Lessons drawn from ongoing and additional experiments

Deliverable D8

STODAFOR – Storm Damaged Forests

May 2004

Dr. Udo-Hans Sauter
Christian Pfeil
Matthias Wurster
Matthias Secknus

FVA, Germany
Participants:
The following 16 partners under the global coordination of CTBA currently carry out this European project.

CTBA, Technical Institute for Wood Technology and Furniture Manufacture (France):
Didier Piscchedda – Coordinator
Emmanuel Bastet
Pierre Vautherin
Ann Huguet

FVA, Forest Research Institute of Baden-Wuerttemberg (Germany): Udo Hans Sauter
Matthias Wurster
Matthias Secknus

KVL, Royal Veterinary and Agricultural University (Denmark): Andreas Bergstedt

EMPA, Swiss Federal Laboratories for Materials Testing and Research (Switzerland): Martin Arnold

CBE, Biomass Centre for Energy (Portugal): Joana Carinhas

BFH, Bundesforschungsanstalt für Forst- und Holzwirtschaft (Germany): Rolf-Dieter Peek

UPM, Universidad Politecnica de Madrid (Spain): Eduardo Tolosona

DLFRI, Danish Forest and Landscape Research Institute (Denmark): Ebbe Boellehuus

TTI, Trees and Timber Institute (Italy): Claudio Pollini
Carla Nati
Raffaele Spinelli

AFOCEL, Association Forêt Cellulose (France): Maryse Bigot
Jérôme Moreau

TUD, Technical University Dresden (Germany): Claus-Thomas Bues

BRE, Building Research Establishment (UK): Keith Maun

FMRE, Institute of Forest and Mountain Risk Engineering (Austria): Ewald Pertlik

ICSTM, The Imperial College of Science Technology and Medicine (UK): David Dickinson

UOP, University of Portsmouth Higher Education Corporation (UK): Rodney Eaton

NISK, Norsk Institutt for Skogforskning (Norway): Jan Bjerketvedt
## Contents

1. **Objectives** .......................................................................................................................................................... 4
2. **General comments** ............................................................................................................................................. 5
3. **Lessons drawn from ongoing and additional experiments with regard to harvesting** .................................. 6
4. **Lessons drawn from ongoing and additional experiments with regard to log conservation** .......................... 18
5. **Conclusions** ....................................................................................................................................................... 29
1 Objectives

The following reports describe research projects that are ongoing in Europe in the field of harvesting and conservation methods. Looking at each investigation there can be drawn lessons from the results. These “lessons“ could be the future know-how in harvesting and conservation fields drawn from several investigations made in different countries in Europe. Herewith can be shown the collected knowledge in harvesting and conservation topics of the last 10 years. These examples can be used for similar situations in the future and for further studies in the treatment of storm-damaged forests.

**Market demands influencing storm management:**

<table>
<thead>
<tr>
<th>Log Conservation</th>
<th>THE WOOD MARKET</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Ponding</td>
<td>-Economics</td>
<td>-Transport</td>
</tr>
<tr>
<td>-Transportation</td>
<td>(maintaining price)</td>
<td>-Work regulation</td>
</tr>
<tr>
<td>-Economics</td>
<td>-Valuable species</td>
<td>-Safety regulation</td>
</tr>
<tr>
<td>(preventing</td>
<td>(hardwoods)</td>
<td>-Environmental regulation</td>
</tr>
<tr>
<td>methods suited)</td>
<td>-High grade quality</td>
<td>-Choice of the method system</td>
</tr>
<tr>
<td>-Sprinkling or</td>
<td>timber</td>
<td>-Training</td>
</tr>
<tr>
<td>sawmills →</td>
<td>-Controlled release ---→</td>
<td>-Reforestation</td>
</tr>
<tr>
<td>Environmental</td>
<td>market place</td>
<td>-Availability of</td>
</tr>
<tr>
<td>controls</td>
<td>-Safe the resources</td>
<td>machine</td>
</tr>
</tbody>
</table>

*soil compaction
*stand damaged
*tree damages and natural vegetation
2 General comments

Several European countries have been affected by storms in December 1999. Forests have been strongly damaged in Denmark, Sweden, France, Germany, Austria and Switzerland and the wind-fallen trees represent in some regions several times the average annual harvested volume.

These damages have been estimated in Europe at the never seen level of about 180 million m3 to be compared to the 250 million m3 harvested each year in the European Union.

For economic and ecological reasons like the prevention of phytosanitary risks and fire, in most cases, it is very important to harvest without delay the wind-fallen or broken trees. This is also the only way to save the quality of that wood from degradation and to keep it in good conservation conditions for the wood industry supply during the coming years.

But these harvesting and logging operations must be conducted in a very short time before the hot season (Spring and Summer) so even the non-directly affected European countries will contribute by sending professional manpower and equipment. They could also participate by their former experience of log conservation methods, which includes their effects on wood quality for timber or paper use.

In fact, the former situation gave the opportunity to a lot of local experiments on safe and efficient harvesting methods, respectful of the environment, in storm damaged forests and on new logs conservation methods concerning a great number of different species and conditions in Europe.

As learnt from the statistics, such storms will occur at a lower level more or less every five or ten years somewhere in Europe. It is important to take benefit of all the experiments that will be conducted on harvesting and log conservation in storm damaged forests to be ready to react more quickly when a new storm will happen somewhere in Europe.
3 Lessons drawn from ongoing and additional experiments with regard to harvesting

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Logistic - Transport</td>
<td>Comments for the practical use of transport by train and by ship with regard to the northern central customer service from the forest administration board Freiburg Baden-Württemberg</td>
</tr>
</tbody>
</table>

**Content**

Assessment of the long distance transport of logs
- By train
- By ship
Shipping of round wood by rail in the future is asking for a new concept after MORAC because literally all railway stations close to the main wooded area are abandoned after 2001. In normal cases the transport of rounds wood by rail makes only sense technically and economically if the mills have own tracks.

