## PART A : DAMAGE ASSESSMENT

First and foremost, the areas concerned must be flown over and aerial photographs taken. Only then can the extent of the damage be partially understood. From the photos the degree of damage and the areas affected can be identified.

Based on the available stand data the volume damaged can be determined by species and log type. Some species are more susceptible to sapstain than others (worst: Strobus, Ponderosa, Contorta, Radiata, Corsican, Douglas fir : most resistence). The value of wood dictates the priority of salvage. Older, larger trees with a large sawlog component should have highest priority for salvage.

Exact volumes damaged is often hard to predict. The only basis for calculation is the mensuration data available which is often outdated and sometimes inaccurate. Assessments of breakage is a difficult task. Aerial photos can help, but there is a need for some ground survey. This is probably best done during the first stages of the logging operation, as the areas are opened up. Logging records from the first salvage operation can assist in predicting breakage in adjacent or similar stands.

Once the areas affected have been identified there is a need for some classification based on the extent of the damage and the salvage prescription.

1. Complete blowdown : complete salvage.

2. Partial blowdown : clearfell and salvage.

3. Partial blowdown : selection salvage.

4. Minor damage : no salvage - waste.

The criteria for classification is based on a number of factors and requires discussions between the forest owner, the logger and the end user. Some, but not all, of the influencing factors are :

1. Size of the blowdown : Small windthrows can be completely salvaged without adversely affecting short or long term wood supply, but large windthrows require immediate action to the worst hit areas and often result in the loss of wood from areas only partially damaged.

2. Market constraints : If markets exist it is often acceptable to salvage all areas, but often markets can be saturated which forces salvage operations to concentrate on the highest value timber.

3. Age of stands : In partially damaged stands of a very young age it is often best to clearfell the stand and start the rotation over again. Middle or older aged stands may require partial logging to leave standing trees for future demands.

4. Future supply : If only stands of similar age classes are damaged it may be necessary to leave as much as possible of that volume standing for the future.

The time delay before sapstain, wood rotting and insect damage occurs is dependent on time of the year, regional climate, and most important, the weather following the windthrow. In general, trees once snapped or broken off the stump will deteriorate almost immediately, lasting a maximum of six months if all conditions are favourable. Trees that are windthrown and have roots intact can be expected to last longer and in some cases up to two years.

Sapstain fungus becomes active once the moisture content of the logs drops to about 90% and the temperature reaches the 22-26° Celsius range. Wet and cold winters will delay the fungus attack. Also, hot temperatures, low humidity, and dry winds, such as those in Canterbury, will dry out the logs and make conditions unfavourable for fungus growth. Insect damage is likely to occur during the warm summer months.

At the start of the salvage assessment of areas, volumes, breakages and classification of areas is crucial. But, the entire salvage should not be based on this initial evaluation. The areas must be reflown and photographed to determine the progress of the salvage and if there has been additional windthrow following the initial storm. Management decisions must be flexible enough to change as updated information becomes available.

## PART B : PLANNING AND OPERATIONAL CONTROL OF THE SALVAGE OPERATION

Once the affected areas have been identified the first job is the clearing of access roads in the area. New roads, if required, should be laid out parallel to the windthrow, when possible, since roading across the windblow is difficult. If the area affected has been previously roaded then additional roading may be required to locate new landings. Generally, roading density is slightly increased but this is controlled by local conditions which affect the difficulty and cost of roading.

With windthrow salvage it is necessary to plan for butt pull extraction to reduce breakage and improve breaking out conditions. This means that the possible area pulled to any one landing is reduced from a 360° to 180° direction. The result is the need to almost double the number of landings. Roads have to be punched in to provide access to these landings.

Haul distance is likely to increase due to butt pulling in a single direction and also the snaky pattern around obstacles. To reduce travel times the landing density should be increased to reduce the haul distance. This also improves safety by allowing the extraction machine to be available to assist fallers at the felling face. In general, landing densities are doubled and haul distances should be planned for a 200-250 metre maximum haul.

