CTBA

FAO

TECHNICAL GUIDE

ON HARVESTING AND CONSERVATION OF STORM DAMAGED TIMBER

By the team of experts from the Concerted Action
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STODAFOR

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CONTENTS

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1 INTRODUCTION

1.1 Context

The storms *Lothar* and *Martin* which occurred on 26th and 27th December 1999, caused huge damage all over Europe and in particular in Denmark, France, Germany, Austria and Switzerland. It is the first time since the very first statistics on forestry were published in 1860 that such storms have been registered. The damage was estimated at the previously unseen level of about 180 million cubic meters as compared to the 250 million cubic meters harvested each year in the European Union. This was in addition to the loss in equipment and human lives undergone by state communities and private owners.

These millions of cubic meters of damaged timber were, of course, an enormous financial loss for the wood chain, which was not properly prepared for such an event. Despite all the effort undertaken to rebuild electricity and road networks as fast as possible, to strengthen the wood-chain professionals' cooperation, many harvesting companies, contractors, sawmills and even secondary wood processing companies have since been forced to close down.

Unfortunately, according to climatologists, such hurricanes are likely to occur more and more often in the near future, and will be even more widespread and stronger than before. Good preparation is thus essential. The better the preparation, the faster the reaction with improvements in the following areas:

- Optimal management of the crisis
- Organisation of the labour force and equipment
- Selection of appropriate techniques and methods
- Implementation of logistics
- Determination of the financial requirements

Open flank for storms.
Grey: normal course of winter low pressure systems.
Black: course of the winter-storms 1990 and 1999.

For example, harvesting and logging operations must be conducted quickly during the hot season (spring and summer). This maintains timber quality and guarantees industrial sourcing within the succeeding years as a result of appropriate conservation methods. For the same reasons, the time taken between the harvesting operations and the beginning of the conservation process in 1999 was so short and the demand for specific equipment and labour force so high that even the European countries that were not directly affected had to contribute by sending professional manpower and equipment. This means that the consequences of such an event exceed regional and even national interests.

The STODAFOR project (Storm Damaged Forests) was initiated by CTBA (French Technical Centre for Wood and Furniture) in order to coordinate all the European experiments and knowledge of the harvesting and conservation of storm-damaged timber.

This Technical Guide has been achieved thanks to a concerted action between many European experts from 10 different countries (Germany, Austria, Denmark, Spain, Italy, Norway, Portugal, UK, Switzerland and France). The project started in November 2001 and finishes in November 2004.

1.2 Characteristics of the impacts of a storm

The impacts and crises following such a storm may be characterised as follows:

- They are unpredictable.
- Huge quantities of wood are damaged in forests.
- The harvesting operations become very hazardous due to the entanglement of the trees. They require highly skilled workers since the risks are considerable.
- More workers and equipment are necessary in order to reduce the time taken between harvesting and conservation.
- When the damage extends beyond a single region, transport also becomes a limiting factor.
- The establishment of storage sites has to be carried out as fast as possible. This implies that the protagonists have to be well prepared.

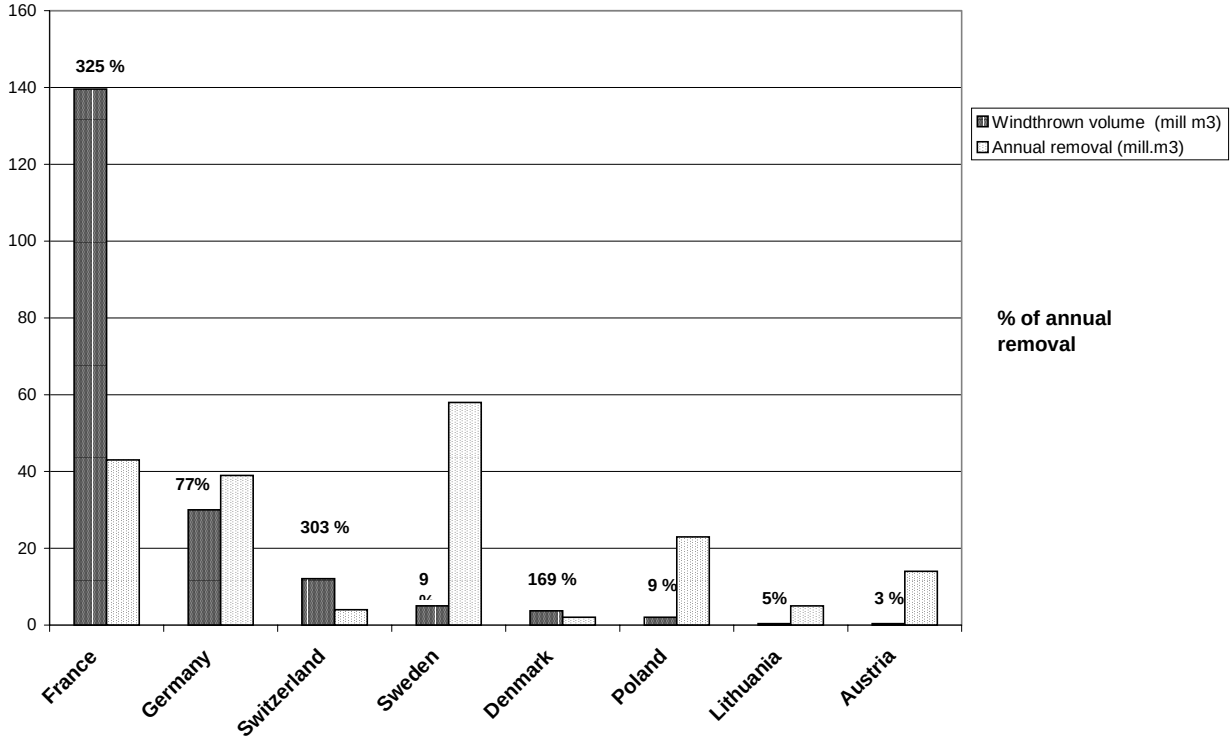


Figure 1: Storm damage volume compared to annual harvesting in Europe after the December 1999 storm (Source: estimation from Unece 2000/02/04)

1.3 Objectives of the Technical Guide

This guide aims to help both public institutes and wood-chain professionals to take decisions, prepare their future actions and improve cooperation in the event of hurricanes. It is of utmost importance to prepare and to decide, before the storm occurs, which actions will have to be taken in terms of methods to apply, training to provide and the different regulations with which to comply.

The main objective of this project is to contribute to answering the primary questions addressed to foresters and wood-industry managers facing storm-damaged forests:

- How can wind-fallen or broken trees be harvested safely to prevent fungal or insect attack and fire risk and to allow for reforestation in ways that are economically and ecologically viable?

- How can wood quality be maintained by efficient log storage and conservation methods in order to preserve supplies to the wood industry and foresters' incomes?

Some practical issues have been presented as case studies to give general information in an easy-to-read format.

The results of the different tasks undertaken by this project, which constitute the basics of this Technical Guide, are available at the following web address: **www.stodafor.org**. This website will be maintained and updated regularly after the end of the project by CTBA.

2 GENERAL CONSIDERATIONS

2.1 First steps

It is obvious that immediately after a storm the focus will be aimed at helping society as a whole. This includes tasks like clearing roads and power lines, removing trees dangerous to the general public etc. Foresters can play an important role in this phase, since they have the competence, the machines and other equipment.

Once the needs of society are met, it is then necessary to open the forest roads to get access to the damaged areas and to get an overview of the damage.

2.2 Evaluation methods

Before making any plans or thinking about strategies for storm damage management, it is necessary to evaluate the extent of the storm damaged forests. Vital information in this phase can be gained from maps, inventory data, aerial and satellite photos and local knowledge. The most important aspects characterising storm-damaged areas follow.

There are three major questions to be answered: what areas are damaged, what are the stand descriptions and what is the stand damage type?

To answer these questions, information is needed about some important characteristics for description of the storm damaged areas:

- Localisation (geographical references) of the storm damaged area,
- Volume of storm damaged wood,
- Percentages of tree damage types (i.e. broken, leaning and fallen trees (Figure 2)),
- Single/group damage or stand damage,
- Percentages of tree species (softwood/hardwood) and dimensions (i.e. DBH-classes describing large, medium and small-sized trees),
- Terrain description: slope, ground roughness and ground bearing capacity,
- Infrastructure: skid trails, tractor roads, forest truck roads.

Wind-thrown trees (coniferous trees or broad-leafed trees)

- Uprooted with low root contact to the moisture in the soil. ……

- Uprooted with good root contact to the moisture in the soil ……

Storm broken trees (coniferous trees or broad-leafed trees)

- Breakage near the stock (stem can be utilised as long pole without problems) ……

- Breakage in 1/3 of the stem height (stem can only processed as short wood) ……

Bent or leaning stems (coniferous trees or broad-leafed trees)

- Only bent tree, root system not affected by storm ……..

- Tree bent and root system slightly lifted but still sufficient contact to soil moisture content …

- Tilted tree hanging in the crown of a neighbouring tree ……
(root system heavily damaged and no sufficient root contact to soil moisture)

Crown damages (mostly on broad-leafed trees):

- Slight crown damage (only one single big branch missing) ……

- Heavy crown damage (more than half of the former crown is missing) ……

- Almost total loss of crown ……..

Figure 2: Short description of different types of storm damaged trees

How can we access this kind of data – and how fast can we get it?

The optimal situation would be to have updated and accurate information about the stand data when the storm arrives, carry out a remote survey (aerial or satellite photos) of the storm damage localisation after the storm, and then combine these two geo-referenced datasets to give an overview of the situation regarding affected volumes of different species and varying terrain conditions.

The potential situation is most likely less ideal. In some areas one will have access to relatively recently collected data like a forest plan (stand map and data), either on paper or digital format. Alternatively, one might get hold of aerial or satellite photos taken before the storm and covering the damaged areas. The last alternative, but not necessarily the worst, is to describe the pre-storm status based on local knowledge.

Ground based, or terrestrial surveying is suitable both for mapping the extent of damage and for registration of stand damage types. The damage extent can be localised by walking around the damaged area, or by the use of GPS (Global Positioning System) and drawing a map. If the topography allows it, one might also map the damages from a viewpoint, i.e. across a valley. The description of the damage type must, for safety reasons, be made from outside the damaged stand. This will reduce the accuracy of some of the important characteristics mentioned above.

The remote surveying can be carried out by use of helicopter, aeroplane or satellite. Helicopters and aeroplanes could be equipped with cameras both for taking photos and video. Connecting the cameras to the aircraft GPS will geo-reference the photos. Different types of film, i.e. IR-film, will enhance specific features (species, soil type etc.) on the ground. It is not always possible to identify storm damaged forest shortly after the accident, but after a while the more severe damaged trees will be recognisable based on changes in reflection. The use of laser-scanner could also prove to be useful.

Satellite images are collected more or less continuously. Many of these images are of very high resolution and could be helpful in the identification of damaged areas. Also the satellite images are of different types, like panchromatic band or multi-spectral bands (i.e. blue, green, red or near infrared). The images are then analysed in a computer program which performs a digital classification. Several studies with different types of images and analysing programs conclude that the results are promising. Some problems have occurred with identifying small areas of damage and one digital classification method is dependent of leaves on the broadleaved trees for tree identification. This will of course reduce the potential suitability for this method, especially when the leaf-free season corresponds with the winter storm season.

In addition to the forest survey, there is another factor that, depending of the extent of the damage, should also be surveyed:

What resources are available to convert the storm damaged forest to potentially valuable goods?

- The number of local forest workers,
- The number of local forest machines,
- The potentially available numbers on a regional, national and international level.

This topic is covered later in sections 2.4 and 3.4.

2.3 Assessment of the situation

Given the often very complex and varying damage conditions after a storm, no detailed and universally applicable decision rules for harvesting and log conservation can be proposed. However, the following general decision scheme is recommended (Figure 3).

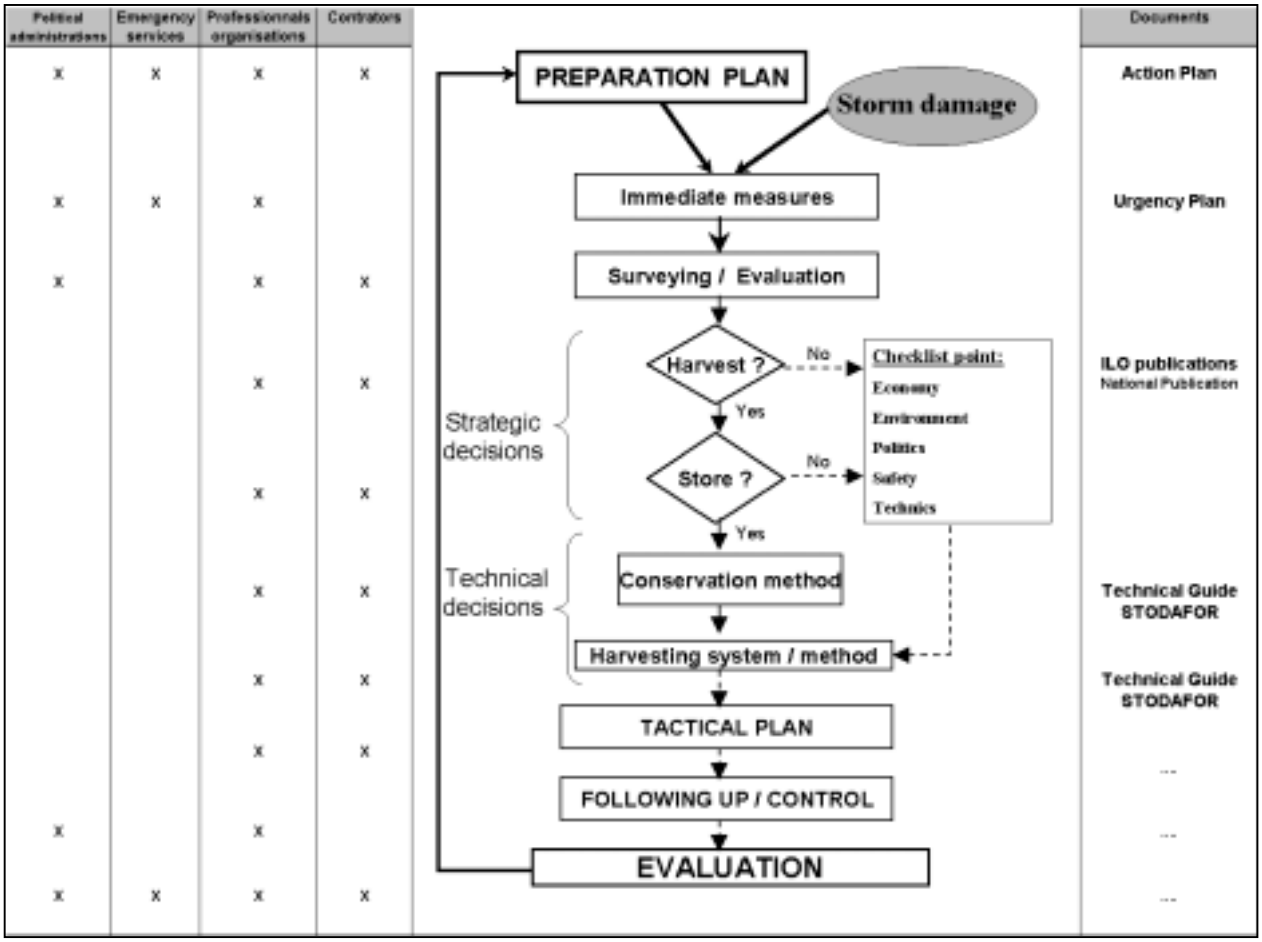


Figure 3: Decision scheme on harvesting and log conservation following a storm

After the immediate measures and the survey following a storm damage two basic decisions have to be taken from a strategic point of view:

- Will the trees be harvested? (or left in the forest?)
- Will the harvested logs be stored before further processing?

If the answer to the first question is negative, no action is required. The reasons for a negative answer can be:

1. Consequential damages for the areas like bark beetle attacks,
2. Management aspects like work safety, utilisation, timber market, conditions for reforestation, influences for game and its potential damage,
3. Ecology and natural protection with regard to modification of habitats and biodiversity,

4. Requirements of the society like recreation, landscape,

5. Economics concerning cost-covering logging and marketing of storm damaged wood,

6. Danger of natural disasters in mountainous terrain, e.g. ground slips, rock falls, fallen timber, erosion,

7. Availability of local and potential forest workers as well as machines.

If the trees are to be harvested, but not stored, a decision must be taken regarding the harvesting system to be used. This choice will be influenced by factors like available machine types, forest conditions and terrain conditions (slope, ground roughness and ground bearing capacity).

Only after a positive answer to these two questions can the choice of a suitable conservation method and a harvesting system come into play. These decisions should be based mainly on technical considerations. The conservation method should normally be selected prior to the harvesting system (based on the selected method of log conservation), because this decision may influence the choice of the harvesting system (e.g. to harvest long poles, or cut to length logs).

The **conservation method options** are detailed in chapter 4.

Storm damage, in general, leads to different patterns of damage on single trees and in stands. The forest manager can select from a number of methods the most suitable conversion method for the wind damaged timber, depending on the susceptibility of the respective wood species, the working capacities and the duration of storage required.

In addition it is important to calculate the effort needed for the conservation, meaning the costs of the ongoing conservation equipment, service etc. An important issue is the choice of the conservation method regarding: storage period, time management, the storage site and tree species.

2.4 Important actors in the operation

There will usually be many different actors involved in the operation after a big storm.

The **forest owners** are a very heterogeneous group; from small private forest owners, through large company forests to state forests. The number of decision makers could be very high. However, in most countries forest owner associations exist, who together with forest authorities on different levels (local, regional and national) would be an important action group close to the forest.

The **forest workers** or entrepreneurs (contractors) have a key role in the operation. Like the forest owners they are also a very heterogeneous group from small one-man firms, entrepreneur groups and company employed entrepreneurs. Large numbers of them are members of national forestry entrepreneur associations. Such associations can provide an efficient communication channel both on national and international levels with respect to moving men and machines, and also regarding the organisational matters connected to working in a foreign country. The European Network of Forest Entrepreneurs [ENFE], which has national entrepreneur associations from 14 European states as members, is an example of an association working at a European level.

Table 1: Support and planning services for foreign contractors

LOGISTICS	**FINANCIAL**
Machine movement	Ensuring payment
Site planning	Bank accounts
Continuity of work	Tax
	VAT
	Measurement and method of payment
SERVICES	**LEGISLATION**
Translation	Working hours
Ensuring immediate access and payment for:	Health and safety
fuel	Lone worker arrangements
repairs and maintenance	Machine standards
supply of spare parts	Certification
accommodation	

The situation for the **timber truck drivers** is quite similar to that of the forest entrepreneurs.

In some areas there could be need for more forest roads (truck roads and forest machine roads). This would involve both **road planners and road construction entrepreneurs**.

The **public road authorities**, both on local, regional and national level, should be able to deal with a situation where the truck traffic intensity would increase dramatically.

Railway companies and shipping lines would also be involved in the timber transport, especially for international transport.

A big storm also creates challenges for the timber market. The **timber buyers** must be able to handle a dramatic change in supply over a short period of time

The **environmental authorities** might get involved in several ways. In connection with the decision of whether to harvest or build a new road or not, the environmental concerns could be the key factor. Also, long-term storage facilities raise environmental issues of considerable importance.

This is only a short presentation of some of the most important actors in the harvesting operation after a storm. No doubt many other actors will also be involved. One major challenge will be to organise this cooperation in a way that minimises additional damage, whether it is related to human, environmental or economic factors.

2.5 Regulations / Laws

A precise knowledge of **national laws and regulations** with respect to log transportation and log storage is essential. Log conservation methods can often be under the control of different authorities. Wet log storage especially (compact piles with water sprinkling or ponding/immersion in fresh water) has different regulations. Please contact local authorities for further information and/or utilise the specialist advice in the conservation section of this technical guide.

The regulations and laws are presented separately for each country. Regulations and laws are available in Annexe 6 for the following countries: Austria, Germany, Denmark, France, Italy, Norway, Portugal, Spain, Switzerland.

2.6 Environmental impacts

Forest operations

The forest operations following a wind throw may have serious impacts upon soil conditions, biodiversity, and water quality. Most often, many trees are uprooted, and salvaging the wood will result in inevitable and heavy disturbance of the soil. Serious consideration should be given to limiting the machinery traffic on vulnerable forest soils (in particular wet soils with high clay content, and organic soils) in order to minimise the effect of soil disturbance and compaction. Machinery with appropriate performance and capacity should be chosen, and whenever possible, traffic on vulnerable soils should be limited to periods of frost or drought.

Care should be taken not to disturb, nor destroy, natural streams and man-made drainage channels to avoid washing soil materials downstream. The denuded, disturbed areas may even be starting points for serious erosion.

Long-term storage of timber

During wet storage of wood (water spraying or immersion in ponds), organic substances are leached from the bark, and to a much smaller extent from the wood. Additionally, small amounts of ionic substances (salts and acids) are leached out, and solid particles are washed from the bark surface. The potential environmentally negative effects of the dissolved and suspended substances can be characterised by the following water properties:

- COD-value (chemical oxygen demand)
The COD-value or the chemical oxygen demand indicates the amount of oxygen necessary for chemical degradation of the slowly decomposing organic compounds contained in the water. In order to evaluate investigation results of wastewater analyses, the guide value given here is the one generally used for municipal wastewater subsequent to biological clarification, i.e. prior to the feeding into natural flowing water. It corresponds to 140 mg COD per litre of water.

- BOD-value (biological oxygen demand)
The BOD-value or the biological (biochemical) oxygen demand indicates the amount of oxygen that is consumed in the course of seven days during degradation of the rapidly degrading, organic compounds contained in the water.

- PH-Value (degree of acidity) and electrical conductivity
The degree of acidity is a measure of the H^+-ion concentration, whereas the electrical conductivity refers to the total load of dissolved ionic substances.

-Plant nutrients and other salts
In addition to ammonium (NH_4) and total nitrogen the investigations occasionally also focus on phosphate, nitrate and nitrite as well as single ions such as metal ions and chloride.

From experience, it is known that the most important property is the oxygen demand (COD- and BOD-values). The runoff water rarely contains toxic levels of any compound, but the breakdown of organic

matter may deprive natural recipients of all oxygen, with detrimental effects upon flora and fauna. The loads of suspended and dissolved matter in the discharge water increase over the first few weeks, or in some cases up to three months. Thereafter, over a period of 1 to 2 years, they return to the original values.

The risk of polluting natural waterways can largely be avoided by recycling the water used for spraying. Simultaneously, the need for fresh water can be greatly reduced. A considerable part of the water is lost to evaporation and to infiltration into the ground, but still practical experience indicates that 50-60% of the water can often be recycled when the storage yard is established on forest or arable land. With wet stores established on a concrete or asphalt surface (e.g. saw mill yard) this figure can be increased.

Storing of round wood in natural, small-scale stagnant water ponds results, as a rule, in interference that cannot be offset and thus permission for such methods is likely to be refused. The leaching of soluble material from the bark and the settling of larger amounts of bark to the bottom may lead to unacceptable damage. Moreover, the riparian zones are considerably damaged, with negative consequences for flora and fauna. Soil material is pushed into the water by the traffic, or washed into the water by subsequent precipitation.

Log storage in larger lakes will hardly affect water quality if the storage zone is confined to only a small proportion of the water surface. In this context, however, concerns of bank protection, nature conservation and species protection as well as possible danger of drifting need to be taken into consideration.

In general, little attention has been paid to the risk of groundwater pollution from dissolved wood and bark constituents infiltrating the ground. As far as the authors are aware, no evidence of groundwater pollution resulting from wood storage has been reported.

Insecticide application

The use of insecticides is restricted in all European countries and should be performed in accordance to national laws. Insecticide treatments are only provided for protection of sawlogs, not for controlling the bark beetle population in general. At sites, where logs are conserved in wet storage, the use of insecticides is ruled out due to their toxic effect on aquatic organisms.

3 HARVESTING

3.1 Introduction

Every year there are storms in Europe which have local importance at least. Storms cause damage to people, buildings, and forests. The people responsible have to react quickly, must think about suitable strategies for storm management and make the right decisions.

The objective of this chapter is to support professional foresters making decisions for harvesting operations in storm damaged areas. The responsible foresters have to solve the problems finding suitable solutions which meet work safety, ergonomic, economic and ecological demands simultaneously.

This part of the Technical Guide particularly is concentrating on “Harvesting”. It gives the user resources and background information on harvesting systems for dealing with different levels of storm management. Suitable methods can be found quickly for various scenarios of storm-damage.

Description of methods will assist the user in finding solutions and aid decision making for dealing with a series of storm events (events that in the future, all European countries will probably face once every 10 years).

The first steps taken in the organisation of harvesting operations in storm-damaged areas are most important. This guide has the capacity to give the practitioner fundamental information on how to avoid economic and ecological errors resulting in financial loss and environmental damages.

In general, forest management after storm events is characterised by fast decision making, acknowledging market conditions. Information for decision making in such situations can be provided by this Guide.