**Conclusion**

Concerning the possibilities of log transport by train and ship, there must be considered the infrastructure of all participants in the logistic chain.

---

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Harvesting operations</td>
<td>Harvesting Systems on Storm Damaged Areas</td>
</tr>
</tbody>
</table>

**Content**

Storm events force foresters to find suitable strategies for the system to use in damaged forest.

The Forest Research Institute of Baden-Württemberg (Dept. of Forest Utilisation) made a technical guide for harvesting operations on storm damaged areas. The knowledge is basing on experiences of the storms Wiebke/Vivian 1990 and Lothar 1999.

**Conclusion**

- The first step must be a suitable strategy for the refurbishment. Do not hurry!
- Priority of necessary working steps in the work flow e.g. log transport…
- Possibility of living conservation with regard to forest protection
- Cutting and use of standardized length can forward the material flow and relieves the construction of wet storage sites
- Moving of forest worker teams to other concerned areas only with the support of excavators that can fix up the storm damaged area helping the forest workers (especially in stands with broad leafed trees)
- Careful contract conclusions with sub-contractors, because of high risk of inflated price demands
### Conclusion
- The capacity of harvesting systems in storm-damaged areas (motor-manual or mechanized) will be underestimated compared to “normal” conditions. The increase of capacity is based on concentrated log amounts, big trees and bigger top diameters and permanent support of machines for the manipulation of the trees.
- Depending on local conditions and available machine power the costs and values of capacity vary concerning the single working steps even within equal working systems.
- The costs of entrepreneurs reflect market prices, but not the real structure of the costs. At the beginning of the work on storm damaged areas the concerned forest companies shall have an agreement about the prices they pay for contractors.
- Contracts with entrepreneurs shall not be placed on units that are too big.
- Mixed calculations for simple/difficult conditions, huge-sized and small-sized logs must be avoided.
- Get references of unknown contractors.
4

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Harvesting operations – Material – Behaviour of the logging firms</td>
<td>1999 windstorms: what consequences for the harvesting sector in France?</td>
</tr>
</tbody>
</table>

**Content**

To determine and qualify what are the consequences of windfall logging for:
- the firms that have invested a lot in new harvesting material,
- the harvesting materials and their technological improvement,
- the productivity and technical costs of harvesting operations,
- the labour force and new needs of training,
- the impact of industrial wood supply.

**Conclusion**

- **Due to financial supports,** the 1999 storms induced a tremendous amount of investment in materials: the total number of harvesters increased from 270 in 1999 to 500 at the end of 2001. Consequently, the average age of the material decreased (around 2 years old at the end of 2001), and the new technology (especially recent onboard computers) spreads widely. Concerning extraction material (forwarders and skidders), 360 engines have been sold in 2000, twice the 1999 sales.

- **The study of a sample of the firms permitted us to identify 4 types of behaviour:**
  - some of them did not react particularly. These companies invested in material but it was often forecasted before the storm,
  - some developed their work capacities by proposing a new service,
  - some developed their work capacities in the same activity (logging and extraction),
  - some acted prudently, but the managers have some investment projects.

  The two first types appear to be in a particular bad situation concerning their accountancies.

- **This study assessed the storm consequences on the workforce in terms of decrease of work accidents:** harvesters will replace a big amount of manual loggers and mechanised harvesting is by far safer. This evolution could save a lot of money for the insurance system: the saving could reach 800 to 2000 K€ per year.

  **The new needs of training were qualified and quantified.** The challenge is to develop the capacity of the training centres for drivers: around 100 harvester drivers must be trained each year (replacement of men who leave the forest sector and need of new drivers in order to fulfil the continuous development of mechanised harvesting in France) and 200 drivers of extraction machines (skidders and forwarders).

- **New relationships between partners involved in wood supply appeared** during the years just after the 1999 storm. Nowadays, it is difficult to assess the future of these new relationships and the integration phenomenon observed in some enterprises in 2000/2001. However, the forest industries have to play a key role if they want to endure the positive improvement of their wood supply conditions.
## Conclusion

- **Numerous sources for productivity loss, but with more or less important impact**
  - The harvester characteristics (rubber-tired or tracked carrier, cutting capacity...) have no effect on productivity, and this one seems to be similar for any of the conifer species studied (pine, Douglas-fir, fir, spruce).
  - In our studies, the ratio Productive Machine Hours / Total Machine Hours averages 86%, and this is the fact of « classical » downtime due to breakdowns, telephone call, etc…
  - We identified several factors specific to operations in blow down that can limit more or less the productive yield of the harvesters.

- **Table I:** In blow down recovering, the global loss of productivity can vary between a few percents to 50%, depending on the stand features and the method applied.

<table>
<thead>
<tr>
<th>FACTOR SOURCE OF PRODUCTIVITY LOSS</th>
<th>AVERAGE IMPACT ON HARVESTER PRODUCTIVE YIELD</th>
<th>MAXIMUM IMPACT ON HARVESTER PRODUCTIVE YIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uprooted trees</td>
<td>-14 to –4 % depending on stem volume*</td>
<td>-20 to –6% depending on stem volume*</td>
</tr>
<tr>
<td></td>
<td>[70% of the trees are uprooted]</td>
<td>[100% of the trees are uprooted]</td>
</tr>
<tr>
<td>Uprooted trees severed from the</td>
<td>-6 to –4%</td>
<td>-40 to –24%</td>
</tr>
<tr>
<td>stumps (by a chainsaw operator)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broken trees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(merchantable pieces)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmerchantable pieces (broken tree</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tops or butts) removal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay due to the chainsaw operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single direction work **</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stumps replacing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsuccessful jammed trees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>extraction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvester chainsaw replacement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* for stands with an average stem volume between 150 and 700 dm³ only.

** at the end of the strip, the harvester stops working and come back to the opposite site before starting to work again.