Existing machinery is usually sufficient to do the harvesting job. Difficulties arise in the breakout phase, but once logs are free the conventional sized machines can handle the wood.

Due to the increased difficulty of breaking out it is often necessary to increase the rope size of the mainline and strops to reduce breakage. Another problem is the roughness of the area, due to high stumps, uprooted stumps and heavy slash. This causes high wear and tear on the machines, especially to the blade rams often used to clear paths. Crawler tractors can be of assistance for clearing skid paths, the felling face, and assisting breakout, but there is a tendency for the blade machine to spend too much non-productive time pushing stumps around.

In windthrown stands productivity usually suffers due to reduced piece size and the difficult working conditions. This usually results in an excess of manpower when compared to conventional harvesting gangs. Particularly in totally windthrown areas where fallers breakout their own trees. It is often advisable to reduce crew size and increase the number of crews by forming new crews with the excess manpower. There may be a need to increase manpower on the landings to assist in log preparation and segregation.

Windthrown areas are often restricted geographically. Thus, depending on the location of the majority of the windthrown areas, average trucking distance can be dramatically affected. This may require more trucks or leave some relatively idle. Since piece size is reduced shorter logs are going to be carted. Loading problems increase and may require truck stanchion modification.

It is important to sort logs on the skids to ensure that logs of proper quality are going to the right end user. Skiddies need to be taught the acceptable quality standard for the various log grades. When log quality is in doubt it is best to remove it on the landings rather than cart it a long distance to have it rejected. The use of transfer yards for log segregation is prohibitive due to the high cost of multiple handling.

## PART C : HARVESTING TECHNIQUES

Felling or crosscutting is often the most difficult and dangerous task in windthrown timber. Various crosscutting techniques developed using under-cutting, boring cuts, offset cutting and angle cuts, are described in the earlier sessions. All of these techniques have been developed to reduce slabbing, prevent chainsaw jamming or kick-back, and most importantly, to improve safety of the faller. Cutting the tree as close to the stump as possible is the first priority to reducing the danger of logs springing and also for recovery of the maximum volume of the high quality butt log. Fallers should fell or crosscut one drag at a time working at the rate of the extraction machine.

Heavily leaning trees have a high potential for slabbing or barber chairing. Side scarfing at right angles to the lean and the use of a boring backcut will certainly help to reduce slabbing. Spars should also be treated with respect,due to the difficulty of judging the direction of lean and will often require a wedge or a felling lever. When tensions within a fallen tree are in doubt, it is advisable to wait for machine assistance or to partially cut the tree and leave some holding wood. The extraction machine can then break the tree off at the stump during extraction. This

is especially true in steep country where stumps and trees can roll down the hill following crosscutting. By leaving the tree slightly attached to the stump the dangers are reduced. During breakout the hauler can extract the log and the stump will usually break-off.

The success of techniques developed are only as good as their actual use by the bushmen. Distribution of pamphlets with diagrams of techniques are helpful, but unless the technique and its advantages can be demonstrated to the bushman, their adoption of the technique is unlikely. Training of the bushmen is crucial and there is a need for trainers, to demonstrate these techniques. Additional people for training are required as supervisors have little extra time available due to their increased workload in windthrow salvage.

When the windthrow is predominantly parallel and there is little crossover, feller-bunchers can be used to shear trees and bunch, (tree size $< 1\ m^3$). By using a machine the safety of the operation is greatly improved, but if trees are laying crossed and tangled, the job of pulling trees loose is too hard on the machine. In tangled trees feller-bunchers have been used successfully to shear the tree and leave it in place, a faller can then delimb for extraction.