3.2 General considerations

3.2.1 Organisation and Planning

3.2.1.1 Important actors in the operation

- Small and large private forest owners,
- Forest owner associations,
- State forests,
- Forest authorities (local, regional, national),

- Entrepreneurs (contractors) and forest workers,
- Timber hauliers,

- Timber buyers,
- Timber processors (sawmills, pulp and paper mills and board manufacturers),

- Road authorities (local, regional, national),
- Road planners (and constructors),
- Railway companies,
- Shipping lines,

- Environmental authorities (local, regional, national).

3.2.1.2 Work Safety

The urgency of rapidly recovering storm-damaged timber to prevent wood decay, but also for clearing roads, electric lines and so on, must not lead to asking anyone to harvest the trees anyhow and anywhere at anytime. Indeed, working in storm-damaged forests means working in very high-risk conditions.

For example, after the 1991 windstorm, many accidents and deaths occurred during logging operations:

- In Germany, for 60 Million cubic meters, around 50 deaths,
- In Switzerland, 31 deaths and at least 3 836 accidents .

The aim of this chapter is not to attempt to analyse typical dangerous situations and list the appropriate good practices in terms of working methods from the safety point of view: this work has been already done in various national manual guides, or international publications (Manual on Acute Forest Damage, Joint FAO/ECE/ILO Committee on Forest Technology, Management and Training).

Rather, we would like to draw the attention of the reader to three different aspects that are of primary importance for the reader who is on the point of starting salvage operations, in his own country or another one, and who wants to ensure a maximum of safety in the logging operations. First, of course, special care must be given to **regulations** concerning operator health and safety. The second important issue is that only **trained people** should work in storm-damaged forest. Thirdly, even experienced people should remain on their guard even if they tend, with time, to carry out salvaging operations from habit: they must **keep in mind the typical high-risk situations** that can lead to a fatal accident at anytime.

❑ **Watch Regulation**

The health and safety regulations may be:

- **Basic rules** defined at the EU level but differently transcribed in national Codes (regulations concerning risk evaluation for example),
- Or **temporary/specific regulations** specially produced, at the national level, to face the catastrophe.

As the first regulations can be modified at anytime and the second are by nature unknown before the event, we recommend the reader to **contact the national organisations** listed in Annexes 8 and 9 to get the appropriate and detailed information regarding national health and safety regulations that he/she will have to comply with if working in storm-damaged forest.

❑ **Be trained**

When it comes to recover storm damaged forests, the observation of what happened in France after Lothar and Martin windstorms in December 1999 can be very useful to demonstrate **the need of training, even for professional loggers**:

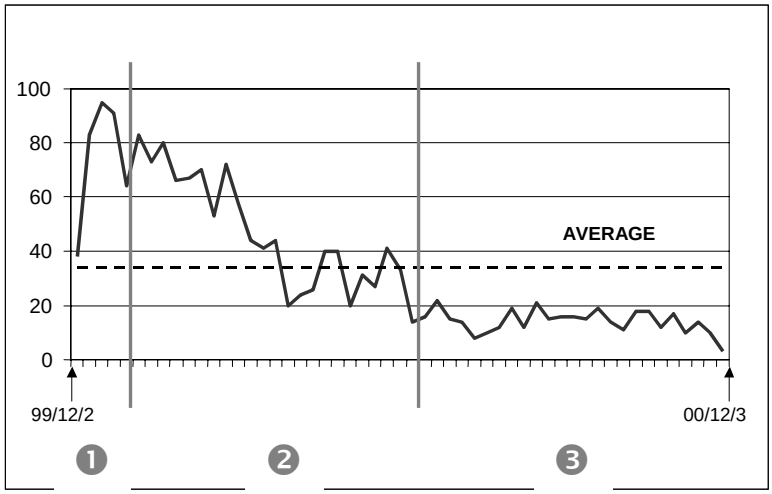


Figure 4: Number of accidents per week in 2000, in France, during logging operations in storm damaged forests

During the very first days following the windstorm ❶ a terrible increase occurred in the number of accidents, concerning both professional loggers and non-professional people (firemen, army, farmers) who "cleared" roads, parks and gardens, etc. For the latter, it is clear than the lack of basic skills and know-how in working with a chainsaw is an important handicap for processing dangerous trees that require special techniques.

A few weeks after the windstorms ❷ a decrease in the number of accidents and stabilisation at a level just a little bit higher than usual, for mainly professional loggers, more or less trained and experienced in working in storm damaged forest salvage operations. This second phase illustrates very well the fact that even professional loggers cannot properly handle the extra risks associated with damaged trees: indeed, in "normal time", they do not have the opportunity to regularly apply and practise the specific techniques and their competence in these situations.

A few months after the windstorms ❸ a new rise and fall in the number of accidents concerning mainly experienced loggers. This can be attributed to the acceptance of the operators to the danger, who, little by little, while increasing their competence in working storm-damaged forest feel more relaxed, and as a result lose concentration.

Training, or at least information, can be provided by many different means and supports organisations. Various initiatives can be undertaken in the different countries, and they are very often complementary:

- Publications: safety guides, booklets, articles in magazines for loggers
- Films and videos
- On site refresher training.

When a windstorm occurs, all kinds of pre-existing publications (safety guides, booklets, etc.) should be distributed to the professional workforce as soon as possible. This action should also be complemented by providing information for the non-professional workers, the general public.

On site training is definitely a really good way to "refresh" logger's knowledge and competence in logging operations in storm-damaged forest. A typical training program (3 – 4 days) could include the identification of the different kinds of damage, the organisation of the logging operations, the equipment (chain saw, safety equipment), risk assessment and emergency procedures. Safety guides are pedagogic documents that can be used for these training sessions. In the UK, for example, specific certificates of competence based on training programmes and assessment are required for working in storm damaged forests (NPTC contact reference under UK in Annexe 9).

As for regulations, we recommend the reader **to contact the national organisations** listed in Annexe 8 to get up to date appropriate documentation or practical information for refresher training.

❑ **Keep in mind typical high risk situations**

When we talk about safety in storm damaged forest, in general, we immediately think of chainsaw operators. But all operators are at risk, especially when different types of machinery (skidder, harvester, forwarder, chain saw) work simultaneously on the same logging site.

We describe in Annexe 3 some real and typical accidents that occurred after the Martin and Lothar windstorms in France:

- To chainsaw operators,
- In semi-mechanised logging operations,
- In fully mechanised logging operations.

Accidents can never be ruled out

But working conditions and working techniques can be made safer.

It cannot be denied that the harvesting of windthrown trees is particularly dangerous and requires specific care. According to the European directive “Risks prevention”:

- As a priority, the source of risk should be eliminated as far as possible,
- Furthermore, the secondary risks should be identified, localised and characterised in order to avoid them and to minimise their consequences in terms of frequency and severity.

Three main areas should be developed:

1. Awareness of the risks
2. Increased competence through training
3. The technical means and management must be adapted to the needs and the field reality

3.2.1.3 Recommendation for Log measurement of storm damaged roundwood

Generally measurement can be separated into two main systems, by manual methods in the forest stand, or by harvester head, at forest road, or at mill site. The place and method of measurement do naturally vary in accuracy and costs.

Logging systems under storm conditions possess their own character. They differ from normal systems. Time pressures and harvesting processes are dominant factors. Log measurement is one part of the logistics, but an important one. It can lead to temporal interruptions in the logistics. The harvesting process can be affected. Above all mechanised harvesting systems are especially affected.

It is important that the basis of sales measure is agreed between all parties particularly as the measurement conventions and units differ between countries.

There are different objectives for log measurement independent of the harvesting system: standing timber measurement; for the sale of round-wood; for payments to contractors and forest workers.

Before choosing a measurement method consideration should be given to the degree of accuracy and costs in relation to the storm damage in terms of the amount of removals and the area. This means that measurement methods can be applied which do not fulfil normal standards. They can be used because of high practicability and less impact on the harvesting process. Examples are representative sampling methods of measurement. They can lead to sufficient accuracy of results by measuring a large number of logs.

Experiences handling the removals of storm damaged forests show that in most cases there are repeated measurements of the same timber which is time consuming and hence costly. For example logs are measured in the forest and also on delivery at the mill site after conservation. Qualified personnel are important for measurement in the forest. In such cases personnel could be used for more important tasks.

Exact measurements in the forest are not necessary for such assortments which get a sales measure on delivery at the mill site in due course. The following two tables show potential measurement methods and their priorities for manual and mechanised harvesting methods. The results are based on the experience of the marketing of roughly 45 million cubic meters in Baden-Württemberg, South-West-Germany (**Table. 2 and 3**) related to the windfalls in 1990 (Vivian, Wiebke) and 1999 (Lothar).

Table 2: Log measurement – manual harvesting methods

ASSORTMENT	PRIORITY			Control measure
	1.	2.	3.	
Long softwood logs with mid-diameter from 15 cm	Measurement on delivery at mill site[1]	Measurement in forest: length and sampling of mid-diameter [4]	Measurement in forest: length and mid-diameter	Measurement in forest: number of logs
Long softwood logs [under bark]	Measurement on delivery at mill site[1]	Measurement by a barking machine[2]	Measurement in forest: length and (sampling of) mid-diameter [4]	Measurement in forest: number of logs
Hardwood logs with mid-diameter from 35 cm	* Measurement on delivery at mill site[1]	Measurement in forest: length and mid-diameter	Measurement in forest: length and sampling of mid-diameter [4]	Measurement in forest: number of logs
Industrial wood, (soft- and hardwood)	Measurement on delivery at mill site[1] (Dimension and Weight)	Measurement on delivery at mill side (Dimension and Weight)	Measurement in forest: length and sampling of mid-diameter [4]	Measurement in forest: number of logs or sampling of industrial wood

Table 3: Log measurement - mechanised harvesting methods

ASSORTMENT	PRIORITY			Control measure
	1.	2.	3.	
Long softwood logs with mid-diameter from 15 cm	Measurement on delivery at mill site[1]	Measurement in forest: length and sampling of mid-diameter [4]	Measurement in forest: length and mid-diameter or harvester measurement[3]	Harvester measurement: number of logs
Short softwood with mid-diameter from 15 cm	Measurement on delivery at mill site[1]	Measurement in forest: special sampling measurement method	Harvester measurement [3]	Harvester measurement: number of logs
Hardwood logs with mid-diameter from 35 cm	Measurement on delivery at mill site[1]	Measurement in forest: length and mid-diameter	Measurement in forest: length and sampling of mid-diameter	Harvester measurement: number of logs
Industrial wood, (soft- and hardwood)	Measurement on delivery at mill site[1] (dimension and weight)	Measurement in forest: special sampling measurement method or measurement on delivery at mill side (dimension and weight)	Harvester measurement[3]	Harvester measurement: number of logs or harvester volume

(Written agreement between the State Forest Administration of Baden-Württemberg and the Timber Industry).

Notes:

1 Regional known customer, round-wood for storage under drying conditions,
2 Calibration and section measurement,
3 Modified measurement (marking of 1m on the reference log or standardised lengths measured by contractor or by managing forester,
4 Large round-wood volume for storage under water: weighing of the loaded trucks and calculating of the volume from the weight,
* This method has not been practised yet.

3.2.1.4 Marking roundwood

The identification of roundwood is an important element in the management of sawmill supply. In addition. control of the raw material cost, through accurate identification allowing secure inventory, is a determining factor in profitable operations.

Most of the time, the supplied information covers the following fields:
- Identification of the supplier,
- Type of product and species,
- Grade and quality marks,
- Dimensions,
- Number of pieces,
- Date of production.

Different identification systems are used to register the information between forest and sawmill. Manual marking is most commonly used, but stacking automation encourages the development of marking automation, thanks to the introduction of the systematic use of barcodes.

Two main systems for identification are used:
a) Individual log identification (each log)
b) Batch identification

Utilisation of GIS (Geographic Information System) and GPS (Global Positioning System) enhances greatly information in the supply chain. This log or batch information is registered in the sawmill log yard. Additionally, the weight and/or the volume may be added by use of a scanner.

It is very common today to use plastic identification tags on high quality timber (both for hardwood and softwood).

The identification system is either a number or a barcode carrying a great deal of information. An optical reader device is used to identify the log or the batch in the forest or at the sawmill. Because of difficult working conditions in the forest (water, dust, mud, etc.) reading accuracy of the barcode is often quite low. The Radio Frequency Identification Tag can be used with a very high reading accuracy (nearly 100 %). Reading range, depending on the reading device or antenna, can reach up to 1 meter.

It is possible to include such RFID in the plastic tag. Some solutions exist to recycle the electronic chip as well as the “domino tag”. The chip is placed on a strong plastic domino which is impact resistant. This domino is just under the usual plastic tag set up on the log. The domino, after the reading operation in the sawmill, can be removed and the chip re-used.

In sawmill conditions, the reliability of reading is often not satisfactory especially with regard to big logs so other types of electronic chips are now available. Other types of RFID can be used as transponders. There are electronic devices with an antenna and a condenser in a glass capsule. Some are active; it means that new information can be added to them, others are passive with only an identification number.

Applications can be done manually after drilling a hole in the wood. A prototype has been developed in Sweden for an automatic application with the harvester head.

New research are ongoing with use of UV sensitive painting which are quiet easy to read in the sawmill entrance. Great developments are expected on this field in the forest sector.

3.3 Harvesting operations – methods and systems

This chapter gives an overview of the most relevant harvesting systems used in Europe after the storm of December 1999. Suitable harvesting systems for storm conditions are described in terms of the forest machines used and the place where the respective work is done. Working range, advantages, and disadvantages are described, and practical information provided.

The most important factors influencing harvesting operations and which should be considered before selecting suitable harvesting methods and systems are the following:

+ Site and terrain,
+ Forest openings like skid trail systems,
+ Kind of damage: single, group or space damage,
+ Species and tree size,
+ Assortments,
+ Debarking,
+ Landing sites and storage on site,
+ Transport,
+ Clearing operations and reforestation,
+ Availability of forest workers and machines.

Figure 5 indicates how the place where the work task is done in the forest varies from one system to another. The systems H, C and A, illustrated below, are fully explained further down in this section.

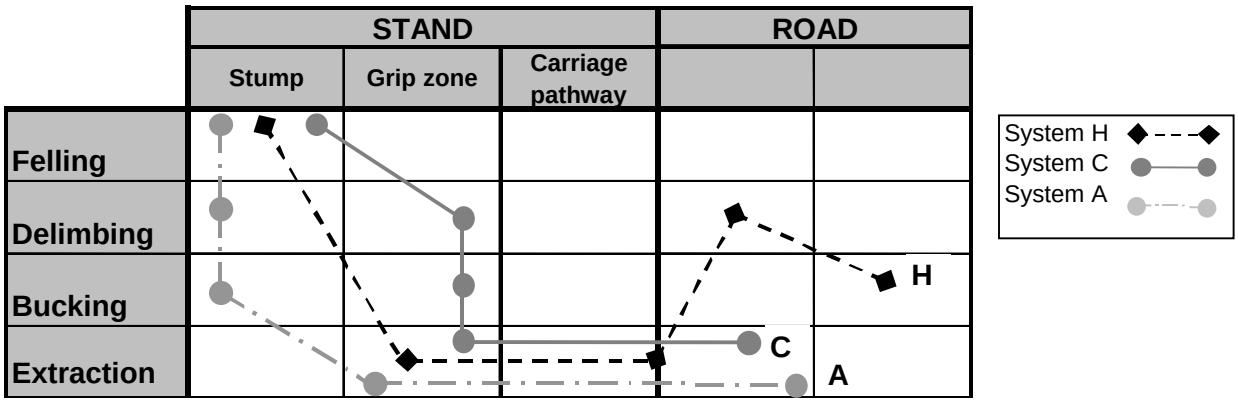
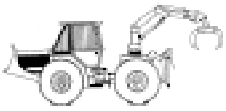


Figure 5: Example of places of the work tasks for three different harvesting systems

The different types of forest machines used in storm damaged forests in Europe are listed in Table 4.

Table 4: Types of forest machines used in storm damaged forests in Europe

FOREST MACHINES AND EQUIPMENT			
	Chain saw		Wheeled or tracked harvester
	Farm tractor		Chipper
	Grapple skidder		Cable skidder
	Forwarder		Clam-bunk skidder
	Wheeled or tracked excavator		Cable yarder Cable yarder with processor head
	Processor		Helicopter

The places where the operations are performed are symbolised in Table 5

Table 5: Location of harvesting operations

Place, where the respective work is done	
	Stand – Damaged area
	Stand – Cleaned area
	Forest road, landing place

Ten different harvesting systems illustrated in this Technical Guide are divided into three main groups:

- **Ground-based**
- **Cable yarder**
- **Chipping**

The harvesting systems, main descriptions and notes are summarised in Table 6, and detailed information on working range, advantages, disadvantages and practical information on each system follows.

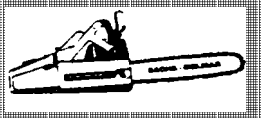
Table 6: Harvesting systems used in storm damaged forests in Europe

System ref.	Brief description	Notes
Ground based		
A	**Motor manual** - all operations carried out in damaged area	
B	**Motor manual** - felling, mechanical separation and motor manual delimbing and bucking in cleared area	Case study available
C	**Partially mechanised –** motor manual felling – mechanised separation, delimbing and bucking in cleared area	Case study available
D	**Fully mechanised**	Case study available
E	**Partially mechanised –** motor manual felling – mechanised separation, delimbing and bucking in damaged area	Case study available
Cable yarder		
F	**Motor manual** – all operations carried out in damage area	
G	**Motor manual** – felling only in damaged area, delimbing and bucking on landing	
H	**Partially mechanised –** motor manual felling – mechanised delimbing and bucking on landing	Case study available
Chipping		
I	**Chipping in stand**	
J	**Chipping at landing**	

3.3.1 Ground-based harvesting systems

3.3.1.1 Harvesting system A

Motor manual - all operations carried out in damaged area.

Cutting	Delimbing	Bucking	Extraction	Piling	
			  		**System No. A**

Working range:	▪ Single/group and area damage for wheeled machine ▪ Softwood and hardwood ▪ Flat terrain until slope < 35 %
Advantages:	▪ Low capital investment for felling operation ▪ Easy organisation and planning because it is a cold system
Disadvantages:	▪ Motor manual cutting of the stem from the stump ▪ Work safety in motor-manual operation, high risk of injuries ▪ Low productivity of motor-manual cutting and processing ▪ Ground slope and size of timber set the limit for forwarder ▪ No computer based bucking system support for log measurement

Practical information:

- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations
- ☞ The machine must use the existing skid-trail system (which must be documented)

3.3.1.2 Harvesting system B

Motor manual - felling, mechanical separation and motor manual delimbing and bucking in cleared area.

Cutting	Separation	Delimbing	Bucking	Extraction	Piling	
	 			 	 	**System No. B**

Working range:	▪ Area damage > 1 ha with regard to excavator for separation ▪ Softwood and hardwood ▪ Also suitable for heavily branched trees ▪ Flat and moderate terrain with regard to excavator for separation, independent for cable skidder
Advantages:	▪ Work safety because of machine support, above all with excavator ▪ Processing of valuable assortments (manual bucking) ▪ Low capital investment and instant availability of equipment ▪ Potential recovery of slash by chipper ▪ Easy organisation and planning because of a cold system
Disadvantages:	▪ Motor manual cutting of the stem from the stump ▪ Work safety in motor-manual operation, high risk of injuries ▪ Low productivity in small-sized timber ▪ Leaving slash on the stand, clearing operations to prepare an active reforestation ▪ High intensity of crossings using the excavator with a short boom reach ▪ No computer based bucking system support for log measurement

Practical information:

- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations
- ☞ Balanced operation requires two forwarding units
- ☞ Small-sized timber and residues can be chipped at the landing
- ☞ Use radio communication systems
- ☞ Use of farm tractors + trailer as forwarder + loading by excavator
- ☞ Flexible harvesting system without slope and stand restriction concerning with using cable skidders
- ☞ With regard to cable skidder, soil preservation is improved because of distances for skid trails > 20 m (provided it is respected)

Harvesting system B
Case study from the Danish State Forest

Harvesting system for hardwood
Cutting, delimbing and bucking by chain saw with some aid from a medium size excavator. Extraction by a cable skidder for big logs and in some cases a forwarder for the smaller logs.

Tree size	> 1 m^3
Resources Workers Machines / equipment	 3-4 forest workers 1 tracked excavator with grapple > 10 tonnes 1 cable skidder and / or a forwarder
Assortments	**Cut to length**
Productivity for the whole system (3-4 workers, excavator and skidder/forwarder)	100 – 150 m^3 / day

Practical recommendations

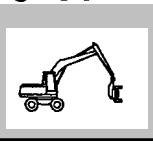
Cutting, delimbing and bucking are done in the stand by chainsaw. Some assistance from the excavator is necessary to separate trees and logs and organise them for the following extraction.

Extraction and piling is done by cable, or a grapple skidder for extraction of the bigger logs, forwarders are more efficient to do the extraction of small logs.

Comments: This method is rather hard for the soil because of a lot of unplanned driving all over the stand. It could be less damaging to the soil using the whole tree method: Cutting with chain saw, carrying out a light delimbing in the stand and then extracting the whole tree to a landing with a cable, or grapple skidder. Bucking and piling on the landing with some assistance from the excavator. This method has the same productivity, or even higher, than the method above. Furthermore there will be less driving in the stand.

3.3.1.3 Harvesting system C

Partially mechanised – motor manual felling, mechanised separation, delimbing and bucking in damaged area.

Cutting	Separation	Delimbing	Bucking	Extraction	Piling	
		 		  		**System No. C**

Working range:	▪ Single/group and area damage for wheeled machines ▪ Area damage > 2 ha for tracked machines ▪ Above all softwood, no large-sized hardwood ▪ Flat terrain until slope < 35%
Advantages:	▪ High productivity for processing and skidding, recover in short time ▪ Wheeled machines: greater flexibility for moving within the forest area ▪ Tracked machines: larger heads able to give greater stability ▪ Slash on the skid trails effect cost savings for clearing operations and reforestation ▪ Low abrasion of harvester chain
Disadvantages:	▪ Motor manual cutting of the stem from the stump ▪ Work safety in motor-manual operation, high risk of injuries ▪ High requirements for organisation, planning and coordination ▪ High intensity of crossings because of distances for skid trails < 20 m ▪ Slope and size of timber limit for harvester and forwarder ▪ High investment required

Practical information:

- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations
- ☞ On steep terrain, use 8x8 forwarders
- ☞ Larger-sized machines are necessary for storm damaged areas compare with normal conditions.
- ☞ Use radio communication systems

Harvesting system C
Case study from the Danish State Forest

Harvesting system for softwood < 0,75 m^3.
Cutting by chain saw. Separation, delimbing and bucking by harvester. Extraction and piling by forwarder.

Tree size	< 0.75 m^3	
Resources Workers Machines / equipment	 1-2 forest workers (CU) 1 medium to large size harvester (HA) 1 forwarder (TRA)	
Assortments	**Whole tree length**	**Cut to length**
Productivity /CU	10-15 m^3/h	10-15 m^3/h
Productivity /HA	14-17 m^3/h	12-15 m^3/h
Productivity /TRA	20-30m^3/h	10-15 m^3/h

Practical recommendations

Cutting: It is common to use a powerful chainsaw with an 450mm bar. Cut the trees as close to the stump as possible to avoid breakage in the timber. It would be better to combine two chainsaw operators with two harvesters. This would avoid one chainsaw operator having to commute between two harvesters. It is important that one chainsaw operator is connected to the same harvester all the time to give a close relationship between him and the harvester operator.

Separation, delimbing and bucking. The harvester has to be in the medium to large size (class II to III). Small harvesters do not have enough capacity in the hydraulic system, and have problems with stability. The harvester has to work in lines 45 to 90 degrees to the direction of the windblown trees.

Extraction and piling. A forwarder fitted with a clambunk extracts the full-length timber and piles it by the roadside at an angle of 90 degrees. A standard forwarder extracts the cut to length timber and piles it by the roadside. It is important that both the front and the back of the pile can be measured.

Harvesting system C and D
Case study from mechanised and partially mechanised harvesting in France

Semi-mechanised or fully mechanised?

From a national observation network based on 30 single-grip harvesters run by skilled operators to provide reliable information on methods, productivity, cost and health and safety for contractors, 71 labour days have been studied. Despite varying contexts and different machines, contractors use *very similar methods. But there are 2 important facts to note:*

❶ A return to the semi-mechanised harvesting process in conifer stands. A lot of contractors decided to pay a chainsaw operator to severe the stumps from uprooted trees.

❷ The start of use of machines to harvest hardwoods. Several contractors developed an innovative concept using harvesters to harvest chestnut coppices blown down by the windstorms.