- **A good quality job**
  
  Most of the time, operators meet the specifications and don’t cause any extra wood-breakage, roundwood piles are organized so that they do not compromise the haulage, etc.

- **Security: frequent failures**
  
  In 75% of the semi-mechanized operations we studied, we observed interferences between the chainsaw operator and the harvester: this one stops his works because the manual operator is too close to the machine. That incures a lot of risk!

- **About costs: no general conclusion**
  
  - We studied maintenance and repair costs on 15 harvesters processing blow down for more than one year. Perhaps because most of them were under 2 years old, we didn’t note any obvious rise in maintenance and repair costs. But this could happen in the near future.
  
  - For contractors working according to the semi-mechanized way, the principle extra-cost is the payment for the chainsaw operator. The problem is that depending on the kind of machine but also stands characteristics; the extra-cost for the chainsaw operator can be higher than the gain in productivity he generates. So we recommend to keep on working according to the fully mechanized way: if you estimate that the productivity loss (if no chainsaw operator) will remain under 25 or 30%, if trees to be harvested are small sized (< 200 dm³), because then it will be hard to negotiate low value products at a price including the extra-cost (≈ + 1,5 €/unit).
The two main objectives were:
- To analyze and evaluate the impacts of forest exploitation and their short term consequences on biodiversity, soil properties and stand development,
- To test several tools and guidelines to limit soil disturbances.

**Conclusion**

From 2000 to 2001, AFOCEL has studied soil perturbations and compaction on 5 sites concerned by storm damages with different logging methods (chainsaw operator + forwarder, chainsaw operator + skidder, harvester + forwarder...).

- **Ground surface disturbances**
  
  On every site, we have used the European harmonized protocol (Concerted Action n°AIR3-CT94-2097) to carry out on a sample area the assessment of soil disturbances.

  Figure 1: State of ground surface in logging sites after forwarding in clear-cuts and thinning

- **Machinery trails occupancy**
  
  An additional measure was also carried out after every machine passage (harvester, forwarder, skidder): the surface area of the trail occupancy. The surface area affected by machinery trails is relatively important: from 30% to 67% of the harvested area.

- **Soil compaction**

- We showed that bulk density and soil strength increased under, beside the machine tracks, and under deep disturbances. Moreover all the horizons (0 to 50 cm depth) are concerned by this change of soil properties and in most cases soil compaction is still persistent after 2 years. A great percentage of the surface of the logging site is affected by these alterations: up to 67%.

- **Advices for forwarding organisation**

  The comparisons between different modalities (in terms of impacts) lead us to recommend some usual and already well-known methods or tools, but that are not used enough by professionals. To summarize, we can give this simple advice to limit site disturbances:

  - a good general organisation for every operation and a good coordination between operations,
  - a rational organisation of the forwarding (driving over the logging residues to limit rutting and soil compaction, concentrating the skid trails over few surface to reduce the area occupied by skid trails...),
  - an use of specific tools such as chains or tracks when necessary because of the climatic and soil conditions.
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Harvesting operations, manual methods; clearing operations; safety and economy</td>
<td>Chainsaw clearance of windblown</td>
</tr>
</tbody>
</table>

**Content**

Harvesting techniques for wind thrown or broken trees. Work safety and types of damage in the forest are considered.

**Conclusion**

- Workers who deal with damaged trees must be well trained
- Before starting to work is necessary to identify the prevalent type of tension present in the wood
- Felling techniques will vary according to different tree condition: leaning, uprooted, entangled, snapped off or broken in order to minimize the hazard

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Harvesting operations</td>
<td>Operations in windblown coastal pine stands</td>
</tr>
</tbody>
</table>

**Content**

Work safety concerns make mechanisation a fundamental need when salvaging windblown timber.

**Conclusion**

- The peculiar characteristics of some Mediterranean tree species may limit the application of a standard Scandinavian-style forestry mechanisation
- A grapple saw represents the most interesting alternative, which benefits from a lower investment cost and a higher operational flexibility
- An excavator fitted with a grapple-saw costs one third as much as a purpose-built harvester and it can be used for felling, crosscutting, bunching and loading
- Productivity reached 100-120 tons/day, for a cost around 15 €/ton
- Extraction does not affect a larger surface than normally affected under Italian conditions and its impact does not seem so heavy as to impact forest stability
9

<table>
<thead>
<tr>
<th>Country</th>
<th>Theme</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Chipping operations</td>
<td>Wood chip harvesting from young spruce plantation in Feltre area</td>
</tr>
</tbody>
</table>

**Content**

First thinnings in softwood plantations are taken in consideration to recover biomass otherwise left in the forest. Operation system chosen is very simple in order to keep harvesting costs at the lowest level. Trees were felled, forwarded and chipped at the forest road side. Wood chip was blown directly in trailer bins and brought to the local power plant.

**Lesson:**

- Using a Fällboy allow to fell trees along a preferred direction, helping in this way next chipping stage
- Chipper with its own grapple makes feeding easier in a narrow space, especially when dealing with whole trees
- Transport must be optimised and forest roads be repaired in order to enable the use of trucks instead of tractor and trailer units, less efficient
- Radio communication systems are kindly recommended to assist in exchange points

10

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Harvesting operations; clearing and economy</td>
<td>Restoration techniques for burned forests: operational aspects</td>
</tr>
</tbody>
</table>

**Content**

Clearing, salvaging and restoration in burned forests

**Conclusion**

- Clearing immediately after the fire is better than delayed action
- All options are more or less expensive and intermediate mechanisation is preferred
- Profitability of salvaging marketable residues must be evaluated very carefully
- A comparison of operational costs supported by dealing with different tree species shows a lower loss in recovering evergreen oak instead of Mediterranean pine
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>Transport of round wood system</td>
<td>Costs of Eucaliptus round wood Transport by road in Portugal</td>
</tr>
</tbody>
</table>

**Content**

Using a set data collected from the national market and Excel worksheet as a tool, it was estimated the cost of transporting Eucalyptus logs by road, for each of the various types of transport units used by a pulp company's transport contractors, in both new and used conditions. Estimates were made of operational cost per hour and per kilometre. These were then used, in conjunction with certain assumptions (e.g. compliance with national legislation), to establish several functions that correlate the costs per ton of wood with the distance travelled. The difference in estimated costs arising from using a new transport unit rather than a used one was analysed for each type of unit. This difference was not significant for the unit best adapted to forest activity (6x4 truck with trailer) nor for the most frequently used unit (4x2 truck with semi-trailer).