Delimbing of windthrown trees should be limited to the safely accessible part of the tree. By delimbing part of the tree prior to crosscutting, a better understanding of the lay of the tree is achieved. When working in standing trees delimbing should be done at the landing or in a safe processing area after breakout, away from the felling face. If processing is done in this manner several sets of detachable strops are advisable to prevent the extraction machine from sitting idle. The machine can break out a drag, transfer the drag for delimbing, drop the drag and then pick up the previous delimbed drag for extraction to a landing. Another technique is to use a separate machine to breakout and bunch the trees away from the felling face. Trees can then be delimbed and are bunched for later extraction. The Bell logger has been used successfully in tree sizes up to $.15\ m^3$ and in larger timber grapple skidders can also be used to bunch for the extraction machine.

Available company and contractor gangs extraction units should be used for salvage. Care must be taken when moving gangs working with small trees into a larger tree size. They must be made aware of danger areas in the larger trees. If possible, only butt pulling should be used. Haul paths should be kept as straight as possible to minimise top breakage through turning. The high stumps and uprooted stumps on the clearfell will force the use of a blade to clear haul paths and blades on skidders will take a physical beating. Crawler tractors are probably the best tool in windthrow. Combined crawler tractor and skidder gangs will allow the crawler tractor to do ground clearing while freeing the skidder for extraction, but it is important to ensure the tractor spends the majority of the time pulling wood rather than pushing it around.

Novel harvesting techniques must not be overlooked. A crawler tractor mounted with a grapple can be effective, so long as haul distances are kept short. Another effective grapple system uses two grapple skidders, one unit breaks out and pre-bunches and the other extracts bunches to the landing. Rubber-tyred loaders have

been used successfully in Canterbury for tree extraction of sizes up to one tonne. For larger trees a tracked loader can be efficient, but in the past proved to be too expensive. Another concept worth investigation is the use of cable crane loaders or hydraulic cranes for picking trees up. Mechanical felling and bunching machines, if available, may improve safety and productivity of the extraction units.

The use of any system is dependent on the piece size, type of windthrow, terrain and, obviously, the available machinery, but new approaches are always worth investigation, no matter how far fetched they appear on paper.

Steep country logging is difficult at the best of times and windthrow only compounds the problems, particularly with hauler logging. Ground skidding systems should be used to their limit. On steep slopes tracking for salvage of completely or partially blown areas is often the most cost effective and successful technique. Where haulers are used skyline systems are far superior to highlead, due to their increased lift and breakout capacity. In partially windthrown areas systems with locking carriages having slack pulling capacity will allow partial logging to leave standing trees remaining for future wood supply.

Productivity of windthrow will be affected by the drop in piece size and the difficult and dangerous working conditions. In old crop skidder operations initially there will be an estimated 15-35% drop in productivity, but as the gangs became more familiar and skilled in windthrow the productivity should level at 5-15% lower than normal conditions. Productivity loses of haulers is even greater, initially dropping about 30-40% and then improving to 15-25% below normal operations. In thinning areas productivity is not as adversly affected because the actual increase in piece size through harvesting of the residual trees. It should be recognised as mandatory that safety is the primary concern. To protect the safety of the bushmen target rates should be set for safe operating levels. There should be no pressure on gangs to try and over-produce at the sacrifice of safe techniques.

## PART D : SAFETY CONTROL - CRITICAL DANGER AREAS

First and foremost, increased attention should be given to safety, particularly where new men are involved. Provision should be made for mobile first aid units and transport facilities (ambulances, or if needed, helicopters). Communication is the key so a radio network linking all gangs to a central headquarters is needed. In the early stages of the salvage meetings should be held with contractors and foremen to outline the course of action in case of accidents. There is also a need, not necessarily just in windthrow, for some first aid training for all contractors and foremen.

The most dangerous aspects of windthrow are associated with felling. Some of the critical danger areas are :

1. Crosscutting thrown trees: Tensions are built up in the stem and when cut the tree can spring sideways or upwards.

2. Rolling stumps: Once the tree is severed the stump can sit back, roll over forward, or to one side.

3. Spars: Trees with their tops broken out are potential killers due to the low centre of gravity, and are likely to fall in any direction. Once felled, spars can bounce and roll unpredictably.