Numerous sources for productivity loss, but with more or less important impact

- **Considering stands with similar average tree volume, productivity is higher in conifer stands than in broadleaved stands.** But 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 of Productive Machine Hours/Total Machine Hours averaged 86%,** and this is the fact of "classical" downtime due to breakdowns, telephone calls, etc.
- **We identified several factors specific to operations in windblow that can limit more or less the productive yield of the harvesters.**

Table I: In recovering windblown trees, the global loss of productivity can vary between a few percent to 50%, depending on the stand features and the method applied

Factor source of productivity loss	Average impact on harvester productive yield	Maximum impact on harvester productive yield
Uprooted trees	-14 to -4 % depending on stem volume* [70% of the trees are uprooted]	-20 to -6% depending on stem volume * [100% of the trees are uprooted
Uprooted trees severed from the stumps (by a chainsaw operator)	Negligible	
Broken trees (merchantable pieces)	-6 to –4% [15% of the trees are broken]	-40 to –24% [100% of the trees are broken]
Un-merchantable pieces (broken tree tops or butts) removal	-1.5% [if < 100/ha]	-12 % [400-500 / ha]
Delay due to the chainsaw operator	-2.5%	-12%
Single direction work **	-7%	-15%
Stumps replacing	-1%	-4.5%
Unsuccessful jammed trees extraction	-1%	-5%
Harvester chainsaw replacement	-1%	-6%

** for stands with an average stem volume between 150 and 700 dm^3 only.*

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

A good quality job

Most of the time, operators met the specifications and did not cause any extra wood-breakage, roundwood piles are organised so that they do not compromise the haulage, etc.

Security : frequent failures

In 75% of the semi-mechanised operations we studied, we observed interference between the chainsaw operator and the harvester: the harvester stopped because the manual operator is too close to the machine. This incurs a lot of risk.

About costs: no general conclusion

- We studied maintenance and repair costs on 15 harvesters processing windblow for more than one year. Perhaps because most of them were under 2 years old, we did not note any obvious rise in maintenance and repair costs. But this could happen in the near future.

- For contractors working semi-mechanised systems, the principle extra-cost is the payment for the chainsaw operator. The problem is that depending on the kind of machine but also the stand 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 the fully mechanised system:

  ❶ if you estimate that the productivity loss (if no chainsaw operator) will remain under 25 or 30%

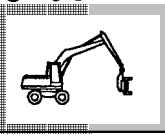
  ❷ if trees to be harvested are small sized (< 200 dm^3), because then it will be hard to negotiate low value products at a price including the extra-cost (≈ + 1,52€/unit).

Perspectives

- To study the evolution in the next few years of repair and maintenance costs to quantify the real impact of windblow operations on machine repair and maintenance costs.
- To retain the observation network on machines working in broadleaved stands.

3.3.1.4 Harvesting system D.

Fully mechanised.

Cutting	Separation	Delimbing	Bucking	Extraction	Piling	
	 			  		**System No. D**

Working range:	▪ Single/group and area damage for wheeled machines ▪ Area damage > 2 ha for tracked machines ▪ Above all softwood, no large-sized hardwood ▪ Flat terrain until slope < 35%.
Advantages:	▪ High work safety because of mechanised cutting of stems from stump ▪ High productivity for processing and skidding ▪ Wheeled machines: greater flexibility for moving within the forest area ▪ Tracked machines: larger head because of higher stability ▪ Organisation and planning ▪ Slash on the skid trails effect cost savings for clearing operations and reforestation
Disadvantages:	▪ High abrasion of harvester chain ▪ High intensity of crossings because of distances for skid trails < 20 m ▪ Slope and size of timber limit for harvester and forwarder ▪ High investment required

Practical information:

☞ Larger-sized machines are necessary for storm damaged areas compared with normal conditions.

Harvesting system D
Case study from mechanised harvesting in Germany

Fully mechanised (Test Wildbad , 2000):
Harvesting by tracked harvester, extraction by forwarder

The tracked harvester "Königstiger" was processing short wood uphill. A Forwarder Valmet 860 carried out extraction (slope 30 – 50 %). The distances between the skid trails were planned by the local forest administration – at first 30m and then with experience extended to 50m.

Results - Harvester:
Altogether the harvester processed a number of 5144 trees with a total volume of 3696 m^3. The averaged productivity was 12,7 m^3/h (17,7 trees/h).

Compared to the production in non-storm damaged areas there was an averaged reduction of productivity of 18% in similar topographic conditions.

During the observation period the following allocation of the work elements was measured:

70%	processing
4%	transport from skid trail to skid trail
6%	repairs
14%	break
6%	service

Machine availability was 74% of the total working time.

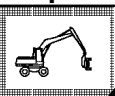
Results - Forwarder:
There were 11 studies in total. The extracted volume was 98,5 m^3 equivalent to 9 m^3/turn.

The averaged production was 16,4 m^3/h. The large number of available logs in storm-damaged areas (300 m^3/hectare) increases the output substantially.

The productivity of the forwarder was 3 m^3/h more than the harvester. This caused problems in co-ordination.

3.3.1.5 Harvesting system E.

Partially mechanised – motor manual felling, mechanised separation, delimbing and bucking in cleared area.

Cutting	Separation	Delimbing	Bucking	Extraction	Piling	
	 			  		**System No. E**

Working range:	▪ Area damage > 2 ha ▪ Softwood, mixed stands, no large-sized hardwood ▪ No small-sized timber ▪ Flat and moderate terrain
Advantages:	▪ Work safety because of machine support ▪ High productivity for processing and skidding ▪ Preservation of natural regeneration ▪ Slash on the skid trails effect cost savings for clearing operations and reforestation
Disadvantages:	▪ High intensity of crossings ▪ Motor manual cutting of the stem from the stump ▪ Work safety in motor-manual operation, high risk of injuries

Practical information:

- ☞ Suitable harvesting system for large-sized softwood stands over natural regeneration
- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations

Harvesting system E
Case study from the Danish State Forest

Harvesting system for softwood > 0.75 m^3.
Cutting by chain saw. Separation and piling in rows by a tracked excavator with grapple. Delimbing and bucking by harvester. Extraction and piling by forwarder.

Tree size	> 0.75 m^3	
Resources Workers Machines / equipment	 2-3 forest workers (CU) 1 tracked excavator + grapple > 20 ton (GRA) 1 large size harvester (HA) 1 forwarder with clambunk (TRA)	
Assortments	**Whole tree length**	**Cut to length**
Productivity/CU	7-10 m^3/h	7-10 m^3/h
Productivity /GRA	20-30 m^3/h	20-30 m^3/h
Productivity /HA	20-30 m^3/h	15-30 m^3/h
Productivity /TRA	25-30 m^3/h	10-15 m^3/h

Practical recommendations

Cutting: It is common to use a powerful chainsaw with at least an 450mm bar. Cut the trees as close to the stump as possible to avoid breakage in the timber. It would be better to combine two chainsaw operators with two harvesters. This would avoid one chainsaw operator having to commute between two harvesters. It is important that one chainsaw operator is connected to the same harvester all the time to give a close relationship between him and the harvester operator.

Separation and piling in rows. The excavator must have a weight of at least 20 tonnes equipped with a heavy grapple and must have a reach of at least 8 meters. The rotator must be able to handle loads of at least 20 tonnes. The work is done in rows of 10 meters and at an angel of 45 degrees compared to the direction of the windblown timber.

Delimbing and bucking. The harvester has to be in the large size (class III). There is a need of a large capacity on the hydraulic system and lot a of stability to handle these large trees

Extraction and piling. A forwarder fitted with a clambunk extracts the full-length timber and piles it by the roadside at an angle of 90 degrees. A standard forwarder extracts the cut to length timber and piles it by the roadside. It is important that both the front and the back of the pile can be measured.

3.3.2 Cable yarder system

3.3.2.1 Harvesting system F.

Motor manual – all operations carried out in damage area.

Cutting	Delimbing	Bucking	Extraction	Piling	
					**System No. F**

Working range:	▪ Area damage with a skidding volume > 500 m³ ▪ Softwood and hardwood ▪ No small-sized timber ▪ All slopes
Advantages:	▪ Easy organisation ▪ Processing and skidding can be separated (cold system) ▪ High soil preservation because of lower impacts
Disadvantages:	▪ Motor manual cutting of the stem from the stump on slopes ▪ Work safety in motor-manual operation, high risk of injuries ▪ Less productivity ▪ Higher harvesting costs because of moving and setting times of the cable yarder ▪ Leaving slash on the stand ▪ Clearing operations to prepare an active reforestation

Practical information:

- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations
- ☞ Availability of enough landing space
- ☞ Uphill extraction provokes less problems
- ☞ Necessity of radio-communication between the hooking crew and winch operator

3.3.2.2 Harvesting system G.

Motor manual – felling only in damaged area, delimbing and bucking on landing.

Cutting	Separation	Extraction	Delimbing	Bucking	Piling	
						**System No. G**

Working range:	▪ Area damage with a skidding volume > 500 m³ ▪ Softwood and hardwood ▪ No small-sized and overlarge-sized timber ▪ All slopes
Advantages:	▪ Processing on the forest road favours work safety ▪ High soil preservation because of less impacts ▪ Necessity of clearing operations ▪ Increased productivity by extraction of stems and safer work on forest roads ▪ Recovery of slash
Disadvantages	▪ Motor manual cutting of the stem from the stump on slopes ▪ Work safety in motor-manual operation, high risk of injuries ▪ High requirements for organisation, planning and coordination ▪ Necessity of a large-sized mobile cable yarder ▪ Removal of slash to the landings ▪ Hauling also of less valuable assortments ▪ Necessity of a large landing space and of a continuous removal of the processed logs ▪ Higher harvesting costs because of moving and setting times of the cable yarder ▪ High risk work for separation by the cable yarder

Practical information:

- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations
- ☞ Necessity of a good road network
- ☞ Availability of enough landing space
- ☞ Uphill extraction provokes less problems
- ☞ Necessity of radio-communication between the hooking crew and the winch operator

3.3.2.3 Harvesting system H.

Partially mechanised – motor manual felling, mechanised delimbing and bucking on landing.

Cutting	Separation	Extraction	Delimbing	Bucking	Piling	
			 		 	**System No. H**

Working range	▪ Area damage with a skidding volume > 500 m³ ▪ Softwood and hardwood ▪ All slopes
Advantages	▪ Mechanised processing on the forest road favours work safety ▪ High soil preservation because of less impacts ▪ High productivity by extraction of stems and for mechanised processing ▪ No necessity of clearing operations
Disadvantages	▪ Motor manual cutting of the stem from the stump on slopes ▪ Work safety in motor-manual operation, high risk of injuries ▪ High requirements for organisation, planning and coordination ▪ Necessity of a large-sized mobile cable yarder ▪ Removal of slash on the landings ▪ Hauling also of less valuable assortments ▪ Necessity of a large landing space and of a continuous removal of the processed logs ▪ Higher harvesting costs because of moving and setting times of the cable yarder

Practical information:

- ☞ Timber fellers must not work alone
- ☞ Necessity of operator training for the felling operations
- ☞ Necessity of a good road network
- ☞ Availability of enough landing space
- ☞ Necessity of radio-communication between the hooking crew and the winch operator
- ☞ Possibility of direct loading by trucks after processing by the harvester or excavator with processor head

Harvesting system H
Case study from mechanised harvesting in Germany

Semi mechanised (Test Wildbad, 2000)
Yarder extraction and mechanised processing at landing.

A forest worker bucked the fallen trees (mostly downhill). Afterwards the trees were skidded with a sky line, a “primitive carriage” and a drag rope to the installation site of the yarder. The crane of the yarder manoeuvred the logs parallel to the forest road for later processing by a processor.

Results - Skidding with the yarder:

During the observation period (23 days) the following allocation of the work elements was measured:

72%	rope skidding
7%	reconstruction
8%	repairs
13%	break

Machine availability was 80% of the total working time, as a result of the robust status of the machine.

In total there were 26 skidding trails processed during the time of the study. The movement time from trail to trail took 31 min. The actual capacity per work time hour was 12,1 m^3/h.

Results - Processing with the harvester

The yarder was used in tandem with a harvester (Timberjack 762B) at the landing site. The harvester processed the skidded trees to short wood and manoeuvred them for loading onto lorry transport. The high self weight of the machine and the robust crane allowed the piled logs to be manoeuvred efficiently.

3.3.3 Chipping harvesting systems for whole trees

Storm damaged stands offer a special opportunity to the production of whole-tree chips, for at least two reasons:

- The wood is often so degraded by breakage and/or poor storage that it cannot be profitably converted into sawlogs, pulpwood logs or other traditional assortments,
- The market is already flooded with such a wide choice of timber assortments that it may be difficult to sell low quality sawlogs and pulpwood.

When the windblown trees are too small or too decayed for being profitably converted into traditional timber assortments, one may chip them whole, saving a lot of time and handling. One may envisage two main systems, based on where chipping takes place; in the stand or at a landing.

Harvesting is economically viable only on terrain that is accessible to the extraction vehicles. Whether the trees are chipped in the stand or taken to a landing, they must be severed from the stumps and gathered in bunches. This is best done with an excavator, equipped with a grapple-saw. Such a machine allows for fast and safe operation, and is cheaper than a feller-buncher or a harvester.

Chipping windblown timber is a special job that poses its own technical problems.

First, the wood to be chipped contains a high percentage of branch material, which is best chipped with a drum chipper rather than a disc chipper. Drum chippers do a better job when treating branch wood, as their chipping device has no slots that can allow small sticks to pass through the machine virtually untouched. In addition, a screen can be installed right behind the drum, at the outlet, so that particles longer than the pre-set value cannot go through the chipper and are fed back to the drum for refining. Since disc chippers have long radial slots in their chipping device and cannot be fitted with a screen, they are preferably used with stem wood, rather than branchwood. To remedy that, new disc chippers can be fitted with an optional screen mounted in the slot just behind the knives or in the casing at the entrance into the spout: these machines produce high-quality chips and can match the quality standards obtained by drum chippers.

Second, windblown wood tagged for chipping is often old and may be considerably decayed. This constitutes a problem for any chipper.

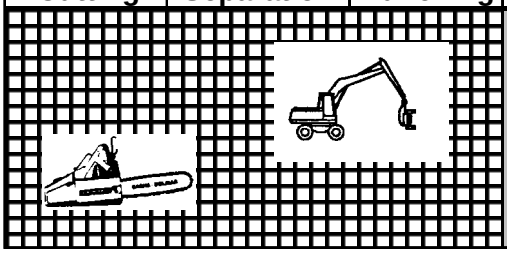
If the wood is just dry, it is important that the moisture content is not too low, or chipping will produce a lot of dust, causing discomfort for the operator and a serious fire hazard. Wood dust is highly flammable: if it sits for too long on the chipper's hot engine and exhaust, it may generate an outbreak of fire. For this reason, it is important that the operator is housed in a closed cab, or at least that he wears a dust mask and goggles. It is also important that the work is stopped every so often and the dust is blown away from the chipper's engine with compressed air.

If the wood is decayed and wet, then it will produce a very poor fuel and it will tend to plug the drum pockets and the chip outlet. For this reason, decayed wood should be fed a little at a time, possibly alternating it with sound wood to clean the machine.

3.3.3.1 Harvesting system I.

Chipping in the stand.

Terrain chipping requires highly mobile chippers and it is somewhat more dependent on good terrain trafficability than is chipping at a landing. On the other hand, it makes wood handling easier, especially if the trees are comparatively small.

Cutting	Separation	Bunching	Chipping	Forwarding	
					**System No. I**

Working range:	▪ Softwood and hardwood ▪ Flat terrain
Advantages:	• Work safety because of machine support • No need for large landing space • Easy handling of the chips
Disadvantages:	▪ Requires chipper with high-mobility ▪ It may be difficult to coordinate the forwarder fleet ▪ Hot system

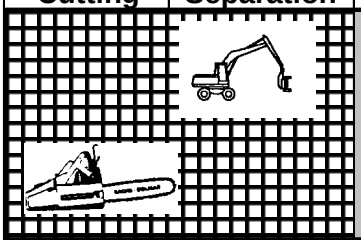
Practical information:

- ☞ Grapple-saw can be used to reduce oversize branches and tops in big trees
- ☞ If the excavator is available at the moment of forwarding, one may use cheap tractor-and-trailer units that will be loaded directly with the excavator
- ☞ Drum chippers are better to chip branches
- ☞ Work must be stopped every so often and the dust blown away from the chipper's engine with compressed air
- ☞ Decayed wood should be fed a little at a time, possibly alternating it with sound wood to clean the machine

3.3.3.2 Harvesting system J.

Chipping at landing.

Extracting whole trees and chipping them at a landing is the best options with larger trees, which can be skidded very effectively: the main drawback of skidding is that the trees can get contaminated with soil and grit, which wear out the chipper knives quite fast. In any case, when the extraction distance exceeds 500 m, forwarding may prove more effective. Forwarding is easiest with small trees, but it can be applied to larger ones if the grapple-saw is also used to reduce oversize branches and tops. If the excavator is available at the moment of forwarding, one may use cheap tractor-and-trailer units that will be loaded directly with the excavator. This way, the forwarding units do not need to have their own loaders, to the benefit of a lower investment cost and a higher load capacity.

Cutting	Separation	Extraction	Chipping	
				**System No.J**

Working range:	▪ Softwood and hardwood ▪ Flat terrain
Advantages:	• Work safety because of machine support • Better terrain capability with the forwarder, even better with the skidder • Can use heavy chipper, with high productivity ▪ Truck loading can be done in one sequence with chipping
Disadvantages:	▪ Need for large landing space

Practical information:

- ☞ Operator should be housed in a closed cab or at least wear dust mask and goggles
- ☞ Drum chippers are better to chip branches
- ☞ Work must be stopped every so often and the dust blown away from the chipper's engine with compressed air
- ☞ Decayed wood should be fed a little at a time, possibly alternating it with sound wood to clean the machine.

3.4 Recruitment of men and procurement of machines

3.4.1 Principles

When damage has occurred it is important to have quick access to professional workers and machines. Some of these facilities may have to be brought from other regions within the country, or from abroad. The transfer of men and machines over long distances and national or international boundaries is subject to an administrative procedure which can be both complicated and time consuming, but it is facilitated by:

- An established network of contacts for recruitment of professionals and procurement of machinery,;
- Prepared routines for information on working and social conditions for worker/contractors,;
- Advance agreements with authorities about actions in acute situations.

It is necessary to give a clear description about working and social conditions at an early stage of recruitment.

3.4.2 Engagement of forest workers

Only professional forest worker should be engaged

Recruitment is best done from regions with similar, or more difficult, conditions. The workers (or contractors) should fall under the same basic employment regulations as the ordinary workforce.

Sources of recruiting professionals are contractors, forest enterprises, consulting enterprises.

General information about working conditions; which shall be provided in connection with recruitment shall include:

- Type of damage on stands and sites,
- Volume to be salvaged,
- Duration of contract,
- Legal or practical hindrances to salvage operation,
- Health and safety work regulations,
- Measuring or scaling of harvested volume,
- Prices, wages,
- Terms of payment.

When personnel are recruited to a place other than their normal place of residences, information has to be given on facilities for:

- Catering,
- Housing,
- Transportation,
- Spare-time activities,
- Communication facilities.

This becomes of special importance when works site are located in isolated areas, with few alternatives of accommodation.

A routine should be prepared for application of daily allowances and travel expenses.

When it is intended to bring personnel from other administrative regions within the country or from foreign countries, the following administrative routines have to be cleared.

Before the workers can leave their own country, application has to be made at the embassy/mission in their home country for:

- Visa,
- Residential permit and/or,
- Work permit.

Questions regarding social security have to be cleared as regards:

- Accident insurance,
- Health insurance,
- Pension funds.

Bilateral agreements should be observed concerning rules for taxation of salaries

- Rates of taxes,
- Resolution of potential problem of double taxation,
- Reimbursement of taxes.

Work descriptions, safety rules and other information must be given, both verbal and in a printed version, in a language clearly understandable by the workers.

3.4.3 Engagement of companies

Additional questions which relate to foreign contracting companies:
- Registration of enterprise,
- Enterprise taxation,
- Value Added Taxes (VAT) on services,
- Financial safeguards/guarantees.

3.4.4 Transfer of equipment and machinery

Aspects to consider when an increased amount of equipment and machines are needed to ensure smooth progress of work, avoid delay and ensure safe working conditions:

Technical consideration :
- Service and repair personnel,
- Spare parts,
- Maintenance and repair equipment,
- Special lubricants, oil, etc.,
- Health and safety work regulations, protective equipment,
- Compatibility of measurement systems and software.

Economic considerations:
- Transportation cost,
- Value Added Taxes,
- Traffic taxation on vehicles.

Administrative considerations:
- Insurance,
- Value Added Taxes (repayable/non-repayable),
- Temporary exemption from Value Added Taxes,
- Transport rules (forwarding machine on public roads, max weight by axle.

4 LOG CONSERVATION

4.1 Introduction

By taking advantage of the machine-power available in today's forestry industry, the salvaging of logs after storm damage could probably be carried out rather quickly. However, the large and sudden supply of raw material that subsequently becomes available may by far exceed the conversion and sales capabilities of the sawmilling industry. The result could very well be a collapse of the round timber market. Eventually, a large proportion of the wood could be lost due to rot and insect infestation. Solutions such as storage of logs on site or in special storage yards should therefore be seriously considered in order to spread the supply of wood over a longer period of time and to avoid loss in value.

During transportation out of the forest to wood-processing enterprises high-grade round timber is exposed to various dangers that contribute to a considerable loss in use value. In the following sections the causes of biotic and abiotic damage of round timber are demonstrated using selected examples. Advice for the proper handling of round timber during transportation is also provided.

4.2 General considerations

4.2.1 Reasons for and goals of log conservation

Round wood storage aims at maintaining the properties of high-grade wood for the future buyer. In addition, round-timber storage may ease problems for the timber market and stabilise wood prices.

Depending on the length of time involved, log storage may be subdivided into two groups:

- Storage of round timber in the forest after tree harvesting (generally for a few days to a few weeks)
- Longer-term storage of round timber (subsequent to calamities, i.e. for a few months to several years).

The risks associated with round-timber storage are: formation of checks after drying or seasoning of the external log parts too close to fibre saturation point; discoloration; infestation with insects; and destruction of the wood by infestation with fungi. These phenomena occur as a result of inappropriate storage and care of the timber. In general, this causes a partial reduction in the value of the wood. In extreme cases, round timber can be completely devalued. Depending on the duration of storage, a number of factors can contribute to a reduction in wood quality, necessitating various kinds of strategies for storage.

4.2.2 Deterioration of stored logs

❑ ***Susceptibility***

Every year, forest sector industries worldwide lose millions of dollars when sap-staining fungi attack and discolour the sapwood of freshly felled timber. However, this damage is largely cosmetic, the strength of the wood is barely affected and decay is absent. Of all the Conifer species, Pines are the most susceptible to sap stain whilst species of Spruce show some measure of resistance to infection. **Three distinct groups of fungi are recognised as the cause of the problem**.

The **first group,** sometimes known as deep stainers, include the genera *Ophiostoma, Ceratocystis* and *Aureobasidium,* which penetrate into the wood. Their pigmented hyphae grow in the tracheids and rays of the wood tissue producing a blue-black discoloration visible when affected logs are sawn. These fungi are commonly described as sapstain or bluestain fungi and are generally considered to be the most important and prolific of the three groups in softwoods.

The **second group** comprises fungi that grow mainly on wood surfaces causing superficial staining. They include black yeasts such as species of *Hormonema, Aureobasidium, Rhinocladiella* and *Phialophora.* These fungi are most frequently found after the initial stages of timber processing on timber and on debarked logs.

Photo 1: Bluestain fungi in pine sapwood

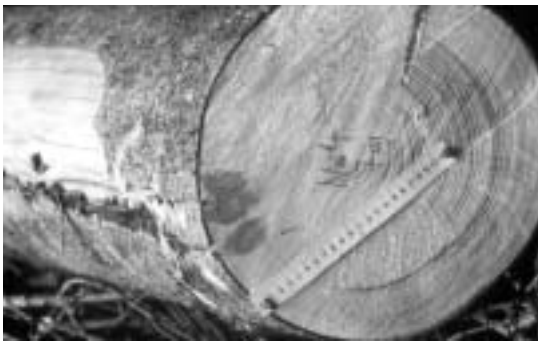


Photo 2: Brown discoloration on spruce wood as a result of incorrect round wood storage

The **third group** also grow superficially, often on freshly felled timber, and discolour the wood by producing abundant pigmented spores. These are mainly mould fungi including *Alternaria, Cladosporium, Penicillium* and *Trichoderma.*

Bark beetles (members of the family *Scolytidae*) spread the deep-staining fungi when they seek out breeding material in the form of weakened or felled trees during the summer. The females bore tunnels in the cambium and deposit their eggs. When the eggs hatch, the larvae create galleries below the bark and, when mature, they pupate. Following the final metamorphosis, the adults bore their way through the bark and emerge via exit holes.

Many staining fungi also gain access to wounds or cut log surfaces all the year round through rain-splash, the wind dispersal of infected fragments of wood and by casual dispersal by arthropods as they graze on fungal mycelia. However, the degree of infection is also dependent on the timber species, with marked differences occurring in susceptibility to sap stain. This may reflect qualitative and quantitative variation in the pre-formed anti-fungal constituents of conifer resin, which is known to differ between species.

The ability of sapstain fungi to invade host cells may also be influenced by their ability to overcome cellular defences induced in living bark and wood following wounding and attack by pathogens. It has been stated that sapstain fungi range from truly pathogenic species, which invade healthy living trees, to those colonising weakened and stressed trees and saprotrophs found on dead timber. It has been shown for instance, that species of *Ceratocystis* and *Ophiostoma* can respond very differently when introduced into living wood, reflecting their different pathogenic characteristics.