**Conclusion**

A sensitivity analysis test was made of the table of estimated costs for the transport unit composed by a truck (6x4), trailer and a truck crane. Results indicated that the table is quite sensitive to the assumption "unloading time"; transport cost per ton increased substantially with increasing unloading time at the mill or train-station. As to assumptions "average speed" and daily working hours", potential variations in normal conditions do not lead to significant changes in costs.
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DK</td>
<td>Management of harvesting operations and sales</td>
<td>Collection of experiences from the windblow in the southern part of Jutland in 1999 with focus on the organisation of harvesting and sales Internal report. Danish Forest and Nature Agency</td>
</tr>
</tbody>
</table>

**Content**

- Interview of managers, contractors and workers involved in harvesting and sales of windblown timber in the state forest in the southern part of Jutland.

  - *Experiences* concerning organising, harvesting methods, safety and ergonomics, communication and competence.

  - *Economical* analysis of harvesting and extraction.

**Conclusion**

- It is very important to make an organisation strong enough to handle such a catastrophic situation. Make it absolutely clear how the line of command is function, and who have competence and responsibility for what. Be aware that there will be a weary hard strain on some key persons in the organisation and it is important to keep those persons fit for fight.

- Choose of harvesting methods must be done with background in practical conditions e.g. the market for wood, tree species and size, terrain and soil conditions, availability of working power, machines and transportation possibilities. Make sure that the measuring system and software on new contractors harvesters, compete with your own software, and measuring regulations.

- Forest workers, machine drivers and other relevant persons must have a brush up course as soonest possible and before the work has started for full. Accidents and nearby accidents have to be highlighted and disgust all over the workplace, and proper precautions taken.

- Make the communication lines as short as possible and delegate competence to people close to where tings happens.

- The economical analysis showed that the harvesting and extraction costs was around 15 to 30% higher than for normal standing trees.

- Next windblow! Make a plan and be aware it has to be changed! It’s better than no plan. Don’t panic and keep your resources intact for the real battle.
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Economics of windthrown timber transportation from France to Spain</td>
<td>Granting policy effects, means of transportation and round timber and sawn timber market effects (experiences of 2000-2004 timber imports from France to Spain)</td>
</tr>
</tbody>
</table>

**Content**
- The fast and strong beginning of the round timber flow was only possible because of the fast reaction of France government that created safe and effective distance-depending grants to blowdown timber transport.
- Due to the technical and structural problems of railway transportation between France and Spain (different railway width, lack of station in most Spanish mills), the road transportation was the most effective and almost only one. For larger distances, probably maritime transport would have been more interesting than railway.
- Spanish market was definitely able to face the offer strong increase. Domestic round timber production did drop but also new mills were established (mainly construction timber and pallet). Transport means – trucks – and contractor’s machinery to work in French forests did rise strongly.
- Large round timber flows from France to Spain has become frequently permanent after windblown timber has been completely consumed, now on the basis of green timber. This fact has caused some problems due to the lack of offer in domestic French market.
- In Spain, the increase domestic offer has led to a prices drop in construction timber. The prices have not yet recovered although French raw material prices have become normal. This fact is producing some economic problems in local industry that was created after the French storm.

**Conclusion**
- Granting policy by the French government did permit the quick absorption of windthrown timber by Spanish market.
- Almost all the transportation has been by road trucks.
- Spanish forest enterprises have grown to actively participate in every steps of logging, transport and transformation.
- This fact has led to a many important market changes.
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Windthrown timber imports by road transportation from France to Spain</td>
<td>Optimization of long distance transportation means (experiences of 2000-2004 timber imports from France to Spain)</td>
</tr>
</tbody>
</table>

**Content**

- Actual experiences have shown that the new investment opportunities created by a big storm must include the purchasing of optimisation devices for long distance transport. For example, the new trucks should be equipped with weighting devices to control the load and GPS to choose the optimum route.
- The semi-trailer truck without a crane has proved to be the best transportation vehicle from France to Spain. This is due to the following causes:
  - Windthrows in France have taken place in plain forest in which timber extraction with crane-equipped tractors or trucks have been possible, so trucks’ loading does not need a self transported crane.
  - This kind of trucks fits well to the dimensions required by Spanish final timber users.
  - The use of not-specific round timber trucks has allowed the complementary transportation of other goods from Spain to France to return with blowthrown timber.
- In some circumstances, the use of a conventional large truck to transport an empty smaller one mounted on it has been very useful to save time and cost. This permits the return trip of both trucks loaded, being the costs saving very interesting for very long distances.

**Conclusion**

- The techniques and materials oriented to lessen long distances transportation cost have been definitely very effective to maintain the timber flows during and after the storms period.
### 15

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Combined transportation of windthrown timber from France to Spain and other goods in the return trips.</td>
<td>Convenience of certain productions adaptation to the demand of complementary goods in windthrown areas (experiences of 2000-2004 timber imports from France to Spain)</td>
</tr>
</tbody>
</table>

**Content**
- In some Spanish big sawmills the chippers have been adapted to the potential French consumers requirements to avoid the empty trips for returning with windthrown round timber.
- This practice has actually lessened the transportation combined costs.
- In some cases even the transportation trucks specific for chips has been used for returning with round timber loads, despite they are not well-adapted to this kind of material.