4. Felling leaning trees: Felling leaning trees can result in tree slabbing, or barber chairing.

5. Felling into standing or partially leaning trees: This may dislodge broken tops or push a spar in the direction of faller.

6. Kick-back during delimbing: Since trees are thrown to the ground, limbs from several trees are often crisscrossed and held in tension. The cutting of one limb may release another limb from tension, snapping it back towards the operator.

7. Log movement during extraction: During breakout fallers should be alert to moving logs. The breakout of one log often frees another log from tension.

8. Sprains and bruises: Throughout the operation conditions are more difficult and there will be a higher occurrence of sprained ankles and bruises.

9. Inexperienced workers: Lack of skills can create hazards with a new man and the experienced bushman who is called in to correct the problem. If possible, only the most experienced gangs should be used in windthrow salvage.

Training is the key to reducing accident rates in windthrow salvage. At the start-up of the salvage, meetings are required to stress safety, critical danger areas and operator techniques for reducing the hazards. Material describing safe techniques should be distributed to all gangs, but this is only the start. Trainers should demonstrate techniques in the field to all the gangs to show how to use them and to demonstrate the advantages of the technique. Visual persuasion, not reading materials, will get the best results. This may be a job for some of the excess manpower in the gangs to learn the techniques and to demonstrate them to others, or it may mean training one man in each gang for him to teach his co-workers. Both company and contract gangs must be trained.

Throughout the salvage there is a need to stress safety. Initially, discussion, distribution of materials and training are required but the job doesn't end there. Bushmen can become over confident in windthrow which can lead to carelessness and accidents. Supervisors must stress the need for caution and safety. To offset the expected drop in productivity concessions should be made so targets should be set for safety.

In conclusion, the Bay of Plenty region can be very proud of their safety record and it indicates the importance placed on the welfare of the workforce. After all, everyone loses when accidents occur - the injured man, lost time accidents deprive the gang of manpower, and the industry could suffer through increased ACC levies.

## PART E : WOOD PRESERVATION

Most windthrows result in a large supply of wood on the ground beginning to deteriorate. If markets exist all the volumes can be harvested and utilised as soon as possible. However, markets are often saturated or volumes exceed utilisation capacities so there is a need to preserve the wood in log form.

The cost of log preservation prohibits the storage of pulp logs but can be effective for storing export and domestic sawlogs. There are currently three options available in New Zealand.

1. Log pond storage.

2. Underwater sprinklers.

3. Chemical treatment.

The first approach using ponds is generally not feasible because of the large areas of shallow water required, problems of getting logs out of storage, and the fact that part of the log remains unsubmerged, making it susceptible to fungi and insect attack.

Storage under sprinklers is currently the most viable approach. In the past, logs have been stored under sprinklers for over three years with little or no quality loss. Storage areas required must be flat, well drained, have electricity and a clean supply of water (2 million litres per day for 20,000 $m^3$). Only logs of good quality with no sapstain should be stored. Logs stored underwater for long periods (over one year) should be sawn within one week of removal. Logs stored for short periods (two months) may be suitable for export, but this is untested since in the past sprinkler storage has only be used for domestic sawlog material.

The third option of chemical treatment is costly and should be used only for high value export logs. This technique involves the debarking and anti sapstain spraying of logs 8-13 metres long. The logs are then crib stacked for storage. A second application of chemicals may be required to touch up areas missed in the first spray. The chemical spraying has proved effective and in addition, there was a 25% weight loss which reduced trucking costs.

The feasibility of log storage is dependent on cost of storage, market conditions, local utilisation capacity, future wood supply and the volumes damaged in the windthrow. For storage to be cost effective only the best quality logs should be preserved. In order for storage to be feasible, enough wood must be stored to have a realistic effect on supply, i.e. storage of 80,000 tonne in an area with a weekly consumption of 40,000 tonne only extends supply for two weeks, but the same volume in a lower user area of 10,000 tonne per week will extend the supply 8 weeks, which is very substantial.