- ***Importance of wood moisture content***

It has been widely recognised that the **moisture content** of timber may play the most important role in determining the extent and diversity of fungal colonisation. Above fibre saturation point (approx. 20% moisture content) wood is vulnerable to infection and two forms of fungal decay are able to destroy the structure of wood cell walls leading to complete strength loss of the timber. **White rot fungi** are commonplace in the forest and the decay they produce gives a familiar bleached appearance to the wood, particularly in hardwood species. These fungi produce enzymes capable of degrading all three of the major wood cell wall components: cellulose, hemicelluloses and lignin. **Brown rot** fungal attack causes the wood to become darker in appearance and only cellulose and hemicelluloses are destroyed; the lignin component is undamaged or slightly modified. Both types of decay are caused by **basidiomycete fungi** and the large reproductive fruit bodies which emerge from decaying wood bear an abundance of spores which are typically wind dispersed and germinate on exposed woody surfaces. White rot decay in hardwoods, notably in woodland situations, is also attributed to members of the higher **ascomycetes**. Like sapstain fungi, decay fungi exhibit a spectrum of invasive activity ranging from the truly pathogenic fungi, which attack standing trees, to the saprotrophic forms, which attack dead timber. The moisture content of the wood must not be too high, i.e. saturated and therefore oxygen depleted, or too low and therefore too dry, for these fungi to invade successfully.

Drying of wood, beginning immediately after felling the tree, causes the ratio of water content to air content in the cells to change. As a result, secondary pests such as fungi can infest the stored wood. For fresh wood with moisture contents of about 150% (coniferous woods) or 90% (broad-leaved species), based on oven-dried weight, the risk of secondary pests due to insufficient oxygen supply is low. At a wood moisture content below 100% or at about 20% air volume in the wood secondary pests enjoy good to ideal living conditions. The danger of an infestation, with corresponding devaluation of the wood, is increased. Below fibre saturation point (approx. 30% wood moisture) the risk of infestation with fungi decreases markedly due to lack of moisture (see Figure 6).

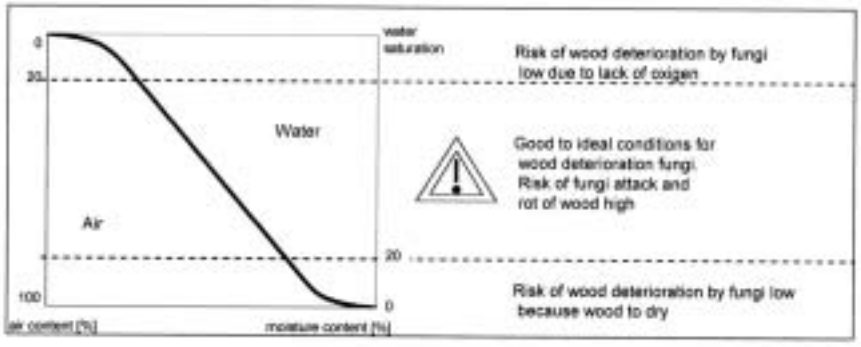


Figure 6: Wood moisture content and its effect on the risk of the development of secondary pests (Source: Wiebe 1990, modified)

High or low wood moisture is therefore the best protection from fungal attack!

Seasoning of round timber starts immediately after felling the tree by water evaporating from the log ends, and, on debarked logs, from the total stem surface. The rate of evaporation depends on the number of log ends, so few resawing cuts should be made, and on the following conditions:

- size of the debarked log surfaces
- the season when felling and storage takes place
- place of storage
- presence of live crown on the stem.

The quality may deteriorate sequentially during the continuous drying process:

- infestation with fungi,
- discoloration,
- attack by insects,
- cracks.

4.2.3 General recommendations

In order to prevent loss of wood moisture below 120% to 100% for coniferous trees and 80% for broad-leaved trees, round timber should not be debarked. Bark is regarded as the best packaging material for logs and should only be removed if there is a risk of bark beetle infestation. Bark not only protects against moisture loss, but also protects the wood from damage due to manipulation of the stem. Moreover, when assessing round timber quality, bark is also an indicator of local defects, i.e. wood characteristics.

When storing wood over a longer time period, two strategies may be pursued regarding moisture content of the wood:

- allowing the wood moisture content to remain (or reach) as high as possible (above 100% or 80% related to oven-dry weight)
- lowering the natural wood moisture content to below fibre saturation point as fast as possible (about 20% moisture content related to oven-dry weight).

The risk of log deterioration is highest during summer: approximately from May to October for hardwood and from March to October for softwood.

4.2.4 Choice of conservation method

The choice of conservation method depends on the following factors:

- kind of storm (see table 7)
- kind of storm damaged trees (see table 8)
- anticipated duration of storage (1 vegetation period up to several years)
- availability of storage yards and their handling capacity
- staff and financial considerations
- legal aspects (see chapter 2.5)
- industrial safety.

The following table gives a brief classification and description of storms and their devastating effects on single trees. To guarantee the comparability of future research work on storm damage of trees and forests this classification is recommended to characterise particular storm events.

Table 7: Storm Damage-Potential Scale for woody plants, based on the Scaling after TORRO as adjusted to Middle Europe (Source: Hubrig 2001)

T0 76 ± 14 km/h	Incipient breaking off of single branches. Diseased (e.g. decayed trees) or particularly unstable trees (long thin stems, crown base higher up the stem, sparse system of shallow roots) may break or get uprooted (in the case of root rot and/or on unstable, wetted sites).
T1 104 ± 14 km/h	Branches, even thick and healthy ones break to an increased extent, particularly during the growing season when broad-leaved trees are foliated. Diseased (e.g. decayed trees), or particularly unstable trees (long, thin stems, crown base higher up the stem, sparse system of shallow roots) often break or get uprooted. Trees with root damage/rot or on unstable, wetted sites are subject to wind-throw.
T2 135 ± 16 km/h	Numerous branches break, including thick and healthy ones, in particular during the growing season when broad-leaved trees are foliated. Diseased (e.g. decayed trees), or unstable trees (long, thin stems, crown base higher up the stem, sparse system of shallow roots) are almost always broken or get uprooted. Trees with root damage/rot or on unstable wetted sites are almost always subject to complete wind-throw. Even less firmly rooted, healthy trees get uprooted if soils are water-soaked and wetted due to the weather at certain, but not necessarily unstable, sites (e.g. thick strata of loess-loams). Trees of less stable condition due to the specific species and varieties, e.g. broad-crowned lowland spruces are wind-thrown or break, while slim upland spruces or healthy oaks remain standing. Trees in forest stands which, due to the stand structure, have poor single-tree stability (too narrow planting, lack of tending operations, in particular coniferous trees in monocultures) are often subject to wind-throw or breakage. During the period of sap flow trees with a firm rooting, but unstable stems, are often affected due to damage by pressure.
T3 167 ± 16 km/h	Numerous branches, including thick and healthy ones break, even when broad-leaved trees are bare of foliage i.e. not during the growing season. Stable and healthy trees are also subject to wind-throw or breakage to a higher degree. During sap flow pressure damage occurs relatively often.
T4 202 ± 18 km/h	Even stable trees/forest stands are almost always completely wind-thrown or broken. Trees with large crowns, provided they are safely anchored by roots, are mostly broken. If trees remain standing at all, a larger number of branches, including the non-foliated ones, are torn off.
T5 238 ± 18 km/h	Even the most stable trees or shrubs such as border trees, storm-proof hedges, bushes and field woods show almost 100% damage either by uprooting, stem or crown breakage or the tearing off of a large number of branches, including all twigs.
T6 275 ± 20 km/h	No indigenous woody plants, if the stem remains standing, will survive such a storm without heavy damage.
T7 315 ± 20 km/h	or T8 (356 ± 22 km/h), according to Fujita only beginning from F4 (334 B 422 km/h): Incipient debarking of tree stems which remain standing, or parts of the trees (caused by debris such as sand and the like, flying around at high wind velocity).
T9 400 ±22 km/h	Total debarking of tree stems that remain standing, or of parts of the trees.

Depending on the kind of stem damage caused by the storm, a distinction can be made between wind-throw, wind-breakage or tilted stems hanging in the crowns of other trees. This is particularly the case for broad-leaved trees with different types of crown damage (see table 8). The following survey gives a short description of the types of damage that can occur and the following table shows the most suitable storage methods, depending on the respective type of damage. As storm damage, in general, leads to different patterns of damage on single trees and in stands, the responsible person can select the most suitable methods from a number of possibilities and organise the conversion of the wind-damaged timber, depending on the susceptibility of the respective wood species, their working capacity and the duration of storage.

❑ ***Short description of different types of storm damaged trees:***

Wind-thrown trees (coniferous trees or broad-leaved trees):

- uprooted with little root contact with the moisture in the soil (1)
- uprooted with good root contact with the moisture in the soil (2).

Storm-broken trees (coniferous trees or broad-leaved trees):

- breakage near the stump (stems can be utilised as long poles without problems) (3)
- breakage in 1/3 of the stem height (stems can only be processed as short wood) (4).

Bent or leaning stems (coniferous trees or broad-leaved trees):

- Tree bent, root system not affected by storm (5)
- Tree bent and root system slightly lifted, but still sufficient contact with soil moisture content (6)
- Tilted tree hanging in the crown of a neighbouring tree, root system heavily damaged and insufficient root contact with soil moisture (7).

Crown damage (mostly on broad-leaved trees):

- Slight crown damage (single large branch missing) (8)
- Heavy crown damage (more than half of the former crown is missing) (9)
- Almost total loss of crown (10).

Remark: Compression creases are a frequent failure in timber from the storm damaged forests. Though this is not a failure caused by the storage, they have a very strong influence on the utilisation of the timber and on the costs related to handling the timber. The earlier logs with compression creases are identified and removed, the better.

Table 8: Most suitable options for log storage to maintain highest wood quality. Numbers 1 to 7 can be used for both soft and hardwood species. Numbers 1, 3, 4, and 7 are trees with little or no root contact. Numbers 8, 9 and 10 show additional damage to hardwoods.

Storm damaged tree type	Most suitable options for log storage								
	In-situ storage		Wet storage		Storage under drying conditions		Storage under humid conditions		Special methods
	Live-conservation	Drying by transpiration	Compact pile with water sprinkling	Ponding/ immersion in fresh water	Log pre-drying in covered cross-piles	Fast log pre-drying in open cross piles	Compact piles	Compact piles covered with plastic sheets	Log conservation under oxygen exclusion
 1	-	X	X*	X*	X	X	-*	-*	-*
 2	XX	-	X	X	X	X	X	X	X
 3	_	X	X*	X*	X*	X	X*	X*	X*
 4	_	X	-*	-*	X*	X	X*	-*	-
 5	XX	-	X	X	X	X	X	X	X
 6	XX	-	X	X	X	X	X	X	X
 7	-	X	X*	X*	X	X	X*	X*	X*

Storm damaged tree type	Most suitable options for log storage								
	In-situ storage		Wet storage		Storage under drying conditions		Storage under humid conditions		Special methods
	Live-conservation	Drying by transpiration	Compact pile with water sprinkling	Ponding/ immersion in fresh water	Log pre-drying in covered cross-piles	Fast log pre-drying in open cross piles	Compact piles	Compact piles covered with plastic sheets	Log conservation under oxygen exclusion
8 	**XX**	**-**	**X**	**X**	**-**	**-**	**X**	**X**	**X**
9 	**X**	**-**	**X**	**X**	**-**	**-**	**X***	**X***	**X**
10 	**-**	**-**	**X***	**X***	**-**	**-**	**X***	**X***	**X***

Relevant notes:

X	possible option
XX	most preferable option
-	not recommended
*	time factor (moisture content) is relevant

4.2.5 Economic aspects

Different economic aspects must be considered. The primary goal is to maintain the monetary value of round wood by protecting its quality. Furthermore, after a storm a marketing strategy must be organised in order to control the sale of round wood and to prevent the depreciation of its value. This situation demands the temporary storage of the wood.

The benefits of maintaining the value of the wood and avoiding price reductions must be considered in relation to the cost of storing the wood. Capital costs may be very important because the total costs of logging and storage (including transport, equipment, maintenance etc.), as well as the value of the wood, may be tied up for a prolonged period of time, leading to a heavy financial burden.

An important issue is the choice of conservation method. The following points must be considered:

- Storage period

  Capital and maintenance costs are strongly influenced by the length of the planned storage period, depending on the conservation method used (e.g. dry storage up to 5 months or wet storage up to several years).

- Time management (organisation and speed of work)

  It is important to maintain the value of the wood by correct handling of the logs during and after the logging operation (e.g. no unnecessary delay between cutting in the forest and the onset of water sprinkling at the storage site). There will often be a shortage of logging equipment following a storm. To meet the time limits of wood deterioration it may be necessary to use less-than-optimal equipment, thus increasing costs compared to normal operations.

- Storage site

  On-site storage (i.e. in the forest) is relatively cheap, whereas establishing a special storage site may lead to costs such as land rent, equipment, communication with the authorities, solving of environmental issues etc.

- Tree species

  Vulnerability to deterioration and the quality expected by the end-user varies widely between different tree species. True heartwood species (e.g. Oaks) often have good keeping ability without the need to take any precautions, whereas sapwood species (e.g. Maple) require immediate action. Slight discoloration may be tolerable in some species (e.g. Spruce for structural use) but not for others (e.g. Pine for furniture or flooring). Depending on the special features of the species the best conservation strategy must be chosen.

If the total wind-throw does not exceed the amount of timber that can be sold within a year, the most advantageous solution is normally to leave the trees untouched in the forest, as long as not too many are broken or severely damaged. Delimbing and further processing can then wait until just prior to industrial utilisation. However, in order for this to be successful it is important that the roots have enough soil-contact to provide the crown with water. Also, the re-planting of the area must be considered, as invading grass and weeds may become cumbersome if the ground is left untouched for a whole growing season before planting.

For maintaining wood quality over longer periods of time, storage under sprinklers is believed to be the best solution.

4.2.6 Management/Operation/Health and Safety

❑ ***Management/operation***

On-site storage (leaving the trees where they have fallen) generally puts little strain on the management and activities of the forest owner. An inventory of the wind-thrown logs is appropriate and quality assessments (drying damage, insect attack, discoloration, fungal attack) should be carried out at regular intervals.

If the logs are **to be stored in piles in the forest**, more stringent organisation is required. Machinery with appropriate performance and capacity should be chosen. Serious consideration should be given to limiting machinery traffic on vulnerable forest soils, in order to avoid soil disturbance and compaction. The piles should be positioned in such a way as to assure both favourable storage conditions (shade, shelter) and also to facilitate easy loading and transportation. All-season lorry access to the piles may not be possible without serious damage to forest roads.

Storage yards are even more demanding of facilities and management. If wet storage is to be employed, the minimum demands are:

- the ground should be trafficable by heavy lorries even in soaked conditions
- access roads should be usable during all seasons
- water supply should be adequate
- electric power for pumps, etc. should be available
- the yard should be sheltered from strong winds
- daily inspections should be possible.

In addition, the possibility of re-circulating runoff water may be necessary. To fulfil these demands, a storage yard at a sawmill or another industry will often be the best choice. Here, trafficable ground, access roads, power and personnel is often available, minimising the cost of establishing and operating new sites

❑ ***Health and safety***

The maintenance of logs under humid conditions i.e. compact piles covered with plastic sheets, or using "special" methods involving wrapping in plastic sheets or covering with geo-textile fabric, may result in the growth of thermotolerant and thermophilic moulds and actinomycetes on the timber. The high humidity under the sheeting plus elevated temperatures resulting from incident sunlight may generate temperatures in excess of 40^{o}C which will support the growth of these freely sporulating micro-organisms. At the same time, the elevated temperatures will inhibit and possibly inactivate the vegetative hyphae of decay and sapstain fungi.

The production of large quantities of mould and actinomycete spores is a potential health hazard, since inhalation of significant numbers of spores could generate allergenic responses in operators removing the sheeting. This risk can be avoided by the wearing of protective facemasks during this operation.

Logs in wet storage may become very slippery, presenting a risk for the personnel involved in inspection and maintenance of the equipment. Also, the risk of logs sliding or rolling down when climbing the stacks must be considered.

4.2.7 Process monitoring and wood quality

Process monitoring is an important part of conservation work. By implementing proper monitoring procedures it is possible to document the development of wood quality in relation to operational parameters (e.g. watering intensity) and the initial condition of the wood. Monitoring of storage conditions as well as wood quality should be carried out over the entire duration of storage. Records of wood quality in relation to species, type of storm damage, logistics and storage conditions may provide valuable help for decision-making in the event of future storm calamities.

The primary goal of storage is to conserve the quality of the wood for future use in the wood processing industry, hence quality parameters are the most important figures to monitor, as a considerable loss of value can occur over time if the wrong storage method is used. However, quality monitoring usually implies laborious and destructive procedures, e.g. crosscutting and inspecting a number of logs, or processing a number of logs with subsequent quality assessment of the boards. To conclude, it should be outlined that wood quality is strongly linked to the quality of the functioning of the conservation method.

4.3 Conservation methods

4.3.1 Overview

Choosing the appropriate conservation method requires the consideration of both the conditions likely to foster wood deterioration and the attack mechanisms. The principles are reiterated below :

MAIN PRINCIPLES OF WOOD DETERIORATION MECHANISMS

1. Three conditions must be present for deterioration to occur. If one is not present, no attack will take place:
   - High moisture content (below around 25%, fungi's development stops)
   - Oxygen (fungi cannot develop without O_2)
   - Sufficient temperature (below 10°C, fungi's development is considerably slowed down while the conditions become ideal above 18°C

2. Fungi penetration into the wood mainly occurs via the end sections of the log/billet. This phenomenon is much more difficult via the stem, particularly when the bark remains in good condition.

The conservation of windblown but still living trees (in situ conservation; root system is sufficient) prevents fungi reaching the most suitable contamination pathways.
For the windblown trees which much be harvested, the most efficient methods consist in removing or at least reducing as much as possible the oxygen rate in the wood by:

- Saturating the wood fibres with water (Wet storage)
- Storing logs in confined atmosphere where the oxygen rate is kept down at a very low level

The period and the latitude at which the storm occurs are of main importance regarding the choice of the conservation method and the logistics to implement.
Hence, conservation under drying conditions of compact piles covered with plastic sheet, geotextile, snow, or other mineralic suspensions, will work properly in a cold climate but may be disastrous in a hot one.

Before taking any decisions, the following elements should be considered:

- Conservation method and storage conditions
- Type and conditions of the windblown timber
- Susceptibility of the species
- Investment and operating costs
- Duration of storage

Example of the most frequently used conservation methods:

Conservation method	Type of windblown trees	Costs (investments + functioning costs)	Duration of storage
In situ storage	Trees still alive with sufficient root contact and not directly exposed to sunlight	No investment but some monitoring visits	Up to 2 years
Storage under water spraying	Uprooted or dangerous trees (must be harvested)	High investment costs; Good reliability of the method	Up to several years for most species
Ponding/immersion in water	Uprooted or dangerous trees (must be harvested)	High investment costs	Up to several years for most species
Storage under O_2 exclusion	Usually for high-value timber (veneer; etc.)	High investment costs	Up to several years

Remarks: Chemical preservation remains of interest in the period between harvesting and implementation of the storage site when the timber is highly exposed to insects and fungi deterioration, and particularly during warm temperatures (from spring where the temperature is above 12°C and can reach more than 18°C very quickly).

In order to draw unambiguous conclusions regarding the different conservation methods, it is important to review them and to define the terminology used.

Table 9 lists known conservation methods. They are grouped according to the storage conditions of the logs (wet, dry, humid) to reflect the particular importance of wood moisture content in their preservation. For the 'hybrid' and more 'exotic' methods a 'Special' group is included. 'Supplementary conservation measures' are occasionally used in combination with one of the main conservation methods (e.g. chemical wood protection or end-grain sealing with compact piles). However, only selected combinations are effective and some are even prohibited (e.g. chemical wood protection with wet storage).

The table contains all the reported conservation methods, irrespective of how much they are being used or how proven they are. However, the most important and most widely used conservation methods are highlighted in grey and are described further down in this chapter. For more detailed information on all the conservation methods (including references) see the state-of-the-art report on log conservation (**www.stodafor.org**).

Table 9: Systematics of conservation methods

Group *(Principle)*	**Method**	**Description**
In-situ storage *Logs left untouched in place in the stand*	Live-conservation of wind-thrown trees	In-situ storage of living, uprooted trees with sufficient root contact
	Drying by transpiration	In situ storage of entire trees (with crown) with a cross-cut at the stem base
Wet storage *Storage under (controlled) wet conditions keeping the wood saturated*	Compact pile with water sprinkling	Compact pile with water sprinkling (logs with bark)
	Ponding (immersion in water)	Storage of logs in running or standing water (logs with bark)
Storage under drying conditions *Storage under (uncontrolled) conditions resulting in slow or fast drying of the logs*	Log pre-drying in covered cross-pile	Pre-drying of logs in covered cross-pile (logs debarked)
	Rapid log pre-drying in open cross-pile	Rapid log pre-drying in open cross-pile (logs debarked)
Storage under humid conditions *Storage under (uncontrolled) changing conditions*	Compact pile	Compact pile (logs with bark/debarked)
	Compact pile covered with plastic sheets	Compact pile covered with plastic sheets (logs with bark/debarked)
'Special' methods	Log conservation under oxygen exclusion, compact pile wrapped in plastic sheets	Compact pile wrapped and sealed in plastic sheets resulting in oxygen free conservation atmosphere (logs with bark)
	Compact pile covered with geo textile fabric	Compact pile covered with geo textile fabric (logs with bark)
	Compact pile covered with a mineralic suspension	Compact pile covered with a thin layer of mineralic suspension (protection against insects)
	Storage in gravel pits	Compact pile buried in a hole in the ground or on level ground covered with thick layer of clay/soil
	Storage in mines	Storage in unused mine tunnels
	Compact pile above timberline	Compact pile above timberline (logs with bark)
	Storage in snow	Compact pile covered with snow
	Compact pile covered with organic material	Compact pile covered with bark chips, wood chips, sawdust etc.
Supplementary conservation measures *Supplementary to main methods ('integrated methods')*	Chemical protection	Wood protection by chemical agents
	Biological protection	Wood protection by biological agents
	Physical protection	Wood protection by physical measures (e.g. end-grain sealing)

4.3.2 Description of the most important methods

4.3.2.1 In-situ storage: Live-conservation of wind-thrown trees

❑ ***Principle***

Natural water balance and the natural defences of the trees are to be maintained and desiccation delayed.

❑ ***Tree species***

Experiences and research results are available for Beech, Douglas Fir, Spruce, Pine and Maritime Pine.

PRECONDITIONS

Points to be considered before taking the decision to store wood in-situ:

- Root plate merely lifted up, not shifted laterally
- Roots needs to have sufficient contact with the soil (the existing contact between root-stock/soil should account for at least 20 to 25% of the root volume)
- Minor stem and crown damage
- No direct solar irradiation on stem and root plate
- No risk of infestation with bark beetles.

❑ ***Advantages***

- Immediate storage without prior tree processing (delimbing, bucking, debarking, log transportation) or storage site preparation.
- No technical equipment necessary.
- Low cost (only for wood quality control).
- Live conservation can be regarded as a cheap alternative to other conservation methods, but only for a limited time period. For deep-rooted tree species this method conserves the value of the wood whilst more urgent storm damage can be dealt with.

❑ ***Disadvantages***

- Dependence on climatic conditions.
- No control over the development of wood moisture content.
- Storage time is limited as unacceptable secondary wood defects can develop.
- Risk of bark-beetle attack. Even before storm damage, the existing bark beetle population can seriously effect conservation.
- The decision about whether the storm-damaged trees should be left in living conservation depends largely on the personal experience of the forest worker.

❑ ***Practical Experience***

Beech (Fagus sylvatica)

- *Sawing*: The general results are rather encouraging. French studies report that after one year of storage the percentage of logs attacked by fungi (involving an economic loss) ranges from 7% to 16% for scattered blown trees and 29% for blown trees located in totally damaged areas (i.e. exposed to 100% sunlight). After 2 years, the percentage of wood deterioration increases considerably with regard to scattered blown trees, ranging from 27% to 35% (average recorded for every sample area). In highly exposed areas, wood deterioration reached more than 55% after 2 years of conservation.

  German experiences show that with in situ live-conserved Beech trees after winter storm-throw, only minor quality losses were discernible up to the following early autumn. On the other hand, in situ live-conserved Beech in open spaces had already been subject to deterioration. After two growing seasons a drastic loss of quality was apparent in Beech trees in open spaces and scattered wind-thrown wood beneath canopy was already deteriorating.
  In conclusion, scattered wood from winter storm-thrown Beech can still be live-stored beneath canopy for up to one year, (comprising one growing period and the subsequent winter season), with tolerable losses in value averaging 35%.

- *Kraft Pulp*: There is a strong correlation between pulp and paper properties and moisture content. This explains the considerable decrease in pulp yield that occurred during the second year of storage. The pulp yield decreased by 5% within the second spring/summer period. Nevertheless, the pulp properties following the first live-conservation year remained satisfactory.


