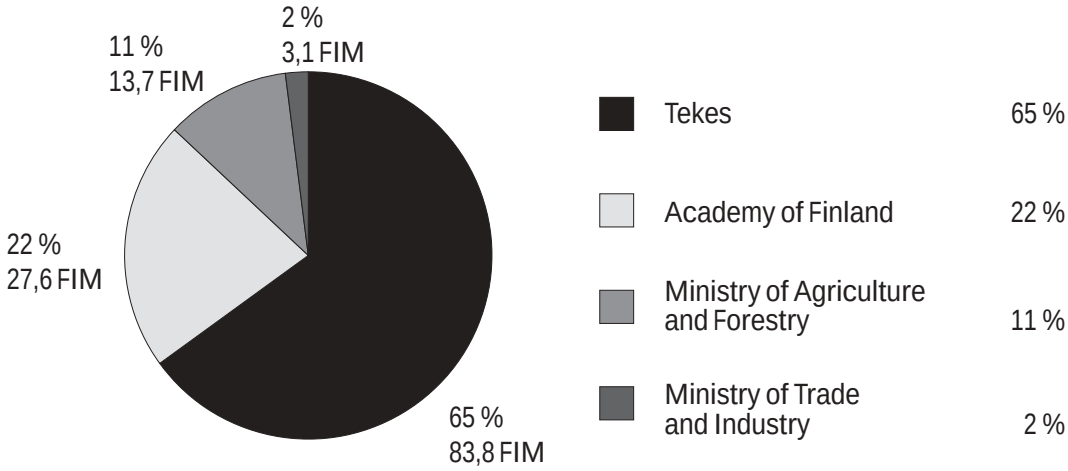
WOOD WISDOM FORUM

Expert forum arranged on different topics:
Wood Wisdom Forum I, in 1999: Effective utilisation of Finnish wood raw material
Wood Wisdom Forum II, in 2000: How research can meet the demands of the globalised forest industry

APPENDIX 3
FUNDING OF WOOD WISDOM



Total funding approx. FIM 195 million (EUR 33 million)



Total public funding approx. FIM 130 million (EUR 22 million)

APPENDIX 4
STATISTICS

– Consortia	34	
– Total number of projects	156	
– Researchers	789	
– of whom female	287	(36.4%)
– Researcher years approx.	460	
– Research units	67	
– Partners	67	
– of which companies	53	
– other organisations	14	

FURTHER TRAINING IN WOOD WISDOM

Total number of degrees earned	83
– Doctor	19
– Licentiate	12
– Master	51
Degrees to be earned	54
– Doctor	44
– Licentiate	3
– Master	7

58 degrees of 136 earned or to be earned by women (42%)

The Finnish Forest Cluster Research Programme Wood Wisdom (1998-2001) has been evaluated. A total of 34 research consortia with 156 projects received funding worth EUR 33 million. The programme was co-funded by the National Technology Agency Tekes, the Academy of Finland, the Ministry of Agriculture and Forestry, and the Ministry of Trade and Industry, and private sources.

The evaluation showed that the scientific and technical competence was excellent in all consortia; however, the level of scientific competence was often better in scientific and technological projects than in technological-economic ones. The programme has generated added value in scientific co-ordination, multi- and interdisciplinary collaboration, number of scientific publications and researcher training. The evaluation panel recommends that more papers should be published at international level and international co-operation should be further developed. High priority should also be put on research developing new research areas, such as material science, and finding new industrial use of wood-like wood composites.

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