## PART F : UTILISATION AND MARKETING PROBLEMS

In the initial stages of the salvage of windthrown trees, there needs to be examination of the available markets with regard to customer specifications and production requirements. There is a need for close co-operation and communication between the forest

owner, the logger, and the end users. The first step is to determine volumes damaged and estimate the recoverable volumes (sawlog, pulpwood). Then operational constraints must be identified, such as capacity of the user industries, productivity from salvage operations, and the time delay before windthrow material is beyond recovery.

Once an analysis has been done decisions must be made about priority of the salvage operation. Two main options exist, to maximise value recovery by concentrating on the salvage of sawlogs to supply existing users and make additional outside sales or log exports. The other option, is to conserve the resource and maximise volume recovery under current sales agreements. To reduce recovery period exchanges can be made with outsiders users unaffected by windthrow, supplying windthrown wood in exchange for standing trees in the future. In some cases, outsiders productive capacity can be used to assist with windthrow logging.

The log export market is the most lucrative and restrictive of the existing markets. Logs must be delivered to tight specifications of length and quality. Due to tree breakage during windthrow the percentage of export volumes may be reduced. Logs must be free of sapstain and insect damage. It must be remembered that logs often sit on the wharf for two months so any sapstain present initially will only get worse.

The occurrence of windthrow can often blow down immature stands and cause high levels of breakage. This results in smaller diameter and shorter logs arriving at the domestic sawmills, and a much higher percentage of pulpwood. To reduce the level of pulpwood forest owners can drop minimum sawlog specifications, but this will add to the sawmillers problems since lower volume logs reduce profitability.

Existing saw rigs are greatly affected by changes in log size. Smaller logs will result in a number of problems. From past experience the following estimated losses are indicative :

1. A 5% drop in log to sawntimber conversion.

2. A 16% drop in sawmill productivity.

3. A reduction in the quality grades recovered (7% drop in appearance grades, 10% drop in building grades, resulting in a 17% increase in lower quality industrial grades).

4. Drop in sawntimber size which affects the ability to produce the more profitable product lines such as wide boards or large squares for export.

In addition to the change in log size there can be log quality loss occurring through shattered or split log ends, compression shake and as time wears on, sapstain. Certain levels of sapstain are acceptable, but eventually some of the production will have to be downgraded due to the stain. Sapstain affects the outer portion (highest value) of the log, so with smaller diameter logs the problem is greatest. To assist the sawmillers, the forest owners might then have to raise the minimum sawlog specification.

Compression shake is unrecognisable in log form but will show up in the lumber by reducing its strength properties.

Wood that is unacceptable to the sawmills ends up at the pulpmill. Normally, for mechanical pulp the mix of thinnings wood to tops of old crop is approximately 50/50. After the windthrow this relationship will change to utilise the windthrown wood. Initially, this should cause no problems, but after several months the brightness of the refiner pulp will start to fall. This will be partially due to the sapstain, but also due to the increased amount of dark heartwood content from the bigger logs. Bleaching of the pulp will have to be increased, often to a point three times higher than normal. Even then newsprint quality can still drop so the level of windthrown material may have to be reduced.

Kraft pulping production can actually benefit from windthrow. In the Bay of Plenty, the decision to give P.radiata salvage priority meant an increase in radiata material from 30-96% of kraft mill input reduced problems with sheet breakage and productivity rose 5-10%. Sapstain does not affect kraft paper quality so this is not a problem. Another minor benefit is the increased quality of turpentine caused by the increased radiata component.

In general, the ability of end users to utilise additional windthrown volumes is limited. Pulp mills are usually operating at near maximum productive capacity. Sawmills can only increase productivity by adding extra shifts to the work schedule. This limits the volume utilisation rate to the productive capacity of the industry. To utilise, more markets must be developed through exporting or trade agreements with sawmills outside the region, or by using log storage techniques. Outside constraints can restrict options available. Domestic or overseas markets can collapse, reducing demand and at the same time raising acceptance quality standards.