Photos 3: Scattered blown trees and blown trees located in totally damaged areas (Source: AFOCEL, 2002)

Spruce (Picea abies)

- The duration of forest protection is very relevant for Spruce; there is good evidence that conservation can be guaranteed for a period of 6 to 12 months.
- Danish studies show that damage after a 16-month storage period was modest for trees left with untouched crowns. Trees with reduced crowns were appreciably more damaged and, when the sawing was postponed for another four months, damage had sometimes more than doubled.

Pine (Pinus sylvestris)

- The duration of forest protection is similar to that of Spruce.
- Storage until winter is possible, as long as there is good root contact.
- Where the stem touches the soil surface there is danger of bark damage and blue stain.

Maritime Pine (Pinus pinaster)

- *Sawing*: The contamination of wind-blown trees by fungi remains limited. In the southwest of France, one year after the storm, 40% of saw logs observed were not contaminated by blue stain. Before insect attack occurred no bluestain damage was noticed on logs on the dry site but there were several logs contaminated on the wet site. On such land, tree contamination could have happened through broken roots. After insect attack contamination of the logs rapidly reached 60% on both types of site.

- *Kraft Pulp*: Blown trees stored on site were well preserved until the end of the first summer. Fibre and paper properties were affected initially, then pulping yield, but much less than in harvested logs. After a two-year storage period, the majority of trees left on site could still be used for Kraft pulp and papermaking. After more than two years paper properties decreased rapidly.

Douglas Fir (Pseudotsuga menziesii)

Kraft Pulp: Very good conservation was maintained during the first two years of storage. After three years a steady decrease in paper properties occurred.

❑ ***Recommendations (application, time limits)***

Generally speaking, the quality of *in situ* conservation depends on three major factors.

THE THREE FACTORS TO CONSIDER TO ACHIEVE GOOD RESULTS

1. Susceptibility of the species.

	Very susceptible (1 vegetation period, risk of blue stain)	Susceptible (1 vegetation period)	Resistant (2 vegetation periods)
Softwood	Pine - Spruce	Maritime Pine	Douglas Fir - Larch - Cedar -Yew
Hardwood	Maple - Hornbeam - Ash - Poplar	Beech - Elm - Alder - Cherry - Walnut	Oak - Chestnut - False Acacia

2. Type of damage to trees/roots: the greater the contact between the root system and the ground the better the conservation.

3. Degree of dissemination (scattered or not) of the wind-blown trees: either disseminated wind-blown trees (i.e. sun-protected trees) or widely exposed to sunlight. The more the blown trees are exposed to sunlight, the higher the deterioration rate because of a more rapid decrease in wood moisture content.

❑ ***Quality monitoring***

Live conservation of trees allows the quality to be monitored throughout storage time in the stand. It is therefore possible for the forester to monitor the condition of the trees. The followings indicators of vitality can be taken into account:

Sprouting behaviour; ability of the tree-top to straighten up; resin exudation; bluish-silvery needle discoloration; occurrence of shade indicators (bark covered with green algae or root plate covered with plants); changes in moisture content (drying from below to above and from inside to outside).

Since there is a significant correlation between tree moisture content and degradation, a simple way to monitor the quality of the wood stored in situ is to measure wood moisture content.

❑ ***Environmental issues***

The storage method itself has no impact on the environment. The risk of bark beetle attack and spreading of bark beetles should be considered when no chemical pest control is used. The application of chemicals can harm the environment.

❑ ***Costs***

The expense of frequent quality monitoring (once a month) and for checking moisture content would be incurred.

4.3.2.2 Wet storage: Compact pile with water sprinkling

❑ ***Principle***

Storage of compact piles of logs with bark under sprinklers is the most common way of storing wind-thrown trees. The experiences referred to in the following account are from the two storms in 1967 and the storm in November 1981 in Denmark, the storm in November 1972 in Germany, the storms in 1982, 1984 and 1987 in France, and the storms in 1990 and in December 1999 in many European countries.

Photo 4: A long pole storage site in France (Source: ENGREF; 2001)

Using artificial water spraying the desiccation of round timber can be prevented by maintaining the green wood condition i.e. maintaining wood moisture as high as possible. The principle involved is that by maintaining a wet log surface the water acts as an oxygen barrier, thus preventing contamination by wood-destroying fungi.

❑ ***Tree species***

Experiences and research results are available for Beech (*Fagus sylvatica*), Spruce (*Picea abies*), Pine (*Pinus sp*.), Fir (*Abies alba*) and Oak (*Quercus spp*.).

PRECONDITIONS

Points to be considered when storing logs under sprinklers:

- The location of the sprinkler storage (a wind-protected site is preferable)
- The condition of the soil and the terrain at the site (vehicle traffic, drainage etc.)
- Permission to set up the storage site must be obtained (cf. 2.5. Regulations and laws)
- Accessibility to water
- Accessibility to electricity
- Distance to a sawmill
- Feasibility of surveillance/control

❑ ***Advantages***

- Long-lasting storage method.
- Relatively safe round-timber storage method compared with other methods.
- Large quantities of timber may be stored (up to tens of thousands of cubic meters).
- Much information on storage technique and wood quality is available.
- An accepted conservation method by most of the wood processing industry.
- Wood quality monitoring possible by water spraying management.
- Water sprayed timber can be sawn more rapidly than fresh cut timber, because the water in the timber makes the saw blades run smoothly towards the timber.
- Even a short period of conservation may lead to significant savings of raw materials, especially during spring and summer time (e.g. oak).
- Compared to immersion in water, uptake by logs is much easier.

❑ ***Disadvantages***

- Significant investments that may have to be made prior to storage (cf. below).
- Brownish-reddish discoloration occurs in the outer part of the sapwood during drying of Spruce as a consequence of bark leaching and oxidation processes between bark extractives and cellulose **(cf.** Photo 6).
- Over penetration of coatings and paints, especially in the case of Pine, due to the heterogeneous bacterial attack of pit membranes can lead to a rejection of water-sprayed wood by certain wood processing industries (e.g. window frame manufacturers or furniture industry).
- The risk of fungal attack (Armillaria sp.), even under best sprinkling conditions, can lead to very rapid deterioration of the timber within a few months (cf. Photo 5).
- An increase in processing time for kiln drying has to be expected unless pre-drying has been performed.
- During the hot season, one or even two daily inspections are necessary.
- Compared to immersion, a greater amount of water is required.

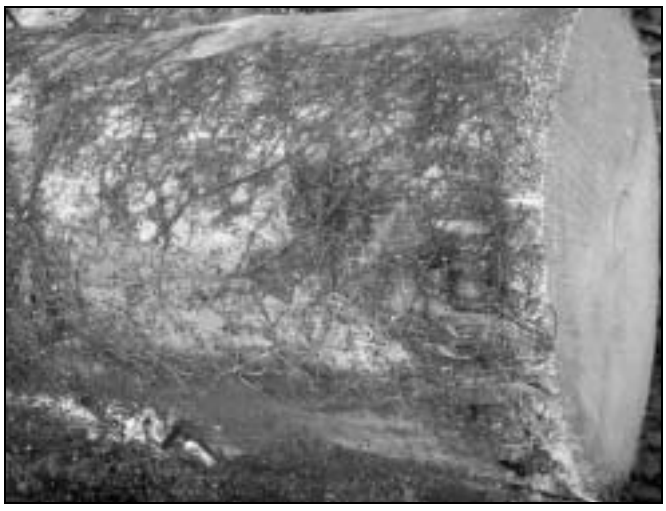


Photo 5: Spreading of Armillaria on a Spruce log (Source: CTBA)

Photo 6: Peripheral discoloration of spruce (Source: CTBA)

❑ ***Practical Experience***

In Europe, the sprinkling period varies according to latitude (the hotter the climate, the longer the period). For instance, the logs are normally sprinkled from April to October in Denmark, from May to September in Norway, and from March to the end of October in France, but variations may occur according to weather conditions.

MAIN DIFFICULTIES ENCOUNTERED DURING IMPLEMENTATION

- Coordination between forests, sawmills and truck-drivers
- Insufficient lorry capacity
- Segregation of species into separate piles may delay the building of the sprinkler-system
- Log measurement: administrative matters concerning measurement of the logs can cause delay because of different haulage contractors using different measurement systems
- Administrative matters concerning security, environmental issues and working laws may delay or even prevent storage under sprinklers

Evaluation for different tree species

Water-sprayed logs, compared with fresh cut timber, have the following characteristics:

- *Sawing process*: Easier and faster. Gain in productivity according to species and moisture content.
- *Debarking*: Easier, but the size of bark pieces is also bigger and they can clog up the debarker
- *Colour*: Immediately after the sawing process, the boards produced from water-sprayed logs seem to be slightly darker. However, this difference tends to disappear after the drying process.
- *Kiln drying:* Drying rate rises compared to green wood, but this gain is offset by the much greater amount of water to withdraw. As a result of the combination of these two phenomena, kiln drying of water-sprayed planks generally takes longer than for planks derived from fresh wood, unless the products are pre-dried.

Specific observations were made for different species, as outlined below:

Maritime Pine (Pinus pinaster)

- *Sawlog:* Pine in good condition after three years. Significant improvement in mechanical properties with regard to vinyl gluing. Using MUF glue, the mechanical characteristics of the bond remain the same. Some discoloration may occur after two years (black line, between rings).

- *Kraft pulpwood:* Storage of Maritime Pine under water sprinkling, provided it is well carried out, preserves the wood quality for pulpwood very efficiently. After more than 40 months of wet storage, the quality of pulping logs is maintained. Even a steady increase in pulp yield is observed due to a decrease in the quantity of wood extracts.

Spruce and Fir (Picea abies and Abies alba)

- *Sawlog :* Both retained good mechanical and aesthetic properties over a period of three years. Thereafter, the logs with bark could suffer stronger fungal attack (Armillaria attack). Nevertheless, provided that the “nine commandments” are kept, only a very little percentage of timber is damaged after 5 years or even after a longer period of storage.

- *Mechanical and Kraft Pulp:* Wood discoloration occurred after less than six months of storage, resulting in a large reduction in the whiteness of the mechanical pulp. There were no problems with Kraft pulp.

Characteristics specific to Spruce:

- Brown coloration in peripheral parts of the log was observed (cf. Photo 5).
- Soak preservation treatment: improvement in product impregnation, but product consumption increases.

Beech (Fagus sylvatica)

- *Aesthetic matters:* After 6-12 months, discoloration occurred which seemed to increase when the bark was damaged. This can be reduced by using a steaming process to homogenise the colour providing that a light-coloured product is not required. To achieve the same colour, the steaming process is estimated to be between 15% and 20% shorter for water-sprayed wood compared with fresh timber. It is strongly advised to kiln dry the timber rapidly after processing to prevent any further discoloration. Some Danish studies concluded that after 18-24 months, the logs can still be used for veneer manufacture and after 24-36 months they may be used for flooring provided that the wood is either stained or steamed.
- Mechanical properties are unchanged after four years.

Oak (Quercus spp)

- After three years positive results were obtained, but discoloration of sapwood may occur in certain cases.
- *Kiln drying*: characteristics similar to green wood were observed provided that the planks were pre-dried. Homogeneity was slightly better.
- *Logistics*: The benefits of this conservation method are significant. Actually, the latter prevents the wood from deteriorating during springtime (dote, mould, brown striped, etc.) and from being downgraded.

❑ ***Recommendations (application, time limits)***

THE NINE COMMANDMENTS TO ACHIEVE GOOD RESULTS

1. The time lapse between cutting the wood and when it is under water should be as short as possible, especially during the warm season. The interval can range from a few days to 2 – 3 weeks depending on weather conditions.

2. Only freshly cut or wind-thrown trees should be stored.

3. All stems shall be cut clean of visible breaks and any infection by fungi since hyphae from the fungi can be present further up the stem.

4. The logs must not be debarked to prevent any drying.

5. When building the timber stacks the butt end surfaces must be placed carefully so that they are all flush with each other.

6. A separate sprinkler-pipe to sprinkle directly on to the end surfaces (especially the butt ends) should be established.

7. Daily inspections are necessary in order to find and solve problems before any damage results, especially during warm periods.

8. Logs should be processed as soon as possible after storage.

9. Sawn boards from water sprayed logs must be correctly dried (air or kiln-dried).

❑ ***Log storage/Basic requirements***

Careful storage will save space, decrease the number of necessary sprinklers, reduce evaporation and increase the wood volume/wood surface ratio.

- Logs must be stacked in parallel.
- Logs should be sorted according to length, diameter, species, owner and quality. The most important consideration is to reduce the time lapse between cutting and watering of the logs.
- Butts must be aligned vertically. This will allow efficient water streaming on all the log ends.
- Logs must be stacked near the pathways and perpendicular to them in order to facilitate their uptake at the end of the conservation.
- Piles should not exceed 5m in height to remain within normal craning capacity.

- For long length storage, head-to-foot storage saves space and increases the used surface.

Remarks: The wood surface/wood volume ratio can range from 7,000 m^3/ha to 18,000 m^3/ha depending on the height of the stored piles, the length of the logs and the quality of stacking.

Photo 7: Example of a good stacking (Source: AFOCEL, 2001)

❑ ***Water supply***

- Minimum: 3 to 5 m^3 of water/hour/1000m^3 of logs (500 m^3/day/ha ≈ 50mm/day = 50 l/m^2 of surface sprayed/day).
- When air temperature is more than 10°C water spraying must not be interrupted, especially during the day. *
- When it is freezing, below 0°C, water spraying may be stopped. If these conditions last long, it is then advisable to drain the remaining water from all the pipes.
- A water recycling system can save more than 70% of water depending on the type of soil and the soil drainage system.
- Climate controlled sprinkling (i.e. according to weather conditions) is likely to save a great amount of water and increase the amount applied during warm periods.
- Wind influence: if the site undergoes many changes of wind direction, some parts may be poorly sprayed. Two solutions are suggested:
    - The site location chosen is protected naturally from wind e.g. a valley bottom.
    - The number of sprinklers should be increased (which means pressure capacity must be increased) i.e. some overlap between the sprinklers is recommended.
- Ground bearing capacity must be sufficient to withstand a 50 T truck. If a long period of water storage is envisaged, the appropriate infrastructure should be developed (water drainage, sufficient pathway width, gravelled pathways etc.).
- Environment/surroundings.
    - The site should be far from a forest infested by wood-destroying insects.
    - The site must be far from inhabited areas.

* Remark: In order to achieve ~ 50mm/d an intermittent spraying can be used

Photos 8 and 9: Different sprinkler types (Source: FVA and AFOCEL).

❑ ***Equipment***

The hydraulic pump:

- Pump capacity should be directly related to water requirement. Two phenomena have to be taken into account:
  - Hydraulic loss related to the distance from the pump: if the level remains the same, the hydraulic loss is equal to 2.5 N/100m from the pump provided that the water flow is equal to 20 m^3/h and that the pipe diameter is 3 inches).
  - Hydraulic loss related to the height: 1 daN loss per 10 m increase in height.
- Construction of a shelter around the pump will protect it from vandalism, snow, heavy rain, etc.
- An alarm can be also provided in case of an abnormal decrease in pressure.

Remarks: The expected volumes of timber at the beginning of the project are always underestimated.
It is important to filter the water before it reaches the pump, especially if the water supply comes directly from a river.

The sprinklers:

The distance between sprinklers depends on the type of sprinklers and the capacity of the hydraulic pump, the idea being to keep a steady stream on all log ends. However, the following figures may be given (cf. Figure 8):

- 8-12m apart for sprinklers located on top of the pile.
- 4-8m apart for sprinklers located at the side of the pile.

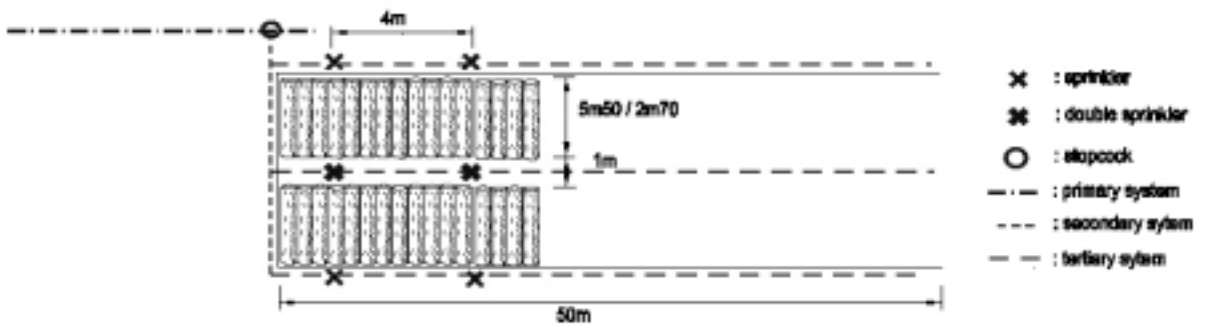


Figure 7: Short length storage, detail of the water system (Source: AFOCEL; 2000)

Remark: the utilisation of sprinklers on both sides of the pile is not necessary provided that the logs are correctly stacked and their length is longer than 10m. For shorter lengths (< 10m), spraying is recommended on both sides

The pipes: both flexible pipes (hose) and rigid pipes may be used provided that:

- They are protected
- Their coupling is easy
- Some intermediary gate valves are included at strategic points.

Remarks:

- Particular attention should be given to handling the logs since they become very slippery and their weight increases by up to 15% due to water uptake. It is also recommended that previously established storage yards are maintained for future wind-throws. In the interim they can be used as buffer-areas for wood storage.
- A professional "watering" company should be contracted to calculate the needed capacities (pumps, sprinklers and pipes) and to plan the sprinklers positions and also establish the system.

❑ ***Quality monitoring***

- Log appearance: Green/white/black streaks will appear at the ends of each log (see Photos 10).
- Maintenance/monitoring of the system: The pipes may be repeatedly filled up by suspended particles in the water and must be cleaned regularly. This is expensive but essential. During warm periods, one or two daily maintenance checks are necessary since the logs may be exposed to fungal attack after only 3-4 days without water.
- Water discharge: This must be channelled to prevent the ground from collapsing. The best solution is to use a water-recycling pond.

Photo 10: Normal aspect of the butt end of a water stored log (Source: CTBA; 1984)

Long-term wet storage (up to 5 years) of round timber under sprinklers leads to a significant increase in the bacterial population in particular for softwoods, notably in Pine, and a marked depletion of soluble carbohydrates. The permeability of the wood is then increased because of bacterial degradation of the pit membranes of the wood cells, although the strength properties of the wood are more or less unimpaired (specific gravity, modulus of elasticity, bending strength and compression strength). Generally speaking, this phenomenon leads to an improvement of the wood treatment process in terms of homogeneity, but the consumption of chemicals also rises.

After kiln drying, sawn timber is bright in appearance even after five years storage and sawn timber from long term stored logs suffers very little fungal defacement for up to three months when kept in humid conditions. This is attributed to depleted carbohydrate reserves in the wood and the presence of significant numbers of bacteria. In comparison, sawn timber from six-month wet-stored logs is badly defaced after three months in damp conditions, exhibiting an early flush of moulds followed by progressive development of sap stain.

Fungi and discoloration cause some problems if not dealt with. Fungi and discoloration nearly always spread from the central part of the butt. In some cases fruit bodies of *Fomes annosus* have been found, sometimes destroying the heartwood from the butt for 3-4 m up the stem. In these cases, in spite of careful removal of all butt ends with visible fungal attack, hyphae of *F. annosus* must have still been present in the logs at the time of storing.

With regard to quality, there are some rules that must be observed concerning the insects already present in the wood and the possible infestation of adjacent forest areas. Permanent sprinkling must be carried out because these storage sites always attract fungi and insects. If interval sprinkling is to be used, it is essential that it be first proved to be effective.

❑ ***Environmental issues*** (see also chapter 2.6. Environmental impacts)

The most important characteristic is the COD-value (chemical oxygen demand). In order to evaluate investigation results of wastewater analyses, the guide value given here is generally valid for communal wastewaters subsequent to biological clarification, i.e. prior to feeding into the flowing water. It corresponds to 140 mg COD per litre of water.

In general, no pollution is observed for small-scale piles (< 40,000 solid m^3). An increase in organic compounds and the COD-value is only likely to occur at the beginning of water spraying, but this phenomenon decreases rapidly after a two-three month period and remains, in all cases, less than 140 mg/l.
With regard to large-scale piles (> 40,000 solid m^3), some individual cases may show an increase of two to three times the limit value, decreasing, however, to harmless values after the same period of two-three months.

The values for pH, conductivity, concentration of various metal salts, ions, total nitrogen etc. show no rise and stay largely below their respective limit values.

The particular case of water spraying in recycling water systems

During the first months of sprinkling, the water running off the stems contains such large amounts of dissolved organic substances that if discharged directly into streams it can cause damaging pollution. However, this occurs only in situations where the discharged amount is very high compared to the amount and renewal of water in the stream. If there is a risk of this, the water should be recycled.

Advantages of using recycled water:

- The water is oxidised, leading to biological degradation of organic substances.
- The use of water is reduced.

Disadvantages of using recycled water:

- Suspended solid particles in the water bay cause the sprinklers to malfunction.
- The high reproduction rate of micro-organisms in the sprinkling water may cause bacterial slime to form, in extreme cases clogging the sprinklers.
- Observations indicate that breakdown of pit membranes in Conifer timber may take place faster if the sprinkling water is recycled, leading to permeability changes.

Groundwater pollution

No systematic investigations of groundwater pollution in connection with wet storage of logs have been carried out so far. Sampling is not expected to show any serious changes in groundwater quality even where good soil penetration occurs and where the surface of the groundwater is near ground level.

❑ ***Costs***

This is a relatively expensive method that is suitable for the conservation of large amounts of logs. The total costs in the first year are generally rather high due to the investment costs. Thereafter the incidental ongoing costs are relatively low. The method has been in use now for a long time and it is one of the most practical and economical methods available for log conservation.

Three types of costs:

1. Preliminary investments: infrastructure (road, drainage, etc.); equipment to water spray logs; electrical wiring; manpower to construct the site; etc.
2. Functioning costs: rent of the terrain; electricity and water consumption; maintenance; insurance; daily monitoring.
3. Costs following the period of conservation: log uptake; site restoration; log transport.

Table 10 and Figure 9 give a summary of these costs. The details are given in Annexe 5.

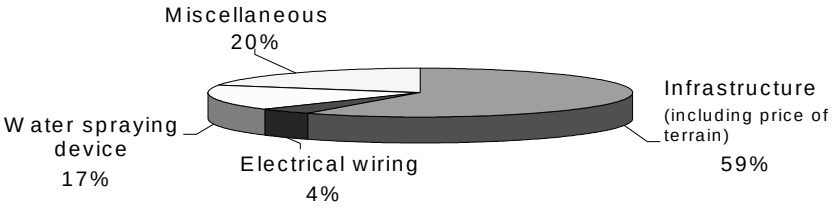


Figure 8: Details of the costs of preliminary investments

Remarks:

- There is usually a significant difference in investment cost based on whether the site is designed to be permanent or not. A permanent site costs in average 6 €/m^3 more than a non-permanent site.
- Usually, more investment is made for hardwood conservation than for softwood due to the higher initial value of the raw material.
- A recycled water system costs around 30% more than an open water system. For this reason, it is advisable to construct a recycling system in case of water shortage in the vicinity of the storage yard, unless water recycling is made compulsory by the authorities.
- Whatever the quantity of stored logs, the costs of implementation of the site per cubic meter remain similar. There seems to be no scale effect.

Table 10: Costs of log conservation under water spraying

	Mean (Euro/m^3)	**Min (Euro/m^3)**	**Max (Euro/m^3)**
Preliminary investments	13	6	34
Breaking load costs	8.3		
Functioning costs	1.8 €/m^3/year	1.4 €/m^3/year	2.2 €/m^3/year
Costs following storage		2.5	11

4.3.2.3 Wet storage: Ponding/Immersion in water

❑ ***Principle***

Desiccation of round timber may be prevented by immersion in water (ponding), thus maintaining or increasing the moisture content present in the standing tree. Wood moisture should be kept as high as possible. Infestation of the wood by fungi and insects can be largely averted, although certain bacteria are able to degrade wood soaked in water.

Photo 11: Site implementation for ponding (source: ONF, 2001))

Photo 12: Storage by immersion in water (Source: ONF, 2001

❑ ***Tree species***

Experiences and research results are available for Beech, Oak, Spruce, Pine and Fir. Species with specific gravity >1 in green condition, e.g. Beech and to some extent Fir are well conserved. "Floating" species (Spruce) may encounter degradation of parts protruding above the water surface. In this case, either the protruding part should be water sprayed or a device, such as a concrete pole, should be devised to sink the log.

❑ ***Preconditions***

Artificial or natural ponds/lakes must be available. Permission from authorities is necessary, at least when utilising natural waters. Access roads to the water and firm embankments must be present. Special equipment may be needed for recovering the wood at the end of the storage period. The opportunity to empty the pond is very advantageous. Timber must be freshly cut and any desiccation, as a result of floating too high in the water, should be avoided.