**Conclusion**
- Spanish adaptation of some productions to French industrial requirements in storm areas has produced an important decrease in windthrown round timber transportation costs.

### 16

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>Organisation of windthrown French timber stocks for Spanish importation.</td>
<td>Convenience of intermediate large round timber landings (experiences of 2000-2004 timber imports from France to Spain)</td>
</tr>
</tbody>
</table>

**Content**
- The renting or purchasing of large pieces of land to stock round timber inside the affected areas has been very useful.
- This is due to the following causes:
  - Improvement of transportation scheduling.
  - Best possibility to meet temporal requirements for throwntimber extraction without bottlenecks.
- The location of these landings should have into account future transportation opportunities. For example, landings located close to some French railway small stations have been useful, after the storm period, to receive timber from areas far from there and have permitted to manage a wider origin of raw material.

**Conclusion**
- Large intermediate landings well-located close to the windthrown areas are very convenient to properly manage round timber long distance flows.
- Other future opportunities should be considered when deciding the location of these landings (connection to other timber production areas, proximity to railway station, etc.)
4 Lessons drawn from ongoing and additional experiments with regard to log conservation

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Wet storage</td>
<td>Assessment of beech (<em>Fagus sylvatica</em>) properties and more precisely its coloration following a period of immersion or water spraying and with or without a period of in-situ conservation prior to wet conservation</td>
</tr>
</tbody>
</table>

Content

2 years of conservation (only wet storage or in-situ storage combined with wet conservation). Consists of an examination of the sawn planks from the conserved logs. Some planks were steamed. Some veneers were also cut and examined.

Results:

- In terms of colour, the water sprayed logs are better conserved than the immersed logs (immersed logs darker in colour). In the case of immersed wood, the discoloration starts after 1 month after the beginning of the storage. Concerning water sprayed logs, discoloration occurs after 6 months of conservation.

- After 5 months of immersion and 7 months of water spraying, 50% of the logs suffered from discoloration. After 13 months, almost all the immersed logs are heterogeneous in colour. Comparatively, this threshold of 50% of discoloured logs appeared only after 10 months of in situ conservation + 14 months of wet storage (either water spraying or immersion) i.e. after 24 months of conservation.

- The steamed planks present homogeneous colour and are barely distinguishable from the planks coming from green logs. The steaming process seems to be achieved more quickly than for green wood (the necessary time for the steaming process decreases by 15 to 20% for water sprayed logs and by 20 to 25% for the immersed logs).

- The veneer manufacture occurred without particular problems apart from a small percentage of attacked logs by fungi.

→ Conclusion:

- It does not seem possible to obtain planks clear in colour with water storage methods as far as beech is concerned.

- Steaming process is an appropriate method to make planks homogeneous in colour.

- With regard to the environment, PH, COD value (Chemical oxygen demand), nitrogen value and O₂ content were measured. No pollution was obvious. On the contrary, water quality seemed to be enhanced in the case of immersion.

- The combination of in-situ storage and wet storage is by far the most efficient method to maintain the wood quality both in terms of mechanical and physical properties and in terms of coloration (provided that the root contact still exists and direct exposure to sunlight is limited in the case of live storage).
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Water sprinkling</td>
<td>Comparison between logs conserved under water spraying conditions and green timbers in terms of sawing, drying, and planing processes, and in terms of environmental and trade issues</td>
</tr>
</tbody>
</table>

### Content

The aim of this study was to determine the differences between green timbers and logs conserved under water spraying in terms of environmental and economic issues and in terms of management throughout the sawing, planing and drying processes.

The work was currently carried out within French companies. Three species were examined, namely oak (*Quercus Spp*) for hardwoods and fir (*Abies Spp*) and spruce (*Picea Abies*) for softwoods. The study is still ongoing and is expected to last 2 years from 2002 to 2004.

**Results:**

- At an equal energy consumption level and for the same log diameter, the speed of the sawing process is 10% to 20% higher for the water sprayed logs than for the green logs, which represents a gain in productivity ranging between 2% and 5%.
- Kiln drying: Provided that the planks have not been pre-dried, the processing time will be longer for the ones conserved under sprinklers since the initial moisture content is much higher than in the planks issued from fresh timber. However, the drying speed rate in the case of water sprayed planks is generally higher. This offsets the much bigger initial MC.
- Debarking: easier but the size of the bark pieces is also bigger and they can obstruct or clog up the debarker.
- Immediately after the sawing process, the boards issued from the water sprayed logs seem to be slightly darker. Besides, this difference tends to disappear following the drying process.
- On a logistic point of view, it seems that the benefits involved by this conservation method are significant. Actually, this latter prevents the wood from deteriorating during spring time (dote, mould, brown striped, etc.) and being downgraded.

**Conclusion:**

Apart from the drying process which might be longer than for fresh wood (provided that a pre-drying is not carried out) and some slight problems of discoloration for spruce (*Picea abies*), the utilisation of water sprayed logs for the wood primary processing of spruce, fir and oak brings some undeniable advantages in terms of economic benefits and sourcing homogeneity.
This project deals with beech (*Fagus sylvatica*) live conservation over a 2 years period. 704 blown trees were examined, scattered in two French regions (‘Meurthe et Moselle’ and ‘Haute Marne’). Just after the storm, these trees were still living since their roots were partly damaged or even not damaged at all.

Concerning harvested logs, in order to slow down the drying speed of the logs, a method using wax on the faces, was also assessed.