❑ ***Advantages***

Ponding/immersion is a long-term and safe round timber storage method in comparison to other methods. A considerable amount of information on this storage technique and the resulting wood quality is available. The conservation method is accepted by most of the wood processing industry. Wood stored under water can in some cases be sawn more rapidly than freshly cut timber. Provided that the wood has been properly stored its mechanical properties can be maintained for at least two years. Maintenance costs are very low compared to artificial water sprinkling.

❑ ***Disadvantages***

Spruce: A brownish-reddish discoloration of the outer sapwood occurs during storage due to bark substances being leached into the wood. Bacteria attacking pit membranes can cause increased permeability leading to excessive and uneven penetration of coatings and paints. This is not acceptable by window-frame manufacturers and the furniture industry for example.
Beech: Immersion may cause a yellowing or reddish-brown discoloration of the wood, which is more prominent than with water spraying. The wood should normally be steamed after sawing to ensure uniformity of colour.

Remarks: Surprisingly, the phenomenon of discoloration of Beech seems to slow down considerably after a period of in situ storage (cf. 4.3.2.1) followed by a period of immersion in water.

❑ ***Recommendations***

At least two thirds of the stems' diameter has to be permanently immersed, but even then the protruding part may suffer degradation. To facilitate the recovery of the timber it is advisable to tie the logs together in rafts or bundles. Coniferous wood should be bundled loosely into units of 10 to 20 solid m^3, whereas bundles of 6 to 12 solid m^3 should be used for broad-leaved species. Buoys should mark bundles of sinking species if the pond cannot be emptied.

❑ ***Environmental issues***

If the flora and fauna in natural ponds/lakes is to be protected from damage, it is important not to store large quantities of wood in small bodies of water. The oxygen consumption during the decomposition of the dissolved and suspended organic matter may have a fatal effect on fish and other aquatic organisms in small stagnant waters. Bark particles settling to the bottom may have a detrimental effect on the conditions for bottom-dwelling organisms. Wood that has previously been chemically treated in order to prevent insect infestation should never be immersed.

❑ ***Costs***

Two different scenarios are possible:

- The pond already exists, no excavation works are to be undertaken, but graveling of the embankment and some miscellaneous work such as the inclusion of a device to fill and empty the pond: **15 EUROS/m^3 plus VAT.**
- The pond must be built, excavation and other miscellaneous work is required and the embankment needs to be gravelled: **35 EUROS/m^3 plus VAT.**

Cost of operation: no maintenance should be necessary, but recovering the timber may become rather costly and, in some cases, even impossible.

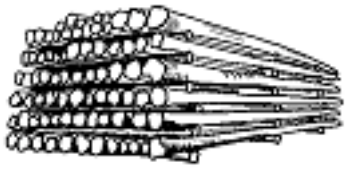
Remarks:

- In spite of these rather high costs, it should be emphasised that these ponds may also be used for fishing, tourism, water reserves for animals, etc.
- If further storm damage occurs, the ponds can be re-used immediately at no expense.

4.3.2.4 Storage under drying conditions: Log pre-drying in cross-pile (logs without bark)

❑ ***Principle***

By debarking and careful piling to allow for good aeration, wood moisture can be rapidly reduced to a level where there is no risk of infestation. (25-30% wood moisture related to oven-dry weight, that is below fibre saturation point).



❑ ***Tree species***

Experience and research results are available for Douglas Fir, Spruce, Larch and Pine.

❑ ***Advantages***

- In the case of dry storage, timber designated for construction can be pre-dried without using kiln drying. Such timber shows no increased problems of deformation after sawing when compared to other timber. This storage method could allow traditionally oriented sawmills to respond quickly to customer demand for construction wood. Furthermore, the pre-drying of logs in this way is viewed as an environmentally friendly option for construction.
- The target moisture content of 25-30% in sapwood is achieved with winter felling followed by drying in the spring and summer. Rapid seasoning of sapwood prevents fungal infections.
- Expensive sheeting, which has a short lifespan, can be avoided.
- Advanced piling technology allows for unidirectional piles to be handled faster and more economically.
- The short time periods allow for continuous delivery of the pre-dried round wood to the sawmills in the peak summer periods.
- The piles can be maintained within normal forest operations in the forest districts.
- Investment costs for sprinklers are not incurred.
- Permission according to water legislation is not necessary.
- There is no environmental pollution due to discharge of water from sprinkling.
- The ease with which piles can be accessed for quality assessment means that timber can be sold when marketing.
- Large piles of up to 200 m^3 can be used, depending on the range of the truck-crane, the size of the storage yard and the intended volume of the quantities to be sold.
- The conserved wood may be well below fibre saturation point, generally between 15 and 22%, depending on the weather. This permits the delivery of lumber that is dry, largely size-consistent, of arbitrary cross sections, without the need for further kiln drying.
- Sawn wood produced from the pre-dried round timber is largely size-consistent.
- The sawn wood can be subsequently kiln-dried quickly, economically and at a high drying capacity.
- Round timber conservation is more economical and carries fewer risks than kiln drying of large diameter lumber.
- Pre-dried round timber can be transported more easily.
- In periods of frost pre-dried round timber contains very little ice, compared to green round timber. It can, therefore, be easily sawn.
- Insecticide application to round timber is unnecessary if debarking is performed early.

❑ ***Disadvantages***

During the process is it possible for cracks to appear and infection can occur due to debarking, especially where there are side cuts. Storage should be limited to less than five months and it should be remembered that it is generally more suitable for sawn timber rather than round wood.

- Seasoning must be disrupted prior to reaching fibre saturation point to avoid excessive checking.
- Depending on the weather, large checks may form after initial drying. If sawing is not possible prior to this, then the uni-directional piles should be disassembled and loose piles formed to reduce the drying.
- Air-drying, by definition, is dependent on the weather and is therefore difficult to control.
- If drying is too slow, fungal damage can occur. If drying is too fast, there is a risk of excessive checks.
- The forestry and timber industry lack experience of this method.
- In the case of large storms the area needed for dry conservation is also large.
- Sawing of pre-dried round timber requires more energy than sawing of green wood. When sawing pre-dried round timber dust formation is more intense. The pulp industry prefers wet chips. However, using dry woodchips for chipboard production has advantages.
- Extra costs are incurred for round timber piling and maintenance.

❑ ***Practical experience***

Before preparation

Only healthy wood should be used. After debarking the logs should be pre-dried for one to two weeks.

Pile construction

Firstly, a layer of strong logs should be made as a base for the pile. It is important that there is enough distance between this layer and the ground. Spacers should be used when the pile construction seems unstable. The top layer should extend beyond the pile to facilitate covering. Construction takes 2.5 hour per 150m^3, excluding transportation time.

Sheeting

Sheeting, to protect the pile from rain, does not have to be carried out immediately unless rain is likely. Plastic foil with a textile structure is recommended. Sheeting takes 1.5 hours per pile. With correct construction the pile is maintenance free.

Suitable tree species

Conifers (without bark): Spruce, Fir, Douglas Fir, and Larch.

Spruce and Fir

- It is not possible to control the process as the piles are exposed to prevailing weather conditions.
- Excessive sunlight can cause cracks.
- Spruce is more likely to crack than Fir.
- Cracks can cause infection with blue stain and red stripe.
- The process is relatively expensive.

❑ ***Recommendations (application, time limits)***

This process should only be applied with the cooperation of the buyer. If properly applied, storage damage can be eliminated for up to three to five months. The success of the process depends on various conditions and beetle infestation can affect the quality of the wood. The use of plastic sheets requires neat piles and good spacing to soil level. The storage site should be situated in an airy, warm place that is not too exposed to solar radiation. The possibilities for successful conservation, especially in the case of Spruce and Fir, are good, but storage should take place not more than three weeks after debarking. Fast drying reduces moisture content, preventing biological damage, but if it is too rapid, cracks may occur.
The success of dry conservation of coniferous round timber whilst maintaining wood quality depends on the piling technique and on local weather conditions during the storage period. Only extremely rapid drying guarantees effective prevention of fungal discoloration.

❑ ***Quality monitoring***

This method can work well with Spruce, Larch and Douglas Fir, but blue stain is a major problem with Pine. It is recommended that fresh, healthy cut wood with no signs of beetle or fungal attack is used.

❑ ***Environmental issues***

Log pre-drying in cross piles is a cost effective and ecologically acceptable alternative to chemical wood protection and kiln drying. There is no need to use insecticide on the logs after rapid debarking. Furthermore, high CO2 emissions caused by kiln drying, can be avoided

❑ ***Costs***

An example of the costs in Southern Germany is approximately **10 Euros/m^3**. This includes 8 Euros for transport of the logs to the storage site and 2 Euros/m^3 for manipulation and maintenance of the pile. Extension of the storage period has little effect on the costs.

4.3.2.5 Storage under humid conditions: Compact pile (logs with/without bark)

❑ ***Principle***

In large compact piles, logs at the centre dry slowly. However the "uncontrolled" humid conditions that prevail with this method may lead to extended periods of high moisture and risk of wood decay (see chapter 4.2.2).

❑ ***Tree species***

Experience and research results are available for Spruce, Fir and Pine.

❑ ***Preconditions***

Healthy green logs with undamaged outer bark and no other defects; rapid storage; storage possible within the stand, in shady locations or sheltered moist hollows.

❑ ***Storage***

Large compact piles without bearers, alternating butt-end first and top-end first, and root collars trimmed.

PRECONDITIONS

Points to be considered before storing logs under humid conditions:

- Simple and inexpensive conservation method
- Availability of shady, sheltered and moist storage sites
- Availability of enough space for large, high piles
- Also suitable for (short) cut to length logs
- Only limited phytosanitary risk

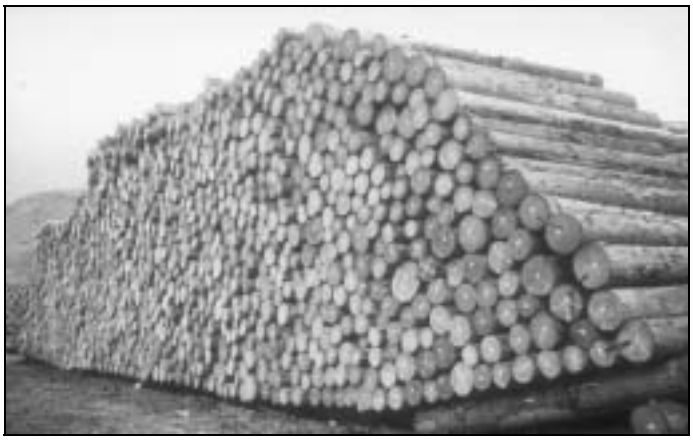


Photo 13: Example of storage under humid conditions' in a compact pile (Source: EMPA)

❑ ***Advantages***

- Logs can be stored within the stand in shady locations; on slopes of northern aspect; in sheltered hollows in conditions of high air humidity and gentle winds.
- Relatively low cost.

❑ ***Disadvantages***

- Dependence on climatic conditions.
- No influence on the development of wood moisture content.
- Only limited storage time without acceptable secondary wood defects.
- Risk of bark beetle attacks.

❑ ***Practical experience***

Spruce (Picea abies) and Fir (Abies alba)

Saw logs: After a six-month period of conservation of Spruce (Picea abies) and Fir (Abies alba), using compact piles, logs without bark and no water spraying, the measured loss in yield was 2% on average compared with the yield that would have been obtained with green sawn timbers (quantitative criteria). With regard to the economic loss due to downgrading of the sawn timber (according to European standards), the average loss was 18.5% in cost (qualitative criteria).

❑ ***Recommendations (application, time limits)***

Storage under humid conditions of large amounts of round timber is recommended only for healthy, green coniferous wood during the winter season, assuming the wood will be sold within one year. Maintaining wood quality greatly depends on the climatic conditions and is not, therefore, easy to predict.

It is possible to spray the logs with insecticides during construction of the piles. Ripcord 40 [Cypermethrin] will be effective for over six months against wharf borers (Nacerda melanura) and bark beetles in coniferous and broad-leaved trees. For protection against Spruce Longhorn (Tetropium castaneum) the logs need to be debarked prior to mid-August.

End sealing may also be considered.

THE COMMANDMENTS TO ACHIEVE GOOD RESULTS

1. Store only freshly cut (green) and defect-free logs with undamaged bark in large compact piles.
2. Allow only a short period from harvesting to piling.
3. Place lower grade logs in the lowermost and uppermost pile layers to protect the main pile against soil moisture and exposure to sunlight and rain.
4. Over-cut logs to allow for generous removal of infested parts.
5. Store uniform log lengths and grades.
6. Process the logs as soon as possible after storage.

❑ ***Quality monitoring***

- Observation of discoloration/fungal attack on fresh cut end-grains of protruding logs.
- Monitoring of wood moisture content.

❑ ***Environmental issues***

Very little impact to be expected. Some soiling of the storage site from fallen bark.

❑ ***Costs***

Standard expenses for transportation and piling. No additional “special” expenses.

4.3.2.6 Log conservation under oxygen exclusion, compact pile wrapped in plastic sheets (logs with bark)

❑ ***Principle***

This method conserves logs by the exclusion of oxygen, thus avoiding attack by fungi and insects.

Photo 14: Log storage under O_2 exclusion in Germany (Source: FVA)

❑ ***Tree species***

The method is applicable for several tree species. The following species were tested: conifer trees (Spruce, Fir, Douglas Fir and Pine) and broad-leaved trees (Beech and Sycamore Maple)

❑ ***Preconditions***

- Flat terrain.
- Plastic sheets of high diffusion resistance (e.g. PE-silo sheets).
- Gas-proof thermo-welding.
- Healthy, green wood.

❑ ***Storage***

- Storage in piles arranged longitudinally or transversely to the forest roads.
- All-sided wrapping in plastic sheets.
- Gas-proof thermo-welding of the protruding ends of the sheets.
- Checking the condition of the plastic sheet, sealing of leakages.

❑ ***Advantages***

- The conservation of quality using this method is considered to be good.
- This type of conservation is suitable for long-term storage only.
- Plastic film storage is mainly successful in terms of quality and fungi and beetle attack during storage.
- Subsequent maintenance is low, thus saving costs.

❑ ***Disadvantages***

- Mice, fox and marten damage might occur if the quality of the plastic film is insufficiently robust.
- The condition of the underlying layer should be strictly defined (planar, sandy soil).
- The demands on the packing team are high because of the large size of the objects that must be packed and air-proofed.
- This method is especially applicable for regions where sprinkling storage is not an option.
- To be effective, this conservation method requires more effort compared with traditional methods.

❑ ***Practical experience***

Spruce and Fir

The unpacked wood shows no essential qualitative change and its use is not limited. The wood quality remains good over a period of about three to four years.

Beech and Maple

Beech and Maple are more susceptible with this storage method. The risk of uneven colour in Beech could be reduced by steam-processing There are positive results for Beech veneer.
Germany: good results over period of about 15 to 18 months for Beech veneer, but after that there is a risk of uneven colour developing.
France: After three years the wood quality remains good if the initial quality was good. Experiments are still ongoing.

❑ ***Recommendations (application, time limit)***

Setting up of signs warning of the danger of suffocation for anyone crawling into the plastic sheets.

❑ ***Miscellaneous***

Experiments show that the value can be maintained over longer periods of time. In some cases, a thin layer of white mushrooms has been observed on the pile at the opening of the plastic sheets but, apparently, without any influence on the wood quality. The same type of discoloration appears to occur in both the drying off and wet storage method.

This method offers alternative long-term protection against insect and fungal attack without depending on climate, storage site, tree species and size of the pile. It is applicable in nature-conservation and water protection areas too. The complete costs for the first year are comparable with those of water storage. The input for monitoring and maintenance is low. Monitoring to detect damage to the plastic film needs to be done only periodically.

❑ ***Quality monitoring***

Quality monitoring is only possible after unpacking the piles. During the conservation period it is possible to measure the interior atmosphere (oxygen/carbon dioxide content) of the wrapped pile with a measuring instrument that remains outside the pile. It is possible to record changes in the interior climate of the wrapped pile at defined time intervals.

❑ ***Costs***

	Pile Spruce / Fir Length: 18.5 m / Vol.: 235 m^3	**Pile, Beech veneer Length: 6.5 m / Vol.: 100 m^3**
Material / m^3	2,80 euros	3,27 euros
Amortisation costs / m^3	0.70 euros	0.70 euros
Staff costs / m^3	3,32 euros	6.14 euros
Extraordinary costs / m^3	Excavator 0,33 euros	/
Total costs / m^3	**7,15 euros**	**13,03 euros**

4.3.2.7 Supplementary conservation methods

❑ Chemical wood protection

Principle

In order to avoid attack from wood-boring insects and/or fungal discoloration, the wood may be treated with insecticides and/or fungicides.
The function of insecticide application is to prevent or repel adult beetles from boring into the bark in order to lay their eggs. Once the beetles are under the bark or within the wood they are largely safe from chemical sprays and the application of insecticides is useless, hence the treatment must be carried out in late winter or in early spring before the adult beetles begin their search for breeding material. If the expected duration of storage extends beyond one summer, other ways of protecting the timber should be sought.

Log preparation

- Perfect delimbing.
- Crosscutting to provide clean cut-ends.
- Removal of lichens and mosses from the bark with a metallic brush.

Material

- Small log storage: a garden home sprayer is sufficient.
- Large log storage: a knapsack sprayer.

Methodology

For efficient protection:

- Treatment must be undertaken as soon as possible
- Temperature > 0°C
- Dry weather/no rain during application (pollution risk + inefficient treatment)
- Each log must be completely treated, including the part in contact with the ground
- Wounded parts must be treated particularly carefully
- Application of an anti-check product where bark is missing.

Precautions

- Avoid contact with skin and mucous membranes.
- Use protective clothing (trousers, gloves, glasses, etc.).
- Avoid shaking the products during transportation.
- Respect the chemical products' specifications. Some products may be prohibited for use in forests.
- Manufacturers' recommendations, risk and COSHH assessments must be adhered to.

Alternatives to insecticides

- To reduce beetle attack effectively storage periods must be reduced, particularly in the spring. Logistics could be improved in order to minimize the time between logging and conversion, or the processing speed could be reduced in favor of live conservation, provided that the fallen trees have maintained sufficient root contact.
- Dry storage is another method that can be used to avoid beetle attack. The logs must be debarked, transported out of the forest and stored in open sites. The duration of storage should not exceed 5-6 months. A beetle infestation cannot be excluded totally but only few species will attack debarked logs.
- In wet storage with proper intensity and coverage by sprinklers, beetles will die and the brood cannot develop further.

❑ Biological wood protection

The use of biological control to prevent decay and/or stain in green timber has many attractions. Although many laboratory and small-scale trials have been encouraging, field trials have resulted in limited success and, in many cases, total failure. Even with shorter term storage of sawn timber there has been limited success. In longer term log storage, recent work has been directed towards decay prevention in pole material. Again larger scale trials have been disappointing.

At the present time it is felt that biocontrol cannot be recommended. However, it is felt that research that specifically addresses the shortcomings should be encouraged.

❑ Physical wood protection

End-sealing of logs

A well-known method for protecting round wood (especially hardwood logs) is coating exposed parts of the wood with a material preventing the passage of air and water. The effect of the method is prevention of drying and, probably, an increased carbon dioxide concentration within the log.

The sealants used commercially are mostly wax dispersions, e.g. Anchorseal (Bates Co.) and Mobil-Cer (Mobil Oil). Earlier experiments have also shown good results from applying the product Permaroof, a substance originally developed for the water-proofing of leaking roofs. This bitumen-based compound is still available on the market.

Sealing of log ends may be used in combination with fungicide treatment in order to minimise fungal discoloration.

ANNEXES

Annexe 1: Terminology / Definitions for log conservation

Category	English (synonym)	Definition	Français	Deutsch (Synonym)	Italiano (sinonimo)	Español (sinónimo)	Portuguese	Danish ()
General term	wind-blown timber (storm-damaged timber)	timber from trees damaged by a storm (broken, thrown or leaning trees)	chablis	Sturmholz	legno proveniente da schianti	derribos	madeira derrubada pelo vento	stormfældet træ
General term	log conservation (log storage)	long-term (several months) storage of logs with the goal to preserve the wood quality	conservation des grumes (stockage des grumes)	Rundholzlagerung (Rundholzkonservierung)	conservazione dei tronchi (stoccaggio dei tronchi)	conservación de trozas	conservação de toros (armazenamento de toros)	lagring af stormfældet træ
General term	round timber	harvested part of tree stem	bois rond	Rundholz	legno tondo	madera en rollo	rolaria	[coniferous] =tømmer, [deciduous] =kævler,
General term	long pole	whole stem	grume	Langholz	fusto	fuste	árvore inteira	hel stamme
General term	cut to length	stem cut into shorter pieces	billon	Kurzholz (Trämel)	toppo	madera tronzada, trozas	madeira torada	korttømmer, korttræ
General term	overcut (overmeasure)	addition in log length to account for staining in the end-grain	surcote	Übermass (Zumass)	soprammisura	holgura en longitud de tronzado	medida acima do corte estabelecido	overmål
General term	with bark	logs with bark	avec écorce	in Rinde	con corteccia	con corteza, c/c	com casca	med bark
General term	without bark (debarked)	logs with bark removed	sans écorce	entrindet	scortecciato	sin corteza, s/c	sem casca (descascada)	afbarket
General term	conservation method	particular technique to achieve goal of log conservation	méthode de conservation	Lagerungsmethode	metodo di conservazione	método de conservación	método de conservação	lagringsmetode (opbevaringsmetode)
General term	pile	heap of logs	pile	Polter	catasta	pila	pilha	stak (stabel)
General term	compact pile	heap of closely piled logs	pile compacte	Haufenpolter	catasta compatta	pila compacta	pilha compacta	tæt stablet træ
General term	cross-pile	heap of logs with perpendicular intermediate layer of single logs allowing free ventilation	pile à rangs croisés	Lagenpolter	catasta con strati perpendicolari	pila encastillada	pilha com troncos cruzados transversalmente	krydsstablet træ
General term	standing tree	tree in upright position (inclination 90-60°)	arbre sur pied (arbre debout)	stehender Baum	albero in piedi	árbol en pie	árvore em pé	stående træ
General term	leaning tree	tree with inclination 59-30°	arbre penché	angeschobener Baum	albero inclinato	árbol inclinado	árvore inclinada	hældende træ
General term	uprooted tree	thrown tree with inclination 29-0°	arbre déraciné	geworfener Baum	albero sradicato	árbol desarraigado	árvore arrancada	rodvæltet træ (rodvælter)
General term	broken tree (snapped tree)	tree broken in 2 (or more) separate pieces	arbre cassé	gebrochener Baum	albero spezzato	árbol tronchado	árvore partida	knækket træ
Cons. method	in situ storage	logs left untouched in place in the stand	conservation in-situ	Lagerung im Bestand	stoccaggio in situ	almacenamiento in situ	armazenamento no local do povoamento	lagring på faldstedet
Cons. method	live-conservation of wind-thrown trees	in situ storage of living, uprooted trees with sufficient root contact	conservation sur site des bois partiellement déracinés	Lebendkonservierung im Bestand	stoccaggio in piedi di alberi danneggiati dal vento (ma ancora radicati)	conservación en vivo de árboles parcialmente desarraigados	conservação em vida de árvores derrubadas pelo vento	lagring på faldstedet af stormfældede træer med rodkontakt og levende kroner
Cons. method	drying by transpiration	in situ storage of entire trees (with crown) with a cross-cut at the stem base	séchage par transpiration	Physiologische Trocknung (Ganzbaumlagerung)	Stagionatura per traspirazione	secado natural, secado al aire	secagem por evaporação	udtørring af træet ved fordampning fra kronen ("syrefældning")
Cons. method	wet storage	storage under (controlled) wet conditions keeping the wood saturated	stockage sous eau	Nasslagerung	stoccaggio in acqua	almacenamiento en húmedo	conservação com água	våd lagring
Cons. method	compact pile with water sprinkling	compact pile with water sprinkling (logs with bark)	pile compacte sous aspersion d'eau	Nasslagerung durch Beregnung	catasta compatta con aspersione d'acqua	pila compacta bajo aspersión	pilhas compactas com sistemas de expressão de água	vandlager med sprinklere
Cons. method	ponding (immersion in water)	storage of logs in running or standing water (logs with bark)	immersion	Nasslagerung in Gewässern	immersione	inmersión	conservação de toros por imersão	lagring i sø eller damme
Cons. method	storage under drying conditions	storage under (uncontrolled) conditions resulting in slow or fast drying of the logs	stockage à l'air sous conditions asséchantes	Rundholzwortrocknung	stoccaggio al riparo dagli agenti atmosferici	almacenamiento en condiciones de secado al aire	armazenamento de toros ao ar livre	tør lagring under ukontrollerede betingelser

Category	English (synonym)	Definition	Français	Deutsch (Synonym)	Italiano (sinonimo)	Español (sinónimo)	Portuguese	Danish ()
Cons. method	log pre-drying in covered cross-pile	pre-drying of logs in covered cross-pile (logs debarked)	Pré-séchage des grumesen pile croisée couverte	Rundholzvortrocknung in gedecktem Lagenpolter	pre-essiccazione in cataste, con strati perpendicolari, coperte	pre-secado de trozas en pilas encastilladas bajo cubierta	pré-secagem dos troncos em pilhas cobertas	tørring af afbarket træ under tag eller afdækning
Cons. method	rapid log pre-drying in open cross-pile	rapid log pre-drying in open cross-pile (logs debarked)	pré-séchage rapide des grumes stockées en pile croisée ouverte	Schnelle Rundholzvortrocknung in offenem Lagenpolter	pre-essiccazione veloce in cataste, con strati perpendicolari, non coperte	pre-secado de trozas en pilas encastilladas descubiertas	pré-secagem de pilhas ao ar livre com troncos cruzados	lufttørring af afbarket krydslagt tømmer
Cons. method	storage under humid conditions	storage under (uncontrolled) changing conditions	stockage humides en pile compacte	Lagerung unter feuchten Bedingungen (Feuchtlagerung)	stoccaggio all'aperto	almacenamiento en condiciones húmedas no controladas	armazenamento em condições humidas	lagring under fugtige ukontrollerede betingelser, f.eks. på skovbunden
Cons. method	compact pile	compact pile (logs with bark / debarked)	pile compacte	Haufenpolter	catasta compatta	pila compacta	pilha compacta	tæt stablet træ
Cons. method	compact pile covered with plastic sheets	compact pile covered with plastic sheets (logs with bark / debarked)	pile compacte recouverte d'une bâche plastique	Haufenpolter mit Folien-Abdeckung	catasta compatta coperta da teli di plastica	pila compacta recubierta con plástico	pilha compacta coberta com plásticos	tømmerstak afdækket med plasticfolie
Cons. method	'special' methods	conservation methods with protection mechanisms not fitting into main categories	méthodes spéciales	Spezialverfahren	metodi particolari	métodos especiales	métodos especiais	specielle lagringsmetoder
Cons. method	log conservation under oxygen exclusion, compact pile wrapped in plastic sheets	compact pile wrapped and sealed in plastic sheets resulting in oxygen free conservation atmosphere (logs with bark)	conservation en atmosphère confiné, pile compacte enroulée dans une bâche en plastique scellée	Rundholzkonservierung durch Sauerstoffentzug	stoccaggio del legno in assenza di ossigeno, cataste compatte avvolte da teli di plastica	conservación en atmósfera pobre en oxigeno de pilas compactas bajo plástico hermético	conservação de troncos em pilhas seladas sem entrada de oxigénio cobertas com plásticos	lagring i lufttæt plasticfolie i iltfri atmosfære
Cons. method	compact pile covered with geo textile fabric	compact pile covered with geo textile fabric (logs with bark)	pile compact recouverte d'une feuille de géotextile	Haufenpolter mit Geowies-Abdeckung	catasta compatta coperta con tessuto geotessile	pila compacta cubierta por tejido geotextil	pilha compacta coberta com tela têxtil	tømmerstak afdækket med "geotekstil"
Cons. method	compact pile covered with a mineralic suspension	compact pile covered with a thin layer of mineralic suspension (protection against insects)	pile compacte recouverte d'une suspension minérale	Haufenpolter mit mineralischer Schutzhülle	catasta compatta trattata con una sospensione minerale	pila compacta cubierta por una suspensión mineral	pilha compacta coberta com uma folha de mineral em suspenção	tømmer beskyttet mod insektangreb ved hælp af kalk eller andet mineralsk stof
Cons. method	storage in gravel pits	compact pile buried in a hole in the ground or on level ground covered with thick layer of clay/soil	stockage sous terre	Erdlagerung	stoccaggio per interramento	almacenamiento de pilas enterradas	armazenamento em subterrâneos ou ou pilhas cobertas com barro	lagring ved nedgravning i grusgrave
Cons. method	storage in mines	storage in unused mine tunnels	stockage dans des mines	Lagerung in Bergwerken	stoccaggio in miniera	almacenamiento en minas	armazenamento em minas	lagring i minegange
Cons. method	compact pile above timberline	compact pile above timberline (logs with bark)	pile compacte stockée au-dessus de la limite supérieure des forêts	Haufenpolter oberhalb Waldgrenze	stoccaggio in altitudine	pila compacta bajo el límite altitudinal del bosque	pilha compacta em zonas de montanha, acima da linha de crescimento da	lagring i bjerge over trægrænsen
Cons. method	storage in snow	compact pile covered with snow	stockage sous la neige	Lagerung unter Schnee	stoccaggio sotto la neve	almacenamiento bajo la nieve	armazenamento na neve	lagring i sne
Cons. method	compact pile covered with organic material	compact pile covered with bark chips, wood chips, sawdust etc.	pile compacte couverte de matière organique	Haufenpolter mit Abdeckung aus organischem Material	stoccaggio con materiale organico	pila compacta cubierta por materia orgánica	pilha compacta coberta com material orgânico	lagring i kule
Cons. method	supplementary conservation measures	conservation measures supplementary to main methods (integrated methods)	mesures supplémentaires de conservation	zusätzliche Schutzmassnahme	misure supplementari di conservazione	medidas suplementarias de conservación	medidas suplementares de conservação	supplerende beskyttelsesforanstaltninger
Cons. method	chemical protection	wood protection by chemical agents	protection chimique	chemischer Holzschutz	protezione chimica	protección química	protecção química	kemisk beskyttelse af træ (med insekt- og/eller svampemidler)
Cons. method	biological protection	wood protection by biological agents	protection biologique	biologischer Holzschutz	protezione biologica	protección biológica	protecção biológica	"biologisk træbeskyttelse" ved hjælp af bakterier, antagonistiske svampe eller lignende
Cons. method	physical protection	wood protection by physical measures (e.g. end-grain sealing)	protection physique	physikalischer Holzschutz	protezione con mezzi fisici	protección física	protecção física	fysisk bskyttelse f.eks. smøring af endeflader
Processes	input	process of building up a log storage	mise en place	Einlagerung	inizio (del processo di stoccaggio dei tronchi)	montaje	entrada	opbygning af lageret
Processes	removal	process of extracting logs from a log storage	reprise	Auslagerung	interruzione (del processo di stoccaggio dei tronchi)	retirada	remoção dos troncos do armazenamento	tømning af lageret
Material	sprinkler	device to produce artificial rain	arroseur	Kreis-/Sektorregner	aspersore	aspersor	aspersor	sprinkler

Annexe 2: Glossary / Definitions for harvesting

Category	Term	Definition	Synonyms	German	French
General terms	Harvesting	cutting, processing and extraction of timber		Holzernte	Exploitation forestière
General terms	harvesting method	combination of machines/manpower and order how to process the timber		Holernteverfahren	Méthode d'exploitation
General terms	harvesting system	defined by the level of processing the timber (log,stem,tree)/ level of mechanisation		Holzerntesystem	Système d'exploitation
Harvesting system	CTL (cut to length system)	stem is bucked into logs inside the stand on specific length/diameter combination		Kurzholzsystem	Coupe à longueur
Harvesting system	french log system	crosscutting to specific (user orientated) diameter		Ablängen/Trennschnitt (kundenorientiert)	Système Bois en longueurs spécifiques
Harvesting system	full tree system	stem with roots is extracted from the stand		Vollbaumverfahren	Système à culée noire
Harvesting system	shortwood system	bucking on fix lengthes		Fixlängen	Système Bois en courtes longueurs
Harvesting system	stem system	stem without branches is extracted from the stand		Stammverfahren	Système Bois en grandes longeurs
Harvesting system	tree length system	stem (with/without branches/toped) is extracted without any bucking		Langholzsystem	Système Bois en grandes longeurs
Harvesting system	tree system	stem with branches is extracted from the stand		Baumverfahren	Système Bois en arbres entiers
Harvesting method	fully mechanized harvesting	all processing is made with machines		Voll mechanierte Holzernte	Exploitation mécanisée
Harvesting method	manual harvesting	all processing is made without any powered tools		händische Holzernte	Exploitation manuelle
Harvesting method	motor manual harvesting	the cutting/delimbing/bucking is done by chainsaw, other processes mechanized		Motor-manuelle Holzernte	Exploitation semie-mécanisée
Harvesting method	partial mechanized harvesting	in minimum one process step is forced by manpower (for example chainsaw)		Teilmechanisierte Holzernte	Exploitation mécanisée partielle
Equipment	cable yarder	machine with a tower to fix and winches to operate the lines	tower yarder	Seilkran	Câble -mât
Equipment	chain saw	powered saw	power saw	Motorsäge	Scie à chaîne
Equipment	chipper			Hacker	Broyeur
Equipment	clam-bunk skidder	with standing grapple to put stems/trees with a loading crane into the grapple		Klemmbankschlepper	Débusqueur à pince
Equipment	debarker	machine removes the bark (minimizing pest risk)		Entrindungsmaschine	Ecorceuse
Equipment	delimber, rotor	machine removes the branches by rotating tools		Entastungsmaschine, rotierend	Ebrancheur, machine
Equipment	delimber, strike boom	machine push the tree against fixed tools		Schubentaster	Ebrancheur, grue
Equipment	farm tractor	standard tractor logs/stems attached directly		Agrarschlepper	Tracteur agricole
Equipment	feller	machine to cut single tress mechanical		Feller	Abatteuse
Equipment	feller buncher	machine to cut and collect the trees		Feller Buncher	Abatteuse - empileuse
Equipment	forest tractor	adapted with process tools (winch,loader,grapple) and safety tools		Forsttraktor	Tracteur forestier
Equipment	forester		harwarder	Kombinierte Holzernte- und Rückemaschine	Combiné
Equipment	forwarder	wheeled/tracked machine to transport timber, free of ground, to the road		Rückefahrzeug	Porteur, débardeur
Equipment	grapple skidder	with hanging grapple to get the timber from the ground		Zangenschlepper	Débusqueur à grappin
Equipment	harvester, one-grip	wheeled/tracked machine with felling/processing aggregate on a crane		Eingriffharvester	Machine de bûcheronnage à une prise
Equipment	harvester, two grip	wheeled/tracked machine with felling aggregate on a crane and processing aggregate on the chassis		Zweigriffharvester	Machine de bûcheronnage à deux prises
Equipment	loader	wheeled/tracked machine to load and pile		Lader	Chargeur
Equipment	loading carrier	carrier to transport timber, free of ground, to the road		Hänger	Remorque
Equipment	processor, bank	machine which puts the stems/trees by crane to the processing unit (delimbing,bucking)		Bankprozessor	Tête d'abattage,...
Equipment	processor, crane	processing head (delimbing,measurement,bucking) mounted on a crane		Kranprozessor	Tête d'abattage, grue...
Equipment	skidder	specific tractor for timber extraction (timber touch the ground)		Knickschlepper	Débusqueur
Equipment	swing boom grapple			Krangreifer (mit Schwingkopf)	Grue articulée

Category	Term	Definition	Synonyms	German	French
Equipment	winch skidder	with winch for in hauling of logs/stems/trees		Windenschlepper	Débusqueur à câble
Work task	bucking	crosscutting the stem into merchantable length/diameter combinations	crosscutting	ablängen	Découpe
Work task	cuttting	crosscut a tree on the bottom	felling	umschneiden	Abattage
Work task	debarking	removal of the bark, manual or mechanical		entrinden	Ecorcage
Work task	delimbing	removal of the branches, manual or mechanical		entasten	Ebranchage
Work task	forwarding	extraction of timber, timber don´t touch the ground	logging	Rücken (mit Forwarder)	Débardage
Work task	hauling	pulling the timber to the skidder/yarder		zuziehen	Halage
Work task	logging	extraction of timber (yarding/skidding/forwarding)	hauling off	Hieb	Vidange des bois
Work task	piling	storing logs/stems in stable layers		stapeln	Empilage
Work task	separation	move stem/part of stem into a stable and safe position for further processsing		entzerren	Séparation
Work task	skidding	extraction of timber with ground bases systems, timber touch the ground	logging	ausschleppen	débardage
Work task	toping	cutting off the not merchantable top of the tree		abzopfen	Ecimage
Work task	yarding	extraction of timber with cable systems	logging	ausseilen	Débardage par câble
Sylvicultural operation	afforestation	planting of young trees to establish a new stand (species, mixture)		Aufforstung	Plantation
Sylvicultural operation	clear cut	harvesting of each tree on a stand		Kahlschlag	Coupe rase
Sylvicultural operation	final cut	removal of the old trees after natural regeneration fulfills the needs		Endnutzung	Coupe finale
Sylvicultural operation	natural regeneration	establishing a new stand by seedlings of the former stand during the last years before the final cut happens		Naturverjüngung	Régénération naturelle
Sylvicultural operation	residual stand	remaining trees after a harvesting operation		verbleibender Bestand	Peuplement restand
Sylvicultural operation	thinning	removal of a part of the stand following silcicultural management principles		Durchforstung	Eclaircies
Traffic lines	cable line	lines / corridors for setup of cable cranes	cable corridor	Seillinie	Couloir de câble
Traffic lines	forest road	paved surface for trucks		Forststrasse	Route forestière
Traffic lines	secondary road	unpaved not for trucks connecting strip road/ skid trail to forest road		Forstweg	Piste forestière
Traffic lines	skid trail	temporary traffic lines inside the stand		Rückegasse	Voies de débardage
Traffic lines	strip road	permanent systems of traffic lines inside the stand (geometric / random)		Rückeweg	Cloisonnements
	leaning			lehnenend	Inclinaison
	log	merchantible diameter/length combination		Bloch	Grume
	site restauration			Flächenvorbereitung	Restauration
	solid volume			dem Konoid entsprechendes Volumen	Volume
	stump			Stock	souche
	top end diameter volume			Volumen des dem Zopfdurchmesser entsprechenden Zylinders	Diamètre petit bout
	volume			Volumen des dem Mittendurchmesser entsprechenden Zylinders	Volume
	broken/blowdown/fallen			Bruch/Sturmwurf/Wurf	Cassé, chablis, tombé
	protokoll terms			Definitionen	Terme de protocole
	transport			Transport	Transport

Annexe 3: Safety reports

Leaning tree falls and kills a logger

BACKGROUND:
In the morning, four chain saw operators were working in a storm damaged forest, composed of spruce and beech. The logging site was flat and the weather was good enough. But it was really hard to move away because of the entangled trees, the root plates and the branches under tension.

PERSONAL CHARACTERISTICS:
The chain saw operators were divided in two crews with two loggers in each one. They did not wear their personal protective equipment and clothing (helmet, protective trousers).
The 29 year old logger had been working as a chain saw operator for three years. His colleague was a chain saw operator's apprentice and he had been working for few months in this enterprise. None of them had ever attended any logging safety training programs for salvage operations

ACCIDENT:

The chain saw operator delimbed an up-rooted tree, lying in the ground. 12 meters away from him, the apprentice cut another up-rooted tree free from its stump.

The apprentice finished cutting the trunk. So the root plate fell back in its hole.

Then, an unstable leaning tree, which had been kept in a standing position with the root plate, fell. This 15 meter tall tree hit the chain saw operator in the face.

INJURY:
His colleagues immediately contacted emergency medical personnel and the police. But the logger was killed instantly.

RECOMMENDATIONS FOR CORRECTION:
- Whenever possible, fell or remove snags, up-rooted trees, leaning trees, lodged trees, and other dangerous trees with mechanical means to minimise employee exposure.
- Ensure that there is a distance between tree fellers (and operators in general) of at least twice the average height of trees being felled, even with up-rooted trees.
- Only fellers with special training, appropriate experience and of course personal protective equipment should cut these dangerous trees.
- In storm damaged stands, start cutting the trees located on the top and then the leaning trees.

Trunk under tension crushes logger's hand

BACKGROUND:
In the middle of the morning, a chain saw operator was working in a storm damaged forest. The logging site was flat and the weather was good.

PERSONAL CHARACTERITICS:
The 22 year old logger had been working as a chain saw operator for only one year. He had never attended any logging safety training programs.
He was working with two other chain saw operators: his manager, who was considered fully skilled, and another employee who only delimbed the trees. Just as the accident was happening, the victim was working 50 meters from his colleagues.

ACCIDENT:
The accident occurred when the chain saw operator was cutting an up-rooted 80cm diameter spruce free from its stump. The chain saw was equipped with a 75cm length guide bar.
The up-rooted spruce lay between two standing trees. The trunk was under heavy vertical tension. Moreover, the root plate leaned a little bit over the trunk and it was supported by a standing beech.
The logger stood over the root plate hole, one foot on a root. He began cutting from the compressed side of the trunk to the opposite side. Just as the stem was separating from the stump, the root plate moved. The root, which the logger had put his foot on, suddenly broke. He fell in the hole and pulled his chain saw away. In order to keep standing, he put his left hand on the root plate which was still supported by a beech. The spruce trunk under tension struck the root plate and crushed the logger's left hand.

INJURY:
He called his colleagues who took him immediately to the nearest hospital. Within 15 days, he had returned to work. This accident could have had worse consequences if the root plate had moved back.

RECOMMENDATIONS FOR CORRECTION:
- First analyse the situation: where there are tensions, determine how the stem will move after cutting.
- Work in a safe area and clear in advance an unobstructed fall path for the tree to be cut. If it isn't possible to work in safe conditions near the stump, cut the trunk one or two meters from the root plate.
- Remove the tensions before cutting. In this case, the top of the tree was also under heavy tension. Starting the work by delimbing (if it was possible) would have suppressed the tensions, before cutting the trunk free from the stump.
- Use mechanical means (cable skidder) in order to help manual operator and to avoid risks.

Harvester falls lodged tree onto worker

BACKGROUND:
An harvester and a chain saw operator were both working in semi mechanized logging operations in storm damaged forest. The spruce stand was composed of 30cm diameter and 25 meter tall trees.

PERSONAL CHARACTERISTICS:
The 20 year old harvester operator had not attended any basic training or up-dating training for salvage operations. The harvester was a tracked excavator with a harvesting head.

The 30 year old chain saw operator was a contractor. He wore all his personal protective equipment. He had been working only a few times with the harvester operator.

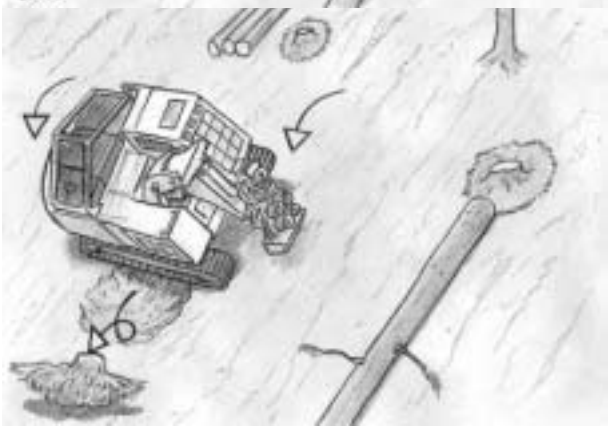
ACCIDENT:
The contractor was working 20 meters from the harvester. He was always in front of the harvester in order to cut the up-rooted trees free from their stump.
There were two standing spruces between the harvester and the chain saw operator: one was undamaged, the other was partially up-rooted, leaning and lodged in the first one.
The harvester cut first the undamaged tree. Just as the tree was cut, the hanging spruce was dislodged. It fell on the chain saw operator's head. The contractor who was concentrating on his work did not see the falling tree and did not move and get away.

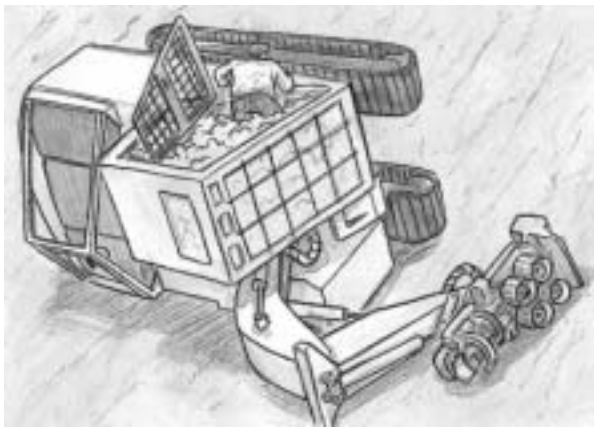
INJURY:
The harvester operator immediately phoned for help. But the chain saw operator had been killed instantly.

RECOMMENDATIONS FOR CORRECTION:

- **Always maintain safety distance between operators: at least twice the height of trees being felled.** Logging workers should be assigned to separate working areas. Do not go in the working area of a harvester (or any machinery), except if stopped.
- **In a storm damaged forest, begin cutting danger trees,** particularly the lodged trees. Finish the cutting by the broken trees or the undamaged trees.
- **Only fully qualified forestry workers (including machine operators) should participate in salvage operations**. When acute forest damage has occurred the qualified forest workers should be given on-site refresher training.
- When employees of two enterprises work on the same logging site, safety rules should be established and explained to the forest operators (description of the potential dangers and the way to avoid them).

Harvester falls on a slope





RECOMMENDATIONS FOR CORRECTION:

- Do not work across slopes. With this kind of machinery, in a slope up to 20-25%, the harvester can work in a steep terrain, but in the direction of the main slope.
- In storm damaged forest, drive carefully because of root plates and their holes which represent some obstacles. Turning over can occur very often.
- A fire extinguisher filled with powder must be fixed outside of the cab. A little extinguisher with CO_2 can be put in the cab only if the cab is correctly ventilated.
- All the objects in the cab (fire extinguisher, tool box) have to be securely fastened.

BACKGROUND:
An harvester was working in a steep terrain. The stand was storm damaged. Most of the trees had been felled down in the direction of the main slope.

PERSONAL CHARACTERISTICS:
The harvester operator had been working for 6 months in this enterprise. Just before, he had attended a training course for one year in order to drive this kind of machinery.
The harvester was a tracked excavator with an harvesting head.
A forwarder and the forest owner were also present on the logging site.

ACCIDENT:
At the beginning of his working day, the harvester operator went to finish the delimbing and bucking of trees which had been already cut by a chain saw operator.

The harvester worked on the slope. The lower track was on a cut root plate. The operator started cutting an up-rooted tree in front of him. Then he felt the root plate which supported the track moving down. He left the tree that he was delimbing and brought the harvester head nearer the cab in order to counterbalance the machinery.

But all the machine weight was at that time on the unstable root plate. Then the last roots broke and the plate rolled downhill. The harvester fell down on to its side.

With the fall, the fire extinguisher of the cab fell down and filled the cab completely with powder. The operator was blinded and came near to suffocating. He had some trouble to find the handle, but he succeeded in opening the door.

INJURY/DAMAGE:
The operator wasn't injured but he swallowed a great quantity of powder from the extinguisher. He spent one day under observation at the hospital. Fortunately, the powder was inoffensive.

Two skidders and one dozer were necessary to stand up the harvester. The engine and hydraulic jacks were damaged as a result of the fall.

Annexe 4: Model Contract

CONTRACT No.

_____

Mr. _____ Address:

_____

Telephone:

_____

As owner of the cutting area:

_____

Or manager for the forest ownership group:

_____

Other (specify):

_____

SELLS THE FOLLOWING UNPREPARED WOOD, BY UNIT OF PRODUCT:

- Locality
- Cadastral references
- Boundaries
- Approximate area
- Species concerned (specify)
- Cross-cutting requirements for commercial wood (specify by species)
- Cross-cutting requirements for pulpwood (specify by species)
- Cross-cutting requirements for fuel-wood (species concerned):
- Location of primary processing-storage sites: ……..

To Mr. _____ Address:

_____

Telephone:

_____

Harvesting contractor:

_____

Other (specify):

_____

- The present contract shall be executed from (date):
  _____
- It shall expire with the full completion for the felling and clearance, not later than:
  _____
- Penalty for delay in clearance: YES _____NO _____
- If YES, define:
  _____
  _____

The purchaser, Mr. _____ undertakes all measures necessary to ensure compliance by the fellers and skidding operators with the operating conditions specified and counter-signed on page x of the present contract.

In the event that an enjoinder of performance communicated by a registered letter subject to acknowledgement of receipt produces no result within a period of 10 days, termination of the present contract by the seller for reasons such as non-performance, desertion of the site or non-compliance with provisions of the contract, shall become effective automatically and without any legal formality. In this event, the seller shall be able to conclude a contract with another purchaser, and the sums already paid by the purchaser shall be retained as contractual damages.

In the event of non-performance of the seller's obligations, termination of the contract by the purchaser shall take effect automatically, without any legal formality, following communication by registered letter subject to acknowledgement of receipt of an enjoinder of performance that produces no result within a period of 10 days.

The seller shall place at the purchaser's disposal the processing and storage areas necessary for the harvesting.

The terms of sale (prices, acceptance of loads, terms of payment) shall be those set out overleaf.