Results:
- Technique using wax on the faces to prevent the log from drying is totally inefficient
- Among the factors likely to influence wood deterioration, the far most important is the sample area’s light level. The more the blown trees are exposed to the sunlight, the higher is the deterioration rate since the quicker decreases the moisture content. Other factors, such as the site type, the ground contact, the crown damages or the log diameter are negligible compared to the light level. However, the following observations were noticed:
  1. The effect of the log’s ground contact seems to influence the wood quality only the second year but remains negligible.
  2. The more the crown is damaged, the higher the deterioration rate.
  3. The bigger is the living tree’s diameter, the higher the deterioration rate. This trend is only obvious the second year of live conservation.
  4. When the tree falls down, the more its roots’ network is displaced, the higher the deterioration rate

> **Conclusion:**

As far as beech is concerned and despite the fact that this species is likely to colour quickly, live conservation is a rather efficient and inexpensive method within the first year following the storm. It could even be worth using it during the second year provided that the blown trees are scattered in the forest (trees not or partly exposed to the sunlight).
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Wet storage</td>
<td>Experimental site for maritime pine’s log conservation (Pinus Pinaster) using three different methods</td>
</tr>
</tbody>
</table>

**Content**

An experimental platform has been implemented in the South West of France (Aquitaine) to assess within a 3 years period, the wood quality and the impact on the environment of 2 different log conservation methods (water spraying, immersion).

Results:

By a period of 2 years, the toxicity involved by the 2 different types of log conservation seems to remain low but fluctuates within the very first months.

The mechanical features do not degrade even after a 3 years conservation period of time.

The first results after 8 months showed that whereas most of the untreated logs were bluestained, 73 % to 100 % of water-immersed logs and 94 % to 100 % of water-sprayed logs were preserved with less than 6 % of bluestained area.

**Conclusion:**

Wet log conservation of maritime pine (Pinus pinaster) is still valid after more than 3 years.
Assessment of wood quality. A first assessment was made 10 months after the beginning of the conservation.

Results:

1. **Compact pile covered with plastic sheets**

With regard to the results obtained after kiln drying, no significant differences appeared between fresh timbers and beech conserved under compact piles covered with plastic sheets (PVC). Slightly less deformations in the case of beech wrapped in plastic sheets, final Moisture Content homogenous, drying time similar, no discoloration after sanding.

As far as veneer manufacture is concerned, no particular difficulties were encountered during the process and the quality of the veneer was similar to the one manufactured from fresh wood.

Finally, concerning the visual aspects of the planks sawn from the conserved logs, 4% were stained (brown stains), 1.5% were attacked by white rot, no soft rot attacks neither dote were obvious. In other terms, after 10 months of conservation, the conserved logs were still in perfect conditions.

2. **Compact pile covered with polyethylene sheets**

After 10 months of conservation, the overall results were quite bad (white rot attack, blue stain, bad bark condition, dote). This method should not be applied in the future to conserve beech.

---

**Conclusion:**

Very efficient method to conserve logs in term of wood quality. But expensive. Valuable in case of high valued timber.
6

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Storage under drying</td>
<td>Assessment of storage under drying conditions (compact pile / log</td>
</tr>
<tr>
<td></td>
<td>conditions</td>
<td>without barked) of spruce (<em>Picea abies</em>) and fir (<em>Abies alba</em>)</td>
</tr>
</tbody>
</table>

Content

Assessment of the loss in yield and economic compared with fresh timber

After a 6 months period of conservation, the measured loss in yield was 2% in average compared with the yield that would have been obtained with green sawn timbers. With regard to the economic loss due to downgrading of the planks (according to the European standardisation), the average loss was 18.5% in prices.

→ Conclusion:
This method is worthy but for a rather short period of time (between 6 months and 1 year)

7

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Economic aspect of water spraying</td>
<td>Log conservation in France by water spraying / Economic aspects</td>
</tr>
<tr>
<td></td>
<td>method</td>
<td></td>
</tr>
</tbody>
</table>

Content

Economic study of water sprinkling conservation method according to the type of companies (sawmill, forest owner, paper industry, trader-transport company, forester, etc.). This study also answers the species that have been conserved, the type of wood (industrial wood or lumber), the input and output on the storage yard, the grants that have been attributed by the government in terms of equipment, loan and transport.

→ Conclusion:
- The quantity of logs stored following the December 1999 storm was rather small compared to the volume of windblown trees (only 5%), leading to a limited effect on the market.
- In general the costs of implementation of the storage yard are high, leading to a rather poor profitability. However, with regard to the calculation of the costs, neither the perpetuation of the site nor the influence on the wood market (in the case of no conservation implementation for instance) were taken into account
- There is usually a significant difference in investments whether the site is designed to be perpetuated or not. A perennial site costs in average 6 €/m³ more than a non-perennial site.
- Usually, more investments are dedicated to hardwood than to softwood due to a higher initial value of the raw material.
- A recycled water system costs around 30% more than an opened water system. For this reason, it is advised to implement a recycling system just in case of a shortage of water at the vicinity of the storage yard.
- Whatever the quantity of stored logs, the implementation costs of the site related to the volume of stored logs remain similar. There seems to be no digressive scale effect.
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Log conservation under oxygen exclusion</td>
<td>Special methods – Log conservation under oxygen exclusion, compact pile wrapped in plastic sheets</td>
</tr>
</tbody>
</table>

### Content
After the storm in Baden-Württemberg were made several tests concerning conservation of wood in plastic film. Reaching a good result the teams for packing must be educated to use the welding apparatuses, gas measures and tools for manipulating the plastic film rolls. The method was tested in seven Forest Administration areas (ca. 30 500 cubic metre)

### Conclusion
For using this method there must be guaranteed that you have a well-trained team for packing the piles, in order to keep the wood in the highest quality that is possible. This method is only applied for timber with high value.

<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Wet storage – Compact pile with water sprinkling</td>
<td>Attack of root rot (armillaria mellea s.l.) in water stored log piles</td>
</tr>
</tbody>
</table>

### Content
The investigated methods were applied under two conditions:
- under practical conditions with a random test was tested every meter of the length of the stem
- under laboratory conditions were made tests over a period of 6 weeks with 168 quadrates of spruce sapwood. These test objects were treated with moisture and heat and then infected with root rot

### Conclusion
1. With good sprinkling quality, in case of spruce and fir conservation, there is not excluded that after a period of 3 years an attack of root rot is probable
2. The destruction of the wood is limited partly on the stem surface and on the peripheral area of the sapwood
3. In the 4th year there is ongoing intensive attack of root rot
4. There is no sign of dependence on place, tree specie, dimension, moisture content and altitude
### 10
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Basic principles – Choice of conservation method</td>
<td>Conservation (demonstration of various conservation possibilities concerning tree species and their application after “Lothar” storm)</td>
</tr>
</tbody>
</table>

**Content**
- Consultancy in questions of various storage methods
- Controlling of reclamation cases
- Documentation and estimation of wood damages after storage with protocols
- Composing of guidelines for practical use in storage areas

**Conclusion**
The arrangement of a “staff position storm” in Baden-Württemberg was very important to coordinate the single actions concerning conservation of logs that were made by the forest companies. The documentation part will be helpful for the organisation of future conservation areas after storm damage.

### 11
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>Sapstain susceptibility</td>
<td>A comparison of the susceptibility of five commercially important softwood species to sapstain fungi</td>
</tr>
</tbody>
</table>

**Content**
Experimental logs cut from freshly felled Scots pine, Lodgepole pine, Sitka spruce, Norway spruce and Japanese larch were exposed for four months during the summer in a compact pile. All logs retained their bark. Logs were cut 5 and 50 cm from the ends after 4, 8 and 16 weeks exposure and the percentage surface area of sapstain infection on the cut faces was measured.

**Results:**
The relative susceptibilities of the five tree species was as follows:
Scots pine = Lodgepole pine >> Norway spruce > Japanese larch > Sitka spruce. The mean stain areas for the respective species was as follows: 61%, 59%, 10%, 4%, < 1%.
Both pine species were highly susceptible to infection compared to the other species and both pine species showed the least loss of moisture over the course of the trial.

**Conclusion**
Such marked differences in staining clearly illustrate that sapstain susceptibility can vary greatly between species. A quantified rank order for species susceptibility would allow more accurate prediction of long-term storage potential of different timbers.
<table>
<thead>
<tr>
<th>Country</th>
<th>Topic</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Log Conservation</td>
<td>Quality damage at the forest landings caused by blue stain fungi</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evaluation of the value loss</td>
</tr>
</tbody>
</table>

**Content**

- Quantify the amount of blue stain
- Determine the amount of blue stain in relation to the storage time
- Verify the impact of harvest time on the development of blue stain
- Estimate the relevance of “air-borne” or “beetle-vectored” blue stain
- Examine the species spectrum of blue stain fungi
- Explain the relationship between wood moisture and blue stain

**Conclusion**

The results of these investigations should give us the seasonal differences for the quality degrades caused by blue stain.
**Country** | **Topic** | **Title**
--- | --- | ---
CH | Log conservation | Collection and analysis of current experiences with different log conservation methods after the 'Lothar' storm in Dec. 1999

**Content**

National research programme consisting of 4 projects started after the Dec. 1999 storms

Projects:
1. Co-ordination / integration of earlier and international experience
2. Experience with different log conservation methods
3. Entomology (Xylosandrus germanus)
4. Wood quality monitoring by ultrasonic

Overall objectives:
1. Collection and analysis of the 'Lothar'-experiences from a scientific, economic, social and political point of view
2. Compilation of a decision help to cope with future damage events (e.g. revision of 'Forest damage manual' and 'Decision help for storm damage in the forest')

**Conclusion**

**Statistical data:**
- Of the 12.5 Million m$^3$ of storm-damaged timber in Switzerland about 10 Million m$^3$ were harvested. About 80% of the damaged trees were softwoods, about 20% hardwoods.
- About 1 Million m$^3$ were put on long-term storage with 70% on compact piles with water sprinkling and about 20% on compact pile covered with plastic sheets. The remaining 10% were conserved with a whole range of different conservation methods. Compared to the 1990 storm damage, the percentage of wet stored timber was doubled.
- No systematic data on the amount of live-conserved trees is available.

**Existing knowledge / strategies:**
- Because of the quite recent experiences from the 'Vivian' storm in 1990 a lot of practical knowledge on log conservation was still available locally. The exchange of this knowledge between the concerning individuals worked quite well.
- Depending on the regional (by cantons) strategies, the amount of stored timber and the preferred conservation methods differed substantially. Quite frequently the decisions were ruled rather by political than by technical circumstances.

**Experience with log conservation methods:**
- The suitability of the water sprinkling method has been confirmed, particularly for large amounts of timber. Quality conservation is usually very good. However, possible Armillaria attacks after 2-2½ years have to be taken into consideration.
- The success of compact piles covered with plastic sheets was varying from case to case, with no clear indications for the decisive parameters. The risk of devaluation is clearly higher than with wet stored timber.
- 'Special' solutions which make use of local possibilities (e.g. storage in gravel pits) may be valid alternatives to the main conservation methods.
- Because of the very heterogeneous solutions generally valid statements on the costs of the different log conservation methods are not possible. The reported costs range from CHF 5.-/m$^3$ to over 40.-/m$^3$ (EUR 3.-/m$^3$ to over 25.-/m$^3$) for a storage duration of 2 years.
Decision helps / measures:

- The existing forest damage manual has proven to be a quite valuable help regarding the information on log conservation. However initially the knowledge on the content of the manual was insufficient at the practitioner's level. With the release of a new edition more emphasis has therefore to be put on the presentation of its content and practical relevance.
- To ensure a good communication and to avoid misunderstandings, a common terminology should be defined and used.