The price terms (per unit of product) for unprepared wood from the windblow area are as follows:

Species	LOGS		PULPWOOD	
	Diameter (over bark)	Pre-tax price/m3 (over or under bark) (1)	Diameter and length	Pre-tax price/stere; Pre-tax prince/ton

The seller is liable for VAT: _____ No _____ Rate: 5,5%

Purchaser's bank references: _____

Time-limit for payment following roadside acceptance of following shipment of the timber (specify number of days) (1): _____

Method of payment (bank cheque, bill of exchange bank bill) (1): _____

An invoice will be made out by the seller

- after uplifting of each truckload (1)
- after roadside reception (1)

The penalty for late payment shall be 1% per month.
The volumes uplifted and invoiced shall be those recorded by the seller or his agent (see clause 11 below). For each load uplifted, the seller and purchaser must be informed of:

- The date of uplifting by road
- The name of the carrier
- The registration number of the truck
- The destination
- The species concerned
- The type of wood (saw or peeler logs, pulpwood, logs or steres) (2)
- List of identification plate numbers
- Individual volume of the log corresponding to each identification plate
- Volume per outgoing truck (m3, steres, tons)

Signature of the seller

Signature of the purchaser,
with manuscript annotation
"Read and approved"

Done in two copies

At: _____

Date: _____

(1) Delete as appropriate
(2) In the case of wood sold by stere or tons, specify the number of steres or the tonnage

Clause 1: Logs shall be professionally cut so as to avoid shattering the butt logs of uprooted trees when separating them for the stump. Consequently, the purchaser shall ensure that fellers having to cut stumps with a base diameter in excess of 40 cm all use 8-10 hp chainsaws equipped with a guide 60 cm or more long and begin the severing of butt logs by making a slot extending to the heat and cutting as far down into the wood as possible, even if it is in the ground, on either side of the stump. The upper part of the stump shall only be cut at the last moment before the stump settles back into its hole. The feller shall ensure that roots below the butt log are perfectly cut so as to avoid during skidding.

Clause 2: The purchaser shall ensure that stumps which have had to be cut too high are immediately cut back to ground level.

Clause 3: The trees that are harvested shall all be lopped beyond the merchantable point of the stem to 8 cm top diameter or less, as the case may be. To this end, the purchasers shall ensure that the feller has the assistance of a skidding tractor whenever it is necessary, prolonged absence of the skidding tractor entailing the halting of work by the fellers.

Clause 4: All the above-mentioned wood shall be skidded at its full length down to 8 cm top diameter to the roadside processing-storage area.

Clause 5: The products - standing broken trees included - shall be processed and skidded in the order in which they turn up.

Clause 6: The cutting to merchantable length, the estimation of commercial volume and attachment of identification plate to logs shall be carried out at the roadside with the assistance of the seller or his agent. Should a purchaser of hardwood insist on accepting it at the felling site, cutting to length shall still take place at the roadside, following skidding at full length.

Clause 7: Primary processing of top logs to the requirements of purchasers of pulpwood shall be carried out at the roadside (buffer stocks be processed when skidding in the forest becomes too difficult).

Clause 8: Hardwood tops intended for fuel-wood shall be processed at the felling site by the purchasers and the wood shall be skidded when the condition of the ground permits.

Clause 9: Wood shall not be skidded over ground that is too soft; should skidding be halted, the time-limit for completion of operations shall be extended.

Clause 10: The seller shall make available to the purchaser one or more processing-storage areas of sufficient size and accessible to trucks.

Clause 11: Each time a log truck departs, the seller or his agent shall not the number of the plate on each log and shall have in his possession the original or a copy of the register of merchantable volume of commercial wood. He shall also note the number of steres uplifted on the departure of each truck carrying pulpwood

Clause 12: On any given property, the purchaser shall not, without the seller's signed consent, commence working in any new compartment until he has finished the skidding and felling in the preceding compartment

Clause 13: When there is a risk of a period of wet weather, operations shall begin on the areas of windblown in which the ground is still firm but which are likely to become inaccessible in the months ahead. The most accessible areas shall be kept for the most difficult periods.

Annexe 5: Details of the costs for compact piles with water sprinkling method

❑ ***Preliminary investments***

- Infrastructure
  - 0 to 5.500 €/ha for a site partially or totally prepared (in terms of transport accessibility).
  - 7.000 to 9.500 €/ha for a site where many works of road reinforcement have to be undertaken.
  - 13.500 to 19.000 €/ha for a site where almost everything has to be done.

- Equipment necessary to water sprayed the logs
  - 1.8 €/m^3 for an efficient / tight storage.
  - up to 2.6 €/m^3 for a scattered storage (scattered piles).

- Electrical wiring
  - 0.3 to 1 €/m^3 depending on the distance from the electrical source.

- Labour force necessary to implement the site
  - 0.3 €/m^3 .

To illustrate these figures, the mean, the minimum and the maximum prices with regard to 15 sites followed in Aquitaine after the 1999 storm in France, are summarised in the table below:

	Mean (Euro/m^3)	Min (Euro/m^3)	Max (Euro/m^3)
Infrastructure	7.65	1.42	24.2
Electrical wiring	0.61	0.25	1.07
Water spraying equipment	2.24	0.81	3.09
Miscellaneous	2.62	0.46	6.86
TOTAL	**13.13**	**5.93**	**33.76**

❑ ***Breaking load costs:*** 8.3 €/m^3

❑ ***Functioning costs***

Rent or purchase of the terrain: 0.07 €/m^3/year
Electrical consumption: 0.37 to 0.55 €/m^3
Water consumption: 0.1 €/m^3
Maintenance: 0.1 €/m^3
Assurance: 0.1 €/m^3
Daily monitoring: 0.91 to 1.31 €/m^3 depending on the distance of the site from the company in charge of the storage yard.
Installing / de-installing of the water spraying device: 0.1 €/m^3
More globally, the functioning costs range from approximately 1.43 *to 2.2 €/m^3*

❑ ***Costs following the period of conservation***

Log uptake: 0 to 2.3 €/m^3
Site restoration: 0.1 to 0.76 €/m^3
Log transport: 2 to 8.5 €/m^3 depending on the distance from the storage yard to the sawmill.

Annexe 6: Regulations and laws

❑ Austria

Area	Laws/regulations	Required approvals: authorities
Work Safety	Forstgesetz (1975) Land- und forstwirtschaftliche Unfallverhütungsverordnung Land- und forstwirtschaftliche Dienstnehmerschutzverordnung NÖ Landarbeitsordnung 1973 Steiermärkische land- und forstwirtschaftliche Dienstnehmerschutzverordnung Land- und forstwirtschaftliche Sicherheits- und Gesundheitsschutz- Verordnung	Bundesgesetz Landesgesetz (OÖ) Landesgesetz (Salzburg, Burgenland) Landesgesetz (Niederösterreich, Wien) Landesgesetz (Steiermark) Landesgesetz (Tirol)
Water discharge	Wasserrechtsgesetz (1959) AEV Pflanzenschutzmittel Allgemeine Abwasseremissionsverordnung	Bundesgesetz Bundesgesetz Bundesgesetz
Transport	Ein- und Durchfuhr von Nadelholz mit Rinde Kraftfahrgesetz Abschnitt II Straßenverkehrsordnung §42,45,61,71	BGBl.Nr. 536/1988 BGBl.Nr. 267/1967 zuletzt geändert durch BGBl. I Nr. 60/2003 BGBl.Nr. 159/1960 idgF
Water storage Sprinkling	Wasserrechtsgesetz (1959)	Bundesgesetz
Treatment	Forstschutzverordnung	BGBl. II Nr. 19/2003

❑ Germany

Area	Laws/regulations	Required approvals: authorities
Water storage	Wasserhaushaltsgesetz (WHG)	Rahmengesetz des Bundes
	Wassergesetze der Länder	Wasserwirtschaftsämter
	Verordnung über Pläne und Beilagen in wasserrechtlichen Verfahren (WPBV)	
Sprinkling	Wasserhaushaltsgesetz (WHG)	Rahmengesetz des Bundes
	Wassergesetze der Länder	Wasserwirtschaftsämter
	Abwasserabgabegesetz	Bbbbbb
Storage under drying conditions	Baugenehmigung	Landesbauordnung

❑ Denmark

Area	Regulations/laws	Required approvals: authorities
Road transport	Færdselsloven, LBK 712 af 02/082001	Excessive loads: Rigspolitichefen
Working safety	Lov om arbejdsmiljø LBK 784 af 11/10/1999	Arbejdstilsynet
Storage in general	Lov om planlægning LBK 763 af 11/09/2002 Lov om naturbeskyttelse LBK 577 af 04/02/2002	Amtskommunen Skov- og Naturstyrelsen
Wet storage	Lov om miljøbeskyttelse LBK 753 af 25/08/2001 Lov om vandløb LBK 632 af 23/06/2001	Amtskommunen Amtskommunen

❑ France

Area	Laws/regulations	Required approvals: authorities
Water storage	- Installation du site : Arrêté relatif aux prescriptions générales applicables aux installations classées pour la protection de l'environnement soumises à déclaration sous la rubrique n°1531	- Service du préfet
	- Prélèvement dans un cours d'eau : Décret n°94-354	- Direction départementale de l'agriculture et de la forêt - Police de l'eau
	- Collecte et analyse des rejets d'eau : Arrêté n°1531	- Inspection des installations classées
Use of chemical wood protection	- Traitement insecticides des grumes : Info – Santé – Forêts, note technique n°1	- Département de la santé des forêts
Health and safety regulations		- Ministère de l'agriculture: DGFAR / Département du travail et de la santé

❑ Italy

Area	Leggi/Regolamenti	Approvazioni richieste: autorità
Work safety	D.Lgs. n. 277 del 15.08.1991 "Protezione dei lavoratori contro il rischio di esposizione ad agenti chimici, fisici e biologici" D.Lgs. n. 626 of 19.09.1994 "Linee guida sulla sicurezza nei luoghi di lavoro"	ASL ASL
Transport	Dlg. 30.04.1992 n. 285, articoli 10,61,62 del Codice della strada	

❑ Norway

Agreement between forest related employers and workers associations 2002 – 2004	' 4.4 Safety routines
Transport regulations	Norwegian Pollution Control Authority
Road transport regulations	Public Road Administration

❑ Portugal

Area	Laws / regulations	Required approvals: authorities:
Segurança no Trabalho	**Decreto-Lei nº 141/95 de 14 de Junho e Portaria nº 1456-A/95, de 11 de Dezembro** Estabelece os sistemas e os princípios de sinalização de segurança Define a posição e o uso de sinalização. **Decretos-Leis n^{os} 26/94 de 1 de Fevereiro, 7/95 de 29 de Março e 109/2000, de 30 de Junho** Define os serviços de sáude, higiene e segurança no trabalho. Estabelece as medidas de segurança, higiene e sáude no local de trabalho. **Decreto-Lei nº 349/93, de 1 de Outubro e Portaria nº988/93, de 6 de Outubro** Estabelece os equipamentos de protecção individual que poderão ser utilizados pelos trabalhadores. **Decreto-Lei nº 347/93 de 1 de Outubro e Portaria nº 987/93 de 6 Outubro** Estabelece a organizaçao do trabalho e regulamentaçao geral do trabalho **Decreto-Lei nº 330/93 de 25 de Setembro** Estabelecimento de regras na movimentação manual de cargas. **Decreto-Lei nº 72/92 de 28 Abril e Portaria nº 9/92 de 28 de Abril** Estabelecimento de protecções correctas ao nível do ruído, no local de trabalho. **Decreto-Lei nº 441/91 de 14 de Novembro** Estabelecer o enquadramento da saúde, higiene e segurança no trabalho.	Todas as portarias e os decretos de leis são válidos somente para Portugal. A legislação é estabelecida pelo Ministério do Trabalho
Descarga de águas	**Portaria nº 429/99** Estabelecimento do limite da descarga das águas residuais, nos leitos de água ou no solo. **Decreto-Lei nº 236/98** Estabelecimento de normas, critérios e objectivos para a protecção dos recursos hídricos e para melhorar a qualidade da água. (Este decreto revogou o decreto-lei nº 74/90 de 7 de Março)	A legislação é estabelecida pelo: - Ministério de Economia; - Ministério da Saúde; Ministério do Ambiente.
Armazenamento de águas paradas	Em Portugal não existe legislação específica sobre este assunto.	Direcção-Geral da Viação (DGV), no qual é a instituição responsável por efectuar os regulamentos relacionados com os veículos e as suas cargas (www.dgv.pt)
Transporte	**Portaria nº 960/2000 de 9 de Outubro** Altera a portaria nº 1029/97, no qual regula os limites de pesos e dimensões dos veículos. **Despacho nº 14339/2000 de 14 Julho** Averbamento do peso bruto **Decreto-Lei nº 72/2000 de 6 de Maio** Aprova o regulamento da CE de modelo de automóveis e reboques, seus sistemas, componentes e unidades técnicas. **Portaria n. 1092/97 de 3 Novembro** Regulamenta os limites de peso e dimensão dos veículos. Revoga a portaria nº 850/94, de 22 de Setembro. **Despacho da Direcção-Geral da Viação nº 45/96 de 24 de Março** O valor máximo da largura das caixas dos veículos. **Portaria nº 682/96 de 21 de Novembro** Define os limites dimensionais dos veículos. **Portaria nº 855/94 of 23 September** Define as categorias de modelos de veículos.	Esta legislação é estabelecida pela. Direcção Geral de Viação

❑ Spain

Area	Regulations	Organisms
Work	Ley 45/1999 de desplazamientos de trabajadores en el marco de una prestación de servicios transnacional Ley del estatuto de los trabajadores. R.D legislativo 1/1995	- Ministerio de Trabajo y Asuntos Sociales. Agustin de Bethencourt 4. Tf: 91 363 00 00 http://www.mtas.es/
Transport	Ley 16/87 30-7 de Ordenación de transportes terrestres	- Dirección General de Transportes por carretera. Ministerio de Fomento. Paseo de la Castellana 67. Tf: 91 597 70 03 http://www.mfom.es/
Railroad	Ley 39/2003 del sector ferroviario	- Subdirección general de planes y proyectos de infraestructuras ferroviarias - Subdirección general de construcción de infraestructuras ferroviarias Plaza de Sagrados Corazones 7. 28071 Madrid. Tf: 91 597 70 00 - RENFE Avda. Pio XII 110. Edificio Caracorlas (Chamartín). Madrid Tf: 91 733 91 62 - FEVE C/General Rodrigo 6. 28003 Madrid. Tf: 91 453 38 00
Ports	Ley 27/1992 de puertos y de la marina mercante	Dirección General de la Marina Mercante. Ministerio de Fomento. Paseo de la Castellana 67. Tf: 91 597 70 03 http://www.mfom.es/ Puertos del estado Avda. del Partenón 10. Campo de las naciones. 28071 Madrid Tf: 91 524 55 00
Health and safety	Ley 31/1995 de prevención de riesgos laborales R.D. 39/1997 Reglamento de servicios de prevención	- INSH Torrelaguna 73. 28027 Madrid Tf: 91 363 41 00 http://www.mtas.es/insht/index.htm - Fundación F4 Apto. Correos 2212. 3180 Pamplona http://www.fundacionf4.com

❑ Switzerland

Area	Regulations / laws	Required approvals: authorities
Use of chemical wood protection	- Verordnung über umweltgefährdende Stoffe - Verordnung über den Wald	**Anwendungsbewilligung**: kantonale Forstdienste
Water storage	- Bundesgesetz über den Schutz der Gewässer - Bundesgesetz über die Fischerei - Bundesgesetz über die Binnenschiffahrt	**Wasserentnahme ab Bach**: Kantonale Fachstelle für Wasserwirtschaft oder Gewässerschutz, evtl. kantonale Fischereiverwaltung (bei Fischgewässern) **Wasserentnahme ab Hydrant**: Wasserwerk der Gemeinde **Lagerung in stehenden Gewässern**: Kantonales Verkehrs- und Schiffahrtsamt **Wasserableitung in Gewässer**: Kantonale Fachstelle für Wasserwirtschaft oder Gewässerschutz, evtl. kantonale Fischereiverwaltung (bei Fischgewässern) (je nach Kanton ist nicht immer die gleiche Fachstelle zuständig!)
Working safety	- Verordnung über umweltgefährdende Stoffe - Verhaltensregeln Arbeitshygiene - Signalisationsverordnung	Information erhältlich bei SUVA Luzern

Annexe 7: Haulage regulations - weight and size

Maximum weight (tonnes)

	Germany	Austria	Belgium	Denmark	Spain	Finalnd	France	Greece	Irland	Italy	Luxembourg	Norway	Netherlands	Portugal	United-Kingdom	Sweeden	Switzerland
Weight per bearing axle	10	10	10	10	10	10	13	10	10	12	10	10	10	10	*	10	10
Weight per driving axle	11,5	11,5	12	11,5	11,5	11,5	13	11,5	10,5	12	12	11,5	11,5	12	10,5	11,5	12
Four axles rigid truck	36	38	39	32	36	38	38	36	35	40	-	-	40	37	32	-	34
Five axles (and over) truck + trailer	40	40	44	48	40	60	40	40	40	44	44	50	50	40	44 **	60	34
Five axles (and over) articulated truck	40	40	44	48	40	48	40	40	40	44	44	47	50	40	44 **	60	34

Maximum sizes (metres)

Tall	4	4	4	4	4	4,20	n.d.	4	4,25	4	4	n.d.	4	4	n.o.	n.d.	4
Width	2,55	2,55	2,55	2,55	2,55	2,60	2,55	2,55	2,55	2,55	2,55	2,55	2,55	2,55	2,55	2,60	2,55
Length	18,75	18,75	18,75	18,75	18,75	25,25	18,75	18,75	18,35	18,75	18,75	18,75	18,75	18,75	18,75	24	18,75
Articulated truck length	16,50	16,50	16,50	16,50	16,50	16,50	16,50	16,50	16,50	16,50	16,50	17	16,50	16,50	16,50	24	16,50

n.d. : not defined - n.o. : not obligatory

* variable - dependant on vehicle type, axle numbers and configuration, and type of suspension

** total number of axles is 6 or more and tractor unit is fitted with a Euro II or Euro III emission standard low pollution engine

Annexe 8: National contacts for health and safety regulation

COUNTRY	Organisation (NAME + *short description*)	Address	Tel / Fax / email
AUSTRIA	Allgemeine Unfallversicherungsanstalt	Adalbert-Stifter-Straße 65, 1200 Wien	Tel: +43 1 33111-0 www.auva.at
	Sozialversicherungsanstalt der Bauern	Ghegastraße 1 1031 Wien Postfach 313	Tel.: +43(1) 797 06 Fax.: +43(1) 797 06-1300 www.svb.at
DENMARK	Arbejdstilsynet The Danish Work Environment Service	Landskronagade 33 DK-2100 København Ø	Tel: +45 – 70 12 12 88 Fax +45 – 70 12 12 89 e-mail: at@at.dk
FRANCE	Ministry of Agriculture DGFAR • Sub-department of Work and Employment Office of Regulation and Work Safety	19 av du Maine 75732 PARIS cedex 15 07 SP	Tel : 33-(0)1-49-55-51-51 or 33-(0)1-49-55-82-17
GERMANY	Bundesministerium für Gesundheit uns Soziale Sicherung	10117 Berlin, Wilhelmstr. 49	Tel.:0049(30) 20 07-0
	Bundesanstalt für Arbeitsschutz und Arbeitsmedizin	Friedrich-Henkel-Weg 1-25 D-44149 Dortmund	Tel.: 0049-231-90 71 0 Fax.: 0049-231-90 71 2454 Email: poststelle@baua.bund.de
ITALY	Ministry of Health • National Institute of Occupational Safety and Prevention	Via Alessandria 220/E - 00198 ROMA	tel.: 06 4425 0648 fax: 06 4425 0972 E-mail: doc@ispesl.it
NORWAY	Norwegian Labour Inspection Authority, Arbeidstilsynet	Postboks 8103 Dep. N-0032 Oslo Norway	Tel: (+47) 22 95 70 00 Fax: (+47) 22 17 63 73 E-mail: direktoratet@ arbeidstilsynet.dep.no
PORTUGAL	Ministry of Agriculture, Rural Development and Fishing - Sub-department: Direcção Geral das Florestas	Av. João Crisóstomo 28, 1069-040 Lisboa	Tel: +351 213 124 800 Fax: +351 213 124 989 E-mail: info@dgf.min-agricultura.pt Web page: http:// www.dgf.min-agricultura.pt
	Ministry of Work Sub department: Secretaria de Estado do Trabalho Activities: - Work legislation	Praça de Londres, 2-15º 1049-056 Lisboa	E-mail: gsetrab@msst.gov.pt Web page: http://www.msst.gov.pt
	IDICT – Institute of Development and Inspection of the Work Conditions Activities: - To improve the work conditions - Promoting the development	Praça de Alvalade, 1 1749-073 Lisboa	Tel: +351 217 924 500 Fax: +351 217 924 597 E-mail: idict@idict.gov.pt

SPAIN	Ministerio de Trabajo y Asuntos Sociales • Instituto Nacional de Seguridad e Higiene en el trabajo	Torrelaguna 73. 28027 Madrid	Tf: +34 91 363 41 00 Fax +34 913 634 327 webmasterinsht@mtas.es http://www.mtas.es/insht/index.htm
SWITZERLAND	SUVA Swiss National Accident Insurance Fund (SNAIF)	Fluhmattstrasse 1 6005 Luzern	Tel: +41 - (0)41 419-51-11 www.suva.ch
GREAT BRITAIN	Health and safety Executive – Forestry sector – National Agriculture Centre	Stoneleigh Kenilworth Warwickshire CV8 2LG	Tel: + 44 (0) 247 6698350 email: hseinformation services@natbrit.com

Annexe 9: National contact for safety documentation and practical information for refreshment training

COUNTRY	Organisation (NAME + *short description*)	Address	Tel / Fax / email
AUSTRIA	Bundesamt und Forschungszentrum für Wald	A-1131 Wien, Seckendorff-Gudent-Weg 8 (Wien Schönbrunn)	Tel. +43-1-87838-1123 http://bfw.ac.at/
	Forstliche Ausbildungsstätte Ort/Gmunden	Johann Orth-Allee 16 A-4810 Gmunden	Tel.: +43-(0)7612-64419-0 Fax: +43-(0)7612-64419-34 www.fastort.at
	Forstliche Ausbildungsstätte Ossiach	Ossiach 21 A-9570 Ossiach	Tel.: +43-(0)4243-2245-0 Fax: +43-(0)4243-2245-55 http://www.fastossiach.at
	Forstliche Ausbildungsstätte Pichl	Rittisstraße 1 8662 Mitterdorf	Tel.: 03858/2201-0 Fax: 03858/2201-7251 www.fastpichl.at
	Forstliche Kursstätte Hohenlehen	Garnberg 8, 3343 Hollenstein	Tel.: 07445/ 225 Fax: 07445/ 232
	Ausbildungsstätte Drosendorf	Wienerstraße 64, 3100 St. Pölten	Tel.: 02915/ 2321 Fax: 02915/ 2340
	Landesberufsschule und Forstliche Ausbildungsstätte Rotholz	6200 Rotholz 46	Tel.: 05244/ 621610 Fax: 05244/ 6216150 www.rotholz.at
DENMARK	Center for Skov & Landskab	Nødebovej 77A DK-3480 Fredensborg	Tel. +45 - 35 28 15 05 FAx +45 - 35 28 15 10
FRANCE	CCMSA (the equivalent of National Health for agriculture)	Les Mercuriales 40 rue Jean Jaurès 93547 BAGNOLET cedex	Tel : 33-(0)1-41-63-77-77 Fax : 33-(0)1-41-63-72-66
	AFOCEL	Domaine de l'Etançon 77370 NANGIS	Tel : 33-(0)1-60-67-00-34 Fax : 33-(0)1-60-67-00-27 email : dir@afocel.fr
	CTBA	10 av de St Mandé 75012 PARIS	Tel : 33-(0)1-40-19-49-19 Fax : 33-(0)1-43-40-85-65
GERMANY	Bundesministerium für Wirtschaft und Arbeit	Scharnhorststrasse 34-37 D-10115 Berlin	Tel.: 0049(30) 20 14-9 Fax.: 0049(30) 20 14-70.10 email: info@bmwa.bund.de
ITALY	MINISTRY OF WELFARE Safety on working sites Division VII	Via Fornovo, 8 – Pal B - 00192 Roma	Tel. +39 06 36754917 Fax +39 06 36754886 e-mail: Div07RapportiLavoro@welfare.gov.it
	Forest Regional Service Refreshment training (i.e. for the North-East: CESFAM	via Roma, 40 33026 Paluzza (UD)	Tel. : +39 0433 775648 Fax :+39 0433 775921 cesfam@regione.fvg.it
NORWAY	Norwegian Labour Inspection Authority, Arbeidstilsynet	Postboks 8103 Dep. N-0032 Oslo Norway	Tel: (+47) 22 95 70 00 Fax: (+47) 22 17 63 73 E-mail: direktoratet@arbeidstilsynet.dep.no

PORTUGAL	ANEFA – Associação Nacional de Empresas Florestais, Agrícolas e do Ambiente (National association of forestry companies, agricultural and environmental)	Estrada de Benfica, 552 - 3.º Dto. Ap. 40079 1500-106 Lisboa	Tel: +351 217 110 261 Fax:+351 217 110 269 E-mail: anefa@ip.pt
	COTF - Centro de Operações e Técnicas Florestais (Forestry Operations and Thecniques Center)	Chã de Freixo 3200 Lousã	Tel: +351 239 990 981 Fax: +351 239 990 989 E-mail: joao.fernandes@dgf.min-agricultura.pt
	CBE . Centro da Biomassa para a Energia (Biomass Center for Energy)	Zona Ind. Valfeijão Ap. 49 3220-119 Miranda do Corvo	Tel: +351 239 532 436/ 488 Fax: +351 239 532 452 E-mail: cbe@mail.telepac.pt
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