Reference (full report about the experiences in Switzerland, in German):
5 Conclusions

1) Planning

- First step is to fix refurbishing strategies and priorities, recovering the use of infrastructures.
- It is important to plan transport logistics from the beginning: it has proven to be basic to settle the appropriate subvention policy from very soon. Grants must be distance-dependent, sure and quick. This has been the most relevant fact to permit strong mechanisation investments and international concurrence, both very important to guarantee the blowntimber fastest extraction.
- Local level is the best for operational planning, but some common rules for all the affected area must be established from the beginning. Because of that, competencies and authority chain should be as clear as possible.
- Anyway, proper early planning is really useful. Even it is much better to have a plan and change it than not to have any plan.
- First decision must include the possibility of on site conservation. Crosscutting lengths must be planned thinking about the possibility of ex site conservation practices.
- The increasing need of training courses must be taken into account and evaluated as soon as possible. On site training programs must be organised quickly and enterprises and professionals must be motivated to attend. Driving of more adequate machines - excavators, harvesters, forwarders, - and safety and health specific contents should be considered when planning the training programs. The choice and recruiting of the enterprises to do the harvesting and extraction of the wood material should be based on the acceptation of the rules or guidelines defined on those training programmes.
- It is very interesting to come up to agreements about prices among the different stakeholders (Forest Administration, Owners, Contractors and Industry).
- It is convenient to register and check the contractors' entrepreneurial conditions in order to get proper references about their size, previous experience, available machinery, software compatibility with measurement rules, etc.
- It is not useful to establish contracts affecting huge areas. It is better to get to agreements with each contractor for a not too big piece of blowthrown forest. Realistic operational planning and control are easier and also it is easier to preview operations' productivities and costs. It is also important to establish security areas that will be harvested later in a way to decrease the density of machinery, workers and transport vehicles in the same area.

2) Machinery

- Strong increase in mechanisation should be facilitated. If the proper subvention policy is established, the needed strong mechanisation growth must be expected.
- Excavators are one of the key machines, as an auxiliary mean to further manual processing. They effectively reduce risks and improve productivity. In some experiences (Italy) the use of grapple saw has shown to be very cost-effective.
- Harvesters are quite commonly useful. Productivity drops in France have been reported to be as an average less than 15% for a 70% of uprooted trees and less than 7% for a 15% of broken trees. Decrease values in productivity can be much
higher where there is a large percentage of merchantable broken trees. A 15-30% increase in harvesting cost has been found in Denmark, while in Germany no clear conclusion has been reached, pointing out even in some cases the possibility of productivity increases if we compare to normal situation.

- In French experiences, productive time ratio and repair costs in blownthrown forests are equal to normal levels.
- Harvester type (wheeled or tracked, different sizes) and conifer species have not appeared as significant regarding productivity in French experiences.
- As a result of French experiments, combined auxiliary chainsaw operator and harvester work is disregarded when productivity drop in harvester work is not expected to be greater than 25-30% and tree average volume is not greater than 0,2 cubic meters.
- The higher traffic inside forest stands has increased the soil damages level to 30 - 67% of total surface in France. Common measures like planning, traffic concentration in designated skid trails and use of chains or tracks when terrain is wet are strongly recommended to lessen these damages.

3) Safety and Health

- The average accident risk has dropped in France because of the high mechanisation level.
- Nevertheless, blownthrown forest harvesting is a very dangerous operation, especially when untrained owners begin to work by themselves in their own forests.
- Besides, the combined work of chainsaw operators and harvesters has shown to be a high-risk work system in France.
- Is very important to include Health & Safety aspects in the training courses.
- To have a good work planning and a right selection the method jointly with the security equipments and work organization will lead to operate in security.

4) Transportation

- Transport is a key factor in planning the blowntimber fastest extraction. Early established distance- depending subventions have proven to be very effective to favour long distance consumption.
- Road transportation has shown to be almost the only option. Railway structural problems in some countries (Germany) and different rail width among others (France - Spain) are constraints difficult to solve. Road transport will likely be dominant even for long distance transportation. For very long distance transportation ships may be a better option than railway.
- Regarding long distance road transportation, the most frequent vehicle has been the semi-trailer truck without crane. In Portugal, significant differences in costs among semi-trailer trucks and trucks with trailer have not been found. The use of non-forest semi-trailer trucks has permitted to reduce transport costs making return trips transporting other goods (Spain).
- The acquisition or renting of well-located intermediate landings has proven to be very important to lessen long distance transportation cost and meets logging deadline requirements.
5) Market effects
- There has been a big growth of the investment in forest machinery and also the industry has adapted their lines or even created mills to meet the new timber offer.
- The best-situated enterprises have been those that have reacted fast to increase their capability inside their activity fields (logging, transportation, industry…).
- There has been a lot of industrial integration, even at the international level.
- Outside France, the best situated industries have quickly adapted to the new raw material flow and also have modified their products to meet French demand, in order to better guarantee return trips.

6) Conservation
Most of the experiments launched after the December 1999 storm in Europe dealt with wet storage (water spraying + immersion) and conservation under O₂ exclusion. Very often, beech (*fagus sylvatica*) was tested since this is a very susceptible species.
Apart from the fact that the efficiency of wet storage and also, in most cases, the conservation of logs wrapped in plastic sheets was proven, some major conclusions may be highlighted:

- In the case of wet storage, even for large-scale piles, the water pollution remains negligible after 2 or 3 months provided that a certain amount of fresh water is added regularly to the system (pond or water spraying in closed system).
- Wet storage for beech implies a quick coloration after only 1 month in the case of immersion, and 6 months in the case of water spraying. Nevertheless, beech may be conserved several years under wet storage provided that the colour is not a key argument for sales or the planks issued from those logs are steamed (homogenisation of the colour)
- The combination of several methods for conservation may reach much better results than a lone method (e.g. for beech live conservation + wet storage). Some research should be undertaken in that field.
- After 2 or 3 years, the attack of water sprayed logs by root rot fungi (*Armillaria mellea*), even under best sprinkling conditions, may lead to severe damages. However, this attack seems to be limited to the outer part of the logs (peripheral area of sapwood + stem surface)
- In terms of profitability, there seems to be no digressive "scale" effect with regard to water spraying method.
- Quite frequently, the choice of the conservation method were rules rather by political than by technical circumstances